

Sustainable Agriculture Whitepaper



Local • Organic • Sustainable • Profitable

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Framing the Discussion: Sustainable Agriculture = Sustainable Society

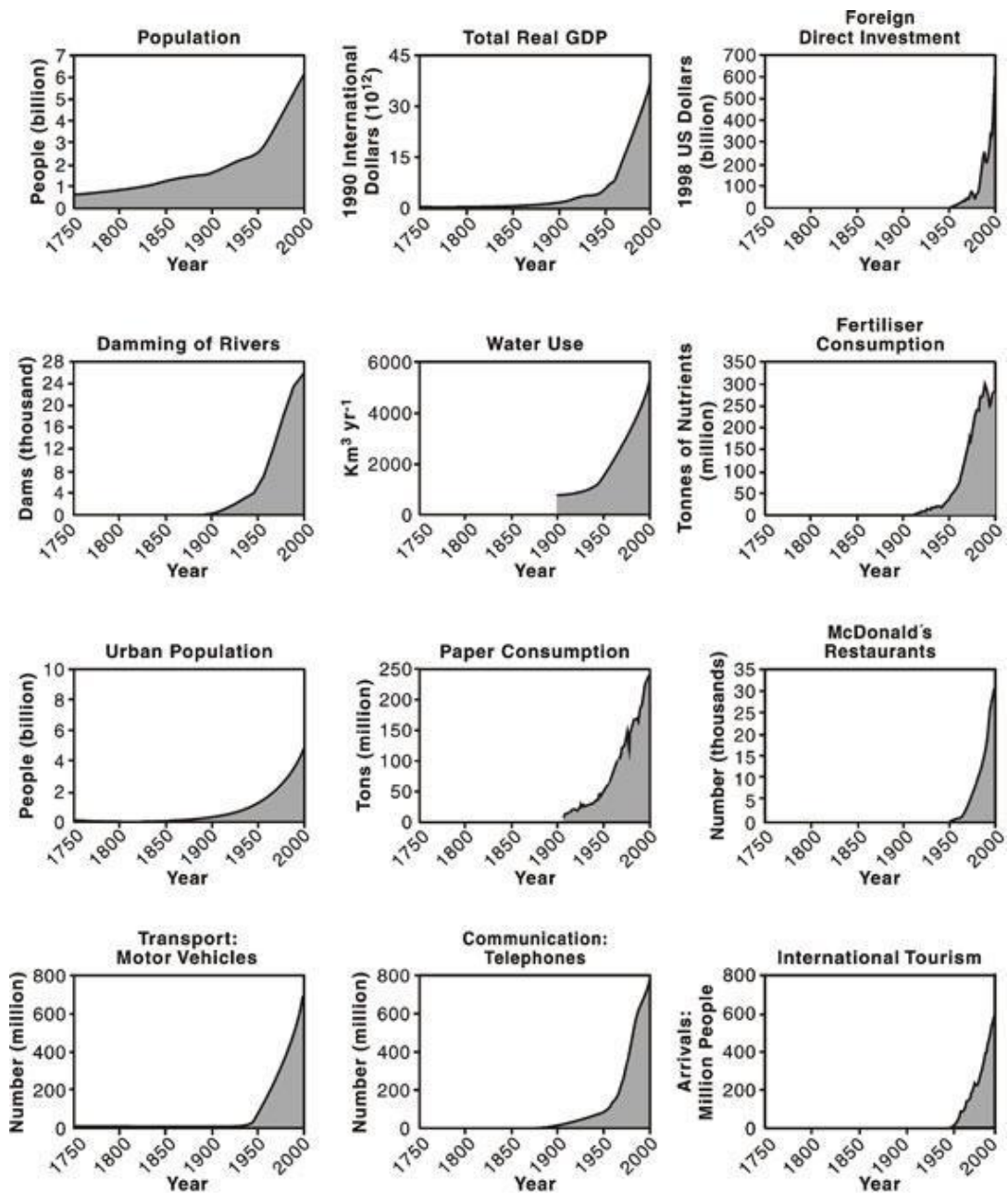
Developing a sustainable agriculture is a necessary part of creating a sustainable society. The root of the word sustainable is the verb, to sustain, which means to nourish and prolong. In social and environmental contexts we say something is sustainable when we believe it can persist indefinitely without exhausting resources or causing lasting damage.

The actions we take as individuals are at the core of both the problems and the solutions. Just by purchasing conventional goods at your local supermarket, you cause 4 lbs of pesticides to be put into the environment each year. The food supply chain averages of 4200 miles to reach your plate, when it could come from local farms and use a fraction of the transportation fuels. And the 2.6 acres of U.S. farmland (your pro-rata share) have lost 50% of the carbon in the soil since 1907, the equivalent CO₂ of burning 90 barrels of oil – on top of your normal carbon emissions.

Cumulatively, agriculture impacts our society at a scope and scale that few appreciate, far beyond the initial realms of our food safety, quality, and the local environment. Due to the scale of natural resources required to provide food, fiber and fuel to 6.7 billion people, agriculture requires continued global-scale supplies of fertile land, clean water, fossil fuels, fertilizers, pesticides, and transportation infrastructure. These issues underpin our civilization's energy security, population distribution and capacity, national security, and cause agriculture to be a key player, for good and bad, in the fate of our planet's climate.

A 2008 article in the popular journal New Scientist titled "How our economy is killing the Earth" included a number of graphics¹ showing the exponential growth in consumption of planetary resources...leading to an exponential growth in problems (Figs. 1 & 2). Agriculture, both directly or indirectly, contributes to resource consumption and pollution, and can be used to benefit or aggravate the situation.

¹ <http://www.newscientist.com/article/mg20026786.000-special-report-how-our-economy-is-killing-the-earth.html>



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Fig. 1. Human economies have increased consumption of resources at an exponential rate.

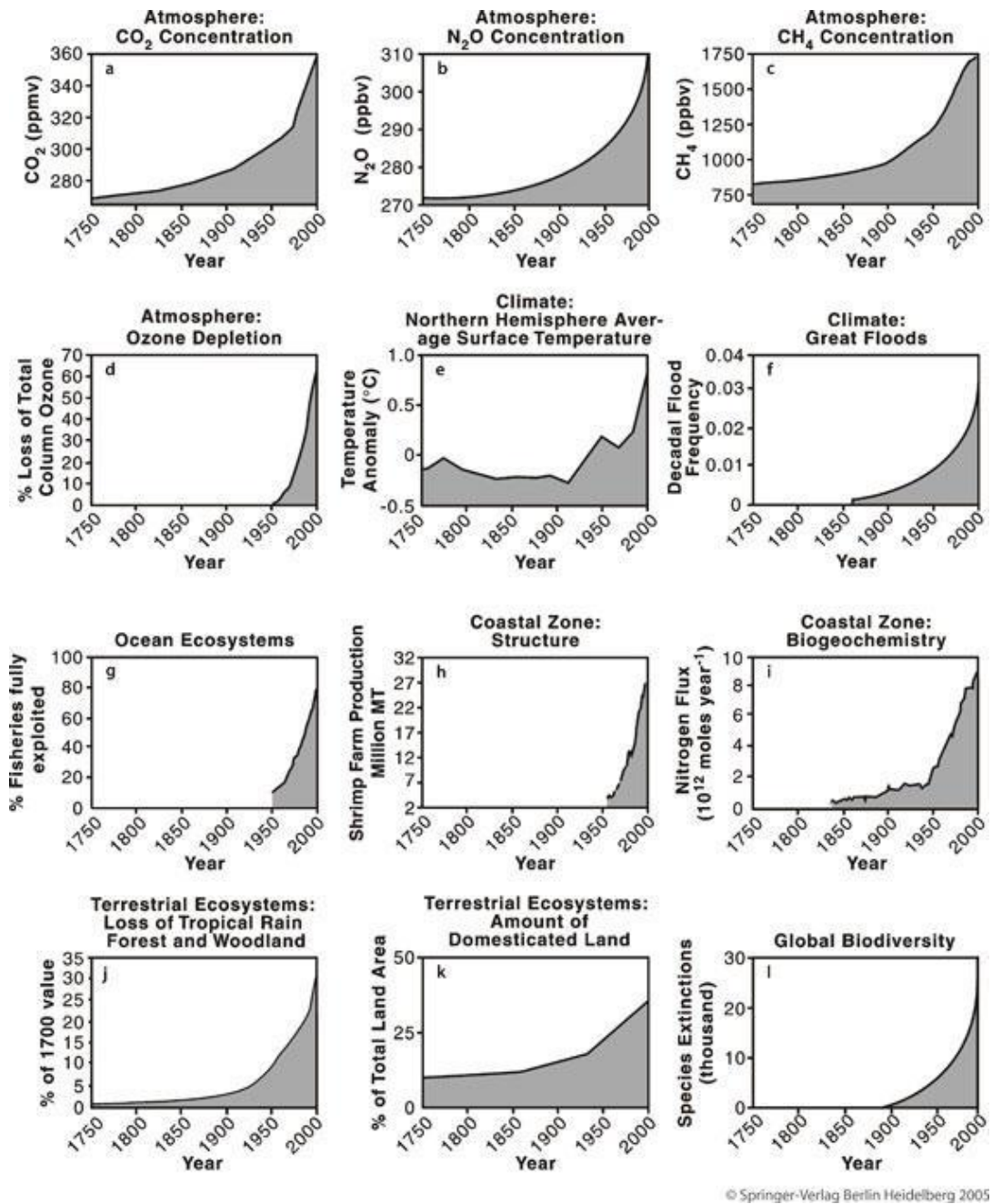


Fig. 2. Negative ecological indicators have also grown exponentially.

Exponential growth is by definition unsustainable, and signs such as fishery collapses, forest loss and species extinctions, and melted glaciers and other evidence of climate change all are warning signs at best...trip-wires at worst.

Discussions of an alternative path, or sustainable development, often begin by reviewing a schematic of development that balances social, economic and environmental parameters, which are often called the “three pillars” (Fig. 3).²

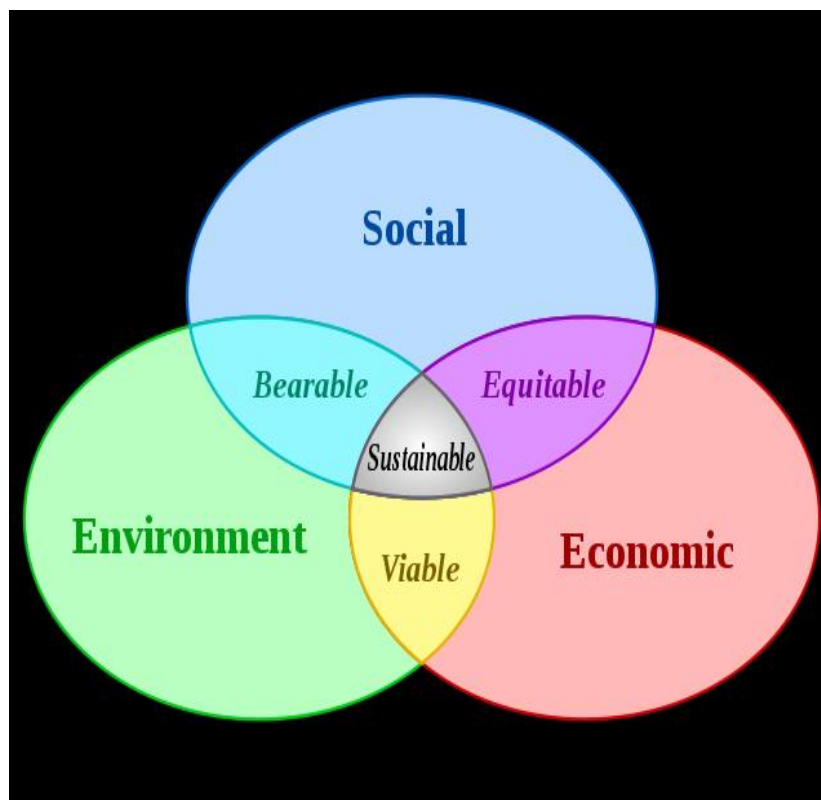


Fig. 3. A common schematic of sustainable development.

Ecological Economists would produce a different schematic that places the economy and all social systems as a subsets of the environment to reflect that humans are a part of and totally dependent upon the environment (Fig. 4).³ In other words, these are not three parts in a balanced relationship but a nested set of parts with a clear hierarchy.

² Graphic from: http://en.wikipedia.org/wiki/Sustainable_development

³ Graphic from: <http://www.uvm.edu/~gflomenh/VTLAW-EcoEcon/>

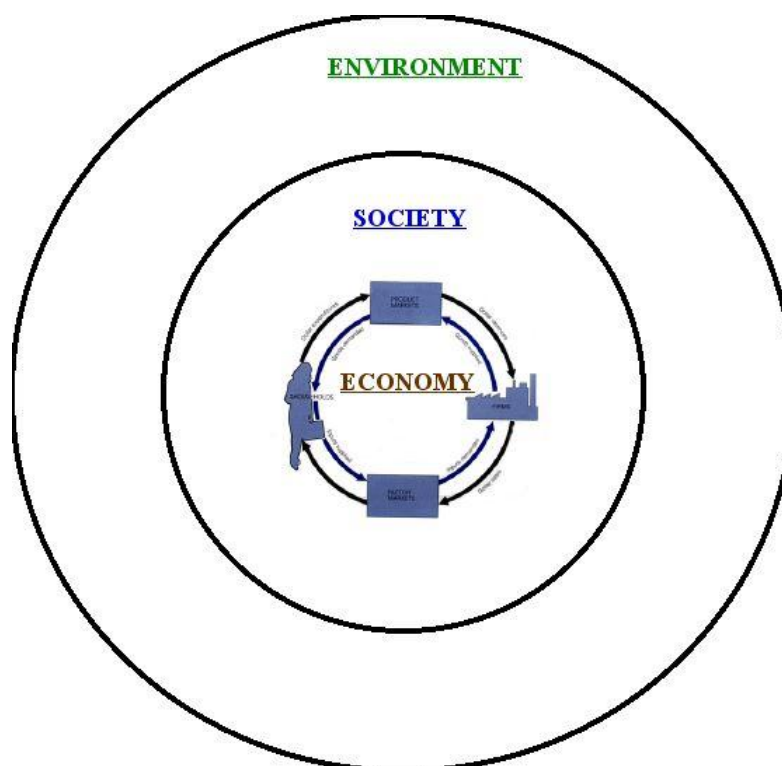


Fig. 4. Ecological economics views the relationships among the environment, society and the economy as being nested.

Both views of sustainability, however, establish criteria for understanding the long-term viability of related environmental, social and economic systems. This white paper will do so for agriculture.

The Impetus for Change

Our modern agricultural system, the so-called “green revolution,” has enabled tremendous productivity gains from the land, enabling us to grow from 2 billion to 6.7 billion people on the planet over the past 100 years.

Modern farming methods are designed to generate maximum financial and production returns, and they do this well over the short and even medium term. For example, conventional farmers usually grow a single crop over large acreage; use herbicides to sterilize the soil prior to planting, then add artificial fertilizers to stimulate crop growth and pesticides to treat overpopulated pests (caused by monocropping); all the while decreasing the productivity of the soil over time. However, such practices have been shown to reduce returns (net of fertilizer, herbicide and pesticide costs) by 25% to 30% in as few as five years⁴, while requiring increasing amounts of costly and toxic artificial inputs. Unfortunately, once started, the system is very difficult to escape.

⁴ Source: “Linking Land Quality, Agricultural Productivity, and Food Security,” USDA, 2003

Even with its history of yield improvements, agricultural production today is no longer keeping up with current demands. For example, from 1998 to 2008 the global consumption of grain has outpaced total production in most years, leading to low carry-over stocks (Fig. 6).⁵

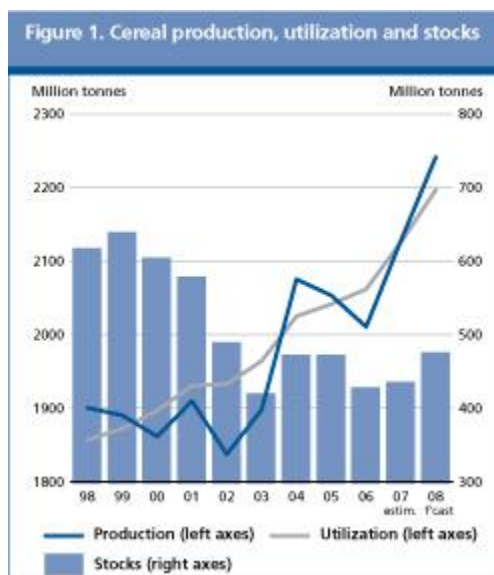


Fig. 6. Production of cereals has generally been lower than consumption for the past decade. (Graphic from FOA's Food Outlook November 2008).

Achieving expected growth is daunting as well. If demographic trends continue, agricultural output will need to nearly double by 2050⁶, yet the available fertile farmland per person will be one-third the levels in 1950.⁷ Demand for farmland production is increasing due to rising population, greater consumption of meat (requiring additional grains to feed the animals), and new biofuel mandates consuming corn and oil-seed crops. Meanwhile farmland acreage worldwide is decreasing due to land development, soil and water depletion, increasing soil salinity, and other factors.

Furthermore, these farm practices are environmentally unsustainable on a global level, as they:

- 1) *Degrade soil, air and water quality* from tillage, chemical applications, and concentrated wastes. Topsoil with low organic matter content and little biological activity is unable to hold onto the added chemicals, with the runoff causing algal blooms and then “dead zones” in fresh water and oceans.

⁵ U.N. Food and Agriculture Organization (FAO), see especially FAO's Food Outlook:

<http://www.fao.org/giews/english/fo/>; and Crop Prospects and Food Situation:

<http://www.fao.org/giews/english/cpfs/index.htm>

⁶ Tweeten, L. and S. Thompson, 2008 “Long-term Global Agricultural Output Supply-Demand Balance and Real Farm and Food Prices,” <http://ideas.repec.org/p/ags/ohswps/46009.html>

⁷ FAO, FAOSTAT & the U.N. Population Division

- 2) *Consume and deplete non-renewable resources* such as ancient aquifers, natural gas and petroleum-based fuels, fertilizers, herbicides and pesticides, and use mined minerals such as rock phosphate to promote productivity.⁸
- 3) *Put 5 billion pounds of potentially harmful chemicals into the environment each year* through pesticide use (includes herbicides, insecticides and fungicides), with over a billion pounds in the U.S. alone.⁹ This goes directly into our food, with 77% of the food consumed in the U.S. containing pesticide residue, and 47% containing residue from multiple pesticides.¹⁰
- 4) *Contribute to greenhouse gas emissions* from the direct use of fossil fuels, and indirectly through the breakdown of soil carbon and the conversion of natural ecosystems such as forests and wetlands. About 16% of greenhouse gas emissions in the U.S. come from food production, distribution and retail (Fig. 5).¹¹

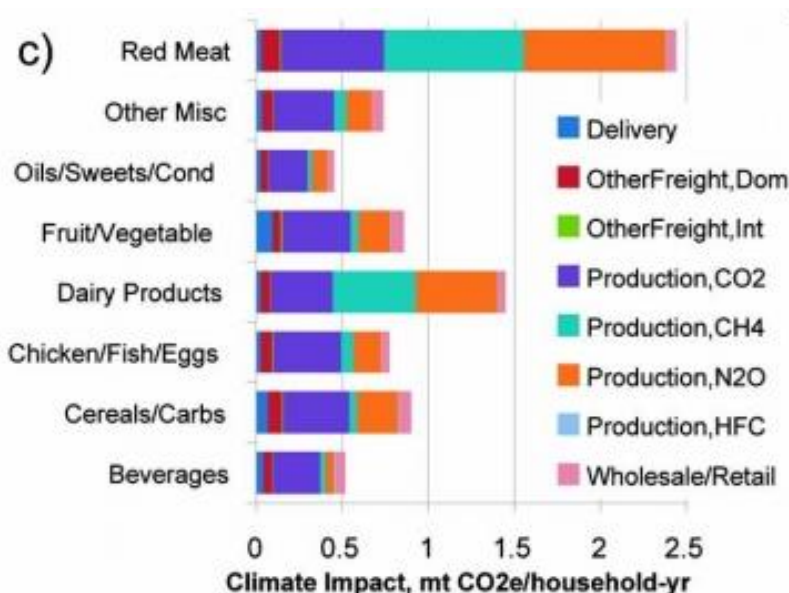


Fig. 5. A study of the relative contributions of foods and their production, distribution and sales towards CO2e for the United States shows that production accounts for 83% of GHG emissions from agriculture. (Graphic from Weber and Mathews, 2008).

⁸ See Heinberg, R., and M. Bomford, 2009: <http://www.postcarbon.org/food> for an excellent review of resource consumption and pollution from agriculture.

⁹ For 20 years of U.S. data see: http://edis.ifas.ufl.edu/document_pi179; Global and U.S. data from 2001 are here: http://www.epa.gov/oppbead1/pestsales/01pestsales/table_of_contents2001.htm; and for a review of trends see: <http://pubs.acs.org/cen/coverstory/87/8707cover1a.html>

¹⁰ See page 165 of this report from the USDA Pesticide Data Program: <http://www.ams.usda.gov/AMSV1.0/getfile?dDocName=STELPRDC5074338>

¹¹ See the U.S. greenhouse gas inventory here: <http://www.epa.gov/climatechange/emissions/usinventoryreport.html>; and a life cycle analysis of the U.S. food system by Weber C. and S. Mathews, 2008: <http://pubs.acs.org/doi/full/10.1021/es702969f?cookieSet=1>

Climate change and water supply issues are likely to significantly affect agricultural production. About 70-90% of global freshwater withdrawals are used for agricultural irrigation.¹² Globally, crop models show a general decline in the yields of major food crops and livestock, with the carbon dioxide fertilization effect being overwhelmed by extreme events and trends in temperature, water availability and pest pressures.¹³ For example, over the course of this century climate models show California's water supply declining overall, but especially during the spring and summer months when irrigation use is critical.¹⁴ A recent study from a University of California agricultural economist projected that the productivity and value of California farmland could drop by about 50% (range 13% to 67% across several models) due to higher temperatures and reduced water availability.¹⁵

In summary, demographic momentum is pushing the human population into a predicament where more and more food is expected to come from less and less land and water, all the while requiring full and growing production and keeping no reserve. While food today is still generally plentiful and inexpensive, the trends suggest we are nearing system limits. At the same time, most agricultural practices degrade key ecological assets, including topsoil, fresh water, and the climate system. Unfortunately agriculture today cannot be easily relocated due to climate change, loss of topsoil or water – the loss of growing regions or growing capacity due to a degraded environment will have a direct affect on us.

Defining Sustainable Agriculture

With respect to the environment, society and economics, sustainable agriculture would:

- (1) Not harm the environment from pollution,
- (2) Not be reliant on non-renewable inputs or degrade renewable ones,
- (3) Nourish people with non-toxic, healthy food and other useful feed stocks, and
- (4) Provide a fair, steady, return on effective investment in labor and capital.

How can these goals be achieved?

Sustainable farms employ productivity systems inspired by nature to deliver high yields through ecological synergy, diversity and resilience (Fig. 7). Sustainable farms are managed as fully-integrated ecosystems, where knowledge of soils, macro and microscopic organisms such as bacteria and fungi, water, crops, weeds, pests, equipment and techniques are used to maximize the long-term health, productivity and economic profitability of the farm.

¹² <http://www.agu.org/pubs/crossref/2007/2006WR005486.shtml>; <http://www.worldwater.org/data.html>;
<http://faostat.fao.org/Portals/Faostat/documents/pdf/world.pdf>

¹³ <http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter5.pdf>;
<http://www.pnas.org/content/104/50/19686.full>

¹⁴ <http://cee.engr.ucdavis.edu/faculty/lund/CALVIN/ReportCEC/CECReport2003.pdf>

¹⁵ Fischer, A. "Determinants of California Farmland Values and Potential Impacts of Climate Change," Department of Agricultural and Resource Economics, UC Berkeley:
http://www.agecon.ucdavis.edu/extension/update/articles/v9n5_2.pdf

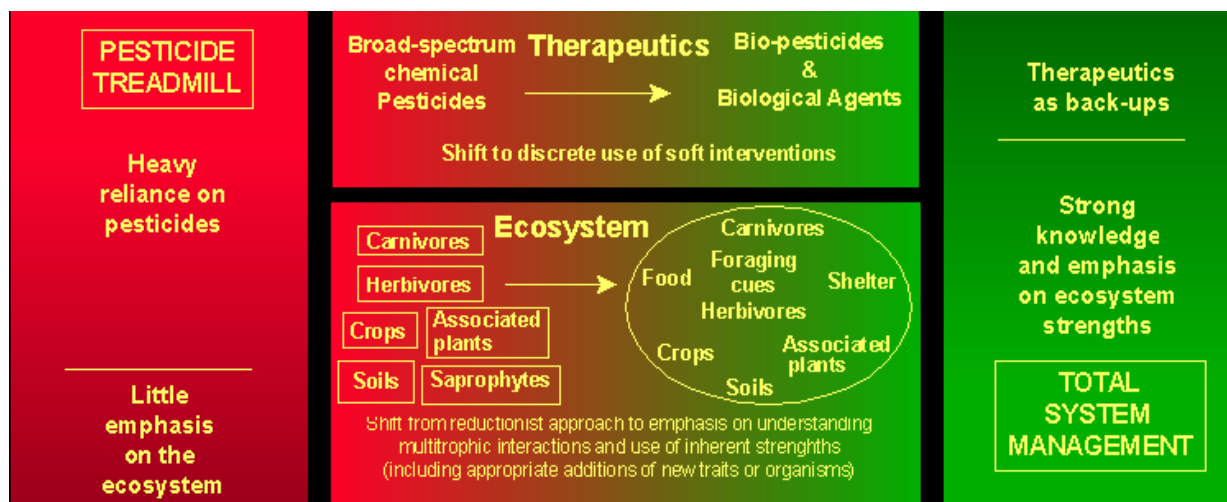


Fig. 7. The transition from conventional to sustainable farming is depicted by the National Sustainable Agriculture Information Service.¹⁶

To know if a farm is sustainable we should be able to measure its impact on the environment, society, and its finances. Does the balance of farm activities emit or sequester carbon dioxide? Is topsoil being lost or built? Is the runoff of water from the farm clean or a burden to local rivers? Metrics can be developed for a number of important sustainability indicators, including:¹⁷

- (1) No build-up of persistent pollutants into the environment,
- (2) Development of soil carbon and a balanced soil food web
- (3) Enhancement of regional biodiversity and ecosystem services,
- (4) Use of renewable energy and recycled mineral resources,
- (5) Humane care of farm animals,
- (6) Food quality and health,
- (7) Worker fairness and safety, and
- (8) Economic viability.

For example, an idealized sustainable farm wouldn't use non-renewable fossil fuels and would store at least as much greenhouse gasses as it emits (Fig. 8). Energy use is a major area where "sustainable" goes beyond the soil management, pesticide and herbicide regulations of "organic" farming. Farms are ideal places to deploy renewable energy systems, as they typically have abundant sunshine and may include significant wind or moving water resources. Liquid fuels are highly valued in farming because they can be used in machines to perform highly time sensitive

¹⁶ Graphic from: <http://attra.ncat.org/>

¹⁷ An example of these metrics is here: http://cuesa.org/sustainable_ag/CUESA_Sustainable_Ag_Framework.pdf

work, such as planting and harvesting. Perhaps 20% of farmland would need to be set aside for biofuel crops for on-farm use.¹⁸ Some are exploring options to electrify tractors.¹⁹

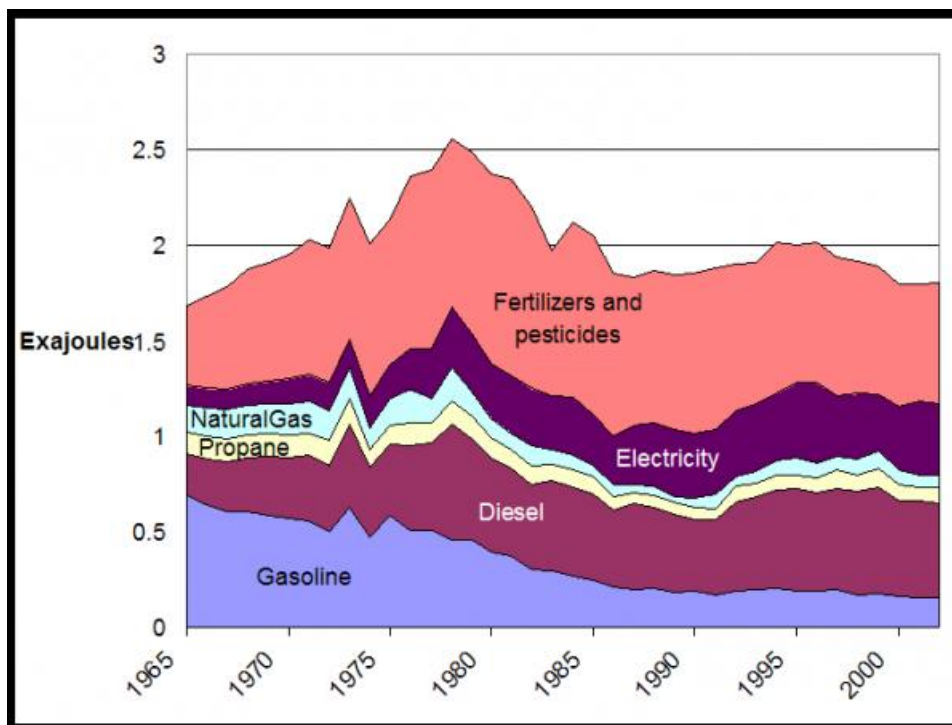


Fig. 8. Trends in energy consumption by U.S. agriculture show that U.S. farms have become more energy efficient, but still rely heavily on fossil fuels. Fertilizers and pesticides generally use fossil fuels as a feedstock. (Adapted from Miranowski 2004, by Bomford and Heinberg, 2009).

The Benefits of Sustainable Agriculture

A compelling need exists for restorative and sustainable agriculture to help address the pressing trends of population, climate, energy, water, soil and food. The science and practices for sustainable and highly productive agriculture exist, and people are paying 50% to 200% premiums for organically farmed goods, but the farmers and farmland are converting slowly...too slowly, as only 0.5% of U.S. farmland is certified organic due to the barriers of cost, knowledge, time, and effort in shifting from conventional to organic and sustainable production.²⁰

Will society make the investments necessary to create a sustainable food system fast enough? Few people probably understand that shifting from conventional, chemical dependent farming takes time. The hidden world of the soil needs to recover. A farmer may need to “wean” fields from chemicals over two years, and then be chemical free for three years before becoming organic “certified” and benefit from both high yields and good prices.

¹⁸ See discussion of this topic in Bomford and Heinberg (2009): <http://www.postcarbon.org/food/>; and graphic from here: <http://energyfarms.wordpress.com/2009/04/16/how-much-energy-goes-into-our-food-system/>

¹⁹ For example, the RAMSES project in Europe, discussed here: <http://europe.theoil drum.com/node/4606/>; and the USDA funded electric tractor conversion project: <http://www.flyingbeet.com/electric/>

²⁰ <http://www.ers.usda.gov/Data/Organic/>

Healthy, organic soils are only one piece of a big picture. Sustainability also means incorporating renewable energy in all aspects of agriculture, transportation and food processing: Are electric or biofuel-driven tractors viable? How can natural gas be replaced when drying grains? Can relocalizing the food system be more profitable, use less energy, and reduce carbon emissions?

While many questions on how to create a sustainable agriculture still remain, the human and environmental benefits of organic farming are scientifically documented. The benefits are reviewed in the context of the environment, society and economics respectively.²¹

Environmental Benefits

- **Improved soil and water conservation:** Organic production methods increase soil carbon (organic matter), water infiltration rates and water holding capacity, making more water available to plants per inch of rainfall received. Soils with less organic matter allow more surface runoff (removing topsoil and nutrients with the water), permit higher surface evaporation, and retain much less water within the soil structure (Fig. 9).²²

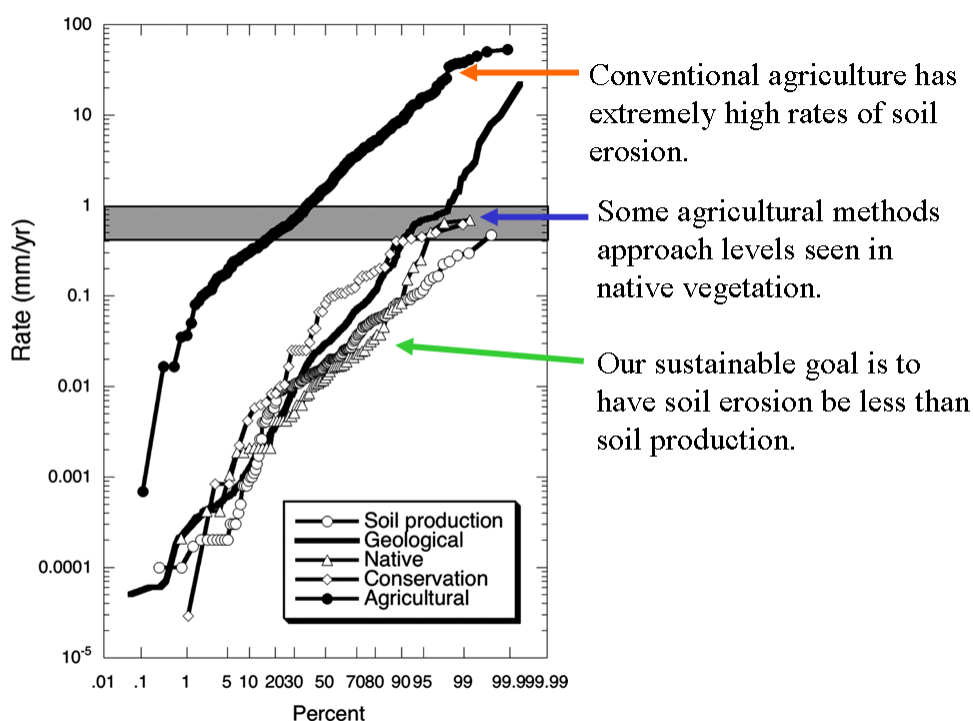


Fig. 9. Probability plots of rates of soil erosion from agricultural fields under conventional (e.g., tillage) and conservation agriculture (e.g., terracing and no-till methods), with erosion rates from areas and plots under native vegetation, rates of soil production, and geologic rates of erosion. (Graphic modified from Montgomery D. 2007)

²¹ See this summary report for non-referenced statistics: <http://www.rodaleinstitute.org/files/GreenRevUP.pdf>

²² Montgomery D. 2007: <http://www.pnas.org/content/104/33/13268.abstract>

- Mitigation of global warming:** Sustainable farming on a large scale could dramatically mitigate CO₂ emissions by increasing energy efficiency, enhancing soil carbon stocks, and switching to renewable fuels (Figs 10, 11 & 12).²³ Agriculture is a major source of greenhouse gases. About 35% of the ice-free land surface is used for crops and livestock, and current agricultural practices produce about 25% of carbon, 50% of methane and >75% N₂O emissions worldwide (including both land and energy use).²⁴ However studies show that sustainable farming methods such as cover cropping and no or minimal till can sequester carbon for 20 to 50 years before reaching saturation.²⁵ Conservatively, if each acre sequesters 0.2 metric tons of carbon per year, then 4 tons would be sequestered over 20 years. For comparison, 4 tons of carbon is emitted by the average U.S. vehicle (20 mpg, 12,500 miles per year) in 2.3 years.²⁶ If these same farming practices are applied to all the world's 3.5 billion tillable acres, close to 9 percent of all global CO₂ emissions would be mitigated. In addition to shifts in tillage practices, pyrolysis of crop residues to form biochar is being studied for its significance in carbon sequestration and enhancement of agricultural soils.²⁷ Furthermore, the process of making biochar releases energy that can replace fossil fuels in many applications.

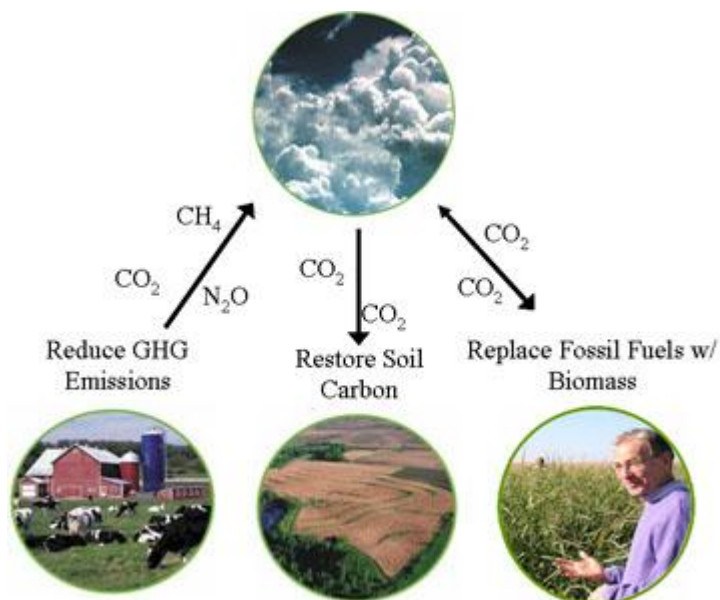


Fig. 10. Greenhouse gas reductions in farming include energy efficiency, sequestering of carbon in soil, and replacement of fossil fuels with renewable energy. We would add development of local distribution channels to be resilient in the context of peak oil. (Graphic from Climate Friendly Farming).

²³ Climate Friendly Farming: <http://cff.wsu.edu/>; Lal, R., et al. 1998. The Potential of U.S. Cropland to Sequester Carbon and Mitigate the Greenhouse Effect. Ann Arbor Press, 128 p.; Soil Carbon Center handout, <http://soilcarboncenter.k-state.edu/docs/C%20sequestration%20Handout.pdf>

²⁴ Tubiello, F. et al., 2007; <http://www.pnas.org/content/104/50/19686.full>

²⁵ <http://www.epa.gov/sequestration/rates.html>

²⁶ http://epa.gov/climatechange/emissions/ind_calculator2.html

²⁷ <http://www.biochar.org/>; <http://www.geos.ed.ac.uk/scs/biochar/>; <http://www.biochar-international.org/>

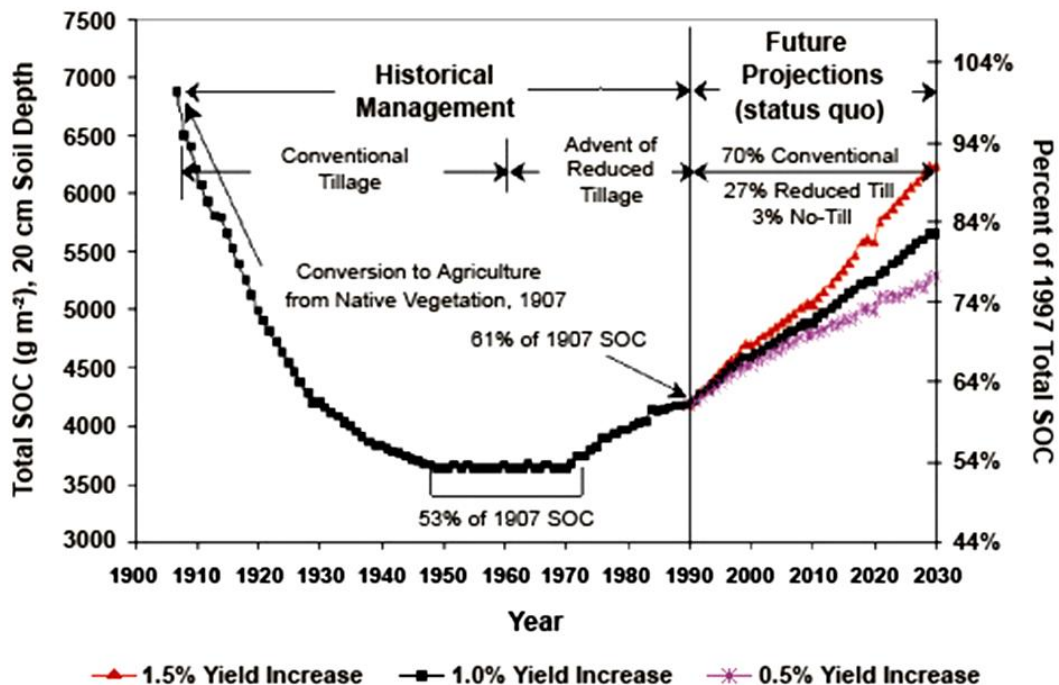


Fig. 11. The U.S. has lost about half of the carbon stored in its agricultural soils since the early 20th century. Improved management methods can put that carbon back while enhancing soil quality. (Graphic from the Soil Carbon Center).

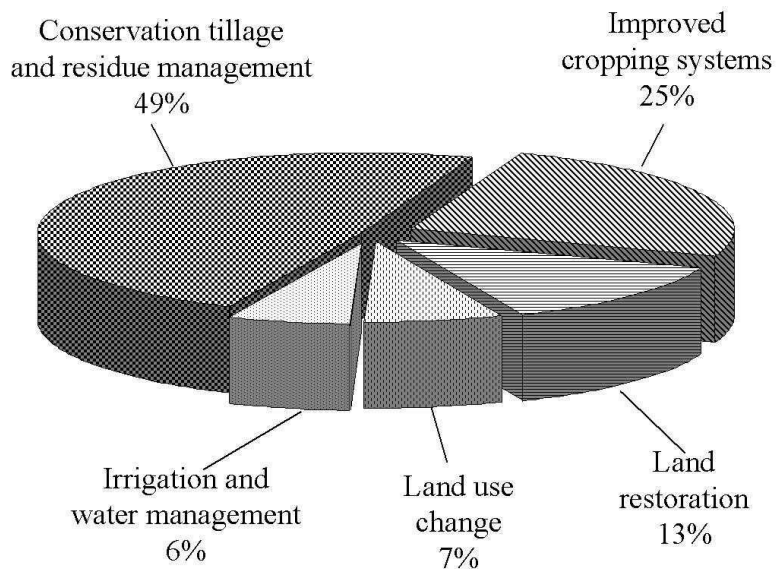


Fig. 12. A number of means exist to use agricultural landscapes to sequester carbon. This graphic estimates the relative contribution of each one (from Lal, R., et al. 1998).

- **Enhanced biodiversity:** Organic systems host a greater diversity of plant species, beneficial insects, and wildlife, thus improving the ecological health of bio-regions. Sustainable agriculture utilizes this biodiversity to its advantage to suppress pests and weeds, enhance nutrient cycling in the soils, and pollinate plants without having to ship in bees (Colony Collapse Disorder may make this essential in the future).
- **Reduction of persistent pollution:** Every year, 1.2 billion pounds of pesticides are applied in the U.S. for agriculture and over 5 billion pounds are applied worldwide.²⁸ Nearly every pesticide that has been investigated has been detected in air, rain, snow or fog across the U.S. at different times of year.²⁹ Many of these pesticides persist for long periods in soil and groundwater and can cause acute poisoning, cancer, birth defects, sterility, neurotoxicity, and damage to developing animals and children.³⁰ Organic farming does not use pesticides, and part of the purpose of the three year organic conversion process is to bioremediate the soils and groundwater.

Social Benefits

- **Increased food nutrient density:** Organically grown foods often contain more nutrients than conventionally grown foods (Fig. 13).³¹ Conventional nitrogen fertilizers tend to increase the water and sugar levels of foods while diluting the phytonutrients and minerals.

²⁸ U.S. EPA, <http://www.epa.gov/oppbead1/pestsales/01pestsales/usage2001.htm>

²⁹ USGS, <http://pubs.usgs.gov/circ/circ1225/pdf/sources.pdf>

³⁰ United Nations Environmental Program, Food and Agriculture Organization (FAO), and World Health Organization (WHO), May 2004

³¹ For a review of the research on organic food health benefits, including nutrition density and pesticides, see Benbrook, C. et al., 2008: http://www.organiccenter.org/science.nutri.php?action=view&report_id=126; Delate, K. et al., 2006: <http://www.plantmanagementnetwork.org/pub/cm/symposium/organics/Delate/>; Heaton, S, 2001: <http://www.soilassociation.org/web/sa/saweb.nsf/a71fa2b6e2b6d3e980256a6c004542b4/de88ae6e5aa94aed80256abd00378489?OpenDocument>; and these popular articles, <http://www.medicalnewstoday.com/articles/10587.php> and <http://www.motherearthnews.com/Real-Food/2004-06-01/Is-Agribusiness-Making-Food-Less-Nutritious.aspx>

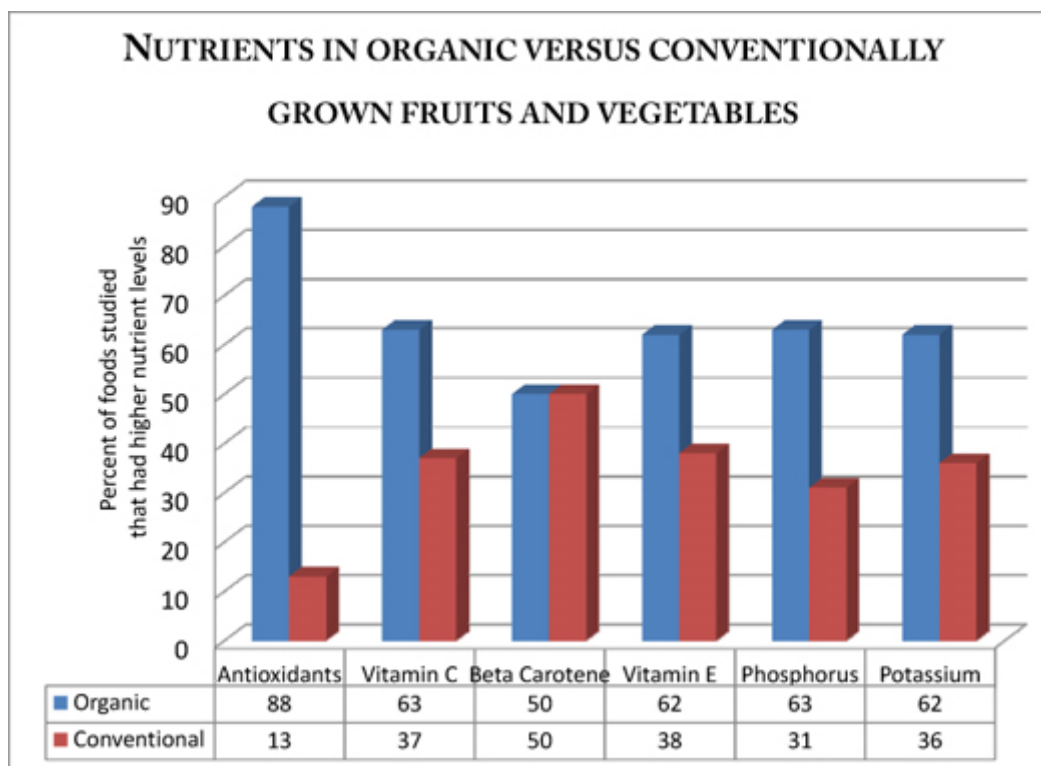


Fig. 13. Vitamin and mineral concentrations tend to be higher in organically grown foods. (Graphic from Benbrook et al. 2008).

Reduced toxic load in adults and children who eat organic: “By substituting organic fresh fruits and vegetables for corresponding conventional food items, the median urinary metabolite concentrations were reduced to non-detected or close to non-detected levels for malathion and chlorpyrifos at the end of the 5-day organic diet intervention period in both summer and fall seasons. . . The findings from this study demonstrate that dietary intake of OP (i.e., organophosphorus) pesticides represents the major source of exposure in young children.”³² Eliminating petrochemical toxins in farming practices improves the health of food, people who eat that food, and the environment.

- **Better conditions for farm workers.** The people who currently apply pesticides, breath dust from tilled fields, and drink polluted ground water would obviously benefit from a healthier environment provided by sustainable agriculture.³³

Economic Benefits

- **Competitive yields:** A recent global review of modern organic agriculture shows similar to higher yields vs. conventional practices (Fig. 14).³⁴

³² Lu C. et al., 2008: <http://www.ehponline.org/docs/2008/10912/abstract.html>

³³ <http://aghealth.nci.nih.gov/>

³⁴ Badgley et. al, *Renewable Agriculture and Food Systems* 22 (2007): 86-108.;

<http://www.newscientist.com/article/dn12245-organic-farming-could-feed-the-world.html>;

http://sitemaker.umich.edu/perfectolab/files/badgley_et_al_2006.pdf

Table 1. Average yield ratio (organic : non-organic) and standard error (S.E.) for ten individual food categories recognized by the FAO¹⁹ and three summary categories. Average yield ratio based on data from 91 studies (see Appendix 1 for data and sources). (A) All countries. (B) Developed countries. (C) Developing countries.

Food category	(A) World			(B) Developed countries			(C) Developing countries		
	N	Av.	S.E.	N	Av.	S.E.	N	Av.	S.E.
Grain products	171	1.312	0.06	69	0.928	0.02	102	1.573	0.09
Starchy roots	25	1.686	0.27	14	0.891	0.04	11	2.697	0.46
Sugars and sweeteners	2	1.005	0.02	2	1.005	0.02			
Legumes (pulses)	9	1.522	0.55	7	0.816	0.07	2	3.995	1.68
Oil crops and veg. oils	15	1.078	0.07	13	0.991	0.05	2	1.645	0.00
Vegetables	37	1.064	0.10	31	0.876	0.03	6	2.038	0.44
Fruits, excl. wine	7	2.080	0.43	2	0.955	0.04	5	2.530	0.46
All plant foods	266	1.325	0.05	138	0.914	0.02	128	1.736	0.09
Meat and offal	8	0.988	0.03	8	0.988	0.03			
Milk, excl. butter	18	1.434	0.24	13	0.949	0.04	5	2.694	0.57
Eggs	1	1.060		1	1.060				
All animal foods	27	1.288	0.16	22	0.968	0.02	5	2.694	0.57
All plant and animal foods	293	1.321	0.05	160	0.922	0.01	133	1.802	0.09

Fig. 14. A study comparing the yields of organically and conventionally farmed foods showed that yields from organic fields were generally higher. (Table from Badgley et al. 2007).

- **Price premiums:** Even when sold to commodity markets, organic food receives significant premiums of 50% to 200% over conventional items.³⁵
- **Direct-to-Consumer marketing channels:** Organic foods can be sold directly to consumers via CSA subscriptions or Farmer's Markets, local businesses such as restaurants, or food service institutions including schools and hospitals. By capturing retail prices, direct-to-consumer sales increase the farmer's revenue by 4x to 5x over the 20 cents on the dollar average farmgate income.³⁶
- **Lower input costs:** Organic farming practices reduce external input costs (e.g., pesticides, GMO seed, and fertilizers) (Fig. 15).³⁷ A three-year study in Iowa demonstrated that corn and soybean returns from organic systems were significantly greater than returns in conventional corn and soybean crop rotations. These organic rotations were more profitable even when market-based organic premiums were excluded from the analysis. "Returns to land, labor, and management were higher in the organic rotations regardless of whether an organic price premium was received or not."³⁸

³⁵ See USDA, ERS, March 2009 Amber Waves Newsletter for a review of produce premiums, <http://www.ers.usda.gov/AmberWaves/March09/Findings/OrganicProduce.htm>; and check Rodale's Organic Price Report for ongoing data on all major food categories, <http://www.rodaleinstitute.org/Organic-Price-Report>

³⁶ USDA, Farm-Retail Price Spreads, December 2008, <http://www.ers.usda.gov/publications/agoutlook/>

³⁷ USDA, ERS, March 2009 Amber Waves Newsletter, <http://www.ers.usda.gov/AmberWaves/March09/Features/FertilizerPrices.htm>

³⁸ Delate et al. 2003, <http://extension.agron.iastate.edu/organicag/researchreports/orgeconomics.pdf>

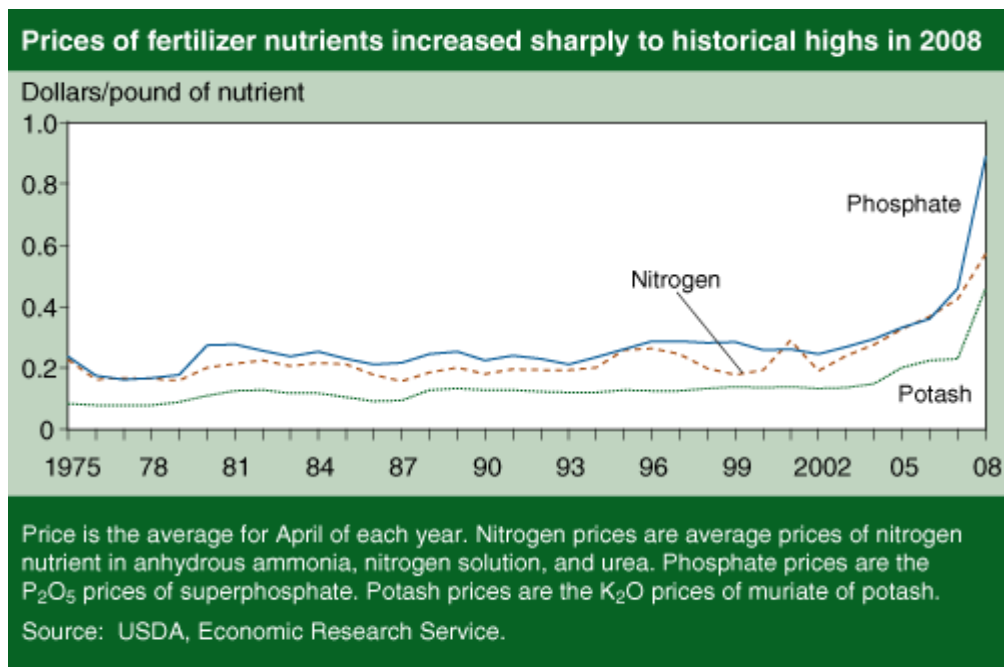
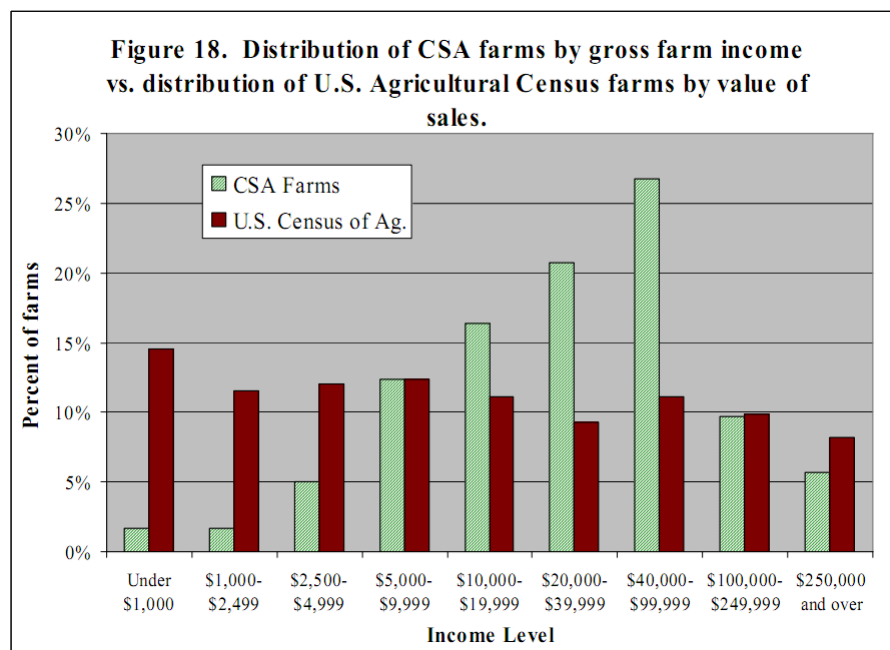


Fig 15. A farm managed sustainably has few outside input needs, making it less vulnerable to the kind of price spikes seen in 2007-2008. (Chart from USDA ERS, March 2009).

- **Higher per farm income:** CSA farms are 2.5x more likely than conventional farmers to earn \$40,000 to \$100,000 per year. About 15% of CSAs earn over \$100,000 per year (Fig. 16).³⁹



³⁹ Center for Integrated Agriculture, University of Wisconsin. <http://www.cias.wisc.edu/>

Fig. 16. CSA farms are more likely to have an income level in the middle to high range compared to non-CSA farms. (Graph from the Center for Integrated Agriculture, University of Wisconsin).

- **Improved resilience/lower volatility:** Organic systems produce significantly better yields under both extremely wet and extremely dry weather years, and produce comparable yields in years with favorable weather conditions. Drought has a major impact on food production, accounting for 60 percent of food emergencies, according to the FAO. The resilience of organic fields speaks to its capability to maintain food production even through erratic and extreme weather events, potentially adapting better to climate change (Fig. 17).⁴⁰



Better water infiltration, retention and delivery to plants helps to sustain yield during drought.

Fig. 17. Crops in organically farmed soils handle stress better than in conventional ones. (Image from the Rodale Institute).

- **Energy savings:** Organic agriculture reduces the energy required to produce a crop by 20 to 50 percent. Reduction of fossil fuel use in agricultural production reduces the exogenous risks of high energy prices on production and profits. A sustainable farming system based on local, renewable energy would reduce energy costs even further.
- **Income from carbon markets:** Minimal tillage practices expect a sequestration rate of 0.2 metric tons of carbon per acre per year. At \$50 per metric ton, a 100 acre farm could earn an additional \$1000 per year.⁴¹

⁴⁰ Image source: <http://www.rodaleinstitute.org/files/GreenRevUP.pdf>

⁴¹ 0.2 metric tons of carbon is equivalent to 0.73 tons of carbon dioxide.

What a Sustainable Agricultural System Will Look Like

Many terms are used to describe alternatives to conventional, industrial agriculture. Organic, local, and sustainable come to mind. Less often used is “agro ecology,” which views the agrarian landscape the same way an ecologist views the natural landscape. Farms also can’t exist in isolation from the broader society. A truly sustainable farm is an integral part of the local community. There are biophysical reasons for this, as plants and animals essentially draw nutrients from the soil that in a closed-loop system must be returned. When food is exported across the globe, soils and water are being exported too. In ecosystems nutrient cycling is predominantly local, and this is why sustainable food systems must be locally oriented.

Because humans are omnivores, our normal diets tend to draw upon diverse agro ecosystems. Tree fruits and nuts are a type of forest. Pasture is a type of mature grassland that can raise meat. Fields of grains and legumes are immature grasslands. And vegetables and root crops represent very early successional plant communities. We evolved from people who combined hunting and gathering across fields and into forests with garden-scale plots. Sustainable farm landscapes reflect the omnivory of human diets.

After reviewing the benefits of organic and sustainable agriculture, it is helpful to summarize what a sustainable farm would be like in contrast to 99% of farms today (Table 1).

Operations and Structure	Conventional Farm	Sustainable Farm
Fertility	Buy tons of compost or inorganic NPK products	Use nitrogen fixing cover crops, compost animal bedding, and recycle local organic waste
Seeds	Buy commercially developed and patented seeds	Select open pollinated seeds and save those that perform best, buy from regional seed developers when necessary
Energy	Buy liquid fuels and electricity for equipment to perform tasks	Whenever possible let biological processes do necessary work, seek local renewable energy options otherwise
Managing biodiversity	Buy chemicals to combat unwanted organisms	Focus on the health of the soil and the appropriate soil biology to grow healthy crops. Know weed and pest biology well enough to keep them in check through smart management of the whole farm. Create habitat along field edges.

Landscape diversity	Low, usually specializing in one class of food, e.g., grains, dairy, vegetables	High, usually adapting production to the landscape and rotating crops as needed.
Distribution	National to global via commodity markets	Local to regional via fair trade and direct to consumer channels

Table 1. Conventional farms depend largely on external inputs, harm the environment, have low diversity, and don't contribute directly to regional food security. By contrast sustainable farms internalize costs, benefit the environment, encourage diversity, and participate in local food systems.

In summary, a transition to organic and sustainable farming is required for environmental, social and economic reasons. Fortunately, organic farming is a robust business model, delivering superior economics over conventional farming on a wide variety of metrics such as crop yields, gross and net income per acre, cost of inputs, per farm income and more. As society provides the financial and organizational capital to re-create agriculture, the living soils, plants and animals will respond, over time, to support us. Each acre converted to organic, sustainable methods is one acre closer to a societal tipping point for sustainability – or at least one less acre as a source of harm.

About Farmland LP

Farmland LP (www.FarmlandLP.com) was established in part to help cross the three-year chasm of production during the conversion from conventional to organic agriculture, thus earning substantial equity returns while also delivering environmental and societal value-add. The Partnership acquires low-utility conventional farmland and transitions it to high-value organic, sustainability best-practices farmland. Investment returns will be from leasing and operating farmland, and from the sale of property.

Management Team

Craig Wichner, Managing Director: Mr. Wichner directs the farmland investment program, including overseeing property acquisitions, leases and sales, and oversees the financial and legal affairs for the Partnership. Mr. Wichner is a seasoned executive with 20 years building companies which have, among other things, developed and currently produces an FDA-approved treatment for metastatic brain cancer, and automated employee contribution programs for Fortune 500 Companies such as GM, EDS, and Charles Schwab. Mr. Wichner has helped raise over \$125 million in 14 funding transactions (including a \$33 million IPO) and has led three M&A transactions. Mr. Wichner served as CEO/President/CFO for three successful companies, two of which were venture-funded, and has served on boards and advisory boards including two venture funds. Mr. Wichner also helps manage a multi-million dollar real estate investment

property company. Mr. Wichner received a Bachelor of Science in Biochemistry and Molecular Biology from the University of California at San Diego in 1992, earning Provost's Honors and performing graduate-level research on HIV/AIDS as an undergraduate. Mr. Wichner's agricultural experience includes spending 10 summers growing up on a ranch and farm, where he did everything from milking cows to tending chickens, crops and horses, to wrangling cattle and building a barn.

Jason Bradford, Ph.D., Manager: Dr. Bradford leads the farmland management program, including organic certification and sustainability planning, cropping programs, and tenant and operations management. Dr. Bradford is a highly-regarded ecological scientist and expert in sustainability and relocalization, in addition to being a successful organic farmer and CSA manager, author and entrepreneur. After receiving his Ph.D., Dr. Bradford worked on issues related to species extinction and the overall decline in global ecosystem integrity, funded by the National Science Foundation and the National Geographic Society. Dr. Bradford was a leader of the Tropical Ecosystem team of BioMERGE (www.columbia.edu/cu/biomerger), a National Science Foundation funded research network of over 100 scientists from 17 countries integrating the study of biodiversity and ecosystem function. Dr. Bradford also taught Ecology at Washington University. Dr. Bradford's focus is now on addressing the problem of ecological overshoot through direct action. Dr. Bradford founded and manages Brookside Farm, certified organic farm in Willits, CA; is a Fellow at the Post Carbon Institute; hosts a radio program on KZYX&Z ("The Reality Report"); is a contributor to The Oil Drum (www.TheOilDrum.com); and serves on the Boards of Directors for the Renewable Energy Development Institute (REDI) and Willits Economic Localization (WELL). Dr. Bradford received his Ph.D. in Evolution and Population Biology from Washington University in St. Louis in 2000, and his Bachelor of Science in Biology from the University of California Davis, with High Honors in 1992.