Energy and Sustainable Agriculture

L. Hunter Lovins

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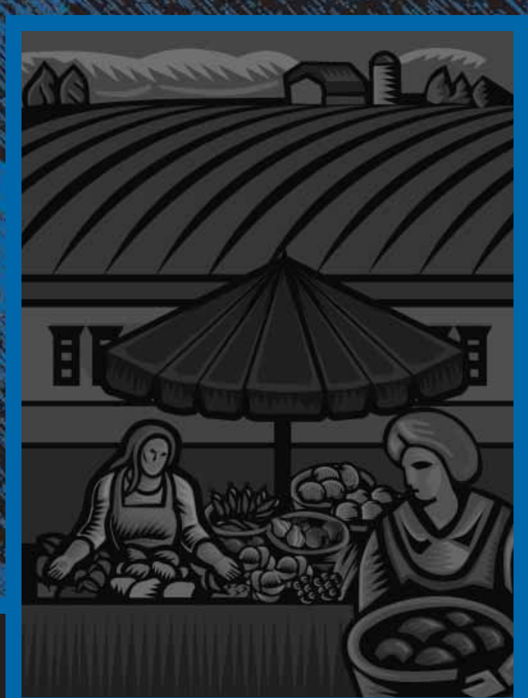

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L. Hunter Lovins

L. Hunter Lovins is the president of Natural Capitalism, Inc., a Colorado-based company that helps businesses, government, academic institutions, and communities become more profitable and environmentally and socially sustainable. Trained as an attorney, she is a globally recognized sustainability and energy analyst, has co-authored nine books and hundreds of articles, presented at prestigious forums around the work, and been honored with numerous awards including being named a *Time* magazine Hero of the Planet in 2000.

She co-authored the 1999 groundbreaking paradigm for the economy, *Natural Capitalism*, with Amory Lovins and Paul Hawken. The principles of natural capitalism include:

- *Radical resource efficiency* for energy, water, and materials;
- *Design for sustainability* through innovative forms of green design processes such as biomimicry; and
- *Management for prosperity and sustainability* to achieve no net loss of natural and human capital.

For more than 30 years, Hunter has advocated for sustainable development through creation and management of several companies and non-profits that promote sustainable resource use and management, taught at various universities, and advised citizens' groups, governments and corporations. She co-founded and co-managed the Rocky Mountain Institute 1982-2002, which developed under her leadership into a world-renowned resource policy center.

She was one of four people from North America selected as a delegate to the UN's prep conference for the World Summit on Sustainable Development and she is a commissioner in the State of the World Forum's Commission on Globalization. She shared the 1982 Mitchell Prize for an essay on reallocating utility capital and received the 2001 Leadership in Business Award and Shingo Prize for Manufacturing Research.

She helped found and is a professor at Presidio World College business school in San Francisco, which offers the first accredited MBA in sustainable management.

PRESENTATION AND PAPER

Energy and Sustainable Agriculture

9 MARCH 2005

L. HUNTER LOVINS*

Introduction

Agriculture lies at the heart of civilization. Cultures that mistreat their soils do not long endure. Modern agriculture seems in many ways to be the pinnacle of human achievement, enabling fewer farmers to feed more of humanity than ever before. Yet much of the practice is unsustainable. This paper will examine one aspect of that unsustainability, the interactions of energy with agriculture. It will explore some of the challenges farmers face from energy issues, especially in a carbon-constrained world, and describe how the principles of Natural Capitalism can help farmers take a leadership role in making their operations and their communities more sustainable.

Natural Capitalism is an approach to business that enables its practitioners to make more money while implementing more sustainable practices throughout their operations.[1] The first principle is to dramatically enhance the productivity with which a business uses all forms of resources. To be sustainable, agriculture must use resources efficiently and in ways that enhance life, making soils richer and communities stronger.

The second principle is to redesign all of the processes and products we use to be more sustainable, using innovation inspired by nature. Natural systems have been subjected to a rigorous testing laboratory over billions of years – products that don't work get recalled by "The Manufacturer." It is sobering to look at the fate of ancient civilizations that over-stepped the carrying capacity of their ecosystems, mistreated their soil, relied on changeable climatic regimes, or were otherwise unsustainable.[2]

"Natural Capitalism is an approach to business that enables its practitioners to make more money while implementing more sustainable practices throughout their operations."

The third principle of Natural Capitalism is to manage companies and human systems in ways that are restorative of human and natural capital. There are many examples of communities that have come together to explore how they use energy, to understand how their current practices are impoverishing their economy and lives, and to put in place programs to better manage how they use energy. These communities are now economically healthier, and are far less vulnerable to external threats.[3]

Farmers have always faced challenges, whether from such traditional sources as prices and weather, or now from globalization and climate chaos. Many of these challenges have a common denominator: energy.

Energy is essential to run farm vehicles, to transport crops to market, and to provide industrial fertilizer. But global energy trends impact farmers in other ways. Middle Eastern oil prices and their impact on financial markets around the globe can create or destroy a livelihood in a small town in Iowa. The carbon-constrained world in which farmers now live will provide opportunities to farmers to begin producing climate-neutral forms of energy, but will also impact how farms are operated. Farmers, like the rest of us, will have to use energy much more efficiently and shift to sustainable sources. Land management practices will have to shift to ensure that they are contributing to the solution by soaking up and holding carbon from the atmosphere.

Energy use has historically grown faster than population. According to the Worldwatch Institute's *State of the World Report 2004*, "Between 1850 and 1970, the number of people living on earth more than tripled and the energy they consumed rose 12-fold. The good news is that by 1970 ways to use energy more efficiently were entering the market." The rise in energy use began to more closely track the rise in the number of people, so that by 2002, our numbers had grown another 68 percent and fossil fuel consumption was up another 73 percent.[4]

The bad news is that both energy consumption and population are still exponentially rising. To live within the limits imposed by the round earth theory, the growth of both must decline while economic development flourishes. Most of the world's scientists now support a global mandate to reduce greenhouse gas emissions up to 70 percent to help stabilize climate, and many now insist that the absolute amount of energy we use will have to decline.[5]

***This paper is co-authored by Christopher Juniper, Founding Vice President of Natural Capitalism Solutions. Trained as an economist, he has served governments, businesses, and non-profits as a leading-edge economic development manager, sustainability consultant, and board director for the past two decades.**

Achieving this while maintaining a high standard of living will not be trivial. The only way to do this is to radically increase energy productivity and to supply it from non-carbon sources.[6]

Failure to use energy more efficiently and to derive it from renewable sources will mean that the attempts to supply ever more energy will ensure a series of military, social and environmental crises. Over 1,400 Americans have died in Iraq, protecting access to Middle Eastern oil. Lest anyone doubt that the Iraq adventure is really about oil, recall that U.S. foreign policy continues to allow rapacious dictators to impose far worse privations on their people than Saddam visited on the Iraqis. Over 12 million have died in Africa's wars during the last 40 years, and the continent presently struggles to care for 10 million war refugees.[7] Because Iraq has the third largest proven reserves of oil, behind Saudi Arabia and Canada, American taxpayers are willing to spend over $1 billion a week prosecuting that war.[8]

The environmental consequences of our current practices are already grim. There is no longer scientific doubt that every major ecosystem on the planet is in decline.[9] Much of the degradation is caused by practices used to extract energy, and the consequences of our profligate use of it. A scientific consensus now exists that the significant global warming over the past several decades is largely caused by the increase in such manmade greenhouse gases as carbon dioxide, released from burning fossil fuels. This poses two primary challenges for agriculture:

- Present industrialized farming practices are energy intensive. Even without the threat of climate change, high energy prices are bleeding money from farmers and farm communities. Dependence on imported oil makes farming communities (and all of America) vulnerable.

"...energy efficiency, and climate-protecting farming and forestry practices that treat nature as model and mentor, can profitably deal with climate change and about 90 percent of the U.S. Environmental Protection Agency's pollution and public health concerns."

- The present patterns of energy use that are changing the climate will threaten agriculture around the world. At the same time, agriculture is also contributing to climate change. Modern farming practices strip the soil of carbon. Other practices contribute gases such as methane that are even more potent climate-changing compounds than carbon dioxide.

There are two primary ways in which agriculture can be part of the solution:

- Shifts in the way in which farming is conducted can reduce emissions of climate changing gases. Using energy more efficiently on farms can reduce emissions of carbon dioxide. Becoming more energy efficient can also make farming communities more economically vibrant and more resilient to natural disaster or terrorism. Farming in ways that increase the carbon content of the soil can actually strip carbon dioxide from the atmosphere in a process called sequestration.

- Agriculture can produce non-fossil energy for itself and the rest of the country. Farmers throughout the heartland are leasing their land for wind farms.[10] Biodiesel and other fuels made from farm products can play an important role in helping America shake its addiction to imported oil.

This is the really good news: Two emphases, (1) energy efficiency, and (2) climate-protecting farming and forestry practices that treat nature as model and mentor, can profitably deal with climate change and about 90 percent of the U.S. Environmental Protection Agency's pollution and public health concerns.

This paper examines the relationship between farming and energy, the challenges it poses and some of the answers that farm communities can begin to implement for themselves.

MEETING AGRICULTURE'S ENERGY CHALLENGES: IMPLEMENTING THE FIRST PRINCIPLE OF NATURAL CAPITALISM

The Challenges

The Cost of Energy

To understand the dynamics and challenges of energy and sustainable agriculture, we must first examine the world's agricultural energy challenges.

The food sector uses about 10-15 percent of all energy in the industrialized countries, and somewhat more in the United States. About two-fifths of the energy used goes to food processing, packaging, and distribution, and another two-fifths to refrigeration and cooking by final users. Only one-fifth is actually used on the farm — half of that in the form of chemicals applied to the land.[11]

Industrialization, and the heavily subsidized interstate highway system enable food to be transported great distances – the average molecule of food travels 1,500 miles in the United States before someone eats it – and heavily processed in ways that decrease food value and increase costs.[12] Yet American farms have doubled their direct and indirect energy efficiency since 1978. They use more efficiently produced fertilizer, diesels and other pieces of machinery, better drying and irrigation processes and controls, and herbicides to replace plowing. Despite such increases, U.S. agriculture uses at least ten times as much fossil fuel energy to produce food as the caloric value embodied in the food.

Iowa State University's John Miranowski found that energy use in U.S. agriculture falls into three major categories: electricity, diesel, and fertilizers, that each account for 20-30 percent of use. Combined they reach 76 percent. The remaining 24 percent is comprised of gasoline (9 percent), pesticides (6 percent), LP gas (5 percent), and natural gas (4 percent). Over the last 40 years, though total U.S. electricity and diesel use by farms has grown dramatically, fertilizer and pesticide use has increased only slightly (and has been declining since 1980) and gasoline use has sharply declined.[13] However, energy price increases in 2000 cost U.S. farmers approximately $3 billion in lost income.[14]

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Professor Miranowski's study of 2002 data found that direct energy accounts for 5-7 percent of farm expenditures: 2-8 percent for livestock operations, and 3-4 percent for "fruit/tree nuts, vegetables, and nurseries." For major crops, direct energy costs per dollar of output ranged from 4.8 percent for corn to 9.2 percent for rice. When combined with indirect forms of energy, which account for another 9-10 percent of farm expenditures, total energy cost per dollar of expenditure is 14-17 percent.[15] The fuel and oil used by farm tractors account for less than one third of the total energy consumed on the farm. Commercial fertilizers accounted for about 45 percent of total agriculture energy consumption in 1998.[16]

U.S. agriculture must implement the first principle of Natural Capitalism and become dramatically more efficient. Traditional economists say that as the price of energy increases, farmers will become more productive. But for a variety of reasons, increasing the cost of energy is not the best way for American farmers to make the transition to becoming more sustainable. Many U.S. farms are already financially distressed – from energy prices, climate challenges, and world markets. The U.S. Department of Energy (DOE) stated in 2004, "In recent years, net farm income decreased as dry conditions in much of the country reduced the forecasted yield of corn, soybeans, and wheat. Lower commodity prices combined with higher fertilizer and natural gas prices forced farmers and ranchers to pursue income from off-farm sources – as much as 94 percent of their total income in 2003."[17] Financially distressed farms will have difficulty accessing the capital to become more energy productive.

Because natural gas accounts for 80-90 percent of the cost of producing anhydrous ammonia for nitrogen fertilizers, farmers bear a double burden when natural gas prices increase. They must pay higher utility bills ***and*** higher production costs.[18] The price of natural gas was 11 percent higher in February of 2005 than it was in February of 2004.[19] Oil prices are at world record highs and some projections have oil prices remaining high indefinitely.[20] The National Sustainable Agriculture Information Service notes that for dairy producers, the cost of electricity alone can determine whether or not they remain in business.

If a farming operation continues to view energy as simply a fixed operating cost, it will gradually lose competitive advantage, and will be seriously hurt when energy supplies become limited or prices jump. For the reasons outlined below, business as usual is no longer acceptable.

Climate Chaos

Cycles of weather and water are changing the world over. Three-quarters of the glaciers in Glacier National Park have melted. Polar ice-sheets are calving off ice flows the size of New England states.

Farmers have always watched the weather. While out of their control and unpredictable, it has always been sufficiently subject to familiar patterns that *Farmers Almanacs* have endured. As climate change shifts weather patterns, will human ability to adapt – and to know what to expect from Mother Nature – keep up?

It may be tempting to rely on predictions that greater warmth in northern U.S. regions from global warming will counterbalance losses in southern regions and therefore cause increases in U.S. agricultural revenues.[21] However, since climate change may be better termed climate chaos, optimistic predictions are risky at best, and gloss over unacceptable risks for ecosystems worldwide. The unpredictability of climate models makes predictions of regionalized precipitation changes utterly fanciful.[22]

Even small changes in global temperatures make enormous differences in environmental conditions. Scientists believe that these will worsen existing threats to the world's ecosystems. According to *A Guide to World Resources, People and Ecosystems, the Fraying Web of Life*, "There are considerable signs that the capacity of ecosystems, the biological engines of the planet to produce many of the goods and services we depend on, is rapidly declining." Half the world's wetlands have been lost in the last century, half of the world's forests have been chopped down, 70 percent of the world's major marine fisheries have been depleted, and all of the world's coral reefs are at risk.[23]

This loss of biodiversity and ecosystem integrity threatens breakdowns that can interactively threaten human survival, first locally and then more widely. Such breakdowns are not only ecological. Losses of soil fertility, forest cover and fuelwood, medicinals, and water resources lead to rural depopulation, joblessness, urbanization, hunger, disease, and hopelessness. This scenario is now being played out in most developing countries around the world, from Haiti to Africa.

"What an irony: carbon, the most fundamental component of our modern energy world and the basic building block of soil fertility, is a major pollutant because of its greenhouse effect."

According to the World Conservation Union, whose "red list" of known species facing extinction now totals 15,589, "Habitat destruction and degradation are the leading threats to endangered species, but other significant pressures include over-exploitation for food, pets, and medicine; introduced species; pollution, and disease. Climate change is increasingly recognized as a serious threat."[24] Taken together, biologists concur, this is leading to the greatest mass extinction since the end of the dinosaurs.[25]

A 2003 Pentagon analysis agrees. Highly respected scenario builders Peter Schwartz and Doug Randall counted global warming as a more serious threat than terrorism to American interests. Climate change, they wrote, could result in a world where "warfare may again come to define human life... As the planet's carrying capacity shrinks, an ancient pattern re-emerges: the eruption of desperate, all-out wars over food, water, and energy supplies."[26]

What an irony: carbon, the most fundamental component of our modern energy world and the basic building block of soil fertility, is a major pollutant because of its greenhouse effect. But it was only recently declared a "pollutant" by California (resulting in predictable lawsuits from the auto industry). The world, however, has come down on California's side. Following Russian ratification in late 2004, the Kyoto Protocol came into force February 16, 2005. This is an acknowledgement by a majority of nations that we now live in a "carbon-constrained world," and a commitment to promote sustainable agriculture by the 140 signatories.

Climate scientists point out that actually reducing the level of greenhouse gases in the atmosphere enough to stabilize greenhouse gas concentrations even at double pre-industrial levels will require emissions reductions of 60 percent or more. A U.K. government study found that "credible scenarios for 2050 can deliver a 60 percent cut, but large changes would be needed both in the energy system and society."[27]

The lifespan of a carbon dioxide molecule in the atmosphere is decades. Human activities have changed the carbon dioxide balance in the atmosphere 30 percent in the last two centuries and 20 percent just since 1960, when three times less greenhouse gas emissions entered the atmosphere than today.[28] Production and use of energy accounts for about 88 percent of greenhouse gas emissions worldwide.[29] Of the approximately seven billion tons per year the world adds to the carbon dioxide of the atmosphere, about half is absorbed and half increases the carbon dioxide concentration.[30]

According to David Crisp of the U.S. Jet Propulsion Laboratory, the ability of earth's carbon sinks to continue to absorb half of carbon emissions is difficult because so much is unknown:

> We don't know where the sinks are. We don't know what the sinks are. We also don't know how they might respond over time as the climate changes. In particular we don't know if they'll become more or less efficient. There are several reasons to believe that the existing sinks may not continue to function the way they are functioning now, and if that happens, the atmospheric build-up could increase rather dramatically.[31]

It is figuratively and literally playing with fire to affect natural balances of fundamental components to this extent both in pace of change and overall effect.

The Pew Center for Climate Change's study of observed climate change effects on the United States, published November 2004, noted the crucial role of climate in "determining geographical distribution patterns of major biomes or vegetation communities." It found that U.S. farms are threatened:

> Healthy ecosystems provide a number of economically valuable goods and services; for example, pollination of farmed crops, pest control by predators, water purification, and soil renewal. However, the ability of ecosystems to provide these essential services may be compromised by the biological effects of climate change. For example, if warming results in insectivorous birds shifting their ranges north faster than their forest habitats can move, their populations will crash, and the controls they exert on pest outbreaks may be lost.[32]

Despite the fact that the U.S. government has refused to ratify the Kyoto treaty, the issue of climate change will still affect U.S. businesses. In September 2004, Jonathan Pershing, a former deputy director of the State Department Office of Global Change, explained that domestic EU producers will be favored over U.S. competitors in Kyoto countries – suggesting that U.S. companies and farmers could be cut off from new markets worth billions.[33] A recent survey of European and Canadian consumers found that 20 percent say they make a conscious effort not to buy U.S. goods because of their anger over U.S. foreign policy. [34]

"Customers, investors, and service providers are beginning to ask businesses whether they have implemented carbon reduction strategies."

Customers, investors, and service providers are beginning to ask businesses whether they have implemented carbon reduction strategies. Swiss Re, the big European reinsurer, recently told its clients that if their companies do not take their carbon footprint seriously, perhaps Swiss Re will not choose to insure them, or their officers or directors. In February 2005, 143 institutional investors of the Carbon Disclosure Project representing over $20 trillion in assets asked the world's 500 most valuable companies to disclose their "investment-related" greenhouse gas emissions. The project aims to establish a common emissions measurement methodology and facilitate its integration into investment analysis.[35]

Climate changes obviously affect agriculture, but the reverse also is true. Farming, as presently practiced, causes about one-fourth of the risk to the climate. American farmland typically has about 20 to 30 times as much biomass below ground as above.[36] This hidden carbon, as much as 44 tons per acre, risks being lost into the air if insensitive farming practices defeat the ability of living systems to fix carbon into soil biota.

By the early 1990s, synthetic fertilizers provided the nitrogen for about half the annual global crop harvest. Nitrogen fertilizers have been praised as "the most important invention of the twentieth century, freeing human populations from the constraints of the natural nitrogen cycle." But excessive use of artificial fertilizers is disrupting the natural nitrogen cycles.[37] And greenhouse gases and nitrogen cycles are directly linked – a pound of artificial nitrogen releases an average of 3.7 pounds of carbon dioxide into the atmosphere.[38]

Turning land that hosted the prairie's hundreds of varieties of grasses and other plants into fields where just corn and soybeans are grown, and substituting synthetic for natural nutrient cycles, puts the huge standing biomass of soil bacteria, fungi, and other biota out of work. When they subsequently die, they release their carbon to the air.

Plowing opens the soil the biological loss from air, heat, and ultraviolet light and to erosion that reduces organic constituents. The resulting "finely pulverized young coal" makes its way into riverbeds and deltas, where it decays into methane, a greenhouse gas 21 times worse for the climate than carbon dioxide.

Agrichemicals are substitutes for the degraded services of the natural ecosystem. Making these chemicals, notably fertilizers, requires about 2 percent of all industrial energy.[39]

The Answers

Energy Efficiency

The solution comes in part from the first principle of Natural Capitalism, using energy and materials much more productively.

In nearly every case, energy efficiency costs less, usually far less, than the fuel or electricity that it saves. It is cost effective to save at least half the energy now used in developed countries at prices averaging around 2 cents per kilowatt/hour.[40] Almost no forms of new supply, and few historic ones, can compete with this. And there is a lot of efficiency that is worth buying. The 40 percent drop in U.S. energy intensity (energy use per Gross Domestic Product) since 1975 has barely dented the potential. The United States has cut annual energy bills by about $200 billion since 1973, yet is still wasting at least $300 billion a year. Efficiency keeps rising as smarter technologies wring more and better service from less energy.

Europe, already markedly more efficient, has appropriately embraced energy efficiency as a central strategy for economic competitiveness. A recent European Commission Green Paper, "Towards a European Strategy for Energy Supply Security," describes a central role for energy efficiency in increasing the security of supply and reducing greenhouse gas emissions.[41] The Energy-Intelligent Europe Initiative is a cross-party and cross-nation initiative of the European Parliament. It calls for making Europe's economy the most energy intelligent in the world. By February 2002, all 15 European member states had signed onto promoting energy efficiency as Europe's number one energy "source." The initiative declares that linking "Energy Intelligence" to the knowledge-based economy "will help Europe to become the most competitive economy worldwide."

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Intelligent energy could be described as the opposite of the "brittle power" we rely upon today. The key to developing resilient energy systems is to combine energy efficiency with renewable and decentralized sources: harnessing the energy of sun, wind, water, or farm and forestry wastes, rather than that of depletable fuels in vulnerable centralized systems. This reduces the need for oil and gas wells, gathering lines, terminals, tankers, pipelines, coal trains, slurry pipelines, and most bulk-transmission power lines.

U.S. farmers reduced their energy use by 41 percent during the 1980s and 1990s, and there is a wide array of ways to increase the energy efficiency of farming operations. For example, the California Energy Commission reports that dairy farmers can save up to 30 percent of energy costs through variable-speed motors and vacuum pumping systems, while vegetable farmers can save more than 25 percent of water pumping, fertilizer, and herbicide costs with subsurface drip irrigation technologies.[42] A Pacific Gas & Electric study of pumping systems found that a new pump and premium efficiency motors can increase pumping system efficiencies by 20 percent.[43]

For example, a North Carolina chicken farmer found that he could increase his income by a quarter by lighting chicken houses with compact fluorescent light bulbs instead of incandescent ones. It even slightly increased egg production, perhaps by reducing overheating. Newly available LED lighting systems are even better.

Using big, slow fans instead of small, fast ones in livestock houses make less noise, saving most of the fans' energy use and improving their reliability. New impellers to move air and water (designed by biomimicing seaweed) make 75 percent less noise and use 45 percent less power.[44] Air-to-air heat exchangers cleanly recover 90-plus percent of the heat or cooling that would otherwise get lost in ventilation while providing fresh air.

Smart companies have learned that technology often improves faster than machines wear out – making it more profitable to purchase energy efficient fans, motors, and lighting than wait until the old inefficient system needs replacing. The agricultural value chain, from farm to retailer, can benefit from the same approach.

Better insulation, weather-stripping, orientation of farm buildings to take advantage of solar heat or shade, and selection of the right roof color can greatly improve indoor comfort in a barn just as it does in a passive solar house. Comfort, in turn, means healthier and more productive livestock.

For example, Richard C. Waybright's 2,500-acre Mason Dixon Farm in Gettysburg, Pennsylvania, has become a national model for profitably producing milk and energy. The farm's 2,200 cows produce 80,000 quarts of milk daily and, since the 1978 installation of a biodigester handling all its manure, a monthly check from the local utility for power generation. Waybright, whose grandchildren are the ninth family generation to live on the farm, also built a 500-cow passive-solar free-stall barn and several energy efficient hay machines. Receiving the first U.S. Dairy Forum Innovation Award in 1999, Waybright noted, "We don't set ourselves up as a model for the large dairy farms. We strive for efficiency, which is every farmer's goal."[45]

A shift away from large-scale corporate farming also can help. It is old news that small farms are more productive than large. A 1989 study found that "well-managed alternative farming systems nearly always use less synthetic chemical pesticides, fertilizers, and antibiotics per unit of production than conventional farms." The 1992 U.S. Agricultural Census found that the smallest farms, less than 27 acres, were more than ten times more productive than farms greater than 6,000 acres.[46]

Small farms aren't only more productive, they are more sustainable. Peter Rosset, former director of Food First, reports that in the United States, small farmers hold more than three times as much of their land as woodlands as compared to large farms (17 percent vs. 5 percent); and that they reserve almost twice the acreage for soil-amending uses, including cover crops and green manure.[47]

The growing trend toward organic farming can help as well since organic farms tend to be more energy efficient. An extensive study begun in 1978 by the Swiss government found organic farms to be 20-56 percent more energy efficient than conventional.[48] Flex Your Power, a California partnership promoting energy efficiency, finds that organic farms are 50 percent more efficient.[49] A U.K. government "desk study" found that, "Organic systems had a lower energy input largely because of an absence of indirect energy inputs in the form of nitrogen fertilizer." Compared to conventional agriculture, the study estimated that large, organic arable production used 35 percent less and organic dairy 74 percent less energy per unit of production.[50] Scientific field comparisons bear out these results – an organic apple orchard plot produced superior apples, greater profitability, and greater energy productivity than conventional adjacent plots.[51]

"Many farmers and ranchers can generate and use on-farm energy from solar, wind, and biofuels to cut costs and increase energy independence."

Water practices can have a dramatic effect on energy use, especially in irrigated areas. According to Flex Your Power, up to 90 percent of an agricultural business' electric bill is associated with water. Therefore, simple pumping and processing efficiencies can save 10 percent of energy bills in the short-run and more in the long-run. When combined with improved water management that decreases pumped volumes, electricity use can be cut 50 percent. California's Agricultural Pumping Efficiency Program has helped farmers save nearly 12 million kilowatt hours with nearly $900,000 in incentives and over 5,000 pump tests. In the Rancho California irrigation district, a $50,000 investment in more efficient natural gas water pumps is expected to save $60,000 per year.[52]

On-farm Production of Energy

For at least three decades, activists have called for adopting renewable energy strategies to reduce dependence on finite resources. Renewable energy can contribute to the transition to a sustainable economy, but it is important, especially in the context of energy produced from farms, that the technologies used be truly sustainable. Systems that diminish natural capital, as do some energy crop systems, are not sustainable.

Many farmers and ranchers can generate and use on-farm energy from solar, wind, and biofuels to cut costs and increase energy independence. According to the National Sustainable Agriculture Information Service, "Perhaps of equal promise [to efficiency] is that farmers can become important energy producers, both for themselves and their neighbors, as well as for the nation's future."[53]

Wind

Around the world, wind power is the fastest growing electric supply, delivering over 5 gigawatts of new energy each year. Wind is one of the cheapest sources of new electricity – very competitive with natural gas turbines. Today the price is between 3 and 4.5 cents per kilowatt-hour and usually quicker to install than fossil-fuel plants. This brings wind energy into the limelight as a prime contender for on-farm generation.

In the United States, installed wind turbine capacity grew 28 percent annually from 1999 to 2003. It now provides over 6,740 megawatts of carbon-free power, and over $5 million in lease fees for landowners. Renewable portfolio standards, already in place in 11 states, were adopted by another seven states and the District of Columbia in 2004. These will increase the adoption of renewable energy. For 2005, four 200-plus megawatt projects have been announced in New York, Washington, Wisconsin, and Minnesota; a 600-plus megawatt development is being planned for a Wyoming ranch.[54]

Chuck Hassebrook, executive director of the Center for Rural Affairs, writes,

> Many areas of the Midwest and Great Plains contain significant wind capacity. Iowa, Kansas, Nebraska, Minnesota, North Dakota, and South Dakota are among the states with the largest potential to harness wind for electricity generation. These states are often referred to as the "Saudi Arabia of wind generation." The DOE found that North Dakota has the largest "reserves" of wind of any state – it alone has the wind capacity to provide 36 percent of the electricity demand for the 48 contiguous states. The three "windiest" states – North Dakota, Kansas, and Texas – could provide enough wind power generation for most of the nation's electricity needs.[55]

Iowa Senator Chuck Grassley has lent his considerable support to wind energy, making the state third in the nation in terms of wind energy developed by 2003. The Iowa Department of Natural Resources estimates that the state has the potential to produce nearly five times its own annual electrical needs through wind power. Iowa already has 472 megawatts of wind energy installed, and another 581 megawatts planned.[56]

Wind does have its critics. One U.K. turbine neighbor said the noise was like Chinese water torture. Some upscale U.S. neighborhoods have sued to prevent wind farms from being erected, but most such lawsuits have been dismissed. Recent media reports have raised the issue of surprisingly large numbers of bats being killed by wind generators in Pennsylvania, and bird kills have been a concern. Such issues are lessened with lower blade speeds and other mitigation technologies.

"...Wind energy offers rural landowners a new cash crop."

Wind advocates counter that even with 100 percent of U.S. electricity coming from wind, turbine-caused bird kills would only be 1/250th of bird kills from other human causes, and that wind energy displacement of coal electricity will help reduce climate change that is endangering birds through habitat changes.[57] The extensive ecological studies associated with wind farm siting procedures rarely find significant ecological effects.

The modern wind industry was developed in the United States, but inept national policies allowed this industry to migrate to such countries as Denmark, which is now getting over 20 percent of its energy from wind. An August 2004 survey in the United Kingdom, which is rapidly developing its own wind resources,[58] found that (1) most people agree wind farms are necessary (72 percent); (2) 61 percent who have seen wind farms disagree that they're noisy, and (3) 70 percent would support development of a wind farm in their area.[59]

The DOE's ***Wind Energy for Rural Economic Development*** states, "Wind energy offers rural landowners a new cash crop. Although leasing arrangements vary widely, royalties are typically around $2,000 per year for a 750-kilowatt wind turbine or 2-3 percent of the project's gross revenues. Given typical wind turbine spacing requirements, a 250-acre farm could increase annual farm income by $14,000 per year, or more than $55 per acre. In a good year that same plot of land might yield $90 of corn, $40 of wheat, and $5 worth of beef."[60] These wind turbines have a very small footprint and do not interfere with ranching and farming operations.

According to Windustry, a Minnesota-based farmer wind energy network, "The most common way for a farmer to participate in a wind project is through leasing land, but there are other options. Wind lease terms vary quite a bit, but general rules of thumb are: $2,500 to $5,000 per turbine, $3,000 to $4,000 per megawatt of capacity, or 2-4 percent of gross revenues. Larger turbines should translate to larger payments. Compensation packages typically are offered as fixed yearly payments, as percentages of gross revenues, or some combination."[61]

Communities are employing wind as a local source of power generation. Sacred Heart Monastery in Richardton, North Dakota, (pop. 619) was facing rising energy costs. They turned to wind-generated electricity, installing two 100-kilowatt turbines at the local Benedictine Monastery. They only plan to keep the turbines in place for 10 years and then replace them with state-of-the-art technology. The turbines cost $120,000, but returned a savings of $41,600 in the first three years, roughly 45 percent of the monastery's electricity costs.[62]

In Moorhead, Minnesota, a city of 32,000, the local utility offered a "Capture the Wind" program that allows customers to obtain wind-generated electricity for approximately $5 per month. Both of the utility's wind turbines are fully subscribed, with over 900 customers in the program.

US Wind Farming Inc. has announced plans to establish small, distributed "Wind Turbine Agricultural Renewable Energy Cooperatives" with farmers nationwide. The first publicly-traded U.S. wind company, it says farmers installing its 1.5- to 2.5-megawatt turbines can expect up to a $100,000-per-year annuity for 30 years.[63] In June 2004, the Ames, Iowa, city council voted to take the next step towards a sustainable energy system by joining a partnership with the DOE to install the most sustainable energy system within our current technological grasp – wind turbines that will generate hydrogen during their off-peak hours.[64]

Solar

Solar photovoltaic and other technologies continue to improve and are the best choice today for remote applications, or where the cost of running lines is high. Photovoltaics are being installed as roofs or walls in commercial buildings, supplementing grid power and providing energy security against grid failures and dramatic price increases. Four Times Square Building in New York City uses solar panels that look like glass in much of the building's south façade. The building cost no more to build than normal, but the developers are able to charge tenants premium rates because they can never lose power.

Photovoltaics are being implemented in agricultural settings around the world. Prices have come down significantly over the last few years and are almost comparable to those of unsubsidized fossil fuels. New advances may bring prices down to comparable with wind power within five years.[65] In often-cloudy Germany, the world's largest photovoltaic power plant, the Bavaria Solarpark (10 megawatts peaking power from 57,600 PV panels), was installed last year on 62 acres.[66]

"Solar photovoltaic and other technologies continue to improve and are the best choice today for remote applications..."

Biomass and Biofuels

The oldest agricultural production of energy is biomass. Farmers have burned dung and wood for millennia, and it remains one of the world's primary sources of energy. In the United States, modern versions are entering the market. The DOE projects more than a doubling in biomass-generated electricity by 2025, with the sector (not including biomass combusted with coal) growing from 1.8 to 4.5 gigawatts.[67] American cars and trucks already burn more than a billion gallons of ethanol, about 1 percent of U.S. vehicle fuels, mainly grown in the Midwest. The EPRI, the electric utilities' research consortium, says that 50,000 megawatts of biomass energy could be on line by the year 2010, equal to half of all U.S. nuclear power plants. Biomass in all forms already delivers about as much energy as nuclear. The biomass power industry supports about 66,000 U.S. jobs, many of these in rural regions. By 2010, it could support more than 283,000 U.S. jobs.[68]

Biofuels generally mean ethanol or biodiesel. Colorado's Blue Sun Biodiesel is reducing the cost of high-grade biodiesel fuel through the development and production of low-cost oilseed crops for dryland agriculture on the high plains. The farmers use rotational crops, avoid monocropping and thus avoid pesticides and herbicides. Biodiesel reduces carbon emissions 78 percent over its life cycle compared to petroleum diesel.[69] American biodiesel consumption has grown 50-fold since 1999, but still is only 1/20th as much as Germany, where biodiesel is cost-competitive with petroleum diesel.[70]

However, it is possible to produce biofuels in ways that are net losses of energy, and that rob the soil of nutrients. In the ***Living Planet Report 2004***, some biofuel production is estimated to have an ecological footprint of 1,000 hectares to produce one megawatt of electricity compared to that of wind at a maximum of three hectares and solar at a maximum of 16 hectares. Fossil fuels are at a maximum of 800 hectares per one megawatt of power. Badly done biofuels can have a larger footprint than fossil fuels.[71]

Cornell University agricultural scientist David Pimentel, in a Mobil Oil-funded study, investigated the efficiency of ethanol production. He claimed that 131,000 BTUs are consumed through planting, growing, and harvesting corn, and then crushing, fermenting, and distilling it in order to produce a U.S. gallon of ethanol. That gallon then contains only 77,000 BTUs. That means that it takes about 70 percent more energy to produce ethanol than the finished product.[72]

There is debate on the true costs and value of biofuels. ***The Guardian*** columnist George Monbiot claims that nearly all of the United Kingdom's cropland would have to be devoted to produce "food for cars instead of people" to reach the European Union's goal of 20 percent biofuels by 2020. For Monbiot, this represents a humanitarian disaster since "in a contest between their demand for fuel and poor people's demand for food, the car-owners will win every time." He also sees the potential for an environmental disaster since the highest producers of biofuels such as oil palms (four times more than rapeseed per hectare) will likely displace tropical rainforests.[73]

Biofuel advocates counter that biofuels have beneficial impacts. Increased use of biofuels improves air quality, supports U.S. agriculture, and strengthens the economy and national security by reducing our dependence upon imported fuel. It also will lessen the numbers of substandard tankers on the high seas. Biofuels can enable farm communities to survive the transition from uncompetitive crops to something different. A group of farmers in the Ontario, Canada, "tobacco belt" announced in January 2005 that they hope to bring an ethanol plant to either Norfolk or Oxford county to revive their faltering economy by growing sweet potatoes in order to produce ethanol.[74]

Profitable Abatement of Carbon

Many available efficiency measures can provide the same services and products that make our lives comfortable while using ten times less energy. According to the 2004 Clean Energy Future for Australia report, "at today's prices and assuming no silver bullet technologies, nations can viably achieve deep cuts of 60 percent of greenhouse emissions over the next 50 years."[75]

"Done right, it can be highly profitable to reduce carbon emissions, whether on farms or in industry."

Done right, it can be highly profitable to reduce carbon emissions, whether on farms or in industry. DuPont Corporation, for example, has set a goal of profitably reducing its greenhouse gases 65 percent from 1990 to 2010. DuPont had already achieved the goal by 2002 while increasing output and sales. It also has committed to get 10 percent of its energy and 25 percent of its feedstocks from renewables by 2010. Since 1990 DuPont has kept energy use the same and increased production 30 percent. DuPont reckons to save $2 billion through its programs to reduce emissions.[76]

The microchip manufacturer STMicroelectronics has gone even further, setting a goal of zero net carbon dioxide emissions by 2010, while increasing production 40-fold over its 1990 levels. It also has set a 2010 goal for obtaining 15 percent of its energy from renewable sources, 55 percent from cogeneration, and 30 percent from conventional sources. By the time it is climate neutral, it will have saved $900 million.[77]

Changes in agriculture can play a crucial role as well. A range of agricultural management practices can sequester or reduce emissions of carbon dioxide, including rotation length, avoided deforestation, biofuel production, crop mix and/or tillage alterations, crop fertilizer rate reduction, rice acreage reduction, grassland conversion, and livestock management techniques. Biofuels and afforestation are at present the higher cost alternatives, whereas soil carbon management, forest management, and reduced carbon dioxide emissions from changed practices are low-cost strategies.

According to ***The Living Planet Report***, "One global hectare can absorb the carbon dioxide released from consuming 1,450 liters of gasoline per year." Sequestration capacity varies by land use, biological factors such as forest maturity, plant cover, and soil health and composition.[78] Recent reports from the U.S. EPA and USDA give conservative carbon sequestration potentials of U.S. agricultural lands. EPA has estimated that under current practices, U.S. agricultural soils and forests sequester about 700 million tons of carbon per year, or about one-tenth of national greenhouse gas emissions. USDA found that at prices ranging up to $35/ton carbon, changed afforestation and soil management practices in the United States could generate another 600 million tons per year (nine-tenths from forests). Others have estimated the potential to as high as three billion tons per year if prices reach $40 to $80 per ton of carbon dioxide.[79]

It is possible to go far beyond current practices. Agriculture featuring such sustainable practices as reduced land clearance, tillage, and fertilization, higher energy efficiency, and greater reliance on renewable energy could probably eliminate most human releases of nitrous oxides, much of which is produced by the reactions of synthetic fertilizer with soil bacteria. Very large carbon dioxide savings could result from building up organic matter in soil humus by accumulating a richly diverse soil biota. Soil loss – especially the physical loss or biological impoverishment, hence carbon depletion, of humus – currently outpaces soil and humus formation worldwide.

This net loss of soil carbon has contributed about 7 percent of the carbon now in the atmosphere. Yet successful conversions to organic or low-input practices, chiefly in the United States and Germany, have demonstrated that after a few years' reequilibration, these carbon losses can actually be reversed. U.S. cropland alone (8 percent of the cropland on earth) could thereby offset about 8-17 percent of U.S. carbon emissions.[80]

Worldwide, the potential for sequestration-based management of forests and agricultural lands and organic farming is far greater. The world's cultivated soils contain about twice as much carbon as the atmosphere. The earth's five billion acres of degraded soils are particularly low in carbon and in need of carbon-absorbing vegetative cover. Increasing degraded soil's carbon content at plausible rates[81] could absorb about as much carbon as all human activity emits.[82] Equally important is to use modern grazing management techniques and to refrain from plowing and burning in "brittle" environments so as to diversify and densify the grasses that cover much of the earth. This often can reverse desertification, restore soils and water tables, increase livestock-carrying capacity, and put large amounts of carbon back into the grassland and savanna soils.[83]

"Increasing degraded soil's carbon content at plausible rates could absorb about as much carbon as all human activity emits."

Nebraska inspired a number of state initiatives to support carbon sequestration by farmers by establishing the Carbon Sequestration Advisory Committee in 2000. It found that while recently adopted conservation practices provide about 1.7 million metric tons (MMT) of sequestration in Nebraska now, up to 0.6 MMT more could be generated if all cropland were farmed using no-tillage systems, and 5 MMT more could be sequestered through better grazing management practices.[84]

Private markets are about to enable farmers to capture the social value of sequestering carbon. Like additions to farm income from production of energy, this new trend may begin to tip the balance of farm economics towards sustainable practices.

Nearly a year ago, Natural Capitalism, Inc. joined dozens of leading companies and governments as a member of the foremost market maker in climate protection: the Chicago Climate Exchange (CCX). CCX is a self-regulated exchange that administers the world's first multi-national and multi-sector marketplace for reducing and trading greenhouse gas emissions. CCX represents the first legally binding commitment by a cross-section of North American corporations, municipalities, and other institutions to establish a rules-based market for reducing greenhouse gases.

CCX and the International Petroleum Exchange, a London-based energy futures exchange, have joined forces to provide a marketplace for European emissions trading – the European Climate Exchange. Despite the United States not being a signatory to Kyoto, and therefore not bound by its mechanisms, the CEO of CCX Richard Sandor says that American companies have incentives to cut their greenhouse gas emissions because it adds to shareholder value.[85]

Carbon prices are relatively low as yet, but farmers should know that there is potential to earn money on these exchanges (and on the Winnipeg Commodity Exchange) through carbon offsets from agricultural land. There are currently 80,000 acres in Iowa enrolled in carbon sequestration, mostly through no-till or low-till practices. The Iowa Farm Bureau is involved in the CCX, working to educate farmers about their potential role in carbon sequestration schemes.[86]

The Challenge

The superficial success of America's farms masks other underlying problems. A third of the original topsoil in the United States is gone, and much of the rest is degraded. Soil productivity in the semiarid Great Plains fell by 71 percent just in the 28 years after sodbusting.[87] Notwithstanding some recent progress in revising soil conservation efforts, topsoil is eroding much faster than it is being formed. In the 1990s, 90 percent of American farmland was still losing topsoil an average of 17 times faster than new topsoil was being formed, incurring costs projected at $44 billion over the next 20 years.[88]

Over-application of nitrogen in the United States is so common that in the early 1990s farmers were applying 56 percent more than their crops could absorb from the soil.[89] Two-thirds of fertilizers have heavy metals content exceeding limits for wastes sent to public landfills.[90] Excessive nitrates in Iowa municipal water supplies are increasing bladder cancer risks among women.[91] Nitrogen now has become the "principal nutrient of concern for U.S. coastal waters."[92] As a result, according to the Pew Oceans Commission, "coastal regions see reduced production of valuable fisheries, threats to biodiversity, and ecosystems less resilient to natural and human influences."[93]

There is also growing global concern that the disruption of the nitrogen cycle may be as serious for the planet's health as emissions of carbon dioxide. According to Worldwatch Institute, nitrogen and phosphorus cycle disruptions join carbon dioxide disruptions as a "profound geochemical flux" threat. They state that the presence of nitrogen and phosphorous in vastly greater than natural quantities "is liable to cause pervasive ecosystem change" partly because too much nitrogen "apparently predisposes many plant species to disease and insect attack." Humans have caused a doubling of the annual global release of fixed nitrogen, not including marine nitrogen cycles.[94] Toxic algal blooms, increased tree death, and loss of rare species can all result from excessive use of nitrogen.[95]

"The superficial success of America's farms masks other underlying problems."

The Answers

Biomimicry-based Agricultural Management

The second principle of Natural Capitalism is to use an approach called Biomimicry to guide the redesign of every product and process that is currently unsustainable. Janine Benyus, author of the book ***Biomimicry***,[96] describes how nature makes a wide array of products and services, but does it very differently than we do. She points out that nature uses low energy flows, conducting most of its manufacturing at ambient temperature, and usually immediately adjacent to something alive. Nature powers itself with sunlight. It makes no persistent toxics, and uses closed loop processes, in which everything is recycled: the output of any process is food for another process. Finally, nature shops locally.

Applying these design guidelines to agriculture would result in a very different and much more sustainable form of farming. Called Natural Systems Agriculture, it is a new paradigm for food production, in which nature is mimicked rather than subdued.

Wes Jackson and his colleagues at The Land Institute, pioneers in this field, asked themselves, "What are the ecological arrangements in nature's ecosystems where agriculture has not penetrated – be it an alpine meadow, a deciduous forest, or native prairie? Stated otherwise, how is it that nature's arrangement so readily and effortlessly manages nutrient recycling and runs on contemporary sunlight?"[97]

The Land Institute looked to the local prairie as a biomimetic model for grain crops. In the prairie, nature features perennials in mixtures, not annuals in monoculture as is used in most current agricultural practices. Institute researchers are investigating the feasibility of perennial polycultures or mixtures of perennial grains. "Perennial roots hold the soil and the diversity of species presents a formidable chemical array to thwart the insect or pathogen that could otherwise create an epidemic. In a perennial polyculture, the natural capital of soil and species diversity is featured. Fossil fuel dependency for fertility and traction and chemical contamination of the countryside would decline."

The Institute has shown the possibility of melding the virtues of the prairie with the requirements of human food production to solve most of the problems of agriculture. The Land Institute now believes that the United States can build an agriculture based on a fundamentally different paradigm than the one humans have featured for the last eight to ten thousand years.

Farm animal management also can be improved to reduce climate change and increase profits. Intensive feedlot production of livestock, especially cattle, causes a host of problems, ranging from energy intensive production of grains to feed the animals to the use of antibiotics to forestall outbreaks of disease in closely confined conditions. But pioneers of ecologically-based grazing are showing that grazing cattle and other animals in the way in which grasslands coevolved with grazing animals can increase the carrying capacity of animals on even degraded land, while improving the health of the grass and the surrounding environment.

Allan Savory's Holistic Management approach uses cows to mimic the movement across grasslands of herds of native ungulates. Hemmed in and agitated by prowling predators, the herd is concentrated in time and space, quickly moves on, leaving hoof prints that catch dung, water, and seed to make next year's grass crop. The animals don't return until the following year, when the grass has regrown. Savory has proved that much of what is commonly considered overgrazed land is actually undergrazed but grazed the wrong way. Range management based on an understanding of the ecology of each piece of land can improve carrying capacity for both livestock and wild grazers, while producing a premium product – the ultra-lean, organic range beef that is now a boutique product in health stores.

Management-intensive rotational grazing (MIRG) has spread through beef, pork, and especially dairy farming in the humid American Midwest, where it has become "the most innovative and fastest growing farming practice." Just between 1993 and 1997, as Wisconsin lost 18 percent of its dairy farms, MIRG operations grew by three-fifths to about 15 percent of all the dairies in the state. The grazing cows yield slightly less milk than confined animals but at far lower capital and operating cost, hence higher income per cow.[98]

"Ordinary organic farming practices modeled on complex ecosystems is an ancient form of farming within nature's balance."

The technique is simple in principle. The cows walk around fetching their own food (grass) and depositing their own manure within a paddock, moving on to another area about every day, so the grass can recover. But this practice isn't simplistic. It requires hands-on management and knowledge of forage ecology to ensure the grass is harvested at its nutritional peak and let it recover for the optimal period. It also ensures adequate time for the manure to return to the soil, closing the nutrient loop without producing toxic runoff (about 35 times less nitrogen runs off perennial grass pastures than the corn-and-soybean fields otherwise used to make cattle feed).[99] MIRG displaces enormous quantities of expensive feed grains, return soil to its original erosion-resistant grassland structure, and restores groundwater. It improves the habitat and wildlife (such as insect-eating songbirds), and the health of the cattle. It reduces contamination by sediments, agrichemicals, and manures (equivalent to the waste output of 24 people per cow).

Ordinary organic farming practices modeled on complex ecosystems is an ancient form of farming within nature's balance. It generally produces comparable or only slightly lower yields than chemical farming but at even lower costs. Farmers therefore earn comparable or higher farm incomes – without taking into consideration the premium many buyers are willing to pay for food free of unwelcome biocide, hormone, and antibiotic residues. Economic advantage from organic practices has been demonstrated in large commercial operations over a wide range of crops, climates, and soil types.[100] It is rapidly gaining market access, customers, and practitioners.

Organic farms also reduce the climate impacts of nitrogen fertilizers. Yields from farms fertilized with legume crops and manure can be as high as those fertilized with synthetic nitrogen – and its attendant carbon dioxide releases.[101] Farm comparisons in Europe have shown nitrate leaching rates on organic farms are 40-57 percent lower per hectare and carbon dioxide emissions are 40-60 percent lower per hectare than conventional systems.[102]

But conventional organic farming isn't the last word in the evolution of modern agriculture. Biointensive mini-farming, for example, is a newer technique that combines four commonsense gardening principles: deep cultivation to aid root growth, compost crops, closely spaced plants in wide beds to optimize microclimates, and interplanting of mixed species to foil pests.

Standard U.S. agricultural practice today requires at least 45,000 square feet of land to feed a person on a high-meat diet, or about 10,000 square feet for a vegetarian. Developing nations aspiring to similar diets have only about 9,000 square feet of land per person available for cultivation, and that amount will probably shrink with further urbanization and ecological stresses. However, biointensive gardening can provide for a vegetarian's entire diet, plus the compost crops needed to sustain the system, on only 4,000 square feet, even starting with low-quality land. Compared with conventional farming, water used per unit of food produced decreases by up to 88 percent. Off-farm energy inputs are reduced by up to 99 percent, land per unit of food produced by 60-80 percent, and land per dollar of net farm income by half. Except for the land and a few locally manufacturable hand tools, essentially no capital or any chemical inputs are required. This works so well that biointensive agriculture is being practiced in 107 countries worldwide.[103]

Some of the most productive kinds of biofarming integrate livestock with crops, and garden and tree crops with field crops. They involve often tens and sometimes hundreds of cultivars instead of just one or a few. A typical Javanese kitchen garden, for example, looks like a miniature forest, growing over 50 cultivars in four layers on scarcely more than an acre. In Asia, there is a rich tradition of integrating many kinds of food production – rice, vegetables, fish, pigs, ducks, etc. – in a sophisticated quasi-ecosystem that efficiently recycles its own nutrients through plant-animal interactions. A recent Bangladeshi adaptation stopped applying pesticides to rice in order to grow fish in the wet paddy fields – whereupon the fish flourished and the rice yields increased by one-fourth, because without interference, both crops could benefit each other.[104]

Biological farming principles also can be adapted to the vast areas now planted to grains. Its many variants can simultaneously reduce farmland's emissions of methane and nitrous oxide, and can reverse agricultural carbon dioxide emissions. Christine Jones' team at New South Wales' Land and Water Conservation Agency are developing a new "pasture cropping" technique with controlled grazing on perennial grass cover but also annual grains sown into the grass in its dormant season. This yields the grain crop and livestock while protecting the soil and holding water.

"Agricultural substitutes for carbon-intensive fossil-fuel products are another opportunity to reduce climate chaos."

Carbon-friendly Agricultural Products

Agricultural substitutes for carbon-intensive fossil-fuel products are another opportunity to reduce climate chaos. When carbon is absorbed by plants that are then made into durable products (and/or effectively recycled many times), especially through more energy efficient processes than existing products, we obtain the services we need from materials like plastics with greatly reduced carbon emissions.

At present, nearly all plastic is made from petroleum. Cargill-Dow LLC's NatureWorks makes PLA polymers that can substitute for petroleum plastics using 20-40 percent less fossil fuels. The NatureWorks plant in Nebraska can use up to 40,000 bushels of corn per day to produce 300 million pounds of PLA per year. Interface Inc., a leader in sustainable corporate practices for the past decade, developed its Terratex fabric for European markets from PLA fibers in 2002. PLA is catching on as a food container as well, with Del Monte Foods, Newman Organics, and Club Fresh switching to PLA-based plastic packaging. Competitors are already sprouting. Japan's NEC has now developed a stronger plastic material by combining fast-growing and climate-friendly kenaf with PLA.[105] However, like biofuels, the promise of such products is tempered by the ability of producers to grow feedstocks using sustainable, natural-capital enhancing practices.

Researchers at Cornell University have recently discovered that orange oil, combined with carbon dioxide, can become a high-quality environmentally friendly polymer from entirely renewable resources. The process sequesters carbon rather than emits it.[106] Fujitsu Limited recently announced that it will completely shift to biodegradable plant-based materials for the embossed "carrier tape" that protects semiconductors in transit. The new material is expected to reduce the carbon emissions of this activity by 11 percent.[107] A Chinese company is marketing soy protein as the new eco-friendly luxury "vegetable cashmere" fabric for clothing; some soy-textile companies already have obtained organic certification.[108]

THE NATURAL CAPITALISM APPROACH TO ENHANCING RURAL VITALITY

Meeting the challenges of global and national climate change will require a shift to more sustainable energy and agricultural practices. Enormous opportunities exist to use energy more efficiently in agricultural activities, to develop farm-based clean energy resources, and to manage agricultural land for sequestering more carbon. Done intelligently, such programs can strengthen rural communities and bring a higher quality of life to farmers.

The best way for agricultural communities to foster this change in a timely manner is to implement community or regional energy strategies. Despite their great resourcefulness, farmers cannot be expected to make the sorts of changes needed on their own. But a community working together can use whole systems approaches such as Natural Capitalism to provide sustainable energy services in ways that are least-cost to both consumers and to natural and human capital stocks.

Community energy strategies need to focus on energy productivity, more sustainable decentralized sources (e.g. "renewables"), advanced energy carriers such as hydrogen, security considerations, and the rapidly developing opportunities for new revenues from tradable carbon financial instruments. Several tools are already available to guide community energy strategic development.[109] The key is a collaborative planning partnership that recognizes how new technologies blur the lines between vehicle fuels and electricity fuels, how distributed energy production blurs the lines between producers and consumers, and the challenges of a carbon-constrained global economy.

Community energy strategies that embrace Natural Capitalism can dramatically impact the health of rural economies. Such approaches often provide critical leverage for the public and private investments that make efficiency, or wind, solar, or biomass production systems viable. Increasing the competitiveness of rural economies also helps support off-farm income opportunities for farmers – often a crucial aspect of family farm economics.

One of the most effective things that a community can do is to understand the cost of its current dependence on energy and options are for reducing this dependence. For example, a typical community spends 20 percent of its gross income buying energy, and 80 percent of those dollars leave town buying imported energy. There are myriad ways to improve such numbers, but several good examples come from the 1970s, the last time that energy was a concern to the nation.

"Despite their great resourcefulness, farmers cannot be expected to make the sorts of changes needed on their own."

A Massachusetts Example

In 1974, a group of citizens in rural Franklin County, Massachusetts, set out to understand the impact of rising energy prices. They found that the average person was annually spending $1,300 buying energy. This amounted to $23 million per year, which equaled the payroll for the county's 10 largest employers. Before the oil embargo price increases, a dollar would circulate in the county 26 times before it left to buy something outside the county. By 1980 it circulated fewer than 10 times. The lowest official forecasts showed that in 15 years the county would be four times worse off.

The study described options in both energy efficiency and renewable energy: how to fix buildings so they used less energy; how to use solar, wind, and micro-hydro plants to provide electricity; and how to provide liquid fuels for vehicles from wood methanol. Needed equipment could be made in local machine shops. The cost of implementing these alternatives would have been $23 million per year – the same that they were then paying for energy – but the money would stay in Franklin County.

When their options were laid out this way, county residents listened and were willing to act. Subsequent studies found that more than 90 percent of county residents polled in 1980 said they had reduced their energy use since 1974. Weatherization projects had cut energy use in half in more than 200 homes. Energy audits saved an average of $560 dollars per audited home per year. Total energy use in the county did not grow during 1976-78. Many farms installed solar and other renewable energy options, while the county utility invested in wood energy and in micro-hydro facilities.

Despite this success, many businesses closed due to the national economic malaise. In response, citizens created the Franklin County Community Development Corporation to support sustainable small business growth and recently, organic food processing firms. During its 25 years of operation, the Corporation has helped create over 1,400 jobs through 250 small business loans, and has developed the Venture Center business incubator (1989) that houses the Western Massachusetts Food Processing Center (FPC), a provider of technical services, best practices, and physical facilities in support of sustainable local agriculture that opened in 2001.[110]

Farmers who want to add value to their crop by preparing food for the retail and wholesale markets rent FPC space and equipment. The FPC is equipped to produce many different types of food through its cold and dry storage facilities, a commercial kitchen, and a packaging area. The FPC helps to support local agriculture and adds jobs and revenue to the area.[111]

And the great work continues. Social entrepreneurs of the Pioneer Valley Photovoltaics cooperative in Franklin County launched Solar Partners in 2003 to assist homeowners, businesses, and institutions with solar electric installations in four counties. Citizen donations and $350,000 from the Massachusetts Renewable Energy Trust will support the installation of 50 kilowatts of photovoltaics.[112]

An Iowa Example

Another early example that has delivered continuing value comes from Osage, Iowa. In 1974, the Osage Municipal Utility was faced with the need to build a new power plant to meet growing demand. Its general manager, Wes Birdsall, realized that if the plant were built it would increase everyone's rates. Instead, he stepped across the meter to his customers' side and helped them use less of his product. Why on earth would a businessman ever do that?

Birdsall realized that what his customers want is not raw kilowatt hours, but the energy "services" of comfort in their homes, shaft-power in factories, illumination, and the other services that energy delivers. People buy energy, but what they really want is the service. If they can get the same or improved service more cheaply using energy more efficiently or from a different source, they will jump at it. Birdsall realized that if he raised his prices, not only would he be doing his customers a disservice, but that they might turn to other options. By meeting their desires for energy services at lower cost, he retained them as customers, and began one of the most remarkable economic development stories in rural America.

Birdsall's program was able to save over a million dollars a year in this town of 3,800 people and generate over 100 new jobs. A report on the program found that, "Industries are expanding and choosing to remain in Osage because they can make money through employees who are highly productive and through utility rates that are considerably lower than neighboring cities."[113]

"...conventional agriculture is at great risk of being squeezed by (1) increasing prices of energy, water, and other inputs; (2) carbon constraints; (3) declining natural capital; (4) shrinking markets, and (5) foreign competitors."

Birdsall was able to reduce electric bills to half that of the state average and unemployment to half that of the national average, because with the lower rates new factories came to town. He held electric growth level until 1984. The program was profiled in the *Wall Street Journal* and was copied by other utilities.

According to a USDA study of Osage, "The local business people calculated that every $1 spent on ordinary consumer goods in local stores generated $1.90 of economic activity in the town's economy. By comparison, petroleum products generated a multiplier of $1.51; utility services, $1.66; and energy efficiency, $2.23. Moreover, the town was able to attract desirable industries because of the reduced energy operating costs resulting from efficiency measures put in place. Energy efficiency has a long and successful track record in Osage as a key economic development strategy."[114]

As powerful a tool as energy efficiency can be, it is even stronger when coupled with sustainable energy.

In 1989, Sacramento, California shut down its costly 1,000-megawatt nuclear power plant. Rather than invest in a conventional centralized fossil fuel plant, the local utility met its citizens' needs through energy efficiency, and such renewable supply technologies as wind, solar, biofuels, and distributed technologies like co-generation. A recent econometric study showed that the program has increased the region's economic health by over $180 million, compared to just running the former nuclear plant. The utility was able to hold rates level for a decade, retaining 2,000 jobs in factories that would have been lost under the 80 percent increase in rates that operating the nuclear plant continued operation would have caused. The renewables program itself generated 880 new jobs and enabled the utility to pay off all of its debt.

CONCLUSION

This paper focuses on energy. It is the one aspect of the broader topic of sustainable agriculture that touches all aspects of farm profitability, community development, and social capital. Sustainability strategies and practices will influence farmers and the entire agriculture value chain to make stronger contributions to long-lasting community and regional economic prosperity. People like to work for businesses driven by more than profit; sustainability often drives profitability gains simply through greater human productivity.

Agricultural businesses would do well to implement sustainability strategies like Natural Capitalism through the integrated and phased approach we call the Sustainability Helix. The Helix provides a whole-system road map to explore, experiment, implement, and eventually mainstream sustainability strategies. It gets the right questions asked at the right time in a sequenced flow that leads to success rather than the stops and starts of piecemeal approaches. It maximizes the synergies of approaching the key components of organizational work – governance, operations, design, human relations, marketing, and partnerships/supply chains – in coordinated, business case-based ways that retain profitability as the core driver.

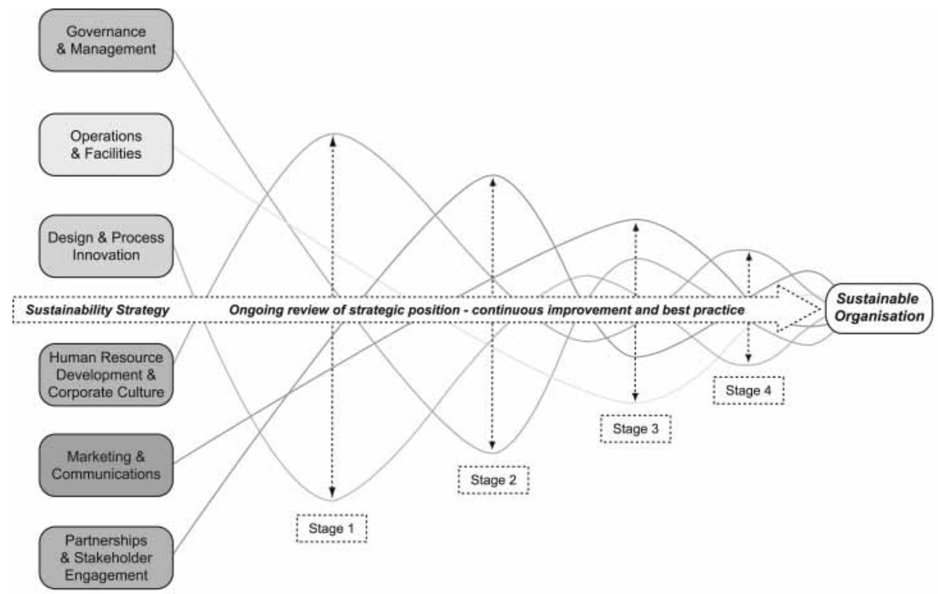
Natural Capitalism principles are at once a set of principles for organizational and community development management, and also a set of broader public policies to foster sustainable commerce on a state or national level. On the community/regional governance level, we call the Natural Capitalism implementation system Sustainable Economic Development Planning. It is a system for applying the competitiveness benefits of Natural Capitalism to all key sectors of a community's business climate – from affordable housing to energy strategies – to ensure that businesses are both globally competitive and aligned with community, regional, and state sustainability goals. The system is based on the principle that without global competitiveness of businesses, jobs are not sustainable and neither are rural communities. One size does not fit all. Each community has its own local culture that needs to be aligned with the local ecosystem. Local communities can then use a sustainable economic system governed by the principles of Natural Capitalism to become judicious in their use of natural capital so as to be self-regulating, regenerative economies.

What you can do is to bring Natural Capitalism to your organization and your community. Without Natural Capitalism strategies, conventional agriculture is at great risk of being squeezed by (1) increasing prices of energy, water, and other inputs; (2) carbon constraints; (3) declining natural capital (pollinators, beneficial predators, soil fertility); (4) shrinking markets, and (5) foreign competitors. Today's "siloed" approaches to these integrated problems will continue to struggle, if not outright fail, and agriculture and the communities that support the people involved will gradually, and perhaps dramatically, decline in their economic and social vitality.

> *"...We have lived by the assumption that what was good for us would be good for the world. We have been wrong."*

A Natural Capitalism economy will behave like an ecosystem. Joe Lewis of the USDA describes an ecosystem as "interactive webs (that) seek solutions with net benefits at a total ecosystem level."[115] Through the simple concept of full-cost, life-cycle pricing mechanisms, the economy would inherently support more sustainable and decentralized energy sources. It also would encourage sustainable agriculture, especially the small scale mixed-cropping and animal-based approach that is more productive and more democratic.

It is the path advocated by visionaries like Wes Jackson, Janine Benyus, and small farm supporter Wendell Berry. Berry reminds us in his *Recollected Essays* that, "We have lived by the assumption that what was good for us would be good for the world. We have been wrong. We must change our lives, so that it will be possible to live by the contrary assumption that what is good for the world will be good for us. And that requires that we make the effort to know the world and to learn what is good for it."



Management Helix for the Sustainable Organisation

A mutually reinforcing process to achieve lasting competitive advantage through lowering cost and differentiating products and services while delivering genuinely sustainable progress.

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DR. JOHN PESEK, IOWA STATE UNIVERSITY EMERITUS PROFESSOR OF AGRONOMY

Dr. John Pesek, Iowa State University Emeritus Professor of Agronomy, has had a long and distinguished professional career. He has made nationally recognized research contributions in agronomy in the areas of soil fertility, crop production, and the economics of soil fertilizer use. His work has led scientists to a better understanding of the effects of management practices on the environment and their combined influence on yields.

In the 1980s, Dr. Pesek chaired a National Research Council committee under the National Academy of Sciences Board of Agriculture that was directed to study alternative methods of soil management. The book resulting from their case studies, *Alternative Agriculture,* was a groundbreaking report that documented how farming systems that used lesser amounts of pesticides, fertilizers, antibiotics, and fuel can be productive and profitable. Its publication generated worldwide attention and brought Dr. Pesek to Washington, D.C., to testify before the Joint Economic Committee of the House and Senate.

Dr. Pesek has been named a fellow of the American Society of Agronomy, the Soil Science Society of America, Crop Science Society of America, the Iowa Academy of Science, and the American Association for the Advancement of Science. He has served as president of both the American Society of Agronomy and the Soil Science Society of America and he helped establish the nation's first National Soil Tilth Center. Dr. Pesek has authored or co-authored more than 75 publications and has been active in international programs in Brazil, Mexico, Egypt, Morocco, Uruguay, Tunisia, and Russia. He was named a Charles F. Curtiss Distinguished Professor of Agriculture in 1981 and received the Agronomic Service Award in 1989.

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