Introduction

by John Schaeffer

Welcome to the 14th edition of the *Solar Living Sourcebook*! As I look back to our humble beginnings at Real Goods in 1978, it's clear that we've made significant progress toward the regenerative and sustainable goals that we set for ourselves nearly 37 years ago. Progress in the solar sector is both dramatic and quantifiable. That first year, we sold a 9-watt PV module for $900, or $100 per watt. Today's prices are well below $1 per watt, a decrease of over 90%!

I've mused about the "dawn of the solar age" for 37 years, and finally, it's true. The "too-cheap-to-meter" nuclear age is on its way to the scrap heap. Utilities have discovered that nuclear power is nowhere near as cost-effective as new solar installations. Last year in the US, a record 4.7 gigawatts of solar was installed, bringing the total to over 10 gigawatts. Each of those gigawatts can power 164,000 homes, making more than 1.6 million homes solar powered. Every four minutes, another American home or business goes solar, and it's predicted that the pace will accelerate to one every 90 seconds by 2025. While impressive, this still represents less than 1% solar electric generation in our country. Meanwhile, utilities are steadily reducing the number of operating nuclear power plants to fewer than 100 for the first time in 20 years. Nine planned upgrades were recently canceled because the investments are no longer economically justifiable.

2013 was another record-shattering year for solar in the United States. According to GTM Research and the Solar Energy Industries Association's (SEIA), PV installations increased 41% over 2012 to reach 4,751 megawatts (MW). Additionally, the cost to install solar fell 15%. Moore's Law (for every doubling of the source of supply, the price declines 15%) proved true again. By the end of 2013, more than 440,000 operating solar electric systems in the US generated well over 10,000 megawatts (10 gigawatts), offering the first real glimpse of mainstream status. The combination of rapid customer adoption, grassroots support, improved financing terms, and public market successes represent clear gains for solar with both the general population and the investment community.

Japan and Germany have, for the last several decades, been the innovators in solar. Germany truly *has* paved the way. Currently 59% of that country's energy comes from renewable sources, 11.2% from solar. In 2013, however, the US surpassed Germany in PV deployed, so, finally, we're truly back in the solar game. It is telling that if we filled the 25,000 square mile Mojave Desert with solar, we could produce 6 times the total electricity demand of the country. (See page 89 for an illustration of how a solarized area less than 100 miles square could provide all the energy needs of the US.)

Solar is proving to be a major job creator. 2013 saw tens of thousands of new American jobs connected with the solar industry, which pumped tens of billions of dollars into the US economy. In fact, more solar has been installed in the US in the last 18 months than in the previous 30 years. 143,000 people are employed in the solar industry, up 20% from a year earlier and 10 times the national average job growth rate. That's a remarkable record of achievement.

When I started Real Goods in 1978, our clientele was a cadre of young and idealistic hippies living in the woods of Mendocino County, California. They were refugees from major urban centers looking for a simpler and more meaningful existence. Many got light from kerosene, heat from wood, food from the garden, social contact from friends and family, and entertainment from books. There were no computers, cell phones, Internet, Google, Facebook, or YouTube. Jimmy Carter was president, Jerry Brown was governor (for the first time), and optimism abounded that

2013 was another record-shattering year for solar in the United States. According to GTM Research and the Solar Energy Industries Association's (SEIA), PV installations increased 41% over 2012 to reach 4,751 megawatts (MW). Additionally, the cost to install solar fell 15%.

This 14th edition of the *Solar Living Sourcebook* is dedicated to supporting the complete lifestyle change necessary to give our planet the best possible path toward the maintenance of a climate and ecosystems that have allowed humanity and other species to flourish.

A sustainable economy needs to run on income from solar energy while not degrading ecosystems by creating wastes or mining nutrients. Relocalization seeks to preserve the "natural capital" of the Earth by acknowledging that our well-being is derived from the ecological and geological richness of the planet.

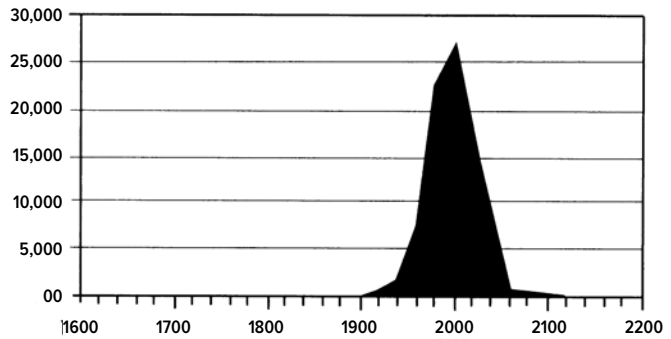
with the strength of our convictions, we would soon overcome the misguided practices of our over-logging, over-consuming, polluting culture. Climate change, calculations of parts per million of CO_2, oil and natural gas fracking technologies, and the Keystone XL Pipeline were still in the future. So was oil depletion. I wrote an editorial in our 1979 catalog that stated, "According to the US Congress's own Office of Technology Assessment, all known oil reserves will be exhausted by 2038." At the time, 60 years seemed like plenty of time to wean ourselves from fossil fuels! But, from the present perspective, time is clearly no longer on our side. Reaching the benchmark 400 ppm of CO_2 in 2013 makes it imperative that we accelerate the pace to correct our fossil fuel addiction. Sadly, it may already be too late.

This 14th edition of the *Solar Living Sourcebook* is dedicated to supporting the complete lifestyle change necessary to give our planet the best possible path toward the maintenance of a climate and ecosystems that have allowed humanity and other species to flourish. While we still call it the "*Solar*" *Living Sourcebook*, you'll find that this book is not limited to the details of solar technologies, but instead engages with all facets of sustainable, resilient, and regenerative living.

Our 14th edition begins with a thorough update of the **Relocalization** chapter that debuted in our 30th anniversary (13th) edition. There, we introduced the "Transition" movement, showing practical ways for individuals and communities to return to a regenerative and sustainable economy. The end of cheap, abundant fossil fuels, and the disruption of long-stable climatological and biological systems—the results of rampant industrialization—are altering life on Earth. When the relocalization movement began at the start of the 21st century, it was focused on concerns about "Peak Oil." Since the amount of oil on the planet is finite, and consumption is rising, at some point in the near future, less will be available and prices will rise accordingly. Peak oil consciousness has evolved from the theory that oil would be gone within a few decades to the more contemporary view that oil won't ever completely run out, but it will become increasingly too expensive to extract. Indeed, the easily developed oil is nearly gone now. What remains will be extracted at a progressively slower rate and will cost much more.

Our present human economy is unsustainable, because it relies on non-renewable raw material sources whose development, production, and consumption create pollution that causes negative "feedbacks" that impair ecosystems and disrupt the climate. A sustainable economy needs to run on income from solar energy while not degrading ecosystems by creating wastes or mining nutrients. Relocalization seeks to preserve the "natural capital" of the Earth by acknowledging that our well-being is derived from the ecological and geological richness of the planet. With roots extending back to the back-to-the-land movement that gave birth to Real Goods in 1978, relocalization encompasses the best of environmental protection, sustainable living, regenerative design, natural building, urban homesteading, Slow Food, and voluntary simplicity. This is a new way of saying "thinking globally while acting locally." It is, at once, a strategic response to peak oil, climate change, and the overshoot of Earth's physical limits. It honors, encourages, and nurtures local businesses, farmer's markets, energy production, and community involvement while rejecting the malign aspects of globalization and our current fossil fuel-based economy. Relocalization and the Transition movement are perfect preludes to the nuts-and-bolts education found in the balance of the *Sourcebook*.

Then, it's right into the essence of the *Sourcebook*. We explore the concept of "home" in the **Land and Shelter** chapter. It all begins and ends with land. Our land and homes are not only the cornerstones of our existence but also the site of



World oil production from 1600 to 2200, history and projection, in millions of barrels per year. (Source: C. J. Campbell)

our largest carbon-footprint impact. The choices we make about where we choose to settle, how we treat the land, what we create for shelter, and how those homes function are fundamental to any notion of sustainability or regeneration.

Shelter is, quite literally, rooted in the land. Our homes are built upon the topsoil that nourishes the plants that make all life possible. The materials we use to build them come from the land. By displacing organisms and extracting resources for our shelters, the decisions made in the building process have profound impact. Through intelligent placement and smart design, we can create shelter—and entire communities—that honor and respect the Earth and its ecosystems. If our goal is to create carbon-neutral homes that minimize their contribution to climate change, the choice of where and how to create shelter becomes critical.

Last year Americans built around 900,000 new homes, each one requiring massive amounts of energy and materials. Wood is still the material of choice for the majority of new houses. In 2012, the housing industry consumed about 32 million cubic meters of lumber in residential construction and remodeling. If cut into conventional 2×4s, that lumber would stretch for half a million miles, circling the Earth 20 times—a mind-numbing illustration of the impact of the building industry on the planet's forests. Besides the number of homes built, the size of homes also pushes the demand for wood. After a short-lived drop-off during the economic downturn that began in 2008, the average house size has rebounded to 2,500 square feet. According to the US Department of Energy, America's homes consume about 22% of the nation's fossil fuel energy, which, in turn, accounts for one-fifth of America's enormous annual release of CO_2.

While humans have accomplished amazing feats and created astonishing civilizations, like all species we depend upon nature for the resources that make our lives and our economies possible. The source of all the goods and services we consume, nature is also the sink for our wastes. We must recognize our limited ability to control nature and learn to live cooperatively with nature to achieve harmony and balance on Earth.

As with all previous editions of the *Sourcebook*, the guts of the book are in Chapters 3 and 4: **Sunshine to Electricity** and **Panel to Plug**. These are the nuts and bolts of renewable energy: photovoltaics, wind turbines, and hydroelectric turbines, along with all the necessary peripherals for living off the grid or on the grid with solar or other forms of renewable energy. Renewable energy is the heart of Real Goods. Dramatic shifts have occurred in the solar sphere since we published our 30th-anniversary *Sourcebook* in 2008. The combination of rapid customer adoption, widespread grassroots support, and the welcome appearance of innovative financial leasing mechanisms has made going solar almost a no-brainer. This has not been overlooked by the public capital markets, whose successes have propelled the industry to the forefront of our economy.

While the solar market has grown annually by nearly 50% since 2008, prices have plummeted by 50%! In 2008, Real Goods sold grid-tied solar systems for around $8 per watt installed; now, the same system sells for less than $4 per watt. Nationwide, solar installations have increased 16-fold from 298 megawatts to 4,751 megawatts. Another change is that "third party owned" (TPO) has emerged as the dominant method for homeowners to install solar. Today, through a lease or a power purchase agreement, as many as three-fourths of all new systems will be third party owned. For the homeowner, this usually means no money down and a significant discount on your monthly utility bill. Cash purchases are becoming a relic of the past, even though PV is still a much better investment than most financial instruments, with annual returns often exceeding 15%. If you live off the grid, like I do, Chapters 3 and 4 will guide you through every aspect of your home energy system, from conception through purchase, installation, and annual maintenance. I still refer to my *Sourcebook* whenever I'm working with my batteries or my monitoring system, or whenever I need a refresher course on the finer points of solar and micro-hydro.

With fresh memories of natural disasters, ranging from Hurricane Katrina to the nuclear meltdown at Japan's Fukushima Daichi power plant, to the accelerating pace of floods, tornadoes, and tsunamis, we've expanded our chapter on **Emergency Preparedness** (Chapter 5). The world can be a scary and hazardous place with power grid failures, disastrous storms, wildfires, fuel price spikes, and terrorist attacks. We all harbor deep fears that our society has become vulnerable to infrastructure disruption. Who can doubt that factors as diverse as growing population pressures, agonizing poverty, economic globalization, political conflict, climate change, and additional natural disasters will continue to place enormous strains on the networks that supply us with food, water, power, and other necessities? Many of us will experience these disruptions and breakdowns in the foreseeable future. You will rest easier if you've taken steps to protect your

In 2012, the housing industry consumed about 32 million cubic meters of lumber in residential construction and remodeling. If cut into conventional 2×4s, that lumber would stretch for half a million miles, circling the Earth 20 times—a mind-numbing illustration of the impact of the building industry on the planet's forests.

The combination of rapid customer adoption, widespread grassroots support, and the welcome appearance of innovative financial leasing mechanisms has made going solar almost a no-brainer.

family from events that threaten to undermine your ability to meet basic needs. Be prepared.

Following the chapters on Renewable Energy and Emergency Preparedness comes Chapter 6 on **Energy Conservation**. Every dollar spent on conservation translates into $3 to $5 savings on solar system costs—another no-brainer. Conservation reduces greenhouse gas emissions, slows the depletion of natural resources, decreases environmental pollution, takes strain off the planet's organic life-support systems, and saves a lot of money. Who can afford *not* to conserve energy? The further beauty of conservation is that regardless of what skeptics say, conservation does *not* mean sacrifice. Many European and Scandinavian societies enjoy a comparable standard of living to the United States, but on a much tighter energy budget. Build smaller rather than larger. Make sure your building envelope is tight. Use passive solar strategies to minimize heating and cooling loads. Install low-flow showerheads, low-flush or composting toilets, greywater systems, and compact fluorescent or LED lights. Buy the most efficient appliances possible for your needs and budget.

Every dollar spent on conservation translates into $3 to $5 savings on solar system costs—another no-brainer. Conservation reduces greenhouse gas emissions, slows the depletion of natural resources, decreases environmental pollution, takes strain off the planet's organic life-support systems, and saves a lot of money. Who can afford *not* to conserve energy?

Conservation is the cheapest, most cost-effective way to "produce" energy. Years ago renewable energy guru Amory Lovins introduced us to the concept of "negawatts," or watts we never need to use. But conservation does not come intuitively. We were raised on a steady diet of cheap fossil fuel energy during the 20th century, especially since World War II. Our society is enormously wasteful of energy. Not only are fossil fuel supplies finite and dwindling, but we now recognize their dire ecological impact on Earth's climate. Energy conservation is the starting point for a sustainable future, *before* implementing the transition to solar and other forms of renewable energy.

Following Energy Conservation is Chapter 7, **Water Development**. Two age-old sayings play preeminently in this chapter: "Water is life," and "You buy the water, and the land comes free." Water is the single most important factor in any homestead. Without a dependable water source, no place is home very long. Unfortunately, today many people literally *are* buying water, often unnecessarily and at outrageous expense. Some are swayed by multimillion-dollar corporate ad campaigns selling bottled water; others are victims of the privatization of previously public water supplies. Globally, *nearly 800 million* people still lack access to clean water. Sadly, as supplies become polluted, privatized, or acquired by for-profit enterprises, that number will steeply rise.

Two age-old sayings are "Water is life" and "You buy the water, and the land comes free." Water is the single most important factor in any homestead. Without a dependable water source, no place is home very long.

Once we have figured out how to develop our water, the next step is to heat it, the subject of Chapter 8, **Water Heating**. Most of us take hot water at the turn of a tap handle for granted. It makes modern life possible. Yet many people do not realize the total costs of this convenience. The average household spends an astonishing 20%–40% of its energy budget on water heating! Those energy dollars are typically dedicated to an appliance that has a life expectancy of only 10–15 years and wastes 20% or more of the energy it consumes. Efficiency improvements to your water heater will reduce overall energy consumption, lower your carbon footprint, and lessen the environmental impact of your home. There are better, cheaper, and more durable ways to get hot water than using fossil-fueled water heaters—in particular, solar hot water. This chapter describes common water heater types, examines the good and bad points of each, and offers suggestions for efficiency improvements. It also provides a comprehensive review of solar hot water systems that underscores their environmental and economic benefits.

Chapter 9 is on **Water and Air Purification**. If you are concerned about the foods you eat and what you put into your body, you want to be equally conscientious about the quality of the air you breathe and the water you drink. Like food, air and water can be the vehicles into your body for the nasty contaminants in our environment. Most people are not aware of the extent to which domestic water and inside air can be polluted. This chapter examines the bad stuff that may be lurking in your air and water, the conditions that contribute to unhealthy levels of contaminants in the living space, and what you can do to alleviate these problems. The Environmental Protection Agency (EPA) states that no matter where you live in the United States, some toxic substances will be found in the groundwater. Indeed, the agency estimates that one in five Americans, supplied by one-quarter of the nation's drinking water systems, consume tap water that violates safety standards under the *Clean Water Act*. Even substances added to our drinking water to protect us, like chlorine, which is still legal in the US while long banned in Europe, can form toxic compounds.

Chapter 10, **Composting Toilets and Greywater Systems**, is especially relevant to the prevailing drought conditions caused by climate change. Both technologies offer outside-the-box ways to save significant amounts of water. Composting toilets, while traditionally employed in country cabins and cottages, are beginning to come into more frequent use in more subur-

ban settings. In our collective rush to sanitize everyhing, we discard a potentially valuable and money-saving resource by designing expensive and energy-intensive disposal systems that pollute surface and groundwater. Conventional plumbing systems mix a few pounds of valuable nutrients and a few micrograms of potentially dangerous pathogens with hundreds of gallons of very lightly polluted greywater from our sinks, showers, tubs, and washers. This chapter takes a fresh look at how to incorporate non-traditional technologies into our homes to convert waste into a valuable resource.

Chapter 11, **Regenerative Homesteading and Farming**, is close to my heart as my wife, Nantzy, and I run a biodynamic farm in Hopland, California, where we grow olives, grapes, fruit trees, vegetables, and lavender. **Biodynamics** is emerging in much the same way as the organic movement in the late 1970s and early 1980s. Conceived in 1924 by Dr. Rudolf Steiner (also the founder of the Waldorf education movement), biodynamic agriculture shares the original foundation of organic and sustainable agriculture. Steiner outlined his principles in a series of lectures to European farmers alarmed at both the growing use of synthetic chemical fertilizers and pesticides, and the corresponding decline in crop and animal vitality.

The biodynamic program focuses on the biological systems of agriculture and advocates making soil amendments directly on the farm, rather than importing them. Importing materials to an organic agricultural system, says Steiner, introduces the same problems as synthetic industrial products. Both require additional natural resources to mine, refine, and transport a myriad of products, a practice that puts pressure on natural resources and systems wherever these materials are mined or harvested. The goal of biodynamics is to be as regenerative as possible by developing inputs on site from the living dynamics of the agricultural system itself.

Permaculture, also featured in Chapter 11, is much more than a style of gardening. It is a fully integrated design system and philosophy in which diverse techniques create a food production system that emulates the natural world. Permaculture design assembles conceptual, material, and strategic components in patterns that provide mutually beneficial, regenerative, and secure places for all forms of life. The permaculture ethos comes from the teachings of indigenous cultures and from patterns found in nature. It is an approach to gardening and a way to manage land as well as a way to create shelter. Beyond these arenas, permaculture design concepts can be applied to all economic and social aspects of society.

Over the last 10,000 years, our species has developed cultures that are the most destructive our planet has ever seen. Based on a short-sighted extractive process, the industrial capitalistic complex has left us in a terrible ecological mess. Our soils are depleted, water and air are polluted, and natural resources are peaking in their supply vs. demand. Limiting permaculture to simply a way of gardening would be like limiting the concept of energy production to only solar power. The concept is much broader, invoking all aspects of a healthy food system and a holistic way of thinking and living. Permaculture is truly about design, connectivity, and relationships.

In conjunction with Permaculture, Paul Stamets is one of the people we think is likely to change the social-ecological paradigm in the 21st century. Paul is the founder of Fungi Perfecti (fungi.com) and Host Defense Organic Mushrooms (hostdefense.com), and among his many accomplishments as a scientist and author, including working with the Centers for Disease Control and the National Institutes of Health, he has pioneered countless techniques in the field of edible and functional food mushroom cultivation. His groundbreaking work on fungi, toxic waste remediation, cancer, and most recently the Colony Collapse Disorder that is devastating bees around the world connects models of sustainable economics and holistic design with strategies for healing the Earth. As Paul puts it: *"We are now fully engaged in the 6th Major Extinction ('6 X') on planet Earth. Our biosphere is quickly changing, eroding the life-support systems that have allowed humans to ascend. Unless we put into action policies and technologies that can cause a course correction in the very near future, species diversity will continue to plummet, with humans not only being the primary cause, but one of the victims. What can we do? Fungi, particularly mushrooms, offer some powerful, practical solutions, which can be put into practice now."* The central premise of his research is that habitats have immune systems, just like people, and mushrooms are the cellular bridges between the two. Our close evolutionary relationship to fungi can be the basis for novel pairings that lead to greater sustainability and immune enhancement. The concept of mycelium as "nature's internet" is a transcendent metaphor that ties together all of the topics covered in this book. I urge you to check out Paul's amazing work, through his TED Talk, "How Mushrooms Can Help Save the World" (rated in the top 10 of all TED talks), his books, and his websites.

Biodynamic agriculture focuses on the biological systems of agriculture and advocates making soil amendments directly on the farm, rather than importing them. Permaculture design—much more than a style of gardening—assembles conceptual, material, and strategic components in patterns that provide mutually beneficial, regenerative, and secure places for all forms of life.

Totally new in this 14th edition of the *Sourcebook* is our extensive chapter on Urban Homesteading. Taking the concepts of homesteading deep into the urban environment can and will make a big difference to wide-ranging communities, and will assist in redesigning our cities on a new template based on nature's bounty and resilience.

Totally new in this 14th edition of the *Sourcebook* is our extensive chapter on **Urban Homesteading**, a trend that has strongly emerged in just the last five years. Urban homesteading is happening in small and large cities across the country, with practitioners relearning heirloom skills that have been largely abandoned in our relentless decades-long march toward convenience. Urban homesteading values thrift and community self-reliance in our homes, while repudiating the cultural forces of speed, need, and greed. It's part of an emerging global movement working for change that is rooted in respect for indigenous peoples and their values, while seeking peace and reconciliation at every level of community. Urban homesteading provides an opportunity to rewrite the story of our relationship to the Earth in the places where most of us live, and allows the possibility of remaking culture around an ethic of care and stewardship for our home base. Taking the concepts of homesteading deep into the urban environment can and will make a big difference to wide-ranging communities, and will assist in redesigning our cities on a new template based on nature's bounty and resilience.

All the systems that sustain us—food, water, shelter, medicine, family, and community—are at risk from the ongoing disintegration of life brought about by global capitalism's disrespect for natural limits. It's time for us to redesign our cities around an ethic of care and remake local systems on the model of the Earth itself—adaptive, lush with diversity, and fertile with possibility. Urban homesteading offers urban folks a strategy for maximizing interdependence, community resilience, and a sense of sufficiency in living locally. Practically speaking, our Urban Homesteading chapter gives you the tools you'll need to live a sustainable urban lifestyle that includes gardening, seed banking, composting, mushroom cultivation, orchards, and energy-efficient green homes. It also will inspire you to integrate animals such as chickens, rabbits, ducks, bees, quail, and even goats into your urban homestead. Further, it delves into harvesting and drying techniques, fermentation, rainwater catchment, greywater systems, recycling and upcycling, and even "humanure."

Lower-carbon and more energy-efficient alternatives to fossil fuels for automotive transportation are finally here. Powering vehicles with electricity or biofuels is now realistic, affordable, and increasingly popular.

Chapter 13, **Sustainable Transportation,** tackles another issue of momentous importance. Driving is probably the aspect of our personal carbon emissions that stares us in the face most obviously and consistently, and often seems the most daunting to change. But in recent years, we've witnessed a sea change in transportation technology. In America personal mobility is practically considered a civil right. The key conceptual shift is to understand that transportation should be about access to people and goods, rather than freedom of mobility. Urban design and transportation policy should favor people and healthy communities over motorized vehicles. However, with more than 300 million gas-guzzling cars and trucks filling roadways in the US, it's clear we need to transform the core concepts behind providing fuel and systems of fuel production while these vehicles still rule our streets. Lower-carbon and more energy-efficient alternatives to fossil fuels for automotive transportation are finally here. Powering vehicles with electricity or biofuels is now realistic, affordable, and increasingly popular.

In this chapter, we've asked long-time Real Goods associates and experts in their respective fields—David Blume (biofuels) and Steve Heckeroth (electric vehicles)—to update the state of affairs with available alternatives. They have very different perspectives about the relative merits of biofuels and electricity as the best choice for addressing climate change in the short term and building a world of sustainable transportation in the longer term—and they're both skeptical about the promise and utility of fuel cells. We've let David and Steve each have his say and will let you, the reader and decision maker in your own life, assess the options that might work for you. We've had several alternative fuel "smackdowns" between David and Steve at our annual SolFest celebrations, so we thought it would be appropriate to air it out here in the *Sourcebook* as well. *Any* shift away from fossil fuels that results in a reduction of greenhouse gas emissions is positive. Ultimately, building sustainable transportation systems will require bold public policy decisions, investment in the infrastructure, and incentives that encourage and assist consumers to kick the fossil fuel habit.

The 14th edition of the *Solar Living Sourcebook* comes to a close with a chapter on a concept whose time has come. Aptly subtitled "The Ultimate Back-to-the-Land Movement," **Natural Burial** is a fitting conclusion to an environmentally responsible life and a righteous send-off to an afterlife, no matter what your beliefs. Think about what's buried along with our loved ones in American cemeteries every year: more than 800,000 pounds of embalming fluid, over 180 million pounds of steel, more than 5 million pounds of copper and bronze, and over 30 million board-feet of wood. Contrast this to the UK, where there's a burgeoning new movement in which people are burying loved ones in biode-

gradable containers—without toxic embalming fluid or synthetics—and returning bodies to the Earth to compost into soil nutrients with a forest of trees marking the spot. We must question the waste management behavior of our society and the wisdom of leaving toxic burial chemicals and other synthetic substances in the ground (and the atmosphere as a result of cremation) for future generations to clean up. As 80 million American baby boomers cross the finish line over the next 25 years (myself included!), the natural burial movement will gain momentum. Because many of us will be "dying to do the right thing," it makes sense to conclude our *Sourcebook* with this topic.

But knowledge is even more powerful than death, so the *Sourcebook* once again wraps up with our comprehensive **Sustainable Living Library**. This final chapter highlights many of our all-time best sellers, mixed in with the best new book offerings for those who want to learn still more about living right. We're proud to offer even more resources to help fulfill your dreams.

When we opened our first Real Goods store in Willits, California, in 1978, our mission was to demonstrate and provide renewable energy alternatives—and it still is. After 37 years, we are better positioned than ever to help you transform your lifestyle in healthy, regenerative, and fulfilling directions, whether your goal is to buy land and build a totally self-sufficient solar home, or to reduce your carbon footprint with energy efficiency, or dabble in urban homesteading with a few chickens and a biodynamic garden, or figure out the best alternative fuel for your next car. Over the years, we've assembled an unbeatable team of renewable energy experts with hundreds of years of combined experience in living the sustainable lifestyle described in this book. Our Real Goods residential and commercial solar divisions (RGS Energy) specialize in renewable energy design and installation, often made possible with no money down and an electric bill that is far below what you currently pay. Our Real Goods eCommerce division (realgoods.com) is online and tree-free, featuring the latest products for energy conservation, healthy living, renewable energy, and environmental education, as well as the most comprehensive sustainable living library on the planet.

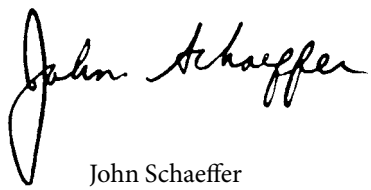
We are headquartered at the Real Goods Solar Living Center in Hopland, California, our 12-acre permaculture oasis where products, ideas, and concepts come alive every day—not only in the interactive displays onsite but in the 200,000 people who annually visit (more than four million visitors since our opening 20 years ago). The Solar Living Center is operated by the nonprofit Solar Living Institute (SLI, solarliving.org), which nurtures and provides stewardship to the site while offering classes and even some professional accreditation on renewable energy, green building, permaculture, urban homesteading, and other sustainable living topics. The SLI's mission is to provide inspirational, environmental education. If you haven't visited northern California's #1 tourist attraction, we invite you to see the reality of sustainability. The Solar Living Center is, of course, 100% solar powered.

I've been a passionate adventurer in the solar industry and the sustainability movement my whole life. I try hard to walk my talk. My wife, Nantzy, and I live in an off-the-grid home (see page 70) built of recycled and green materials, powered by solar (passive and active) and hydroelectric energy, with gorgeous biodynamic gardens and fruit orchards that provide most of our food, a 15-acre biodynamic olive orchard, an 8-acre biodynamic vineyard, and a dozen beehives. I'm fortunate to benefit from the fruits of all our collective labors. As the solar industry continues to grow and mature, and as our cultural consciousness evolves, I remain hopeful that, once and for all, we will get things right in our homes, communities, country, and on our planet. Instead of forever being blamed for the excesses that put our planet on the destructive path, perhaps we can be viewed as the generation that rose above comfort and decadence to turn things around. We are living on borrowed time, but we have a chance, maybe our last, to embrace a vision of a fulfilling and sustainable future.

"The Ultimate Back-to-the-Land Movement," Natural Burial is a fitting conclusion to an environmentally responsible life and a righteous send-off to an afterlife, no matter what your beliefs.

The Solar Living Center is operated by the nonprofit Solar Living Institute (solarliving.org), which nurtures and provides stewardship to the site while offering classes and even some professional accreditation on renewable energy, green building, permaculture, urban homesteading, and other sustainable living topics. The SLI's mission is to provide inspirational, environmental education.

For the Earth,



John Schaeffer
Founder, Real Goods
and Solar Living Institute

CHAPTER 1

Relocalization

A Strategic Response to Peak Oil and Climate Change

As we approach the middle of the second decade of the 21st century, peak oil and global climate change continue to loom as the two most critical issues of our time. The end of the age of cheap and abundant fossil fuels on one hand and the unprecedented disruption of long-stable climatological and biological systems on the other are unquestionably altering life on Earth as we know it. This is not an ideological statement. It is grounded in the overwhelming weight of scientific fact and the laws of physics and ecology as we understand them. Even the last few remaining scientist skeptics—even the last holdouts among the oil and gas companies themselves!—now grudgingly acknowledge the reality of these earthshaking, interlocking trends. We begin the book by exploring some promising strategies for grappling with these profound issues. Many thanks to Daniel Lerch of the Post-Carbon Institute, who tackled the revision of this chapter.

The greatest hope rests in the ability to honestly accept the reality of a situation and then make the best of it.

People may be scared or shocked by predictions of ensuing environmental and social chaos driven by the end of cheap fossil fuels and the decline of the planet's ecological systems. But while awareness and concern about these issues are growing, many people still remain indifferent. How individuals respond emotionally to facts and deductions is important, but if they are unable and unwilling to accept what is true because it makes them feel bad, positive change is not possible. The greatest hope rests in the ability to honestly accept the reality of a situation and then make the best of it.

The world officially woke up to the looming challenge of climate change at the 1992 Rio Earth Summit. Then in late 1999 at the World Trade Organization (WTO) protests in Seattle, the world woke up to another looming (and controversial) challenge—economic globalization. Both trends were driven in large part by fossil fuels: climate change, by overconsumption of coal and oil; globalization, by the dropping cost of transportation and manufacturing enabled by abundant and affordable oil, coal, and natural gas. Suddenly, people who had been separately concerned about the environment, society's oil addiction, and the concentration of economic power faced an interconnected triple threat of global energy, economic, and environmental crises.

The period around the turn of the 21st century proved to be a crucible for new approaches to these vexing challenges. Influential publications exploring the potential of local economies and local action had begun to appear.[1] The November 1999 WTO protests that brought together "Teamsters and Turtles" (labor activists and environmental activists) were quickly followed by Y2K, which prompted not only scattered doomsday panic but also real community concerns around local infrastructure and provisioning—ideas that, publicly, hadn't been much discussed since the oil crises of the 1970s. A few months later, the 30th anniversary of Earth Day in April 2000 turned into a rallying point for environmentalists eager to breathe new life into the second

One aspect of relocalization is buying locally grown produce, such as the fruits, vegetables, and other products available at Rosaly's Garden, an organic farm in Peterborough, New Hampshire.

Photo © Ann Card

half of the "think globally, act locally" mantra. In the summer and fall, Ralph Nader's passionately supported but ultimately doomed candidacy for President on the Green Party ticket gave an unexpected voice to voters disenchanted with the pro-corporate and pro-globalization policies of both the Democratic and Republican parties. And finally, the Supreme Court's awarding of the presidency to George W. Bush in December 2000 firmly closed the door on many people's hopes for progress on the world's sustainability crisis from the US federal government.

Out of those years emerged a scattered but quickly growing grassroots movement of people and organizations focused on local sustainability, some of whom started using the terms "localization" or "relocalization" to describe what they were doing. Where a decade earlier the call was for individuals to make small changes that collectively could impact global issues (see, for example, the famous 1989 book *50 Simple Things You Can Do to Save the Earth*), this new activism was decidedly community focused. Groups organized community gardens, clamored for bicycle lanes, set up car-sharing clubs, launched local currencies, and pushed for their local governments to adopt climate action plans. By 2004, with the release of the movie *The End of Suburbia* and James Howard Kunstler's book *The Long Emergency*, concern about peak oil was added to the mix. The movement started developing a national and even international identity with the launch of the Relocalization Network, the predominant pre-Facebook online meeting place supporting relocalization initiatives and ideas.[2]

Of course, the movement drew from a rich history of activism related to environmental and social concerns. "Relocalization" may have been a new term, but the concept and the activities it encompassed had deep roots. Its precursors include: thinkers like E. F. Schumacher, Ted Trainer, Garrett Hardin, and Wendell Berry;[3] social trends like the conservation movement, the back-to-the-land movement, the voluntary simplicity movement, and the slow food movement; practices like organic gardening, biodynamics, placemaking, natural building, and permaculture; concepts like ecological footprint, import substitution, new urbanism, and ecocities; and centuries-old American traditions of individual and community self-sufficiency. In general, the common themes included the decentralization of political and economic structures; lower material consumption and pollution; a focus on the quality of relationships, culture, and the environment as sources of fulfillment; and downscaling of infrastructure development.

The movement has since grown and evolved in myriad ways. The Transition Towns concept, developed in the British Isles in the mid-2000s, gave rise to the global Transition Network; in 2009, the Relocalization Network was folded into the Transition movement, and in the United States is now coordinated by Transition US. Similarly minded groups also formed and spread (and persisted, or faded away), including peak oil awareness meet ups, Resilience Circles, and Local Living Economy groups.[4] Crafts and skills related to relocalization, like urban farming and DIY (do-it-yourself), have been embraced by popular culture. The number of people—and books, conferences, websites, videos, etc.—involved in relocalization activities has truly grown exponentially.

Before describing some of the details of relocalization, let's examine its basic premises. We believe that these premises are sound, being grounded in good science and common sense. By contrast, the assumptions underlying most of the economic and social models that have led to our current environmental and resource predicaments are essentially unsound rationalizations to justify short-term, often individual, interests. Our society's obsession with growth and gain have blinded us to the real common good, the needs of future generations, and the welfare of nonhuman life on the planet. Changing these paradigms and reorienting the trajectory of our society is a major undertaking, but all of us—as individuals and working together collectively—*do* have the power to make a positive contribution.

Ecological Economics

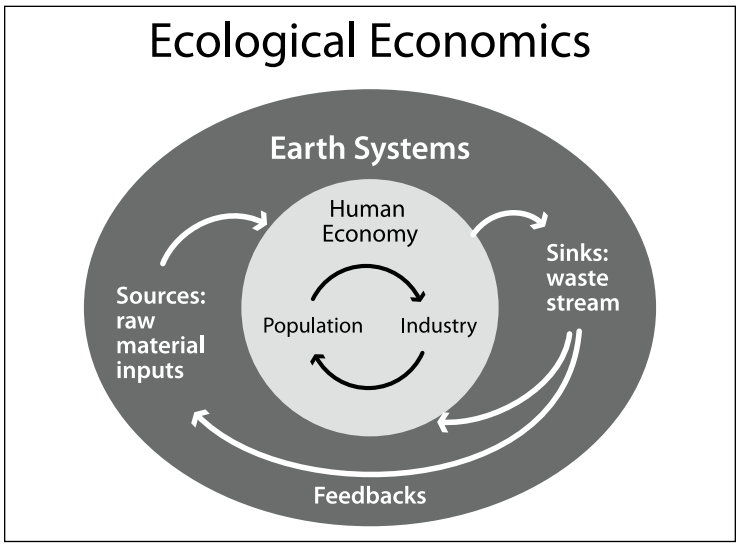
During the era of cheap energy, the study of economics became divorced from an understanding of how human systems are connected to ecological systems. Not surprisingly, the nearly free energy available from fossil fuels, and the rapid technological advances they fostered, made people in modern industrialized societies believe they were no longer constrained by tangibles like food, energy, water, and the weather. But the hubris of our recent past is being revealed, and many are searching for a more honest and realistic reckoning of humanity's place on Earth.

A helpful place to look is the discipline called ecological economics.[5] A conceptual model based on ecological economics is useful both to understand the current economic system and its vulnerabilities and to guide the development of a sustainable alternative.

Mainstream economic thinking usually distorts or fails to fully understand the fundamental interconnectedness of "the economy" and "the environment." Only in recent decades have economists begun to consider the environmental or ecological dimensions of human productive activity. But even when economists do take account of these relationships, their formulations are typically partial or misguided. For example, wealthy and environmentally responsible countries are sometimes touted as examples of how economic growth and stewardship of the planet go hand in hand. But while local measures of air quality, forest cover, and water cleanliness may be high, the raw materials and goods that the wealthy countries consume still have an environmental impact—in the poorer countries where those materials are extracted and those goods are manufactured. The damage—in addition to the jobs—has simply been outsourced.[6]

In the ecological economics model, the Human Economy is a subset of the Earth System, and therefore the *scale* of the human economy is ultimately limited. The human economy depends upon the *throughput* of materials from and back into the Earth system. Just pick up any trinket in your possession and ask, What is it made of? Where did these materials come from? How much energy was used and what happens to the waste products?[7] Limits to the size of the human economy are determined by three related factors: 1) the capacity for the Earth system to supply inputs to the human economy (sources), 2) the capacity of the Earth system to tolerate and process wastes from the human economy (sinks), and 3) the negative impacts on the human economy and the resources it relies on (feedbacks) caused by too much pollution.

For example, mining coal makes available a "source" of energy for industry that produces pollution, including sulfur dioxide that causes acid rain. Too much acid rain degrades built infrastructure and overwhelms the capacity of natural "sinks," such as forests, killing them or slowing their growth. The loss of ecosystems also creates new costs to society for ecological services that were previously accomplished "free of charge" through ecological processes. Clean air and water, stable climates, and species interactions that moderate outbreaks of disease are all compromised when damage is done to ecosystems. The human economy then invests in expensive technologies to try and compensate for this damage, such as pollution control devices, flood control walls and canals, pesticides, medicines, and more.



The ecological economics model of the relationship between the human economy and the Earth system highlights the importance of source, sinks, feedbacks, and scale.

The current human economy is clearly unsustainable because it relies heavily on nonrenewable raw material sources. These are by definition finite, and using them produces tremendous pollution that leads to many negative "feedbacks" that impair ecosystems and disrupt climate. A sustainable economy would need to run on the income from solar energy and not degrade ecosystems through the buildup of wastes or the mining of nutrients.

Relocalization is based on an ethic of protecting the Earth system and its "natural capital," knowing that despite human cleverness, our well-being is fundamentally derived from the ecological and geological richness of Earth.

A sustainable economy would need to run on the income from solar energy and not degrade ecosystems through the buildup of wastes or the mining of nutrients.

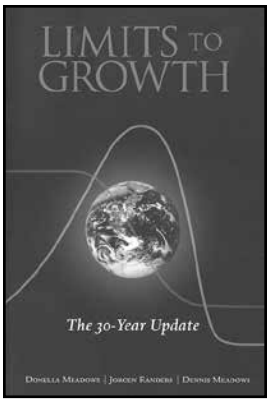
Overshoot

If the scale of the human economy (the inner circle within the ecological economics model) is too large relative to the Earth system, the human economy is in a state of *overshoot*. This means that the environmental load of humanity on the planet is greater than the long-term ability of the planet to support it. Overshoot means we are *above carrying capacity*. This environmental load will eventually be reduced through declines in some combination of population, resource consumption,

and pollution. Either we manage to reduce our environmental load, or resource constraints and pollution will limit it for us—with unpleasant and potentially catastrophic consequences.[8]

The concept of overshoot can be confusing. You may ask, How can a population go beyond the carrying capacity of the environment to support it? Won't a population simply increase until it reaches carrying capacity, and then stabilize? Isn't the human population projected to stabilize in this century? Sophisticated modeling of population, resource, and consumption dynamics provides answers to these questions that persuasively suggest the reality of overshoot.

Population overshoot may happen for several different reasons: 1) resource windfall and drawdown, 2) release from negative species interactions, 3) demographic momentum, and 4) fluctuating carrying capacity. These mechanisms of overshoot are not exclusive, and in fact they can feed positively on one another. Here is an example of how these mechanisms have interacted in modern human history.



The 30-year updated edition of *Limits to Growth*.

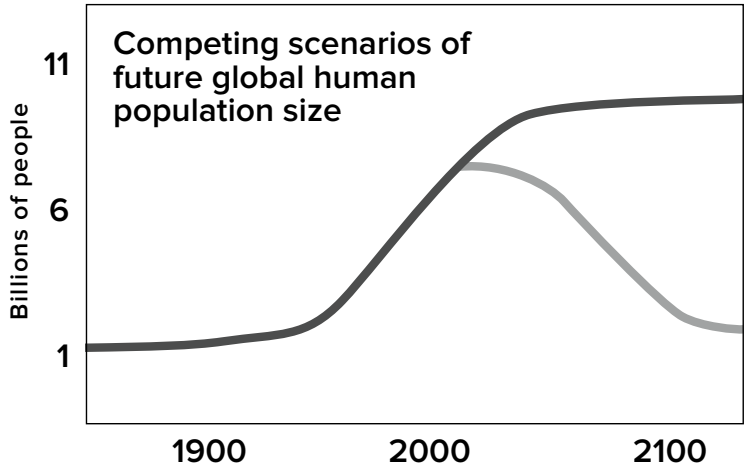
In the middle of the 19th century, people discovered a dense and versatile energy source in fossil fuels, especially petroleum. The use of fossil energy freed up other resources, such as land and labor. Without the need to feed draft animals to power equipment, more land was available to grow food for humans (i.e., resource windfall and drawdown). With fossil fuel-powered equipment, fewer humans were needed for manual labor, enabling extended educational opportunities and a shift of resources into fields such as public health and medicine. Increased societal attention to health and medicine, and corresponding technologies like vaccines, antibiotics, and sanitation, resulted in increased human life expectancy (i.e., reduced negative species interactions). A rapid increase in the human population increased the number of fertile women of childbearing age, leading to an even larger population (i.e., demographic momentum). As this population became very large, it began to impact the natural world around it substantially. Toxic emissions built up that harmed the basic life-support systems humans depend on, eventually making it more and more difficult to provide essentials, such as food (i.e., fluctuating carrying capacity).

Experts in the field of human demography project that the human population will stabilize around the middle of the 21st century.[9] Most people accept this analysis without knowing the underlying assumptions. Unfortunately, most studies of human population are akin to most studies of the human economy. The broader environment is not factored in to models of growth. If you have ever asked yourself, How are we going to feed 9 billion people when the soils are eroding and the aquifers are being depleted and the climate is changing and the deserts are expanding and oil and natural gas supplies are dwindling?—then you have stumbled upon this disconnect between most human population models and the physical world. Biologists studying any population would include those environmental factors in their models, whereas human demographers do not.

However, models do exist that contextualize the human population and our well-being within a dynamic study of resource availability, pollution levels, and even climate change and the fate of ecosystems. The classic example is the World3 model developed by the authors of *The Limits to Growth*, where the baseline scenario shows human population declining after 2020.[10] Another model is GUMBO, from the University of Vermont's Gund Institute of Ecological Economics.[11] These models are not perfect, but they at least begin with the right premises and tell us what aspects of human civilization are likely pushing the boundaries of, or already exceeding, the physical and ecological capacities of Earth.

Relocalization starts from the premise that the world is a finite place and that humanity is in a state of overshoot. Perpetual growth of the economy and the population is neither possible nor desirable. It is wise to start planning now for a world with less available energy, not more.

Human demographic models of population show a plateau this century (solid line is approximate historic and demographic projected), whereas systems models show a decline (gray line). The difference exists because human demographic models do not include negative feedbacks from either resource scarcity or pollution, whereas systems models do.



For the past 40 years, Stephen and Gloria Decater have been powering their 40-acre biodynamic farm in Covelo, California, with some form of solar energy—including draft horses and photovoltaic panels.

Peak Oil and Implications for a Transportation-dependent Economy

To a great extent, the Relocalization movement was sparked by concerns about "peak oil."[12] The concept of peak oil is simply that we can expect global oil production to follow the same pattern that's been observed countless times in individual oil fields and regions: Production climbs, peaks, and falls in a rough bell curve. Oil production has this pattern because the largest and easiest oil deposits tend to be discovered and tapped first. As the easy oil runs out, a point of all-time maximum production is reached, followed by perpetual decline as production shifts to the smaller, less profitable deposits.

With any particular oil field or region, post-peak declines are simply made up for by other fields or regions and oil continues flowing to the global market. The worry with global peak oil, therefore, was that there is no other place to turn for additional cheap oil: Declining global supply would force the price of oil to start increasing, with potentially disastrous results for the world economy. Predictions in the mid-2000s for the future of oil were all over the map: The most pessimistic "peakists" warned of economic crashes and social chaos, while the most optimistic "cornucopians" claimed that markets and innovation would keep cheap oil flowing no matter what.

In reality, global production of cheap oil hit a plateau in 2005—and the nearly ten years that followed have been a whirlwind of economic, technological, and social changes that both fulfilled and disproved parts of just about every prediction. Oil prices indeed rose: from the old "normal" of $10–$40 per barrel to a new "normal" of $80–$120 per barrel. And some economic and social pain has been quite severe: The United States experienced its worst economy since the Great Depression, some European countries are in or near financial collapse, and related economic shocks have played a major role in the latest wave of revolutionary unrest to sweep the Middle East. On the other hand, overall global oil production has managed to keep growing, thanks indeed to technological developments but more so to the fact that a lot of previously unprofitable oil reserves (like deepwater and tight oil) are now quite profitable at prices over $80 a barrel.

Whether the world has technically experienced "peak oil" yet or not is a matter of interpretation that is largely irrelevant.[13] The economic and social unrest predicted by peak oil have already arrived.

In the ecological economics model, peak oil is a "source" issue. Several source problems face the human economy, including peak natural gas and peak water.[14] Greater expansion of the human economy requires greater inputs, and aside from the ecosystem services provided by nature, oil is probably the single most important economic resource on the planet. Oil is critical for at least two reasons: energy density and versatility.

The energy output of a single person doing manual labor, averaged over a period of days, is equivalent to about 200–300 British Thermal Units (BTUs) per hour. A single gallon of gasoline contains about 150,000 BTUs of potential energy, roughly equivalent to 500–750 hours of hard human labor.[15] The energy density of oil

Whether the world has technically experienced "peak oil" yet or not is a matter of interpretation that is largely irrelevant. The economic and social unrest predicted by peak oil have already arrived.

Photo © jupiterimages, comstock.com

has not simply permitted a life of leisure and travel for those with access to it—it has in fact greatly expanded the short-term carrying capacity of the human population. By harnessing the energy of oil (and other fossil fuels), our species has been able to outcompete others for space and resources. The expansion of industrial agriculture and "green revolution" technologies are based on oil and natural gas feedstocks and energy. Construction of large dams, water diversion systems, and pumps for groundwater and water delivery to fields and cities depends upon plentiful fuel. Land, water, and other resources that in the past had been available to a diversity of species are being funneled toward the appetite of only one species—hence the biodiversity crisis.

Highly industrialized agriculture requires about 10 times more energy to grow, harvest, process, and distribute the food than is contained in the food itself.

Oil is versatile because it is a liquid, making it easier to extract and transport than coal and natural gas. Oil is more readily available as a fuel for a global market because it can be put into pipelines and tankers without requiring special treatment. Natural gas, by contrast, needs to be cooled and pressurized for tanker travel, and coal needs to be pulverized into slurry to be piped or put onto freight cars or barges for long-distance transport.

Because oil can be delivered anywhere so efficiently, modern transportation systems have become reliant on it. Some buses and cars use natural gas. Some trains run on electricity. But the vast majority of energy used for transportation worldwide—more than 95%—comes from oil as gasoline, diesel, or kerosene (jet fuel).[16] Consequently, modern economies are extremely vulnerable to shortages in transportation fuels. The relative stability of the oil market in previous decades led to the development of "just in time" delivery of products and to commercial linkages across the globe. Local and regional warehouses are uncommon now, with stores and businesses relying on frequent shipments to maintain a low overhead. Before the era of cheap transportation, each town and city had a full complement of craftspeople who relied on each other. Today, businesses are connected through vast transportation networks, with a manufacturing company in California, for example, relying on components shipped in from Asia and Europe.

The food economy is perhaps the finest example of the insecurity that is now bred into normal societal infrastructures. Markets selling food are typically restocked daily with only a few days' supply available in the store. This fact leads many people concerned about peak oil to reason: no fuel, no trucks; no trucks, no food. The shifts in agricultural practices that have occurred in the past 30 or 40 years make it difficult to quickly switch to a less transportation-intensive food system. Many agricultural regions are overly specialized to serve global markets. For example, a place where granaries, dairies, vegetable farms, and ranches coexisted 50 years ago is now dominated by premium wine grapes.[17]

These developments have been possible only because cheap oil has allowed us to overcome the limitations of local ecologies. And because oil possesses a unique combination of attributes, finding a suitable and equally effective substitute is no easy task—and perhaps is impossible.[18]

All proposed "substitutes" for cheap oil appear to fail the test of Energy Returned on Energy Invested (EROEI).[19] For an energy source to be useful to society, it must deliver more energy than it takes to find, harvest, and distribute it. Our economies have become addicted to energy sources with EROEIs of from 100:1 to 20:1, whereas biofuels, tar sands, and many renewable energy technologies range from about 10:1 to 1:1 or less. If a fuel has an EROEI of 1:1, it is essentially useless, because as much energy goes into producing the fuel as the fuel delivers. A complex and sustainable society will probably require substantial EROEI ratios, such as 5:1 or greater. Energy policies need to be devised based on sound EROEI analyses, which are currently difficult to find.

In the US, a high-EROEI energy source permits about 1% of the population to feed the other 99%. In places without access to fossil fuels, such as Afghanistan, more than 90% of the working population is engaged in growing food. Agriculture is, in essence, a means of capturing solar energy through investment in planting, maintenance, and harvesting. While the Afghan agricultural system looks inefficient from a labor point of view, it is actually far more efficient from an EROEI perspective than US agriculture. The extensive use of fossil fuels in industrialized food systems makes them energy sinks. Highly industrialized agriculture requires about 10 times more energy to grow, harvest, process, and distribute the food than is contained in the food itself—an EROEI of 1:10. Such a system is clearly unsustainable and begs for relocalization. With investment today in the right kind of equipment and training, industrialized nations could transition away from fossil fuel-dependent agriculture and grow food with far less than 90% of their working population engaged in farming. According to some estimates, perhaps a third of the population would suffice.[20]

Climate Change and the Need to Eliminate Fossil Fuels

While peak oil is a source problem, climate change is a sink problem.

During the most recent ages of geologic history, Earth has cycled between ice ages and intervening warm periods. These cycles are primarily driven by orbital variations, both with respect to the angle of Earth's tilt toward the sun and the shape of Earth's orbit around the sun.[21] Carbon dioxide (CO_2) fluctuated as a result of how ecosystems responded to changes in Earth's temperature, and changes in temperature then amplified those ecosystem changes. In systems theory, which is the guiding paradigm for ecological economics and computer modeling, this process is known as a positive feedback loop.

Currently, CO_2 and other greenhouse gas concentrations are rising not because of orbital changes but from the use of fossil fuels. The preindustrial level of CO_2 in Earth's atmosphere was 280 parts per million (ppm); now it's about 400 ppm. Consider that 100 ppm of CO_2 is what separated the Ice Age from the warm, stable climate of the past several thousand years, and that the corresponding temperature transition took about a thousand years. Today, global average temperatures are rising about 100 times faster than during transitions out of ice ages. In fact, the current rate of change in the chemistry of Earth's atmosphere and oceans is comparable to only a few previous mass-extinction episodes over the past several hundred million years that appear to be related to radical, rapid climate change.[22]

The rate of change is perhaps more important to the climate system and life on Earth than is the amount of change. A slow rate of change is akin to gently applying the brakes to stop at a light, while a fast rate of change is akin to hitting a brick wall. Both take the vehicle and a passenger from 60 to 0 miles per hour, only one is faster.

Nobody really knows what this means for the climate system, the pH of the oceans, the physiology of plant growth, and other planetary processes. Policymakers ask scientists how much pollution can be tolerated before "dangerous interference" occurs. Unfortunately, answering how much is too much is not possible, and in all probability, we have already passed some very dangerous thresholds that will become apparent only as the future unfolds.

There are many reasons why a precise answer to "how much is too much" is not possible. Consider that for any factor built into a model, scientists 1) work with what they know, 2) try to incorporate plausible ranges for what they don't know, and 3) obviously exclude what they don't know they don't know. Some would argue that because we can't be sure climate models are correct, we should do nothing. Would "do nothing" skeptics be as cavalier about uncertain dangers if the food their children ate had *possibly* been contaminated by a deadly poison? What you don't know can kill you. Given the stakes, many advocates of energy policies leading to a curtailment of greenhouse gas emissions take a precautionary

Although Americans make up less than 5% of the world's population, we produce about 16% of all greenhouse gas emissions directly, and a significant share indirectly through our consumption of goods manufactured in other countries.

Photo © jupiterimages, comstock.com

A systems view of how ecosystems and biological, hydrological, and climatological processes interact on a planetary scale is sensible. Therefore it is not a stretch to imagine that the changes being wrought by greenhouse gas emissions could, relatively suddenly, inflict even more massive damage to Earth than we are already seeing.

stance.[23] After all, if the US is so concerned about security that it is willing to spend over $650 billion dollars a year on the military, what is it worth to help secure our climate? Regardless, there is no longer any real scientific debate on the basic facts of climate change. A 2013 study of 21 years of peer-reviewed scientific papers on climate change found that over 97% of scientists endorsed the consensus view that climate change is caused by humans and is cause for serious concern.[24]

Climate systems are too complex to allow us to model many of the details of change. For example, models can't scale down to the future climate of a single town, which makes it difficult, perhaps, for local officials to understand the implications of global models. Nor can models usually identify critical thresholds in a complex system with much accuracy. Systems can remain remarkably stable over long periods under stress until something snaps, like a balloon expanding until it pops. The Earth System has been remarkably tolerant of the stresses it is under, but when something finally gives, it will probably be "loud." It is very possible that current models actually underestimate the true threats of climate change.

Those of us living in the United States have a special responsibility to deal with climate change: Although Americans make up less than 5% of the world's population, we produce about 16% of all greenhouse gas emissions directly, and a significant share indirectly through our consumption of goods manufactured in other countries. A constellation of interrelated climate change pressure points examined by Professor John Schellnhuber, former chief environmental advisor to the German government and currently director of the Potsdam Institute for Climate Impact Research, reveals both the complexity of the problem and the shockingly realistic possibility of dramatic environmental damage.[25] Schellnhuber has identified 12 global ecological "tipping points," weak links that could, under the impact of global warming, trigger the catastrophic collapse of some of Earth's critical ecosystems. Because each of these phenomena operates on a planetary scale, disruption of one influences the behavior of others in chains of positive feedback loops. The dozen fragile systems and/or places in Schellnhuber's model are:

- Amazon Rain Forest
- North Atlantic Current
- Greenland Ice Sheet
- Ozone Hole
- Antarctic Circumpolar Current
- Sahara Desert
- Tibetan Plateau
- Asian Monsoon
- Methane Clathrates within Siberian permafrost and ocean sediments
- Salinity Valves in the oceans, especially the Mediterranean Sea
- El Niño
- West Antarctic Ice Sheet

The ways in which these tipping points interact with one another are too numerous and complicated to detail here, but a couple of examples will give a good idea of what's at stake. As the Greenland ice sheet melts, for example, it discharges massive volumes of freshwater into the sea where the vast oceanic river known as the North Atlantic Current delivers warmth to the European continent via a mechanism called thermohaline circulation (THC). That new freshwater dilutes the salt content of the North Atlantic's surface waters; and with enough freshwater, the THC could be disrupted, making parts of Europe considerably colder than they are now. As another example, global warming is expected to increase rainfall along the southern edge of the Sahara, which means more plants would grow and the desert would shrink. But windblown dust from the Sahara seeds the ocean with nutrients that support the phytoplankton population, which is the foundation of the entire oceanic food chain. More rain would mean less dust, and thus less food for the phytoplankton, and thus decreasing phytoplankton populations, and thus less food for fish.… You get the picture.

Of course, these and similar scenarios involving fragile environmental tipping points are somewhat hypothetical, especially when spun out to what some might see as worst-case scenarios. But the point is that the evidence that global warming and large-scale climate change are occurring is real, if not overwhelming, to those who will see it. And a systems view of how ecosystems and biological, hydrological, and climatological

[cr] Photo © Jupiterimages, comstock.com

processes interact on a planetary scale is sensible. Therefore it is not a stretch to imagine that the changes being wrought by greenhouse gas emissions could, relatively suddenly, inflict even more massive damage to Earth than we are already seeing. Indeed, it only makes sense to take Schellnhuber's warnings seriously.

And here's one more sobering consideration. Although climate models have limits, they also do an incredible job of accurately modeling the *past* climate. For example, when comparing images from weather satellites to the most advanced climate models, you can see how well models match the actual formation and movement of storm clouds around the globe.

One of the tests climate modelers perform to decide whether human-induced changes in the atmosphere are causing climate change is to run climate models for the 20th century *as if* we hadn't burned so much fossil fuel. The rise in global temperatures and the shifts in rainfall patterns seen during the 20th century can be accurately modeled only when fossil fuel-induced greenhouse gas emissions are included. Natural variations in solar radiation and the shape of Earth's orbit around the sun do not account for recent climate change. Climate change is our problem.

While we can't know future threats precisely, scientists agree that creating a carbon-cycle-neutral economy should be the dominant task occupying our minds. This is exactly what relocalization aims to do.

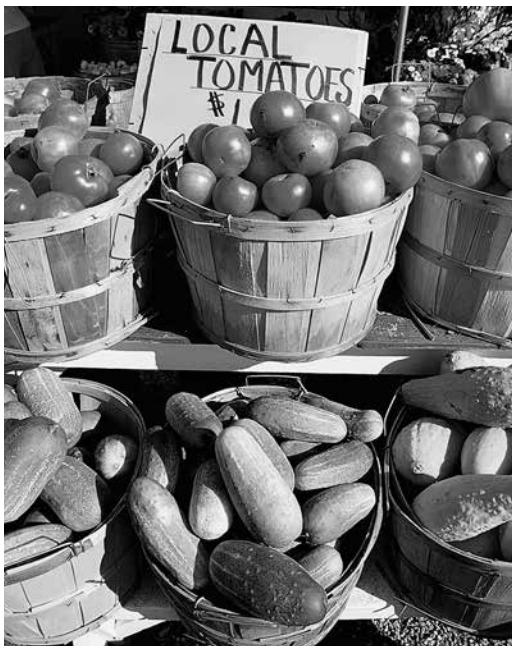
Relocalization: A Strategic Response to Overshoot

Economic and population growth were made possible by the synergies permitted by cheap energy. The limits of productivity in one locality could be overcome by importing something that was produced in excess elsewhere. A global economy emerged, propelled by an imperative that each place seek its comparative advantage and specialize in the marketplace. The spread of "free trade" agreements is further indication that most economists, policymakers, and political leaders see only the benefits of globalized commerce and ignore or minimize the long-term liabilities.

One particular flawed assumption behind globalization is especially glaring, i.e., that transportation costs will always be low, both in terms of fuel availability and the environmental problems associated with their use.[26] If that assumption is false—and certainly peak oil and climate change make it appear false—then localities should not be specializing to trade globally. Take the example of California wine country again. That place grows far more grapes than the local population can eat, but it lacks just about every other kind of food production in sufficient quantity. As long as the region can sell its wine to a global market and buy the other stuff people need, this situation seems reasonable. But a peak oil perspective reveals the region's vulnerability, and a climate change perspective calls this entire socioeconomic system irresponsible.

Relocalization advocates rebuilding more balanced local economies that emphasize securing basic needs. ***Local food, energy, and water systems are perhaps the most critical to build.***[27] The movement toward relocalizing food networks is perhaps the most advanced today. A book by Sandor Ellix Katz, *The Revolution Will Not Be Microwaved*, documented the growth of early relocalization initiatives that worked to restore traditional food production and distribution methods and revive local economies. (Katz's books on fermentation are available at realgoods.com.) Katz's analysis speaks directly to the issues we've been discussing and the promise of relocalization:

> Food-related political activism…seeks to revive local food production and exchange and to redevelop community food sovereignty. There is no sacrifice required for this agenda because, generally speaking, the



Relocalization advocates rebuilding more balanced local economies that emphasize securing basic needs.

food closest at hand is the freshest, most delicious, and most nutritious. This revolution will not be genetically engineered, pumped up with hormones, covered in pesticides, individually wrapped, or microwaved. This is a revolution of the everyday, and it's already happening. It's a practice more of us can build into our mundane daily realities and into a grassroots groundswell. This revolution is wholesome, nurturing, and sensual. This revolution reinvigorates local economies. This revolution rescues traditional foods that are in danger of extinction and revives skills that will enable people to survive the inevitable collapse of the unsustainable, globalized, industrial food system.[28]

In the absence of reliable trade partners, whether from peak oil, natural disaster, or political instability, a local or regional economy that at least takes care to produce the essentials will have a true comparative advantage. Relocalization will promote local and regional stability. Because it reduces the distances that goods travel between production and consumption, it will also significantly reduce pollution and greenhouse gas emissions. Ideally, relocalization is grounded in the principles of ecological economics and is developed around renewable energy inputs and cycling of nutrients. The more we can do, the greater the positive impact it will have on reducing the potential consequences of these impending crises.

A local economy that takes care of its basic needs is also a very interesting place to be.

Approaching Social Change

The problems we face tempt many to drop out of society as much as possible and live a simple life, semi-isolated from the horrors "out there." However appealing this may be, global traumas will most likely catch up with everyone. Reversing course and implementing a complete overhaul of our collective lives requires massive cooperative action.

History shows some instances when societies have responded wisely and plenty of other instances when they didn't change in time.[29] There's no guarantee that relocalization will be successful, but we can hope that our work will improve the odds. And the journey has many inherent benefits in any event.

When approaching others, it's useful to keep an old sales adage in mind: Sell the benefits, not the features. Truthfully, nobody really knows "how" to relocalize economies in any intimate detail. Many examples of the components of a local, sustainable economy can be found, but nowhere can we point to an example of a place where it has all been put together harmoniously. This is something we will have to learn how to do together. So don't get too hung up on the "features" of a local economy beyond some broad principles and working examples. In the meantime, sell the benefits to enroll people in the vision.[30]

Members of the Peterborough, New Hampshire, community garden gather to share the bounty.

Photo © Ann Card

The benefits of a local, sustainable economy would be extensive, beyond the environmental pluses already noted. Such an economy is more responsible, secure, and potentially more "free" in some ways. With greater self-reliance comes greater political autonomy and less vulnerability to instabilities elsewhere. A local economy that takes care of its basic needs is also a very interesting place to be. The diversity of goods, services, and skills required is much greater than what many in the US are accustomed to in their communities. Such a place to live would be attractive to all generations, as each individual would be more likely to find a role suited to his or her talents and interests. The stability of a locally focused economy enhances community bonds. Instead of a hypermobile society in which anonymity is prevalent, people would have the time to get to know each other and work together based on mutual understanding.[31] This social lubricant lowers

what economists call transaction costs, which can be very important for getting work done together efficiently and responding cohesively during crises. It is hard for people nowadays to "love thy neighbor," when in many cases they wouldn't even recognize their neighbor.[32] (For an in-depth discussion of the urban homesteading movement, which seeks to achieve the goals outlined in this paragraph, see chapter 12.)

Beyond the personal level, the challenge is to engage our neighbors and communities in the project of shifting public investment strategies and creating laws that can lead to significant behavioral changes at the societal level. Changing a behavior required to get by on a daily basis, such as driving a car, requires that the built environment make alternatives relatively convenient. That means that tax dollars going toward highway projects and airport expansion need to go instead toward a locally scaled, non-fossil fuel-dependent transportation system. (For more information about sustainable transportation, see chapter 13.)

Activists will often hear this response: "Sounds great, but we have no money." In the United States, however, vast material resources are devoted to expanding freeways, building cities in deserts, generating electrical power using coal and natural gas, and producing military hardware. In truth, shifting public investment resources is mainly a matter of priorities. But that requires involvement in one of the most difficult social environments of all: politics. Bumping up against institutional norms may sound daunting, but the good news is that reality is conflicting with dominant belief systems. This conflict sets up an opportunity to help the disillusioned or confused by offering a coherent explanation of what is happening, and pathways to realign their thinking with the new realities.

Being politically active doesn't require running for office or joining a political party, though those are fine options. Because relatively few Americans are actually civically engaged, a small group of well-organized and thoughtful people can wield great power. After all, this is what professional lobbyists do.

The message that we need to develop local economies is an easy sell because most people readily understand the advantages of greater self-reliance and strengthened communities. Job loss trends related to the dissipation of local manufacturing and agriculture and the disruptions brought on by the economic crisis of 2007–2009 are sore spots that lead many to question the wisdom of globalization. In this context, people are receptive to cogent arguments that reveal the insecurity and environmental problems of our dependence on fossil fuels and other imports, and they are more willing to see the vision of an interesting and beautiful alternative.

Shifting established patterns of behavior and generating the same sense of urgency many activists feel is more difficult. Two parallel strategies can help us to move forward.

The first is a strategy of earnest but careful dialog. Developing a relationship with leaders in your community based on mutual respect and trust is critical. Establishing such personal connections will improve the likelihood that decisions will be made from the perspectives and priorities of relocalization. However, be aware that because the message of overshoot challenges cherished assumptions and intrudes on many people's comfort zones, it can be a somewhat awkward dance getting to know someone and communicating your purpose.

Understanding the art of conversation is a useful skill when navigating interpersonal relationships. Being able to listen carefully to understand others' perspectives, and finding avenues of shared concern, is a great way to start. Build from an initial foundation of respect. Pointing fingers and demanding that people "get on board" is less effective than asking friends to assist in dealing with a mutual problem. Strive for understanding and agreement, but learn how to live with differences and to tolerate tension and conflict. We don't always get along with those we care most about, but we still try to stick together.

The second strategy is modeling through tangible examples the kinds of changes being advocated. Those of us "ahead of the curve," so to speak, will need to pull up our sleeves and create some of the alternatives we're talking about. Examples abound, including local monetary systems, renewable energy devices, community gardens and farms, farmer's markets, bike clubs, and small businesses or nonprofit organizations helping people do all of the above and more. Ideally, as these activities demonstrate success, gain credibility, and become more cost-effective, more and more people will rally to support them.[33]

If you want to work on peak oil, climate change, or relocalization issues in your own community, there's probably already an existing group you can join: you'll find thousands listed at resilience.org/groups. And if there's nothing that appeals to you, start your own group! Most important, don't be paralyzed by indecision and fear. Doing nothing is a capitulation to disaster, while doing something is empowering and potentially transformational.

Those of us "ahead of the curve," so to speak, will need to pull up our sleeves and create some of the alternatives we're talking about.

Pioneering Solar Down on the Farm

Left: The Decaters plow their fields with "original" solar farming technology—draft horses that eat grass fed by the sun. **Above:** Tended by apprentices, compost piles at Live Power Community Farm recycle onsite waste. **Below:** John Schaeffer visits with Steve and Gloria Decater down on the farm.

Live Power Community Farm has been generating its electricity via some form of solar energy for decades. Now the farm is set to add another leg to its legendary system.

Talk about your renewable energy pioneers. For the past 40 years, Stephen and Gloria Decater have been powering Live Power Community Farm, their 40-acre Demeter-certified biodynamic operation in Covelo, California, with some form of solar energy.

Whether it be from the draft horses that plow their fields ("Horses are eating grass and forage, and their energy source is the sun, so, in effect, horses are solar powered," Stephen says) or from photovoltaics (PV), the Decaters have been committed to solar energy for nearly as long as the term *solar energy* has been around.

"Our goal has always been to produce food from solar energy rather than fossil fuel. We designed the farm on that principle," Stephen says.

Right now the farm has completed its third leg of solar power development. In addition to their draft horses, the Decaters currently have a 28 kW PV system that provides much of the farm's power and water pumping capacity. For help designing and installing the third phase, they contacted Real Goods. "The system is getting pretty involved," Stephen says. "The people at Real Goods were extremely knowledgeable in helping us understand the next leg of it."

Powering Community Supported Agriculture

If there's a quintessential statement to be made about reverence for the Earth, it's being made every day at Live Power Community Farm. The farm was one of the first Community Supported Agriculture (CSA) projects in California. CSAs now number between 6,000 and 6,500 in the United States and are based on an economic paradigm vastly different from traditional market-based systems.

Essentially, CSA is a social and economic contract between growers and consumers. "For us, CSA means 100% community based. Members support our annual operating budget, and all the food we grow is distributed to members," Gloria says. "It's an associative economy rather than a market economy. The association is between growers, consumers, and the Earth."

Tech specs

Solar system size	28 kW after new panels installed
Est. average annual savings	$1,600+
Solar panels	32 Siemens SR 100; 72 Shell SP 140; 30 Sharp 165 W modules; 36 Trina TSM-305PD14 modules
Inverters	SMA SB300 for Siemens panels; SMA SB4000 and SMA SB6000 for Shell panels; SMA SB6000U 6 kW inverter for Sharp panels; SMA SBT1000LUS-12 for Trina panels