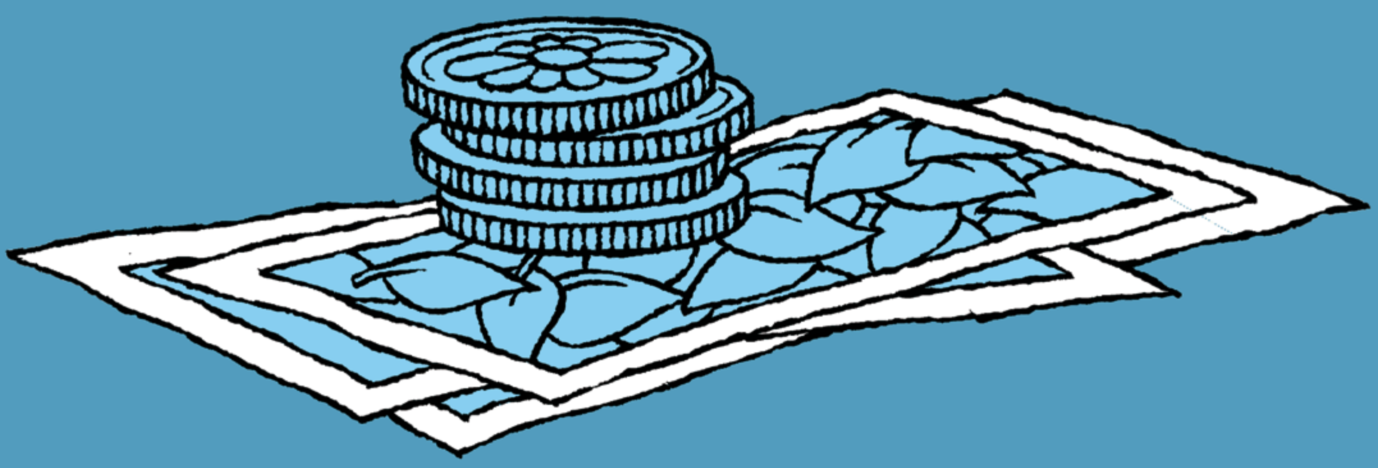
The Post Carbon Reader Series: Economy

# Ecological Economics

By Joshua Farley



## About the Author

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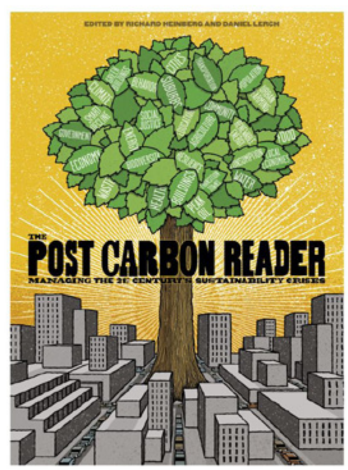


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# Market systems largely fail to account for the impacts of ecosystem degradation on human welfare.

Market economies—in which the prices of goods and services are determined by the interplay of supply and demand in voluntary exchanges—play a critical role in the modern world. Market forces determine the quantity of oil pumped, minerals mined, forests cut, and fish caught. They determine the industries to which these resources are allocated, how much labor and capital are employed to convert them to market products, and who gets to consume those products.

In theory, competitive markets[1] allocate factors of production—resources like energy, raw materials, land, labor, and capital—toward the most profitable goods and services and, in turn, allocate the goods and services toward those who value them the most, as measured by their willingness to pay. The competitive markets described in textbooks in theory maximize monetary value while ensuring that consumers are able to purchase market products as cheaply as they can be produced. What's more, competitive markets achieve all this through a process based on free choice and decentralized knowledge, without centralized coordination.

The Great Depression, however, revealed huge flaws in market economic theory. Markets sometimes left vast numbers of skilled laborers unemployed, left machinery idle, and left food to rot on farms while the poor went hungry. The Great Depression helped economists understand that sometimes markets required government intervention to function well and to allocate resources appropriately. Confronted with this crisis, economists developed the field of macroeconomics, which explained how governments could use monetary and fiscal policies[2] to keep economies healthy and growing.

When macroeconomics emerged, however, practically no one was aware of the coming challenges of global climate change, peak oil, biodiversity loss, resource depletion, or overpopulation. Economists focused on the problem of how to convert seemingly abundant natural resources into apparently scarcer economic goods and services. Since then, production of economic goods and services has increased more than eighteenfold in the United States,[3] and nearly as much in the world as a whole. We have learned that intact ecosystems provide vital life-support functions upon which we, like all other species, depend for our survival, and that human activities threaten the planet's ecosystems.

Unfortunately, market systems largely fail to account for the impacts of ecosystem degradation on human welfare. The ecological and resource crises we currently face are orders of magnitude more serious than the Great Depression, as they threaten not only the economic system but also human survival. We must develop a new type of economics that addresses these shortcomings (see box 20.1 for a glossary of selected terms).

## What Is Economics?

Adapting our economic system to the twenty-first century's interconnected sustainability crises demands that we understand precisely what economic systems are meant to achieve. One widely used definition of economics is "the allocation of scarce resources among competing desirable ends."[4] We use what we have to create what we want.

A series of questions flows from this definition:

- First, what are the desirable ends of economic activity? Until we decide what we want, we can't possibly figure out how to get it.
- Second, what resources do we have at our disposal?
- Third, what are the physical and institutional characteristics of those resources relevant to their allocation?

We must answer these questions before deciding what types of mechanisms for allocating resources will help us achieve our economic goals.

### WHAT ARE THE DESIRABLE ENDS OF ECONOMIC ACTIVITY?

Many people would agree that the central desirable end of economic activity is a high quality of life for this and future generations. Conventional economists argue that humans are insatiable, and therefore economics should focus on endless economic growth and ever-increasing consumption. Considerable evidence, however, suggests that humans are in fact satiable—there is a point beyond which increasing consumption does not make us better off. For 90 percent of human history, we were nomadic hunter-gatherer tribes and faced starvation if we accumulated more than we could carry in our search for food; insatiability was maladaptive.[5] Indeed, quality of life depends on the satisfaction of a wide variety of human needs, which include subsistence, reproduction, security, affection, understanding, participation, leisure, spirituality, creativity, identity, and freedom, very few of which are closely related to market goods and services.[6] Advertising leads us to believe that we can satisfy these needs through material consumption, and when we fail to satisfy them, we mistakenly believe it is because we are not consuming enough.[7]

An economic system designed to sustain a high quality of life across generations must satisfy at least three requirements:

**BOX 20.1**
Glossary

**Ecosystem goods and services:** *Ecosystem goods* are biotic (living) and abiotic (nonliving) raw materials provided by nature that alternatively serve as elements of ecosystem structure. They are stock-flow resources (see below). *Ecosystem services* are ecosystem functions of value to humans. They are fund-flux resources (see below).

**Excludability:** A resource is *excludable* when one person or group can prevent others from using the resource and is *nonexcludable* when this is not possible.

**Feedback loop (negative and positive):** A causal path through which the outcome of an event has an impact on future occurrences of that event. *Negative-feedback loops* have a dampening or stabilizing impact (i.e., they reduce the likelihood or impact of the event in the future), whereas *positive-feedback loops* have an augmenting or destabilizing impact (i.e., they increase the likelihood or impact of the event in the future).

**Fund-flux resource:** A fund is a specific configuration of stock-flow resources (see below) that generates a flux of services at a given rate over time. The fund is not transformed into the services it provides, and the services cannot be stockpiled.

**Market economy:** A system of allocation in which the prices of goods and services are determined by the interplay of supply and demand in voluntary exchanges.

**Market firms:** Businesses that produce market products.

**Market products:** Goods and services that are bought and sold in markets.

**Open-access resource:** A good or service for which no property rights exist.

**Rivalry:** A resource is *rival* when use by one person leaves less available for others to use and is *nonrival* when this does not occur.

**Stock-flow resource:** A resource that is physically transformed into whatever it is used to produce, can be stockpiled, and the rate of use of which can be controlled.

**1. An ecologically sustainable scale.**

The economic system is sustained and contained by the finite planetary ecosystem, so continuous exponential growth of physical economic production is impossible. A sustainable economy cannot extract renewable resources faster than they can regenerate, use up critical nonrenewable resources faster than renewable substitutes are developed, or emit wastes faster than they can be absorbed. Given the current extent of human impacts on the environment, sustainability also demands that we maintain and restore ecological resilience—the ability of ecosystems to recover from disturbances.

**2. Just distribution.**

Numerous studies show that people care about fairness and justice; injustice makes us feel bad.[8] Furthermore, those without enough to eat will sacrifice a sustainable future to feed themselves and their children today, while the wealthy consume more than their fair share of limited planetary resources. Justice is necessary for sustainability.

**3. Efficient allocation, because there exist finite resources and unmet human needs.**

Intact ecosystems provide a flow of goods and services that contribute to quality of life. They can also be converted into *economic* goods and services, but only at the cost of ecological degradation. Efficiency demands that we stop this conversion process before the additional costs of continued conversion exceed the additional benefits. Beyond this point, continued growth in human-made goods and services is uneconomic. Efficiency also demands that we allocate available ecosystem resources toward those products that most enhance quality of life, and those products to those who derive the greatest benefit from them.

## WHAT ARE THE SCARCE RESOURCES?

The first law of thermodynamics states that matter-energy can be neither created nor destroyed—it is only transformed. All economic production therefore requires the transformation of raw material provided by our finite planet, which irrevocably limits the physical size of our economy.

A more binding constraint on resource availability comes from the second law of thermodynamics, which states that entropy—the dissolution of order—always increases. In economic terms, this means that things break down, wear out, fall apart, and become less useful over time, and the production process ultimately and unavoidably increases total disorder. A corollary of the second law is that it is impossible to do work without energy, and that energy cannot be recycled. The ultimate scarce resource is therefore low-entropy matter-energy. The only sustainable source of low-entropy energy is the sun. A sustainable economic system cannot convert raw materials to economic products and then to waste faster than solar energy flows can replenish the order lost in the process. Ecosystems have evolved over millennia to capture solar energy and build up “order” in the form of increasingly complex plants, animals, and relationships. As we degrade ecosystems, we reduce the capacity of solar energy to replenish order.

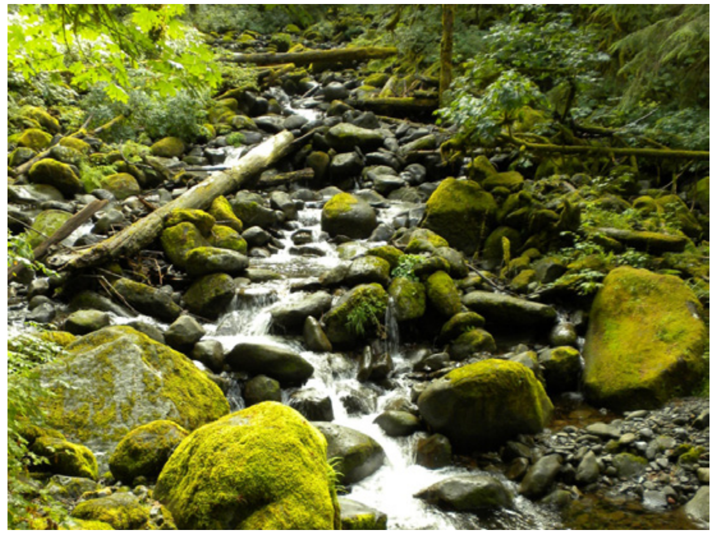
We depend on ecosystems not only for the regeneration of usable raw materials (“ecosystem goods”), but also for the generation of ecosystem functions of value to humans (“ecosystem services”). Most of the raw materials—plants, animals, water, minerals, and so on—transformed into economic products alternatively serve as elements of ecosystem structure (i.e., the building blocks of ecosystems). When we remove ecosystem structure, we also lose ecosystem functions, including vital life-support functions. Human survival requires healthy ecosystems capable of converting low-entropy solar energy and available raw materials into essential ecosystem goods and services.

Two other nonphysical resources deserve mention. One is the institution of money, which, along with financial systems, has enormous influence on how resources are allocated. The other is knowledge, or information, which is essential to all economic activity. We live in an information economy, and new knowledge will play a critical role in solving our current problems.

Unfortunately, conventional economists frequently argue that there are no binding resource constraints on economic production other than human ingenuity (i.e., knowledge), which they claim is essentially limitless.[9] Through the magic of market forces, as a resource becomes scarcer, its price increases, creating incentives to use the resource more efficiently or to develop substitutes. For example, as wood became scarce as an energy source, we developed coal as a substitute, followed by oil and natural gas. We are now developing heavy crude, oil shale, and tar sand. From this perspective, our ingenuity, guided by market forces, eliminates the problem of absolute scarcity.

However, it is no coincidence that both the market economy and the carbon economy emerged together during the eighteenth century. Market production has increased in tandem with the use of fossil fuels. It takes an estimated 25,000 hours of human labor to generate the energy found in one barrel of oil.[10] Many examples of innovation induced by growing scarcity and rising prices are actually examples of increased reliance on fossil fuels. For example, as we ran short of land to meet the global demand for food, we learned to convert natural gas into biologically active nitrogen and petrochemicals into an array of pesticides, herbicides, and fungicides. By shifting from animal-powered to fossil-fuel-powered traction and transport, we freed up land previously used to feed draft animals. The magic of fossil fuels is more responsible for economic production than the magic of the market.

Unfortunately, our capacity to continually increase fossil-fuel use to power ever-increasing economic production has ended. Fossil-fuel stocks are finite and we have already used up the most accessible supplies with the highest net-energy gains. Fossil-fuel emissions threaten climate stability, hence agriculture and civilization. The age of the carbon economy is coming to an end.



## WHAT ARE THE PHYSICAL AND INSTITUTIONAL CHARACTERISTICS OF THE RESOURCES?

To design a sustainable economy, we must understand key characteristics of the resources at our disposal. To begin, we distinguish between ecosystem goods and ecosystem services, which have fundamentally different physical characteristics.

*Ecosystem goods* are the raw materials provided by nature that are essential to all economic products. These include food, fiber, fuels, water, minerals, and so on, and alternatively serve as elements of ecosystem structure. *Ecosystem services* are those ecological functions that contribute to human quality of life. These include:

- Regulation of climate, water, disturbances, and atmospheric gases (regulating services).
- The capacity of ecosystems to reproduce food, fiber, fuels, and water (provisioning services).
- Habitat, nutrient cycling, and pollination (supporting services).
- Recreation, genetic information, and spiritual values (cultural services).

When ecosystems provide raw materials, they act as stocks that are physically transformed into other products; they are used up, not worn out. Think of forests being converted into timber, or fossil fuels being transformed into carbon dioxide and waste heat. Ecosystem goods are "stock-flow" resources. Stock-flow resources can be used up at the rate we choose and can also be stockpiled.

When ecosystems provide services, in contrast, they act as funds, agents of transformation that are not themselves physically transformed in the act of production. A fund is a particular configuration of stock-flow resources capable of generating a flux of valuable services. Ecosystem services are "fund-flux" resources. When a forest regulates water flows, it remains a forest. Fund-flux resources are provided at a given rate over time, and cannot be stockpiled. Ecosystems can transform oxygen, carbon, minerals, and sunlight into a given amount of ecosystem goods and services per day, and human-made capital and labor can transform these into a given amount of economic product per day. While fund-flux resources such as labor and capital are worn out over time, ecosystem fund-flux resources are spontaneously renewed by solar energy.

Another critical characteristic is excludability. A resource is "excludable" when one person or group can prevent others from using the resource. Excludability is not an inherent characteristic of a resource, but rather the result of institutions protecting private or common property rights. Most ecosystem goods have been made excludable; for example, trees, land, oil fields, and mineral deposits typically have owners. Some ecosystem services can also be made excludable; for example, the waste absorption capacity for greenhouse gases in Europe is now a tradable commodity resource as established by the European Union Emission Trading System.[11] A resource is "nonexcludable" when one cannot prevent others from using it, in which case markets provide no incentives to pay for its use, production, or protection, threatening overconsumption and underprovision. Many ecosystem services, such as climate regulation, protection from ultraviolet light, flood regulation, solar photons, and pollination, are inherently nonexcludable as a physical characteristic. Markets are only feasible for excludable resources.

A final critical characteristic is "rivalry." A resource is rival when one person's use of the resource leaves less available for others to use. A resource is "congestible" when it is rival but fluctuates between scarce and abundant ("abundant" means enough is available for all desired uses, and no competition is necessary). All stock-flow resources and hence all ecosystem goods are rival, but so are many ecosystem services. When a rival resource is scarce, there is competition for use. If use is not rationed, the resource is likely to be overused, like the waste absorption capacity for carbon dioxide (for example, if carbon dioxide is emitted faster than the ecosystem can sustainably absorb it), or oceanic fisheries (for example, if a fishery is depleted faster than it can replenish itself). The market price mechanism is one form of rationing because it allocates use of a resource to whoever is willing to pay the most.

A resource is nonrival when one person's use does not leave less for others to use. Examples include streetlights, climate stability, and many other ecosystem services. Knowledge has the special property that it often improves through use—for example, James Watt developed a better steam engine by taking apart and understanding an older, inferior one. Because nonrival resources are not depleted through use (though they can be destroyed by abuse) and hence are not scarce, once they exist it is inefficient to ration them. Take as an example a clean, cheap solar alternative to fossil fuels. A patent makes the knowledge behind the technology excludable, allowing it to be sold at a price. While this creates incentives for markets to produce the knowledge, it also rations use to those willing to pay, thus reducing use. If the price is high enough, countries may continue to burn coal, worsening global climate change. Paradoxically, the economic value of knowledge is highest at a price of zero, in which case markets will not produce it.[12] There appears to be no market solution to this dilemma.

## ALLOCATION

Resource allocation is too important to be left to any one ideology, whether capitalist, socialist, or communist. Rather, appropriate allocative mechanisms for production and consumption should be determined by existing institutions and the physical characteristics of resources. Institutions can be changed, but rivalry and inherent nonexcludability are innate physical characteristics, not policy variables.

When rival resources are scarce, different users must compete for their use—therefore, consumption should be restrained in some way. Market economies do this by "price rationing," which simply means that consumption is limited to those who are able to pay. Price rationing provides an incentive for market production, but other rationing mechanisms or cooperative supply are also possible. In contrast, rationing abundant or nonrival resources via prices or other mechanisms creates artificial scarcity and is inefficient. Open access, which means that there are no rules, regulations, or property rights that limit use, is efficient for nonrival resources and unavoidable for inherently nonexcludable resources. In this case, some form of cooperative or public provision[13] (i.e., production, maintenance, and/or protection) is required.

Excludability is the result of institutions, and hence a policy variable. Rationing is only possible for excludable resources and only desirable for scarce resources. Some form of cooperative provision or protection is required for nonexcludable resources. An approach suitable for potentially excludable resources is to cooperatively make them excludable—for example, a cooperative global effort to limit greenhouse gas emissions would make the absorption capacity for greenhouse gases excludable. Cooperation should be on the scale of the benefits produced—local cooperation for local benefits, global cooperation for global ones.

**TABLE 20.1**
Resource Allocation Matrix: Possible Combinations of Rivalness, Scarcity and Excludability

| | Excludable | Nonexcludable |
|---|---|---|
| **Rival and Scarce** | **Potential Market Goods**<br>Consumption: Rationing required<br>Production: Price rationing creates incentives for private sector production | ***Open-Access Regimes***<br>Consumption: Rationing desirable, but not possible<br>Production: Cooperative or public institutions required to regulate use (i.e., make resource excludable) so that rationing is possible. |
| **Congestible (rival, on the border between scarce and abundant)** | **Club or Toll Goods**<br>Consumption: Rationing required to avoid scarcity<br>Production: Price rationing creates incentives for private sector production | Like ***open-access regimes*** when scarce<br>Like **public goods** when abundant |
| **Nonrival or Abundant** | ***Artificial Scarcity Regimes***<br>Consumption: Rationing creates artificial scarcity and is inefficient<br>Production: Price rationing creates incentives for private sector production | **Public Goods**<br>Consumption: Open access is efficient and generally unavoidable<br>Production: Cooperative or public institutions required |

Table 20.1 shows the possible combinations of rivalness, excludability, and scarcity, along with relevant allocation mechanisms, which are explained below. The regimes in italics are inherently inefficient at increasing human welfare.

## POTENTIAL MARKET GOODS

Market competition can work reasonably well for the production and consumption of resources that are both rival and excludable, but can also fail catastrophically. There are several problems with conventional markets that must be addressed in a post-carbon world.

Markets allocate resources among products, and products among consumers, in a way that maximizes monetary value. The question, however, is whether monetary

Markets allocate resources based on the principle of one dollar, one vote, and future generations have no vote.

value is actually what we want to maximize. If an American is willing to pay more for corn to make ethanol for her oversized sport utility vehicle (SUV) than a malnourished Mexican can afford to pay for tortillas, then converting corn to ethanol maximizes monetary value. Markets allocate resources based on the principle of one dollar, one vote, and future generations have no vote. Markets are guided by the preferences of living individuals weighted by their purchasing power.

Furthermore, markets rely on negative-feedback loops: As resource scarcity increases, prices rise, signaling consumers to consume less and suppliers to supply more or develop substitutes. Prices balance supply with demand. However, the supply of low-entropy matter-energy and land is fixed. When the price of nonrenewable resources like fossil fuels or minerals increases, we may extract in-ground stocks more rapidly to temporarily increase current supply, but at the expense of future supply. If we extract renewable resources like timber or fish more rapidly in response to a price increase, we may actually decrease their capacity to reproduce, again reducing future supply. It is also extremely difficult to develop substitutes for fossil fuels, land, or critical ecosystem services.

Price signals could still balance supply and demand through their effect on consumption. However, as oil, land, or resource prices increase in response to scarcity, speculative demand may also increase, leading to further price increases in a positive-feedback loop. The result is a speculative bubble. Eventually, the bubble pops, and falling prices decrease speculative demand in another positive-feedback loop. The more wealth that concentrates in the hands of a few and the more the financial sector finances speculation, the more money is available for speculation and the worse the resulting instability. In the past decade, speculative bubbles in information technology, real estate, oil, food, and financial instruments have destabilized the global economy. Without extensive regulations on speculation and the financial sector, destabilizing positive-feedback loops can overwhelm the stabilizing function of market price signals.

Finally, when markets allocate ecosystem goods toward the production of market goods and services, this degrades the capacity of the ecosystem to generate nonpriced ecosystem services. There is no price change to signal rising scarcity. While markets can allocate ecosystem structure among different market goods to maximize their monetary value, they are unable to determine how much of that structure should be conserved to provide vital, nonmarketed ecosystem services. Our economic system requires mechanisms, ideally cooperative and democratic, that limit ecosystem conversion, resource extraction, and waste emissions to an ecologically sustainable scale before permitting market allocation.

## OPEN-ACCESS REGIMES

The most serious problem with open-access regimes we currently face is waste absorption capacity, particularly for carbon dioxide. While there is no inherent limit to the stock of carbon dioxide that the atmosphere can hold, the natural rate at which geological and biological processes remove carbon dioxide from the atmosphere—that is, the waste absorption capacity (WAC) of carbon dioxide—appears to be about 20 percent of current emission rates.[14] We must therefore reduce current emissions by 80 percent to stabilize atmospheric carbon dioxide stocks, and how fast we do so determines whether the atmospheric stock will finally stabilize at 350 parts per million (ppm), posing little risk of catastrophic climate change, or 550 ppm or more, posing a substantial risk. If we fail to eventually reduce emissions by 80 percent, atmospheric stocks will simply continue to increase, and with them the risk of catastrophic change. The WAC for carbon dioxide is a rival resource: When one nation spews carbon dioxide into the atmosphere, less absorption capacity remains available to absorb another nation's carbon dioxide. Since few countries currently regulate emissions, the WAC for carbon dioxide is also nonexcludable (i.e., the atmosphere is an open-access regime) at the relevant planetary scale. As a general principle, regulation of open-access regimes must be carried out by cooperative institutions at the scale of the problem and must limit use to a sustainable scale determined by physical and ecological limits, erring on the side of caution. Institutions must also determine a just distribution: Which nations will have the right to emit carbon dioxide, and which firms and individuals within those nations?

Once cooperative institutions have determined both sustainable scale and just distribution, WAC should be efficiently allocated. Economists generally favor tradable emission permits or carbon taxes, which are theoretically efficient in maximizing monetary value. Emission permits can be auctioned off, with revenue spent for the public good, or awarded to specific users. In practice, permits have typically been awarded to

the polluters, ignoring the criterion of social justice. Alternatively, if carbon taxes are used, the state retains property rights to WAC and charges a fixed fee for use. In the "cap, distribute, and trade" approach, supply determines price, whereas with carbon taxes, price determines supply. Because prices adjust quite quickly to supply constraints and ecosystems adjust quite slowly to human activities, caps determined by ecological constraints that are then justly distributed are likely superior to taxes.[15]

## PUBLIC GOODS AND ARTIFICIAL-SCARCITY REGIMES

Nonrival resources have the wonderful property that no matter how much we use them, just as much remains. It is therefore inefficient to ration use, via prices or other mechanisms, in which case markets will not provide them. For resources that are also inherently nonexcludable—such as climate stability, protection from the ozone layer, and the ecological resilience provided by biodiversity—open access is the only option. If there is no way to limit use, there is no way to charge for use and no way to create purely market mechanisms for provision. Public goods must be provided or protected cooperatively.

Potential solutions to climate change and peak oil illustrate the economics of nonrival resources. Society currently faces two critical and conflicting thresholds. The first is an economic threshold. Without fossil fuels, existing technologies could not satisfy the basic needs of 7 billion humans. If we reduce fossil-energy consumption below some minimum level, perhaps 40 percent of current use, our economy is likely to collapse. The second is an ecological threshold. If we fail to reduce carbon emissions by at least 80 percent, runaway climate change may cause agriculture and hence civilization to collapse. Bridging the gap between these two critical thresholds requires new, more environmentally benign technologies, including solar energy.

Solar energy itself is inherently nonexcludable and nonrival[16] at the global level, as the capture of photons by one nation leaves no fewer for others. Since photon flows from the sun are fixed, applied knowledge in the form of new technologies largely determines how much we can capture and how cost effectively we can do so.[17] Knowledge actually improves with use. One policy option, patents, makes knowledge an excludable market good, in which case prices create an incentive for producing knowledge but simultaneously ration its use and create artificial scarcity. A more efficient alternative, for at least five reasons, is cooperative production of knowledge (e.g., through public funding and open-access use):

1. The most serious problems we face today include threats to climate stability and other critical ecosystem services, most of which are public goods. Markets provide no direct incentives to invest in technologies that provide or protect public goods.

2. In spite of the peak-oil threat, energy companies are reluctant to invest in alternate technologies that will substitute for fossil fuels and drive down the value of their existing investments.

3. Though every dollar spent on meeting the needs of the poor is likely to have a greater net impact on welfare than a dollar spent satisfying the wants of the rich, the latter is more profitable.

4. Information improves through sharing. However, scientific teams competing to be the first to patent efficient solar technologies are unlikely to share information with their competitors. Patents on other products and processes essential to developing the new technology further slow down research.[18]

5. Patents on knowledge ration access, and carbon-neutral energy technologies must be widely adopted if they are to prove effective. The challenges we confront are too serious for such inefficiencies.

With the same resources, publicly funded scientists would work cooperatively toward producing technologies that provide and protect public goods and meet the needs of the poor, sharing knowledge to speed the rate of advance. Once developed, technologies would be open access, leaving others free to use and improve the product without worrying about patent infringement. Open-access technologies would be more widely adopted and more quickly improved upon without worries of patent infringement and thus far more likely to address global problems. Cooperation would appear to be inherently more efficient than competition in developing the new knowledge required to solve society's most pressing problems.

A central objection to cooperative supply of open-access knowledge is the problem of funding. However, whether through market prices or taxes, citizens will ultimately pay the costs of new technologies, as well as the costs of climate change, and both are likely to be lower with public funding of research. Unfortunately, the ideological assumption that markets are always more efficient than government undermines the political will required for adequate public funding. Another objection is that, at the international level, we lack the institutions necessary to force countries to contribute, leading to the threat of some countries "free-riding" on the efforts of others. However, when countries free-ride by using carbon-free energy technologies, the country that supplied that technology also benefits. Given the nature of knowledge, the free-rider is likely to develop

The current system of money creation is highly pro-cyclical, enhancing inherent economic instabilities.

improvements, which would then be available to the original supplier.

### MONEY AND THE FINANCIAL SECTOR

Finally, though not a true physical resource, money plays a critical role in determining how resources are allocated—and the existing financial system is not sustainable, just, or efficient. A growing economy requires more money to chase more goods and services. Most money is created when the financial sector simply loans it into existence. The money is destroyed when the loans are repaid, but borrowers must also pay interest. If the economy is not growing, then interest payments are a zero-sum game: a transfer of resources to the financial sector, creating intense pressures for economic growth requiring yet more money creation, which is unsustainable on a finite planet. Furthermore, money that must be repaid with interest can only be loaned for profit-generating market activities, and thus will not be used to finance the provision of public goods no matter how critically important they might be. If, in addition to lending by the financial sector, governments create money to finance the provision of public goods, there is a growing risk of too much money chasing too few goods and services, leading to inflation. Lending money into existence for speculation enhances speculative bubbles. When such bubbles collapse, financial-sector lending freezes up, aggravating the resulting collapse. The current system of money creation is highly pro-cyclical, enhancing inherent economic instabilities.[19]

## Solutions

Given the financial and ecological crises faced by our complex ecological economic system, how do we proceed? Based on extensive research, systems theorist Donella Meadows identified several places to intervene in complex systems, and three are discussed here: changing the paradigm, changing the goals, and changing the rules.[20]

### CHANGING THE PARADIGM: WHAT IS BIOPHYSICALLY POSSIBLE?

A paradigm is a worldview, a philosophical framework that provides the underlying support to our actions and institutions. The dominant economic paradigm of our civilization sees economic activity as largely separate from physical and ecological realities. Several elements of this paradigm must change:

1. We must recognize that the economy is not whole unto itself, capable of endless expansion. Rather, it is part of something larger—specifically, it is a subsystem of the sustaining and containing global ecosystem. The degradation of the planetary ecosystem is an unavoidable cost of physical economic growth. Once it becomes obvious that infinite

economic growth is impossible, the key allocation question is how much economic structure can be converted into economic production and waste, and how much must be conserved to provide vital life-support functions.

2. We must recognize that the economy is not just a complicated system that can be managed by the single feedback signal of prices; rather, it is a complex system characterized by nonlinear change, emergent properties, surprises, and both positive- and negative-feedback loops. In such a complex system, we must actively seek to weaken positive-feedback loops, strengthen negative-feedback loops to cope with the scale of impacts, and create new feedback signals where necessary.

3. We must recognize that competitive markets are not suitable for allocating all resources and that humans are social animals capable of both competition and cooperation. Different institutions can elicit different degrees of cooperation and competition.

## CHANGING THE GOALS: WHAT IS SOCIALLY, PSYCHOLOGICALLY, AND ETHICALLY DESIRABLE?

The goals of an economic paradigm define the desirable ends toward which economic production should be allocated. Our dominant economic goal for well over a century has been simple: increased consumption. But consumption is only one of many human needs contributing to quality of life. Moreover, endless economic growth is not only impossible, it is not even ultimately desirable. Per capita consumption in the United States as measured by gross national product (GNP) has more than doubled since 1969, with little detectable change in people's self-expressed levels of happiness and satisfaction with life as a whole.[21] A recent study commissioned by French president Nicolas Sarkozy concluded that GNP is not an adequate measure of economic well-being.[22] Recent studies of the Canadian and English economies conclude that economic growth is not required to improve quality of life.[23]

We must rethink our goals and ask ourselves, "What, ultimately, is socially, psychologically, and ethically desirable?" To create a sustainable post-carbon economy, we must create a new shared vision of a sustainable and desirable future emphasizing healthy ecosystems, communities, and people over ever-increasing consumption.

## CHANGING THE RULES: INSTITUTIONS FOR A SUSTAINABLE, JUST, AND DESIRABLE ECONOMY IN A POST-CARBON WORLD

The solutions to our most serious problems will require cooperation. But economists have long maintained that humans are by nature purely self-interested. They have argued that institutions based on cooperation are not feasible and have championed more "realistic" market solutions to channel unavoidable self-interest into socially optimal outcomes.

However, numerous studies in evolutionary biology have convincingly established that, while selection within a group leads to the evolution of self-interested behavior, selection *between* groups favors cooperative behavior—the success of the human species actually results from cooperation.[24] Indeed, most human cultures have evolved mechanisms that punish purely self-interested behavior, thus promoting cooperation.[25] Behavioral economists have firmly established that people care about others and about fair outcomes and, together with institutional and political economists, have shown that certain institutions promote cooperative behavior that can lead to effective solutions to the types of problems we now confront.[26] One common element of such institutions is social punishment of selfish behavior.[27] Competitive markets appear to be a rare example within human cultures of an institution that *rewards* selfish behavior.

Some specific institutional changes are necessary to bring our economic systems back in line with both our biologically inherited values and our long-term sustainability needs:

1. We must create institutions that protect, enhance, and declare common ownership of those resources created by nature or by the shared efforts of society. One option here is to specifically assign property rights to common-asset trusts that manage common assets for this and future generations. The scale of institutions should be determined by the natural distribution of asset benefits, from the local watershed level for water regulations to the global scale for management of carbon emissions. For rival common assets, such as waste absorption capacity and fisheries production, the annual increment could be rationed through use of market mechanisms in a cap-and-auction system, with the resulting revenue accruing to the trust.[28] Nonrival assets such as information would not be rationed, but the trust would invest in their provision and protection.

2. The right to create and destroy money must be removed from the financial sector and restored to the public sector, which should then use it to enhance the public good. Specifically, this would require 100 percent reserve requirements for the private financial sector, which would no longer be able to loan money into existence. The goals of the public financial sector would be ecological sustainability, just distribution, and the efficient allocation of resources toward maximizing quality of life. Money could be spent into existence for the production of public goods during economic downturns to stimulate the economy and could be loaned into existence at zero interest for the production of important market goods as necessary. No loans would be available for speculative investments, thus dampening a pernicious positive-feedback loop. A steady-state, no-growth economy would favor a steady-state money supply, in which case money spent into existence should later be recaptured in taxes in a countercyclical, stabilizing system.[29]

3. We need a new Bretton Woods-type agreement for the international economy. The first Bretton Woods agreement was created in 1944 to rebuild the international economic system after the Great Depression and World War II. It established global institutions like the International Monetary Fund and the International Bank for Reconstruction and Development (which later became a part of the World Bank Group) to promote stable growth of the global market economy. A new agreement must be created in response to the current ecological and resource crises, and it must promote the cooperative provision of nonrival and nonexcludable resources, the stable contraction of the market economy, the convergence of global consumption levels, and the improvement of global quality of life. As a simple example, the new Bretton Woods could create the infrastructure for investing revenues from a global carbon-commons trust in open-access, renewable energy technologies.[30]

## Next Steps

The challenges of developing a post-carbon economy are formidable, but so are the resources available. Per capita GNP in the United States has more than doubled since 1969,[31] which suggests that if the United States dedicated half its GNP to solving the problem, its citizens could still sustain a 1969 standard of living.

Straightforward solutions exist, but they require fundamental changes to the existing system. How can individuals help create such massive changes? Donella Meadows's leverage points still apply:

- **Change the paradigm—spread the word**. We must understand and disseminate a new economic paradigm recognizing that the human economy is sustained and contained by the global ecosystem, and together they form a single complex system subject to the laws of physics and ecology.
- **Change the goals—set the example**. We must show that it is possible to live within the planet's biophysical limits while improving our quality of life by relocalizing our communities and adjusting our lifestyles for the realities of the post-carbon world.
- **Change the rules—speak up for change.** We must push for the reform of our political and economic institutions so that they once again act for the public good. From local government policies to international agreements, the structures that define how our world works are ultimately products of political consent, and thus can be changed with sufficient political will.

## Endnotes

1 In a competitive market, no single buyer or seller of a commodity has sufficient market power to set prices. Economic actors are price takers, not price makers. However, so-called competitive markets actually require extensive cooperative behavior—for example, to defend property rights.

2 Monetary policy is basically how the government influences the supply and availability of money in an economy, as well as the interest rate at which it can be borrowed or loaned. Fiscal policy is basically how much money a government spends and how much it collects in taxes.

3 U.S. Department of Commerce, Bureau of Economic Analysis, "Current-Dollar and 'Real' GDP," National Economic Accounts spreadsheet, 2007, http://www.bea.gov/national/.

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31 U.S. Department of Commerce, "Current-Dollar and 'Real' GDP."


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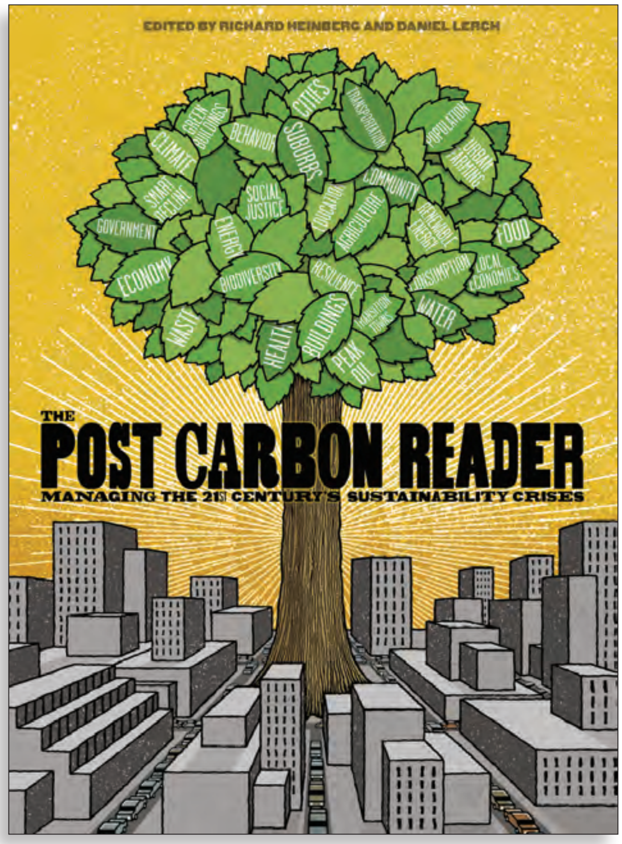


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