Special series: Ecological economics
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As humanity faces the reality of exhausting a number of key natural resources, we realize that our economy, which is fundamentally built on the concept of never-ending exponential growth, must drastically change if we are going to live within the confines of a finite planet, Earth. This series of six articles looks at ecological economics and the idea of a steady state economy that will provide livelihoods while fitting within the footprint of Earth. They were published in *NewsNotes* in 2009 and were updated in 2012.

Part one: A new economics for a full world

The basic rules that guide conventional economics were created at a time when the world seemed empty, when people could expand out into apparently endless lands. Natural resources were abundant and free. Governments were very effective in using up resources to build massive infrastructures and weapons systems, driven by the allure of growing into an apparently limitless world. Yet times are rapidly shifting, and we find ourselves reaching limit after limit in terms of land, water, food, oil, etc. Our full world requires a very different type of economy, an economy that is designed to fit within the physical limits of Earth, not an economy that grows forever.

Traditional economists downplay or even ignore the ways in which our economy depends on resources and natural systems and instead focus exclusively on the importance of labor and capital in producing goods. One example of this absurd thinking was economist William Nordhaus' statement that global warming would have little impact on the U.S. economy because it will merely affect agriculture which is only three percent of the gross national product.

Developed in the years preceding World War II, "economic growth" through the expansion of the gross domestic product (GDP, the total value products and services produced within the territorial boundaries of a country) has been the focus of governments ever since. (Gross national product, GNP, which is the GDP of a country plus capital gains from overseas investments minus income earned by foreign nationals domestically, is used less frequently today.) Both measure economic growth and have been assumed to measure general wellbeing. Yet, as a measurement, GDP is fundamentally flawed.

Numerous studies have shown that self-declared happiness only increases with rising income until basic needs are met. After that, increases in income have little or no effect on happiness. Yet countries in the global North with already high per capita GDPs seek to further increase it in the blind hope that this will make people "happier."

Another enormous flaw in GDP is that it counts the consumption of natural resources as income, instead of an expense, or reduction in capital. If a country extracts non-renewable minerals or cuts down its trees, this action is treated as positive income in GDP measurements, despite the fact that the country is losing irreplaceable natural capital. Businesses must account for depreciation and spending of their human-made capital like trucks and factories, but in the world of conventional economics, GDP treats natural capital as unlimited.

Another serious flaw in calculating the GDP is that it counts defensive spending made to protect ourselves from the unwanted side effects of production and consumption by others as a positive. Think of these as "anti-bads" spending rather than goods. They are incurred to counteract the negative effects

of other people's consumption or production. For example, to avoid overcrowding, crime, and air or noise pollution, many people have moved out of cities, bought more cars and spent more on gas. Or, if someone chose to stay in the city, they might have spent money to soundproof their apartment, install air filters, or buy a home security system. Medical expenses and car repairs after a traffic accident are other examples of defensive costs. Even money spent cleaning up toxic waste sites left behind by irresponsible businesses is counted as positive by the GDP. All of these costs should be counted as a cost of production applied to the activity that made them necessary, which would increase the price and reduce the amount of that activity. Instead we treat them as purely voluntary costs and add them to the GDP. These costs expand the economy, but do not increase well-being.

A truly illogical aspect of our current economy is how conventional economics treats limited goods (including dwindling natural resources like water, oil, minerals, fish, etc.) as non-scarce, placing low or no value on these things, while treating abundant goods, such as knowledge, as scarce through our patent and copyright systems. Especially today, when countries around the world need to rapidly adapt to climate change, the free transfer of knowledge is indispensable. The current patent system must be replaced with one that encourages innovation without resulting in prohibitively expensive prices.

A final area of conventional economics that must fundamentally change is governments taxing "goods" like workers' incomes and production while not taxing "bads" like resource depletion. Taxes are effective tools for influencing behavior. Decades ago, we thought resources were plentiful and seemingly endless, so it made sense not to tax resource use. Our current tax structure encourages employers to hire fewer workers and use more energy-intensive and resource-intensive production methods that are taxed less. By not taxing resource use, we send a message that resources can be squandered.

But we now know that resources are in short supply. Governments should change the tax system – which is an effective tool for influencing behavior – by removing taxes that make hiring people more expensive, and by taxing resource usage. Compensations can be made to assure that people with low incomes would not be priced out of basics like heating their houses or basic transportation.

We place "sin taxes" on products like alcohol and cigarettes in an effort to lower their usage. In the same way, we should use taxes to reduce other modern day sins. (Pope Benedict XVI recently declared pollution and excessive wealth to be cardinal sins.) A "sin tax" on pollution and wages above a certain level would be appropriate.

Ecological, or steady state, economics looks at the real world and designs an economic system that would respect the limits of Earth. The model focuses on the three fundamentals of scale (size of the economy relative to its sustaining ecosystem), distribution of wealth and allocation of resources. We will explore these and other themes in the rest of this series on ecological economics during 2009.

Reflection questions:

1. What is wrong or shortsighted in Yale professor William Nordhaus' statement: "Agriculture, that part of the economy that is sensitive to climate change, accounts for just three percent of national output. That means there is no way to get a very large effect on the U.S. economy"? *For a response by ecological economist Herman Daly, click here and read Daly's input starting on page 12.*

2. Many people acknowledge that the global economy cannot continue to grow forever, but at the same time cannot imagine society changing to a different economic model that doesn't depend on growth.
3. Discuss this quote from Herman Daly: "Currently it seems that we are witnessing the conflict between a physical impossibility (continual growth) and a political impossibility (limiting growth). But in the long run the physically impossible is more impossible than the merely politically impossible."

Part two: Uneconomic growth, "illth"

In the first article of this series, we looked at the problem of using GNP or GDP as an indicator of well-being. In this article, we look at the concept of uneconomic growth, or "illth," an important idea for understanding ecological economics and the limits to growth.

In a speech at the University of Maryland, ecological economist Herman Daly said, "We cannot avoid producing 'bads' along with goods. If we stop depleting, we die of starvation. If we stop polluting, we die of constipation." The important question is how to keep this necessary use of resources "within the natural capacity of the ecosystem to absorb our waste…and to regenerate resources that we can use again." It is when the economy surpasses this natural capacity for regeneration that economic growth becomes "uneconomic" growth. Instead of producing wealth, uneconomic growth produces "illth," a term originally coined by John Ruskin, a 19th century philosopher to mean the opposite of well-being.

Ecological economists spend much of their time focusing on the flow of resources – from extraction to production to disposal – also called "throughput." How large is the economy and its throughput in relation to the earth's ecosystem? How large can it be? But most importantly, is there an optimal size beyond which the growth of throughput begins to have more costs than benefits? These questions are never considered in classical economics, but are fundamental question that we face today as a human community.

A major concern today is that much of the economic growth currently taking place in the U.S. and Europe is uneconomic growth: it is creating more "bads" than goods. To measure this, Daly and others created the Index of Sustainable Economic Welfare (ISEW) which measures 19 items including but not limited to income inequality; public spending on health and education; costs associated with pollution, commuting, etc.; the depletion of natural resources; and the loss of farmland and natural habitats. The ISEW is one of the most advanced attempts to measure economic well-being.

When they created graphs comparing the United States' ISEW to its GDP, they found something very interesting. While the graphs ran together from 1929 until the mid-1960s, after that, GDP continued to grow while the ISEW remained stagnant until the mid-1970s. Since then GDP has continuously grown, while the ISEW actually declined. This means that while the economy has continued to grow, the well-being of people in the U.S. has not improved and has even worsened. This is what is meant by "uneconomic growth."

This does not mean that it is impossible to improve well-being in the U.S. and other overly developed countries, but it does mean that governments in these countries need to pay attention to more than simple GDP growth. They need to identify and increase those parts of the economy for which the marginal benefits still outweigh the costs while decreasing the parts of the economy where the costs of growth outweigh the benefits from that growth.

As we move from an "empty" world to a "full" one, the limiting factor in production will increasingly be natural capital, not human-made capital. For example, while in earlier times, the amount of fish caught was limited by the number of fishing boats, now it is limited by the number of fish in the sea. Irrigated agriculture was once limited by the amount of pumps and pipes used, whereas today, it is limited by the amount of water in the reservoirs. As we move into a full world, economic logic remains the same in terms of wanting to economize what we have less of, but we have not caught up with the fact that natural resources are limited and therefore cannot be considered "free." It is important to study the nature of natural capital and environmental goods and services so as to allocate them better.

For centuries, humans have used science to bend the natural world to our will. We must now use science to better understand the natural world so as to change our ways to be more in harmony with it. The Millennium Ecosystem Assessment represents an excellent beginning in using science for this means. By measuring the condition of and trends in the world's ecosystems such as water, food, forests, flood control, and natural resources, we are better able to understand the full costs and benefits of our economy and make necessary changes to be more synchronized with the natural world.

One workable solution would be to use two sets of national accounts instead of just one. One account would measure the benefits from growth, while the other would measure the costs, including environmental and health costs. The goal of each country would be to find an optimal level of activity where benefits are maximized and costs minimized.

Whatever we do, it is essential to begin to address the size of our economy before it overruns our planet's resources. As Daly wrote, "Some say that it is idle to talk about maintaining a steady state at some limited scale unless we first know the optimal scale at which to be stable. On the contrary, unless we first know how to be stable, it is idle to know the optimal scale. Such knowledge would only enable us to recognize and wave goodbye to the optimal scale as we grew through it! If one jumps from an airplane one needs a parachute more than an altimeter."

Reflection questions:

1. Can you think of any aspects of your personal consumption that might be considered "uneconomic," either from a personal or societal point of view?
2. What aspects of economic growth in the U.S. would you consider to be uneconomic?
3. What does Herman Daly's quote, "If one jumps from an airplane one needs a parachute more than an altimeter" mean in terms of economic policies?

Part three: Exponential growth

In part two of this series we examined the concept of uneconomic growth, or "illth," that takes place when the costs of using up natural resources are greater than the benefits from the new product built with those resources. In this article, we look specifically at the little understood, yet extremely important, concept of exponential growth, which is when something grows at a constant rate over time, for example a bank account that receives fixed interest or world population. Few people truly grasp the profound importance of this concept when we talk about the economy today. As Dr. Albert Bartlett, University of Colorado physics professor, said, "The greatest shortcoming of the human race us our inability to understand the exponential function."

Growth is usually expressed by a percentage of increase per year, for example, a bank account that grows at two percent annually, etc. Yet a steady growth rate is misleading because, unlike the rate of change, that usually stays more or less constant, the amount of growth at a given rate of change per unit of time is not constant at all, but increases more and more with time. If you were to graph anything that grows at a constant rate, it would look like a hockey stick lying on the ground, with a long horizontal line of apparently slow growth that at a certain point turns upward rapidly into an almost vertical line where the amount of increase grows incredibly quickly in a short period of time. A few examples will help to understand this "speeding up" factor:

One way to think of exponential growth is to consider that the interval of time needed for the item which you are measuring to increase by a certain amount shrinks as time passes, even though the rate of change remains constant. Consider world population, which has been growing at about a one percent annual rate: Around the year 1804, Earth's population hit one billion for the first time. That number doubled in 123 years (around the year 1927). By 1959, only 32 years later, the population had grown another billion, and 15 years later (around 1974), the population hit four billion. By 1987, another billion was added, and 12 years later (1999), the population was six billion. The UN Population Fund estimated that Earth's population reached seven billion on March 12, 2012.

Another example is monetary growth in the United States. It took over 300 years (from 1492-1973) for the U.S. (including the colonial period) to create its first $1 trillion in wealth. (It's unclear if this number includes the buying, selling and use of slaves.) The value of everything that was ever created in the U.S. and the colonies that preceded it – every road, building, automobile, etc. – before 1973 added up to $1 trillion. According to Chris Martenson of chrismartenson.com, in the fall of 2008, the most recent $1 trillion that the U.S. made took only 18 weeks to create. Where will this end? When $1 trillion is created in 18 days? 18 hours? 18 minutes?

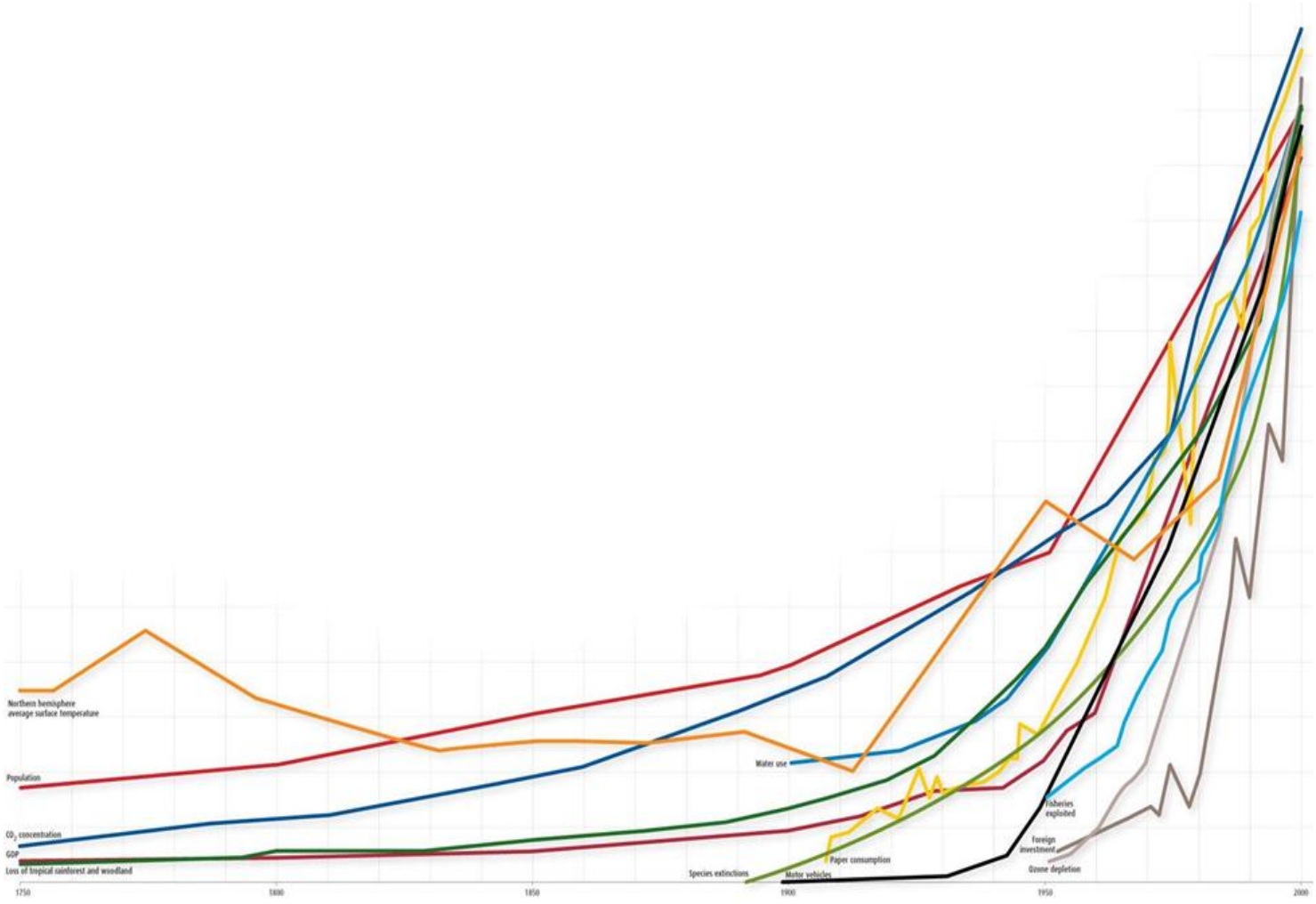
Knowing that this "wealth" creation also represents the consumption of natural resources, it is clear that this exponential growth cannot continue for long.

Another way to think about exponential growth is to think of the amount that is added growing larger with each new time period. An example would be the legendary story of the king who wanted to reward his mathematician for inventing the game of chess. The mathematician said, "My needs are modest. Please take my new chess board and on the first square, place one grain of wheat. On the next square, double the one to make two. On the next square, double the two to make four. Just keep doubling till you've doubled for every square. That will be an adequate payment." We can guess the king thought, "This foolish man. I was ready to give him a real reward; all he asked for was just a few grains of wheat." Yet this simple doubling of grains 64 times over would result in an amount of grain larger than the entire world could produce. Just in the last square alone the king would have to place 184,467,440,737,095,000 grains. And this is equal to the sum of all the previous 63 squares added together.

One final example that may more clearly show how rapidly things increase on the vertical end of an exponential graph comes from Martenson's "Crash Course." Imagine that Fenway Park, a baseball stadium in Boston is sealed off to be able to hold water. You start to drop water onto the pitcher's mound. In the first minute, you place one drop. Double that each minute, so in two minutes, you'd place two drops, in three minutes placing four drops, then eight drops, etc. Now imagine you are on the highest bleacher chained to the fence. If they started to place water drops at noon, at what time would the park still be 93 percent empty? It would be only seven percent filled at 12:44 p.m. At what time would the park be full of water? An hour later? A day? A week? No, it would be full at 12:49 p.m. In fact,

only one minute before you are drowned by the water, the park is still only 50 percent full! While watching the water level slowly rise to only halfway, you would probably not panic, but that would leave you only one minute to escape before being drowned.

This is the power of compounding, of exponential growth. See the graph below, which shows the dramatic growth in population, carbon dioxide concentration, water use, species extinction and other areas. How much longer can these lines continue to rise before we reach the limits of Earth? We will have to rapidly decrease our use of resources before we run out of them completely. And clearly many people's expectation that growth will solve the problem of poverty is unrealistic. Rather, we need to focus on better distribution. Keep these facts in mind as politicians throughout the world strive to get the economy growing as fast as possible once again.



Good websites that treat exponential growth in interesting ways:
Otherwise.com's Exponential growth
Raju Varghese's website
Chris Martenson's Crash Course

The rule of 70: An easy math trick called "the rule of 70" uses the growth rate to estimate how quickly something will double in size. By dividing 70 by the growth rate you estimate the doubling time. For example, world population, which has grown at a rate of about one percent per year, would double in size in 70 years (70 divided by one). Global use of oil has been growing at a three percent rate, meaning we double the amount of oil we use every 23 years (70 divided by three). Next time you are listening to the news and hear about something growing at a certain rate, use this formula in order to have a better idea of how soon it will double in size. While China's recent economic growth rate of 10 percent doesn't mean much to most, knowing that this means the Chinese economy will double in size in only seven years is much more meaningful.

Reflection questions:

1. Reread the example of water filling up Fenway Park. What does this make you think in terms of the rate that we are using up of natural resources today? Using the timeframe of beginning at noon and being full at 12:49, what time do you think we are at in terms of Earth's resources running out?
2. If you have access to the internet, play around with the fish population game at http://www.otherwise.com/population/exponent.html. Notice how much faster population grows even with tiny increases in the rate of growth. See what happens if the fish grow at 9 percent (the rate that China's GDP grew from 2000-2009)
3. Looking at the graph above, do you think most people are aware of this dramatic increase in our usage of resources and its consequences? Why or why not?

Part four: Distribution of wealth and allocation of resources

Earlier in this series, we focused on the overall size and growth of the economy. The issue of scale or overall size is the key difference between ecological economics and traditional economics: Proponents of ecological economics believe that scale is an economy's primary challenge, while traditional economists rarely consider it. Since these two groups hold dissimilar opinions about the limits to an economy's size, they also hold very different views on the distribution of wealth and allocation of resources, which we will consider in this fourth part of the series.

If you accept the premise that we cannot continue to grow the global economy indefinitely, then distribution becomes the only real solution to poverty. As Brian Czech, president of the Center for the Advancement of the Steady State Economy, wrote, "Given a global economy exceeding its maximum sustainable scale, the only ethical and ecologically economic approach to alleviating poverty while moving closer to sustainable scale is the capping of income and wealth, with pre-existing excess used to alleviate poverty." This cap should be defined democratically and could start with voluntary caps that gradually move to mandatory caps. Another approach would be to define a maximum proportion in income between the highest paid and lowest paid people in a company, city, state, nation, or even on a global level.

A more equitable distribution of costs and benefits is considered controversial for those who believe that the rules of the current market system are fair -- in this mindset, someone accumulates wealth due to his or her hard work or ingenuity. To distribute the "hard-earned" wealth of the rich to the "lazy" poor in such a situation would be an injustice. But when we consider a person's wealth, ecological economists look at how that wealth was created and who bore the costs of that creation. Wealth is often created by nature or society, and many costs of production are borne by society instead of by the

producer. Wealth created by nature or society is part of the commons and should be distributed equitably.

For example, when a subway station is built near a house or business, the value of those homes and businesses increases through no work of their owners. This is wealth created by society. Similarly, if the government were to demand cuts in oil production, this would raise oil prices and profits for oil companies. Again, this wealth was created not by the hard work of oil companies, but by a societal decision. Low income families that spend larger parts of their income on rent and energy would be most heavily affected by both decisions.

Looking at costs, when a business pollutes a stream without penalty, it can maintain its profits since it is not paying to clean up the waste. In this country, those costs are currently covered by society through the Environmental Protection Agency's massive Superfund. Yet the human costs of that contamination are shared unequally as polluting industries are statistically much more likely to be located in communities of color.

Ecological economists design policies that governments could use to reduce overall scale, capture the value created by nature and society, and address unequal distribution. In the case of cutting oil production, for example, the government could create a mechanism to capture the excess profits that oil companies make and distribute the excess to those most affected by rising prices. The cap and dividend system -- money raised from auctioning off carbon rights is then disbursed evenly to every member of the country -- is another workable option.

Many environmentally focused economists think that pricing is the issue. That is, if we could account for all the externalities of production – costs or benefits, like those above, not currently counted for in the market – into the prices of goods and services, then we could rely on the market to achieve the economy's correct scale and a good distribution. Yet determining all externalities is nearly impossible.

First, many goods and services provided by nature have no price – consider the ozone layer, climate stability, natural water systems and dozens of others. There is some movement to measure the value of some of these services, but it is incredibly difficult, perhaps impossible, to measure their true value. Second, to correct all the prices in an economic system would be a staggering task. Resource extraction and waste emissions are part of every economic activity, so at least two new costs must be calculated into most every input in the production of all goods and must be fed into the market to be reflected in prices. Then as the market adjusts to these new prices, it will change costs of inputs, entailing new measurements and new prices. This would require monitoring by a centralized body, which goes against the original notion of using the free market to solve the problem. As Herman Daly and Joshua Farley wrote in the workbook for their ecological economics textbook, "There is … little reason to believe that market economists can calculate the efficient price of nonmarket goods any better than Soviet planners could calculate the efficient price of market goods."

Third, it is very difficult, if not impossible in today's world, to define prices and create markets for ecosystems, species, habitats and other ecological "services" without resulting in the "financialization of nature" where large financial players like investment banks, hedge funds, pension funds and others would come to dominate those markets. We have seen this happen in the food, energy and mineral markets in the last decade especially. Wall Street financial experts are heavily involved in creating these new markets seeing untold opportunities for future profits.

According to ecological economists, the necessity of maintaining the size of the global economy within the limits of earth means that wealth distribution is critical. We can no longer rely on endless growth to ease poverty and acknowledge that without growth, wealth distribution is the only way to achieve poverty reduction. Only after addressing issues of scale and distribution do ecological economists look to questions of allocation. Only when the economic limits have been established within the possibilities of nature, and a legal framework is established that distributes costs and benefits equitably, will a market system work within the limits of the planet, without creating unsustainable inequalities.

Reflection questions:

1. In the Rio+20 Summit in June 2012, world leaders met to discuss the "green economy," a term that for the U.S. and many European governments means to establish prices for different environmental "services" like water, ecosystems, habitats, species, etc. Beside the three reasons listed above, what other concerns do you have with placing a price on nature?
2. The image of the "self-made man" is strong in U.S. culture. What are some of the ways that government and society help create the possibilities for people to be entrepreneurial? Is there such a thing as a "self-made man" in modern society?

Part five: Technological progress

A fundamental conflict exists between economic growth and biodiversity conservation, as there is no way to continue economic growth without also irreparably destroying Earth. This fifth part of the series will explore the issue of technology and show why it will not result in ecological preservation without a parallel shift away from a growth-oriented economy toward a steady state economy. Much of this article is adapted from Brian Czech's "Prospects for reconciling the conflict between economic growth and biodiversity conservation with technological progress," in Conservation Biology, Vol. 22, No. 6, 2008 and www.workersoftheworldrelax.org.

Human beings are completely dependent on plants and non-human animals for survival and these plants and animals are in turn dependent on Earth. It is important to remember that any increase in resource use by humans means a de facto decrease in resources available for other life forms. When a mountain top is blown up to extract minerals, the plants and animals there lose their habitats and food sources. As wildlife biologist Brian Czech puts it, "The foundation of the human economy is agriculture and extractive activity that directly impacts nonhuman species… In the absence of [humans], natural capital is allocated entirely to nonhuman species. The level of human economic activity determines how much natural capital is available for biodiversity."

Yet many erroneously believe that technological advances in the efficiency of our resources will allow us to sustain an ever growing economy while decreasing our ecological footprint. Researcher Annababette Wils writes of three basic types of innovation in relation to resource use: explorative technology that helps find new stocks of resources that were previously undetected; extractive technology that helps extract previously inaccessible resources; and end-use technology that increases technical efficiency. Better technology in exploration and extraction of resources clearly lead to increases in resource use, so only end-use technologies offer any hope to reconcile the conflict between economic growth and biodiversity conservation. Yet we will see that unless the drive for growth is curbed, no technology will be able to resolve that friction.

Consider improvements in fishing technology that increases the amount of fish caught and sold per unit of fuel consumed. This will lead to one of three basic scenarios: either the same number of fish will be

caught and sold while using less fuel, which would reduce economic growth; or the same amount of fuel is purchased and more fish are caught and sold, thus increasing economic growth; or a combination where a little less fuel is used to sell a few more fish. If the overriding goal of the fishers is to grow the size of their operation, they will choose to increase their catch of fish, so the increase in technology does not result in any decrease in any overall resource use. Only by choosing to forego growth would the technology result in a decrease in resource (fuel) use.

In 1865, William Stanley Jevons noticed this phenomenon with the introduction of a more efficient steam engine. In what became known as Jevons' paradox, he showed how instead of reducing overall consumption of coal, the increase in efficiency actually increased consumption noticeably. While the more efficient engine enabled greater production, it made the transportation of goods and people cheaper thus increasing the demand for it. Similar events followed other increases in efficiency.

In 1975, Congress mandated more fuel efficient cars as a way to decrease use of foreign oil. Yet as travel became less expensive, people traveled more, bought more cars and increased fuel consumption: By 1990, engine efficiency had grown by 34 percent, and fuel consumption had grown by nine percent. One way to avoid this increased growth in consumption is through a fuel tax, or a similar policy, that would raise the cost of fuel in relation to the efficiency savings. However, the growth mindset makes policies like this difficult to pass.

A good illustration of combining policy with technology to lower an ecological footprint can be seen in European productivity and GDP levels. In the early 1970s, European productivity per worker hour was about two thirds that of the U.S. and European consumption levels were similarly about two thirds the size of the U.S. Today, however, European productivity is almost equal to the U.S., yet its level of consumption has remained at around two thirds. While the U.S. used technological advances to produce and consume more, Europe used it to create more leisure time. Work hours were decreased and annual vacation hours were increased.

It is only by combining technological advances in efficiency with policies to reduce consumption that technology will help reduce humanity's effect on the planet. If the current drive for constant growth is maintained, technology will only moderately slow down the rate of Earth's destruction, not end it.

Reflection questions:

1. Considering Ms. Wils' three types of innovation in relation to resource use (explorative technology that helps find new stocks of resources that were previously undetected; extractive technology that helps extract previously inaccessible resources; and end-use technology that increases technical efficiency), why does the profit motive make it impossible for these new technologies to reduce the overall consumption of resources.
2. Looking at the example in the second to last paragraph, which countries made the better choice, in your opinion (the U.S. or Europe)? Why?
3. One policy suggestion from ecological economists is to shorten the work week. Why would this be helpful?

Part six: Public policy reform possibilities

The previous five articles of this series have examined the various aspects and challenges of our current economic system. How do we move forward to a steady state economy, which recognizes the limits of economic growth? It will require significant changes in a number of areas, from lifestyles and mindsets to localizing economies and more. Below are a few public policy reforms that would assist in making this great paradigm shift.

New well-being measurements: Gross domestic product (GDP) growth must not be used as the principal economic goal for reasons explained in the first part of this series. Workable alternatives have been created, most recently the green net national product (GNNP). As described by Joseph Stiglitz, co-creator of the GNNP, "The 'green' means that GDP must be reduced to take into account the depletion of natural resources and the degradation of the environment - just as a company must depreciate both its tangible and intangible assets. 'Net' national product (NNP) means that there has to be an adjustment for the depreciation of the country's physical assets. A country that gives away its natural resources will see gross domestic product rise, but gross national product - which focuses on income earned by those inside a country as opposed to what is produced inside a country - may not rise much, since the value of what is produced accrues to foreigners."

Other alternatives include the Happy Planet Index and the Index of Sustainable Economic Welfare (ISEW). Shifting governmental priorities away from increasing GDP to higher scores on these other indexes would result in dramatically more ecological and equitable public policies.

New form of money creation: Currently, new money is created through the fractional reserve banking system, a seemingly simple yet mystifying mechanism. For every $1,000 deposited, a bank is only required to keep a fraction, currently about one-tenth, or $100, on reserve. The other $900 can be used by the bank to be loaned out, with the expectation of interest. This is the method by which most "new" money is created.

Say the $900 loan is used to buy a sofa. The seller of the sofa can then deposit the $900. That bank can then lend out $810 that money, which will eventually be deposited in another bank which then has $729 available for loans, and on and on. Eventually, from an initial $1,000 loan, banks can have $9,000 of "new money" to loan. The Federal Reserve has produced a comic book that describes this process more fully. Chapters 7 through 9 of Chris Martenson's "Crash Course" also explain this well. The important point is that all dollars are loaned into existence, which means that more money must be created to pay the interest on old money, which will again demand even more money. So our money supply also grows at an exponential rate. Clearly this is not a sustainable system.

The fractional reserve system is one of the fundamental drivers of our growth economy, and it must change in order to create a steady state. The alternative proposed by Herman Daly and others is to raise the reserve requirement to 100 percent. Banks would only be able to loan as much money as they had on hand. They would make profits from the difference in interest rates between their deposits and loans. New money would be created by the government that would spend new money into existence on public works projects and other societal needs. As Daly explains, "One hundred percent reserves would put our money supply back under the control of the government rather than the private banking sector. Money would be a true public utility, rather than the by-product of commercial lending and borrowing in pursuit of growth."

Financial regulations: The financial part of the economy should be much smaller than it is now. The 100 percent reserve rate would shrink commercial banks in size, but to diminish the size investment banks, hedge funds and other financial institutions, governments can use financial transaction taxes to reduce the amount of unnecessary trading that destabilizes the market while providing much needed public funding.

Commodity future markets, especially for food and energy commodities like wheat, corn and oil, must be treated differently than regular financial instruments. The deregulation of those markets in the Commodity Futures Modernization Act of 2000 allowed massive influxes of capital from outside speculators. The result was the oil and food bubbles of 2008. The Commodity Futures Trading Commission (CFTC) should place limits on the amount of money from speculators not directly involved in producing and buying commodities. If Congress decides to develop a carbon market, it should also have the same strict standards that are needed for food and energy commodities.

Tax reform: Governments need to create fairer tax systems through international ecological tax reform. It is critically important to put a price on the scarce and currently under-valued contribution of nature. A simple guideline would be to tax what is bad – pollution, resource depletion and environmental degradation – rather than "goods" (value added by capital and labor). Using ecological taxes would help to establish some of the real costs of mineral and resource extraction not included in the current system which will indirectly limit pollution and force greater efficiency in other stages of production.

Ecological taxes would create new incentives toward creating lower carbon technologies generating productive investments in the real economy. Included in this ecological tax reform would be a tax on carbon emissions. Revenues from such a tax could go towards helping small island states and less industrialized countries of the southern hemisphere to adapt to the damaging impact of climate change. Funding could also be directed towards low-income consumers to compensate for higher energy prices, and to the development of appropriate, carbon-neutral technologies in non-industrialized, resource-strapped countries for further qualitative development and poverty reduction.

Labor/Income reform: Despite new jobs in the "green" economy, the cumulative effects of peak oil, climate change and loss of biodiversity will be increases in unemployment. Two policies that address that reality are a shorter work week and a universal income. A shorter work week would generate more employment while allowing people more leisure time and decreasing throughput of resources.

With the rise in unemployment, and increasingly volatile markets, more people face uncertainty and struggle to make ends meet. A universal income, or basic income grant, provides all citizens a basic level of income, as of right, with no means test, and regardless of age, gender, marital or work status. Proposed by John Locke in the 17th century, the idea is growing increasingly popular around the world, with Brazil being the most recent country to adopt a guaranteed basic income in 2004.

Community-based economy: As a response to dwindling resources, we must move away from a global economy to multitudes of sustainable local economies. A host of new business initiatives will help consolidate these local economies, such as community development corporations, employee-owned firms, community development financial instruments, land trusts, co-ops, municipal enterprises, state asset building initiatives and others. Governments at all levels should shift financial and other incentives away from transnational corporations and into local efforts like these.

Commons management of Nature: We should stop using markets to determine the allocation and management of key natural resources and use commons management techniques that guarantee equitable and sustainable access over the long run. Elinor Ostrom, who won the 2009 Nobel Prize for Economics for her work studying commons management techniques around the world, has identified eight principles for commons management:

1. Define clear group boundaries.
2. Match rules governing use of common goods to local needs and conditions.
3. Ensure that those affected by the rules can participate in modifying the rules.
4. Make sure the rule-making rights of community members are respected by outside authorities.
5. Develop a system, carried out by community members, for monitoring members' behavior.
6. Use graduated sanctions for rule violators.
7. Provide accessible, low-cost means for dispute resolution.
8. Build responsibility for governing the common resource in nested tiers from the lowest level up to the entire interconnected system.

Reflection questions:

1. Beside those discussed here, what other policy measures would you recommend to make the economy fit within Earth's limits?
2. Were you aware of how new money is created in our current economic system? What are some problems with allowing banks to create new money through loans?
3. Discuss this quote from Pope Benedict XVI's last encyclical, Truth in Charity, "Perhaps at one time it was conceivable that first the creation of wealth could be entrusted to the economy, and then the task of distributing it could be assigned to politics. Today that would be more difficult, given that economic activity is no longer circumscribed within territorial limits, while the authority of governments continues to be principally local. Hence the canons of justice must be respected from the outset, as the economic process unfolds, and not just afterwards or incidentally."