

## Our Finite World

Exploring how oil limits affect the economy

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### Sustainability: How Humans' Economy Differs from Natures'

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A few years ago, I had an ah-ha moment when it comes to what we as humans would need to do to live in a sustainable manner. It is very easy. All we have to do is leave our homes, take off all of our clothes, and learn to live on the raw food we are able to gather with our own hands. We have a built-in transportation system, so that is not a problem.

Some animals are [eusocial](#), that is, organized in away that allows for cooperative brood care and other joint tasks. If we follow that approach, we would get our extended families to join us living in nature, *au naturel*. We could then co-operate on tasks such as child rearing and gathering food.

#### Nature's Provision for Order

Nature is organized in a number of ways that make certain that there will be modest change over time to adapt to new conditions, but that no one species will dominate. These are a few of the basic parts of the system:

1. Animals tend to have more offspring than required to replace the parents. Through natural selection, offspring that are best adapted to changing conditions tend to survive and grow to adulthood.
2. Animals tend not to kill all prey available because if they did so, they would have no food source in the future. Species are usually fairly balanced in their abilities, so that population will fluctuate within a range, rather than result in a total die-off.
3. Nature provides a great deal of redundancy, both in number of offspring, and in back-up systems. We have two ears and two kidneys, and two of many other parts of the body. The goal isn't maximum efficiency, but to have a good chance at survival, even in the case of injury or damage to one part.
4. Nature has built-in instincts to prevent depletion of shared resources, sometimes called [Tragedy of the Commons](#). Among primates, one of these instincts is an instinct toward territoriality. Males of the species tend to mark off territory much larger than they would need simply for gathering food, and will fight others to death who try to enter to their territory ([Dilworth 2010](#)).
5. In primates, another instinct that prevents excessive population of any one species is a tendency toward hierarchical behavior when population becomes too crowded for resources ([Dilworth 2010](#)). Nature's plan is that if there is an inadequate amount of resources, there will still be some survivors. Those at the bottom of the hierarchy will lose out, but those at the top will survive.
6. Each plant or animal requires energy-related inputs (food for humans) and eliminates waste. What is waste for one species acts as an input for other species. For example, plants need carbon dioxide, even though it is a waste produce for humans.

Using Nature's approach, there is a balance over time. One species may dominate for a time, and then another.

The world tends to cycle from state to state. There is never a complete die-off, no matter how bad things get. Because of natural selection, species evolve to fill new niches. Climate change is a concern from humans' perspective, because we are the potential losers. But Nature is probably equipped to deal with the issue, in one way or another.

## **The Hunter-Gatherer Economy**

Humans, as hunter-gatherers, were “sort of close” to following Nature’s pattern. Man’s big deviation from the pattern of other animals was learning to burn biomass over one million years ago. Burning biomass made man better able to cope with cold weather. Humans also evolved a higher level of intelligence, perhaps in part because cooked food allowed better absorption of nutrients, allowing humans to put energy previously used for creating big jaws and digestive apparatus into a bigger brain.

As humans became smarter, they found ways to circumvent survival of the fittest, both to live longer themselves, and to allow more offspring to survive to adulthood. ([Dilworth 2010](#)) If hunter-gatherer groups wanted to avoid over-population, they had to adopt customs that would keep population down. Such customs might include infanticide, sexual abstinence during nursing, or frequent wars with neighboring tribes.

Research on hunter-gatherer groups that have survived until modern times suggests that very often they spent only a few hours a day hunting and gathering food, allowing much time for leisure activities ([Sahlins 1972](#)). Humans were tall (men averaged 5’10” in height), had few dental cavities, and showed other signs of excellent health ([Wells 2010](#)).

As hunter-gatherers, there was no need for money or land ownership. Sharing within the clan seems to have been typical, perhaps as a [gift economy](#), where status is gained by how much one can give away. Thus, all had access to food. There was no storing up goods for a “rainy day.” The only “storing up” was what nature provided in terms of stored body fat that prevented starvation if food was unavailable for a short period of time.

## **Early Agricultural Economies**

With settled economies came a whole host of complications. Food from crops needed to be stored, so storage facilities were required. Families staying in one place needed homes. There was more division of labor, so there was a need to pay workers so that they could purchase a share of food produced by others.

With fixed areas of land being used for crops, there came a need for “ownership” of land. There also came a need for government for various reasons—to solve disputes, to set up rules, to mint coins, to make infrastructure such as roads, and to provide defense against neighboring groups. With such government, there came a need for taxes.

There also came a need for a means for financial transactions. Contrary to common belief, barter was never widely used. One approach that was used involved a temple acting as a central clearing house that both bought and sold goods. The temple would convert all goods to a common basis (say, bushels of barley or shekels of silver), and run a tab for each patron. In a way, this was an early form of credit ([Graeber 2011](#)). Very little silver actually changed hands. Making enough coins to cover all transactions would have been cumbersome.

As in the Hunter-Gatherer Era, families tended to have more children than needed to replace the parents because of Nature’s plan for natural selection. Humans as in earlier times outsmarted Nature’s plan, putting upward pressure on population. Some groups instituted customs to keep population down, such as sacrifice of

first-born infants to the local deity.

As population pressure grew, farmers found temporary solutions to the need for more cropland—for example, cutting down trees on hillsides, even though this would lead to serious erosion, or irrigating crops to increase yields, even though this would eventually lead to salt deposits and loss of fertility. David Montgomery, in *Dirt: The Erosion of Civilizations* (2007) discusses the serious erosion and soil degradation issues that resulted. Deforestation seems to have occurred in many areas as early as 4,000 B. C. E. (Chew 2007).

As mentioned previously, there is a natural tendency of primates is to be territorial, as a way of limiting population. Human increasingly overcame this tendency through trade relationships. Some religious teachings also helped mitigate the tendency to fight—for example, “Love thy neighbor as thyself” (Matthew 22:39). Wars still continued, very often over resources, helping to hold population down.

With additional food provided by agriculture, individual civilizations still tended to grow. They very often eventually collapsed, as growing population eventually led to diminishing returns in food production in a given area (Tainter, 1988).

During this period, the vast majority of workers were involved in agricultural work, likely 80% to 90% during peak agricultural work periods. The need for so many workers meant that those who were in charge were strongly motivated to make certain that workers received an adequate wage.

The need for so many agricultural workers tended to limit other activities. Government could not grow above the level the tax base would support. Services, such as education and medicine, could not expand very much, because agricultural surpluses necessary to pay for these services were small.

Health was much worse in the Agricultural Era than in the Hunter-Gatherer Era. This occurred partly because of a change in the food eaten, and partly because living so close together promoted greater germ transfer with other humans and with domesticated animals (Wells 2010). Average height of men gradually dropped by 6 inches relative to the Hunter-Gatherer Era.

Spread of disease was a problem, especially in cities. Diamond reports that it was not until the early 20th century that European cities became self-sustaining for population. Before then, a constant immigration of healthy peasants was necessary to make up for the many deaths of city dwellers from crowd diseases (Diamond 1997). This flow of immigrants had an upside—it provided a source of jobs for the growing rural population. Growth in job opportunities also took place after major epidemics reduced population.

## **The Fossil Fuel Age**

The availability of fossil fuels ramped up humans’ ability to quickly turn natural resources into goods and services. In particular, fossil fuels vastly increased our ability to grow food and transport it to consumers. The “catch” is this creates a fossil fuel dependency—it now requires from 7 to 10 calories of fossil fuel energy for every 1 calorie of food energy produced (Heller 2000). With better nutrition, heights of men increased again. In recent years, heights in the United States are back up to those of the Hunter-Gatherer Era (Wells 2010).

By ramping up production of goods using fossil fuels, we also greatly increased the amount of pollution. (See *The Story of Stuff* by Leonard 2007 or [here](#).) Many of goods we make using fossil fuels are not easily biodegradable the way plant or animal products would be. Also, separating desired natural resources from the materials they are found with leaves huge amounts of polluting bi-products, such as mercury found with coal.

There is also the issue of carbon dioxide emissions from burning fossil fuels.

The availability of fossil fuels led to the ability to make metals, glass, concrete and many other materials in great abundance, without the problem of deforestation. This ability allowed humans to adopt many types of technology that would have been impossible without fossil fuels, such as cars and trucks, electricity transmission systems, huge-ocean going ships, and nuclear power plants.

The growth in “stuff” led to much greater accumulation of wealth by a select few. This accumulation of wealth led to a need for a financial system that would allow people to hold onto this wealth and to transfer that wealth from person to person. While early debt corresponded to simply “running a tab,” without much time-transfer involved, the time-transfer aspect became increasingly important with greater wealth accumulation. Of course, this time transfer aspect only works if the system is growing. If the system is shrinking, time-transfer is like playing musical chairs, with ever-fewer chairs.

Debt tends to play a big role in fossil fuel extraction, for several reasons:

1. Debt allows potential consumers to afford new technology that was enabled by fossil fuels, such as cars and refrigerators.
2. Debt provides businesses with funds to build factories to make new devices enabled by fossil fuels.
3. Debt can provide funds for extracting fossil fuels. This is often not an issue initially, but becomes more of an issue as extraction costs rise, when diminishing returns set in.

Both governments and businesses grew greatly in size, as the growth in fossil fuel use allowed the work force to move out of agriculture into other fields. In the United States, only 1% of the work force is currently engaged in agricultural work, while 19% work in industry and 80% in services ([CIA Fact Book](#)).

The removal of the workforce from being directly involved with food production means we can't directly count on our work providing the food we need. While hunter-gatherers could depend on their own work supplying their needs and early farmers weren't too far removed from, we have now created a huge system of intermediaries that together are supposed to supply our needs.

## Looking Closer at the Economy, Governments, and Businesses

In general, world GDP growth tends to correlate highly with energy consumption.

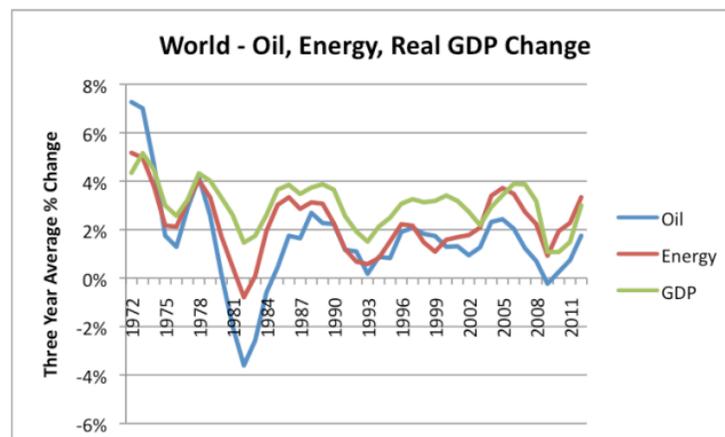


Figure 1. Growth in world GDP, compared to growth in world of oil consumption and energy consumption, based on 3 year averages. Data from BP 2013 Statistical Review of World Energy and [USDA compilation of World Real GDP](#).

There seem to be two reasons for the correlation:

1. It takes energy to make anything, even services that don't seem to use much energy.
2. The amount of energy products that governments, businesses, and individuals can *afford* is determined by wages, taxes, and business revenue. As these sources of revenue grow, potential purchasers can afford more fossil fuels. Economists call this "demand," but I think that "amount affordable" is a better description of the nature of the relationship. Oil is the highest priced of the fossil fuels, so its growth has been least. Businesses substitute away from oil wherever they can, and consumers buy more efficient vehicles.

Because of the importance of energy price, economic growth tends to go to the countries where energy costs are lowest. These countries tend to be the countries that use the least oil as a percentage of their energy mix.

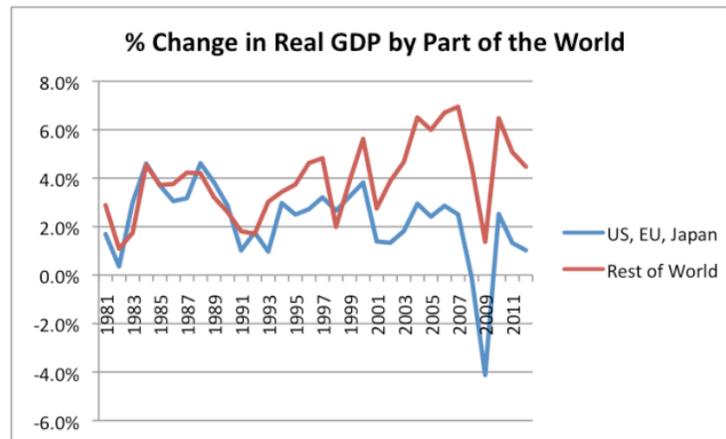


Figure 2. Annual percent change in Real GDP by part of the world, based data of the USDA.

The United States, the European Union, and Japan tend to get a much larger share of the energy they use from oil than the rest of the world. It is these countries that especially have had a problem with falling GDP as oil prices have risen in recent years.

In fact, if we look at detail data, we find that this relationship of poor growth going with countries with the highest oil percentage of energy use from (high-priced) oil tends to extend to smaller groupings. For example, the PIIGS in Europe (Portugal, Ireland, Italy, Greece and Spain), known for their job problems and economic distress, are also countries that were characterized by unusually high percentages of their energy consumption from oil. On the other hand, China gets most of its energy from coal, which is quite cheap. It has been able to soar ahead economically, with job opportunities for its people.

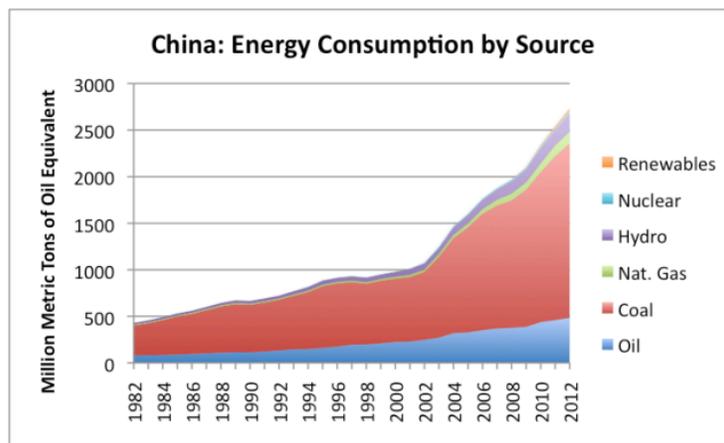


Figure 3. Energy consumption by source for China based on BP 2013 Statistical Review of World Energy.

Figure 3 shows a clear “bend” in China’s coal consumption usage after China joined the World Trade Organization in 2001. This bend points out another issue. Countries with access to cheap coal and cheap labor are now able to compete with the historically industrialized countries, and tend to do very well in this competition. The cheap labor costs are to some extent a reflection of a subsidy by Nature: People living in warmer parts of the world (with more solar energy!) don’t need as much fossil fuel energy to heat their homes and for heated transportation, so can live reasonably well on lower wages. The new competition from inherently lower-cost producers is another reason for the shift of economic growth away from the developed world.

What we end up with in the United States is a trend toward ever-lower economic growth:

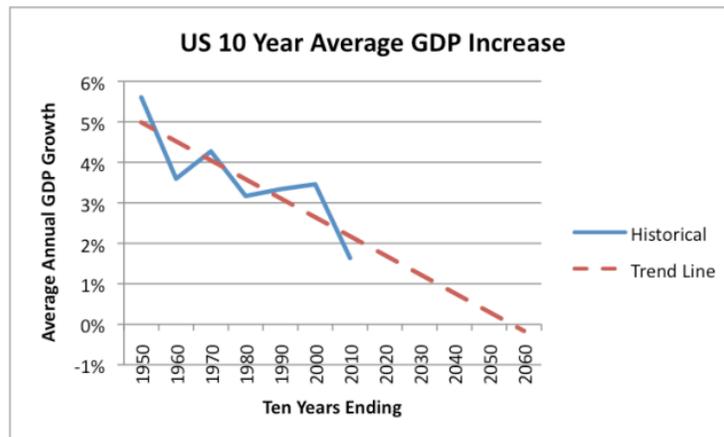


Figure 4. US Ten Year Average Real GDP growth, based on BEA data.

## Dividing Up the Economic Pie

If each of us were growing our own food, or leading a life of hunting and gathering, there would not be an issue of dividing up the economic pie, because our claim on the economic output would be clear.

GDP, as you recall, is the total amount of goods and services produced. If the amount of such goods is growing rapidly, there is not a huge problem with dividing up the output, because the situation is more or less following “plan.” A problem arises when the rate of enough growth shrinks, and there is not really enough for everyone, including government, wage earners, businesses.

Let's think about some of the pressures. Business investment is part of the total use of GDP. If the cost of oil extraction is rising, the cost of oil investment tends to squeeze other investment—either that, or lead to a great deal more debt. Interest payments are part of the total as well, transferring wealth around the system. It is doubtful that wage-earners get much benefit from this transfer. It is more likely that the transfer takes funds from wage-earners and transfers them to financial institutions.

Why should wages rise? Most wages are paid by businesses, and businesses see *profits* as their primary reason for their operation. Businesses have no particular motivation to raise wages. In fact, as globalization allows the pool of low paid workers from around to grow, businesses have little need to raise wages on jobs that can be transferred to parts of the world where wages are low. Businesses also have the option of replacing workers with technology, such as computers handling task formerly handled by humans. Governments are employers as well, but they find it hard to take up the slack in wages, because they have difficulty collecting enough taxes to cover current operations.

Businesses do their best to cut governments out of tax revenue, as well. With their world-wide operations, businesses can choose an appropriate domicile and avoid most taxation. There is also the opportunity to use investment approaches that avoid taxation, such as Real Estate Investment Trusts and Master Limited Partnerships.

These actions by businesses leave governments and workers mostly on their own, when trying to deal with inadequate growth in GDP. Governments find themselves getting most of their tax dollars from wage earners, rather than corporations. Workers, whose wages are not rising very much, find it hard to pay what is asked.

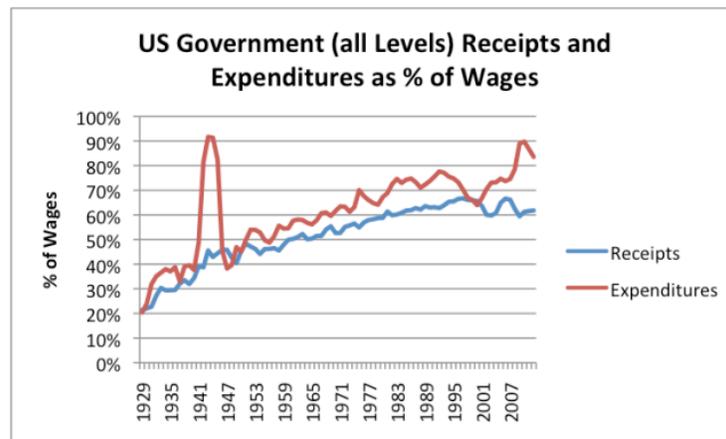


Figure 5. Based on Table 2.1 and Table 3.1 of Bureau of Economic Analysis data. Government spending includes Federal, State, and Local programs.

Figure 5 shows the long-term trend in government spending, compared to wages. There has been a long-term trend toward ever-increasing government expenditures. In fact, expenditures in recent years have come close to those during World War II, as a percentage of wages. Revenue collection has fallen off since 1997. The gap in recent years between revenue and expenditures leads to ever-increasing governmental debt. As the government's share of the economy gets larger, it leaves less for wage-earners, on an after-tax basis.

At least part of the problem governments are facing is the fact that since 2000, there has been a decrease in the percentage of the population with jobs. This time period matches up closely with the big growth in China's economy shown in Figure 3. US baby boomers are also starting to retire, adding to the effect.

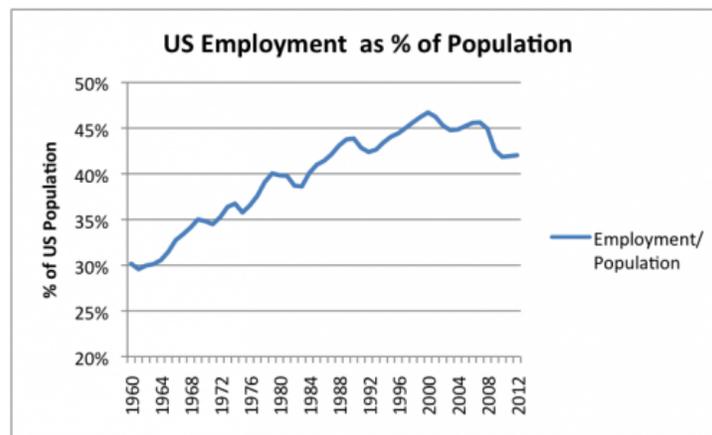


Figure 6. US Number Employed / Population, where US Number Employed is Total Non\_Farm Workers from Current Employment Statistics of the Bureau of Labor Statistics and Population is US Resident Population from the [US Census](#). 2012 is partial year estimate.

Programs such as Social Security, Medicare, and Unemployment Insurance were set up without explaining to the general population that we live in a finite world. Because of this, at some point, growth is going to have to slow and even turn to contraction. All that is available to pay out is what is paid in (plus perhaps funds accumulated in a trust fund, if these funds are truly available). This means that it is likely that at some point, benefits will need to be cut from current levels, even if this is terribly painful.

### A System Set Up for Growth

Businesses in general are set up with the expectation of growth. Businesses have fixed costs. If they can grow, profits tend to increase disproportionately. If businesses shrink, profits tend to drop disproportionately. So businesses have a very strong bias toward growth.

Financial institutions have even a bigger problem with needing growth, for two reasons. First, if the economy doesn't grow, there is a much higher probability of loan defaults, because of the issue mentioned in the preceding paragraph—businesses don't grow, so their profits are squeezed. Some of these businesses default on loans. These defaults affect the income statements of the financial institutions, and also their equity positions.

Second, financial institutions need to be considered "healthy" to continue lending. It doesn't take very many defaults before the equity that allows the financial institution to continue lending becomes impaired. So once the economy slows down, there is a significant chance of bank failures, and a need for bank bailouts, similar to what we experienced in 2008.

We are now at a point of falling economic growth, partly because we are being squeezed by high oil prices, and partly because we are being squeezed by globalization. The oil price issue is really a manifestation of diminishing returns. Oil companies are making increasingly large investments, but are getting fewer barrels of oil out per dollar of expenditure.

Globalization problems reflect the fact that industrialization grew up where deforestation was the biggest problem—that is, where cold weather led to excessive use of forests. Coal use solved the deforestation problem, and brought the bonus of industrialization without much competition from elsewhere. Now, as globalization brings industrialization to the rest of the world, we are discovering that the developed world cannot really compete with the rest of the world's cost structure.

When there is not enough economic growth, someone gets squeezed. The way the system is set up now, it is **wage earners that come out especially badly. Governments also get squeezed**, because their tax revenue drops, at the same time citizens need more benefits because a large number of citizens cannot find good-paying jobs. If banks default, this adds a new set of problems for governments.

The situation looks very brittle. Recently, the US Federal Government came close to defaulting on its debt, supposedly because of differences between Republicans and Democrats. It seems to me that the problem is much deeper than this—there is a huge mismatch between revenue and expenditures that cannot be fixed without cutting major programs. Adding Obamacare, even if some type of health insurance program is badly needed, makes the situation worse.

Since only 1% of us work in agriculture, nearly all of us depend on the system working in order for us to have food to eat. Keeping the system together is difficult, though, because businesses of all kinds—especially financial institutions—depend on economic growth, and economic growth is what is failing.

The government can do what it can to disguise our current problem—ultra low interest rates, continued deficit spending, and continued Quantitative Easing—but none of these really fix the problems. What is really needed, if we are to continue our current system, is a return to economic growth—something that can't happen with diminishing returns in oil production and with continued globalization. Without a return to economic growth, a financial and/or governmental collapse looks likely.

### How about other solutions?

We hear endlessly about wind and solar PV, as if they might be solutions to our energy problems. They are basically irrelevant, or act to make the situation worse. I will try to address them in another post.

We also hear about oil from shale formations, as if that oil will solve the world's economic problems. It is basically too late, and the price of oil extraction is too high to make any difference. We are basically into a situation of diminishing returns. [A recent article from Rigzone](#) says that in order to do the additional development planned, companies developing US shale formations may suffer a *two trillion-dollar* investment funding shortfall, relative to the amount of capital they have been able to raise in the past.

With this kind of shortfall in the US, a person can only wonder how much funding, from where, will be needed to develop shale formations around the world. This issue arises at the same time that world economic growth is slowing, reducing the overall size of the global economic pie for development of all kinds.

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#### About Gail Tverberg

My name is Gail Tverberg. I am an actuary interested in finite world issues - oil depletion, natural gas depletion, water shortages, and climate change. Oil limits look very different from what most expect, with high prices leading to recession, and low prices leading to inadequate supply.