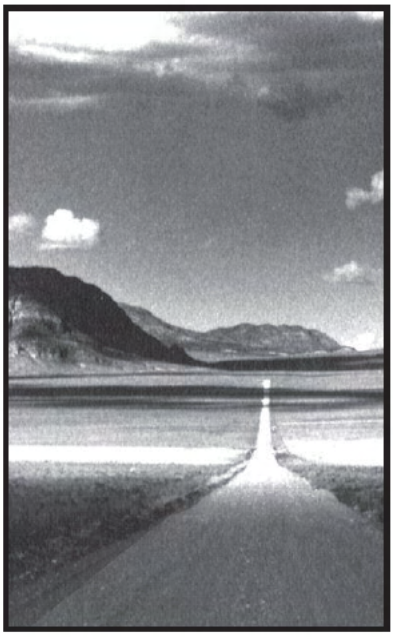

VALEDICTORY:

The Age of Overshoot

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Negative Population Growth, Inc.

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Introduction

Civilizations have overused their resources before, and collapsed or moved on, but never on a scale remotely resembling the present threat[1], and now the Earth is full. There is nowhere to move. There is a fatal disconnect between our national policies, which are geared toward faster economic growth, and our growing scientific understanding of the limits to growth. This country and much of the world are driving into those limits, and only a fundamental rethinking of growth will spare us that future.

Even those who are not wedded to growth often try to solve our problems piecemeal with technical fixes. That is tunnel vision. Such "fixes" alone will not cure the resource and environmental threats generated by past and continuing growth. We face interactive problems: the energy transition, climate change, intensifying fresh water shortages, and present and prospective shortfalls in food production. Together, they warn us that current population and consumption levels will not be supportable in the future.

We should indeed seek technical fixes, but we must begin policies to reverse the growth of demand, and that begins with population and therefore – in the United States — immigration policy. Barring a dramatic change of direction, the Census Bureau projection of 420 million Americans by 2050 is – from past experience — likely to prove much too low. Particularly if the nation adopts the immigration amnesty proposals being made by leaders of both political parties, our population may well rise to 500 million by then, and keep growing.

THE DIALOGUE OF THE DEAF

We live between two mutually uncomprehending worlds. Scientists are documenting the rising damage that increasing human activity is causing to the natural systems that support us, but mainstream economists regularly call for more growth and more economic activity. Our present national debate about mass immigration ignores its principal consequence: the dramatic acceleration of U.S. population growth. And at every G8 summit meeting the heads of state proclaim the need for faster economic growth. Either they are in denial of the scientific evidence or they suffer from cognitive dissonance and try to hold two irreconcilable views of reality at the same time.

In the past two centuries, and particularly in recent decades, man has created disturbances in the Earth's systems more profound than any other species since cyanobacteria began introducing oxygen into the atmosphere in the Proterozoic era and thereby created the conditions for the multiplication of life forms. The cyanobacteria's activity benefitted life; our present human activities do not.

* U.S. and total human populations have quadrupled in one century – to 300 plus million and 6.5 billion. Humans now appropriate nearly half the net terrestrial primary productivity from photosynthesis. To support that growth –

* We have moved carbon, hydrocarbons, methane, sulfur, phosphorus, potassium, mercury, lead, tin and many other metals and radioactive materials from the lithosphere into the biosphere and fundamentally altered their balances and flows.

* We extract inert nitrogen from the air and reintroduce it to the biosphere in much less stable forms.

* We are changing the composition of the atmosphere.

* We are warming and acidifying the oceans.

* We have dramatically altered hydrological flows and overused fresh water resources.

* We have created over two million new chemicals and artificial genetic modifications, close to 100,000 in commercial quantities (depending on one's definition of that term). The European Union (EU) has tried to analyze the impact of thousands of these, and Canada has actually banned some of them, but the U.S. has hardly begun, except for pharmaceuticals.

* We are causing the extinction of other species at an unknown rate, but one that certainly exceeds any change since the Cretaceous extinctions.

– and we are doing it in an instant of geological time.

These changes, interacting, have led to

– worldwide climate change,
– the looming decline of fossil fuels,
– shortages of fresh water and lowered water tables,
– desertification,
– intense competition for arable land,
– the proliferation of harmful chemicals,
– a growing threat from drug-resistant pathogens,
– the problem of "invasive species" of plants and microbes in environments unprepared for them,
– the continuing loss of forest area and quality,
– and more crowded and conflicted societies.

We do not yet know how all those changes will affect life systems, but it is becoming clear that the combination of resources that has supported the population growth is eroding. Present populations – to say nothing of those projected – will not be sustainable after the fossil fuel era at anything like the consumption levels we enjoy in the industrial world.

In this gathering crisis, national and local policies are almost invariably at cross purposes with the environmental knowledge that we are acquiring. China and India, for example, are feverishly pursuing automobile-driven, energy-intensive growth policies even though their leaders know that fossil fuels are both the principal source of global warming and a vanishing resource, and before long we must all accommodate to a much more frugal energy future. (Be it said that there are signs of some unease within the Chinese establishment about the wisdom of that policy.) The United States faces an even larger problem because we have already built an energy-

intensive infrastructure and are intent on expanding it. The consequence will be some form of collapse if we all cannot learn to pursue policies compatible with what we know about limits.

I will try to show where the mainstream economists go astray. (I use this term as a convenient shorthand. There are economists who recognize the perils of continuing growth, but the conventional economists ignore them.)

As to the politicians: I believe there is much more wisdom among the voters than politicians recognize. Money and greed are close companions. Politicians generally respond to money, and greed may lead those who provide it to the denial of limits, but the prospect of losing elections may be a powerful corrective, if the general public malaise at the costs of growth is translated into political activism.

NPG stands for Negative Population Growth. For 35 years, it has argued that growth must not simply stop; it must be reversed. That message becomes more urgent, the more we grow and the more we learn. I hope that the following section will make clear that the current and prospective U.S. population levels will be unsustainable in the face of the global changes already under way. We need to persuade our political "leaders" that a livable future can be achieved only by reversing population growth, changing our consumption habits and indeed our living arrangements, and using technology in a supplemental role, to achieve better and less stressful living patterns with much more limited energy and resources.

THE LESSONS FROM SCIENCE

The Earth is a much less stable and accommodating system than scientists thought a century ago, from continental drift to climate change. What have we learned in recent decades about the threats to the natural systems that support us? I have written about them before.[2] This time, I will simply identify them and show the synergies and interactions that make the total impact more than the sum of its parts.

I will confine myself to four interacting areas: energy; climate; fresh

water; and food production. Some of the other issues identified above may eventually turn out to be just as important, or more so. The U.S. official responsible for dealing with infectious diseases said a few years ago that we are losing the race against pathogens. As biologists regularly point out, we live in and are kept alive by a complex microbial world that we hardly understand. That microbial system supports all life; the changes we are inflicting on the biosphere may indeed imperil their balance and our existence. Those dangers, while vast, are less easily quantified than the ones I have selected, and more speculative. Thus the limits to my coverage.

Science describes the problems. It is up to the political process to develop the solutions. And that can be started only by a consensus among an informed and demanding electorate. I will intersperse the scientific information with brief notes *in italics* as to the policy implications. Little of this is new except for my emphasis on the demographic connections, which have not been introduced by other commentators, as far as I know.

The Energy Transition. We will still have energy even after fossil fuels are unavailable, but less of it, and there will be daunting new problems. Biomass energy must compete with food and fiber for land and water. The other potential renewable sources will be erratic or intermittent, and much costlier than fossil energy. Nuclear energy will be part of the mix, but it is an uncertain and potentially hazardous solution.[3]

The Decline of Oil and Gas. Scientists who warned that we are fast using up our oil and gas resources were dismissed as cranks a few years ago. Now, their warning is mainstream wisdom, and the argument is about "when." The so-called Peak Oil scientists think the peak is imminent. Even optimistic projections such as those by the USGS (U.S. Geological Survey) suggest that oil production will peak in less than 20 years, and gas not much later. After that, production is expected to move down, ineluctably but probably erratically.

Where are we now? The EIA has published a preliminary gross world crude production estimate for 2005: two percent above 2004. It is anybody's guess when that trend will turn, but it won't be long.

The United States is 37 years beyond its peak. We import 75% of the crude oil we consume.[4] We must rely increasingly on some very unreliable

suppliers. We are not the ones who will decide whether we can continue to consume huge and growing amounts of petroleum. We are living beyond our means and running an immense international balance of payments deficit. The competition is intensifying from China and other nations that have large foreign exchange reserves while we have squandered ours. We are an increasingly vulnerable competitor in the contest for oil. Meanwhile, the major exporters have come to realize that they have an oligopoly of a vanishing commodity, and they are getting more and more assertive in controlling their resources and influencing the price and rate at which they will be sold. (See Free Trade discussion below.)

There is another dramatic trend that receives less attention. It takes more and more energy to find and extract gas and oil. Net usable energy output is therefore not keeping pace with gross output. When the energy output from any given field does not much exceed the energy input, extraction will stop, simply because it does not pay. Some pumping may persist, to provide chemical feedstocks, if coal or electricity can be used to extract the oil and gas, but that is not energy production.

Canada's Athabasca oil sands illustrate the problem. They were not considered "conventional oil" until recently. At maximum exploitation, they may add 2 percent annually to present gross world crude production, and last over a century. The catch is that their energy output:input ratio is only 3:2 – i.e. you get only 50 percent more energy than you put in. And right now, good, clean gas is the input, being used to produce a much dirtier output – hardly an attractive swap.

Gas and petroleum are essential to food production. They are used to produce commercial fertilizer and pesticides, and to drive the trucks, tractors and machinery of modern agriculture. In the era of renewables, most energy will be electrical, which is no substitute for gas and oil in those uses. I will come back to that.

Electricity can drive trains and, less efficiently, trucks and automobiles, but not aircraft. Yet we are building for yesterday's realities, expanding and modernizing the world's air fleets, just before the rising price and eventual unavailability of petroleum make them obsolete.

Gas and oil provide the feedstock for much of industry, and crude oil

furnishes the asphalt for our roads. The dislocations as they wind down will be immense, and the search for substitutes will not be easy.

Environmentally, the less fossil fuels we use, the better off we are, but that does not mean that somehow we can simply wave a wand and dismiss them. We would strip the Earth foraging for substitutes. We cannot just walk away from what we have done.

Coal is an unsatisfactory and potentially very dangerous stopgap. It can be converted to synthetic gasoline, but half its energy is lost in the process. That is a stiff penalty as fossil fuels all decline. Used conventionally, it generates much more pollution than gas or oil. Even more important, it generates much more carbon dioxide (CO_2), the leading cause of anthropogenic climate warming.

Prototype power plants have proven that a more benign alternative is available: coal gasification (the integrated gasification combined cycle, or IGCC). The coal is fractionated, and commercially valuable chemicals such as sulfur can be recovered, in addition to the energy itself. It is a more expensive process than simply burning the solid coal. It has been a very slow starter, even in the United States, and the coming giants such as China and India still have no plans to make the shift. Let us hope that we all come to our senses before we choke. (IGCC does not work, by the way, with sub-bituminous or lignite coal, which will require a more complicated cleaning process.)

There is one huge problem with coal, however it is burned. Neither process captures the carbon dioxide released by the burning coal. The CO_2 can be captured (fairly easily during gasification) but then the question arises: where do you put it? Beware the “experts” who promise that it can be sequestered, and who even assign a price to the process. The problem is the scale, not the technical challenge. Presently, we release some 27 billion tons of CO_2 into the atmosphere each year, and the figure is rising. To bring that figure down to a level that would stop driving climate warming, we would need to sequester about 18 billion tons of it each year, and the amount is rising. That is a stupendous amount. It is larger than the annual world production of coal, crude oil, cement, grains and iron ore combined. And being a gas, it occupies a much greater volume.

– It has been suggested that it can be incorporated into silicate rock, but that would double or treble the tonnage, and nobody has determined that the process is practical, or calculated the cost.

– If you put it underground in salt cavities, porous rock and old mines, under pressure, and it escapes, it may suffocate all animals – including humans – in low-lying areas near the vents. (This has happened with natural emissions in Africa.) Even slow leakage would undo the effort to store it.

– Try to bury it in the deep seabed, and what happens to marine life as the water acidifies?

The IPCC (the UN Intergovernmental Panel on Climate Change) has made a preliminary survey suggesting that there is enough subterranean space "technically" available to accommodate all that gas, under pressure – year after year – but that survey is laced with uncertainties.[5]

Coal may help to extend the fossil fuel era for the United States, but not for many countries. Alone, we have 25 percent of estimated world reserves. Another 52 percent is in Russia, China, India, Australia and Germany, in that order. That may be a curse rather than a blessing, because it is such a dirty fuel, but it does provide something like two or three generations to adjust to other energy sources – if we keep most of it for our own use. That poses a conundrum: how do we limit the export of coal, when we now call upon other nations to sell us their oil, in the name of free trade? More on that later.

** We must find a way to trap and sequester CO_2 emissions. If we fail, prepare to try to enforce very low limits on the rate we burn coal and petroleum. If we cannot sell that idea, politically, our descendants will have to head for the uplands, along with everybody else. This puts a particular responsibility on the United States, simply because we have so much of the coal. We could reverse U.S. population growth – and thereby spin out our demand for coal – simply by reducing immigration. (See Solutions on the Demand side below.) Fortunately, the other big players either have declining populations or are trying to stop growth.*

** A declining population would use fossil fuels more slowly. That would mitigate their damage, give us more farmland to raise substitute*

feedstocks and extend the transition to renewables.

** Rising prices will be a powerful stimulant to more efficient energy use, but deliberate policies can encourage the adjustment to the fossil energy transition, such as revising building codes to require more energy-efficient buildings. (This ties in with my suggestions concerning solar energy, below.)*

** We tax the wrong things. Tax pollution, fossil energy consumption, and greenhouse gas production. (The Germans and Swedes are moving in this direction.) This alone would encourage utilities to build gasification plants rather than conventional coal burning power plants. Higher taxes on fossil fuels would slow their consumption, ease the impact on climate and save them as chemical feedstocks, especially for fertilizer.*

** Tax automobiles and trucks much more heavily, and subsidize electric buses, trolleys and light rail until they can recover their market. (The long-haul railroads are already in place. They will eventually have to begin to switch back to electric or steam power, but microeconomics will take care of that transition.) This will promote more energy-efficient ways of transporting people, goods and food and encourage consumption of food from local sources. The revival of urban and interurban bus and light rail services would promote more energy-efficient residential and transportation patterns.*

** Cap and trade arrangements for pollutants and CO_2 emissions are popular with industry because they offer the prospect of profits. They are complicated and less effective than taxes in forcing changes at the scale we need, but they will undoubtedly play a role because they are politically saleable.*

** Promote the spontaneous current trend toward new working arrangements, with more work done in homes, and less commuting. Promote teleconferences rather than traditional conferences and conventions. In other words, encourage less energy-intensive electronic communication to replace physical movement.*

** Education can also be used to encourage the use of more efficient machinery, transportation and household appliances. Rising energy prices as we approach the age of renewables will probably be the most*

compelling form of education, if people know the energy-efficient alternatives and can obtain them. By that time, car-pooling, public transport, clotheslines, hand dishwashing, individually controllable room heating and cooling, and smaller rooms and houses will be back.

** Bring down peak electricity demand. Educate people for a future in which energy supplies will be erratic by offering inducements to limit power use during peak periods, when the demand is highest and power costs the most. Propagate "smart meters" so customers can manage their daily use of power to save money.*[6] *The least efficient and most polluting power plants are put into use in peak demand periods. Bringing the peaks down will benefit the environment and reduce greenhouse gas emissions.*

Nuclear fission and fusion. "Conventional" fission reactors such as we presently use will begin to suffer from resource depletion before the end of this century. Theoretically, the oceans hold an almost limitless supply of uranium, but here again the net energy question arises. Proponents treat extraction from seawater as an assured thing, but nobody has yet shown that it can be recovered cheaply enough to produce a positive net energy output.

"Fast reactors" (breeder reactors) are a very tricky way to extend the resource. They use molten sodium at very high temperatures – which can react explosively with water – as their heat transfer medium. (A molten lead/bismuth heat transfer medium has been suggested for some breeder reactors now in the proposal stage.) Japan and France have shut or throttled down their prototype fast reactors for safety reasons, and only Russia is continuing to operate one. Breeders' fatal attraction is that they produce nuclear fuel – and incidentally, the input for nuclear weapon grade plutonium – even as they produce energy. They are not perpetual motion machines. The recovered plutonium must be mixed at a ratio of approximately 1:3 with uranium 238 for re-use in a reactor. The French have found that they can recycle spent fuel for their conventional light water reactors only two of three times, after which it becomes so saturated with highly radioactive "daughter" elements that it must be incorporated into vitrified ceramic containers for eventual long term storage. The same problem arises, in spades, with the spent breeder fuel. Even so, they will extend uranium supplies several fold if they can be made to work.

A thorium/uranium 233 fast reactor is also a theoretical possibility, but

an unknown quantity. It is more common in nature than uranium 238, but the problem of noxious "daughter" elements is apparently even worse than in the uranium/plutonium reactors.

Nuclear fusion is still a dream, and physicists are divided over the question whether it will ever produce a sustained net output of electricity.

In other words, while nuclear power will almost certainly play a role in the energy transition, there is no assurance that it will be available over the long term.

Nuclear reactors are presently more expensive energy sources than modern coal or gas power plants. The complexity of the proposed breeder and fusion reactors means they will probably be very expensive – if they can be made to work.

** We must continue the research on fast reactors and fusion. That research, and research on carbon storage, are perhaps the most important scientific quests we are engaged in. Even if we succeed, however, it will provide electric power but not the mobile energy and chemical feedstocks we now get from fossil fuels.*

Renewables. Of the various renewable energy sources, only three have the potential to replace a significant fraction of fossil energy: biomass; wind; and solar.[7]

– *Biomass* (plus its relative, methane or "biogas" from sewage plants and cattle manure) comes closest to duplicating fossil fuels' many uses. It can be burned directly, converted to diesel or ethanol, and used as a substitute feedstock for some industrial uses. But it has serious problems. It is a diffuse energy source. It might take roughly 350 million hectares – equal to one-quarter of the world's arable land – to replace something like 5 percent of present world fossil energy production.[8] Proponents treat this as a possible energy solution (exhibiting the tunnel vision that I will criticize later) but they forget that it must compete for land and water with food, fiber, lumber, and (increasingly) chemical feedstocks, including cellulose. The land that can be harvested is, by and large, already harvested for those uses, and the remaining land is likely to be sub-marginal or already used for simple biomass (grass and wood) gathering, particularly in the poor countries.

Moreover, it competes with land that the climatologists hope to use for new forests to combat global warming. And land and water are under rising pressure from desertification, urbanization, and the intensifying competition for fresh water (see below).

We are witnessing a particularly short-sighted effort to replace gasoline with biomass. President Bush has belatedly discovered that petroleum supplies are in peril, and he would like to replace part of our consumption with ethanol. The corn lobby is rejoicing, the use of corn to make ethanol has soared, and now about 20 percent of U.S. corn output is going into ethanol to replace less than 3 percent of our gasoline consumption.

That new industry exists because it is heavily subsidized. Scientists are debating whether we get <u>any</u> net energy in the process, after deducting the energy necessary to grow and convert the corn. However, one consequence is clear. The price of corn went up 80 percent in 2006. This drives up the price of meat and chicken, worldwide. The President has called for us to replace 15 percent of our gasoline use with ethanol (which is less efficient). If we did, we would use all our corn to make ethanol, which would be a disaster for our own food supplies, for our corn exports, and for worldwide meat and chicken production. And (going back to that net energy question) we might not save any petroleum or gas.

That ethanol "solution" illustrates the dilemma we face as we try to adjust to the energy transition. We need to encourage change, because we have little time. But we will waste resources, time and money if we rush into decisions before we understand them. In this case, we would do better to make ethanol from stems and the cellulosic parts of our crops, but that too poses a problem: they are now used for silage and green manuring, which will become particularly important as commercial fertilizer production declines with the decline of petroleum and gas.

** Trial and error is the safest of decision processes. We must encourage experimentation to find the best formula, and be ready to learn if other nations find it.*

The price of petroleum feedstocks for plastics production has been soaring, so chemists have been developing a substitute feedstock from corn fructose. Now they are caught between a rock and a hard place as corn

prices also rise.

Biomass requires fertilizer and water if the yield is to be high enough to warrant harvesting and processing, but here again it must compete with other users[9] for dwindling supplies of both.

** Population size will be a critical determinant of the future of biomass. With a low enough population, the competition would ease, and we could have food, feed, fiber, chemical feedstocks, and biomass energy. But not now. Until populations decline, new biomass production will be limited to the fringes – to the waste cellulose products not presently being used.*

– *Wind* is a concentrated energy source – if the wind is blowing just right. The "sweet spot" is the range between 18 and about 40 mph. In that zone, it is already nearly competitive with fossil energy and cheaper than nuclear energy. However, because the wind is erratic, wind turbines generally operate at only 20 to 30 percent of their rated capacity. And experience in Europe shows that it is too erratic to be counted on for more than 20 percent of the power fed into a grid, because of the cost of the backup fossil generating capacity and the serious operational problems of integrating it with grids that are already managing power fluctuations responsive to fluctuating demand. .

** So long as there is enough fossil and nuclear energy capacity, wind may be relegated to a niche role. However, it is potentially too valuable a resource to dismiss. The subsidies it receives may be a good investment in the future. Utility companies already maintain a large, and often idle, standby capacity in the form of gas turbines to fill in the gap between baseline and peak demand. There will come a time when they will find it useful to have excess idle capacity in wind turbines, to meet peak needs, if they can work around the problem of reliability. I will return to that point.*

– *Photovoltaic and Solar Thermal Energy.* I will deal with solar energy at some length, given the hopes it raises and the negligible results it has so far produced – about 1/700th of all U.S. commercial energy.

It is potentially a major contributor to meeting our energy needs in the post fossil fuel era. In fact, it has fewer theoretical limits than any other renewable — in places with lots of sunlight and space. But it has its

peculiarities and limitations. Let me compare it with traditional energy sources and with gasoline.

– In this age of plenty, we may forget just how useful fossil energy has been. If we are living better than before, credit the petroleum age rather than the Capitalist economy or American know-how. Before the modern era, most energy we used was human physical labor, supplemented in varying degrees by draft animals, firewood and vegetable oil. All forms of energy can be compared, even though they cannot be substituted for each other without some energy loss in the conversion. Using manual labor, one would need to lift a gallon of water up 5.5 feet <u>every second</u> to match the energy that keeps a 60 watt (900 lumen) incandescent lamp alight. Try that for exercise, and see how long the bulb stays lit.

– By contrast, a liter of gasoline (1.057 quarts) contains about 33 megajoules of energy. Theoretically, that could lift over 500,000 gallons of water 5.5 feet, or – depending on how you convert it to light – provide more than 900 lumens of light for days or weeks.

– Enter solar energy. The average solar energy flux from about 10 am to about 4 pm in a very sunny climate is about 600 watts per square meter. The comparison with gasoline is, to me, surprisingly favorable. The newest photovoltaic installations can approach 18 percent efficiency. With a marginal increase to 20 percent, that square meter could keep two 60 watt bulbs (or 8 comparable minifluorescents) burning indefinitely – but only during sunny hours when we don't need light. Therein lie the promise and the limits of solar energy.

We must learn to adapt to the limitations of solar energy to benefit from its possibilities. It is a partial substitute for fossil energy, but it produces electricity rather than concentrated mobile energy, it produces energy on the sun's schedule, not ours, and it is difficult and expensive to store large quantities of that electrical energy.

Right now, photovoltaic and solar thermal energy are more expensive than conventional electricity by a factor of three. (Solar thermal energy is the use of concentrating towers or reflecting troughs to heat a fluid, in turn driving conventional turbines or Stirling engines.) Fossil energy prices will rise with the decline of oil and gas and, eventually, coal. Solar advocates hope that

solar energy prices will come down with technological change, but those hopes may be illusory, because most of the cost of solar energy is in the supporting structure rather than in the solar cells themselves, and those costs will rise as the cost of energy and raw materials rises.

One technology may defy that generalization. It goes under the name of "distributed solar energy." Solar cells are already competitive in many situations requiring only a tiny amount of power – things such as remote sensing devices, satellite, airway, railway and highway signaling and communications systems and signs, particularly those remote from the grid – because they obviate the need for transmission systems. Rooftop solar collectors are a potentially important example of distributed power, and existing technology could make them much cheaper than they are now. There is already at least one company in the business of furnishing rolls of amorphous silicon which generate electricity and also serve as a roofing material. As their technical problems are ironed out, they may become an important part of future energy systems, and they fit in naturally with my next proposal: to multiply passive solar buildings.

Electricity generation is not the only way to exploit sunlight. Perhaps we should literally choose the sunny side of the street. In the United States, 39 percent of our total commercial energy goes to heating and lighting buildings, and most of that energy comes from natural gas, which is following petroleum to commercial extinction. The most efficient use of solar energy is not to generate electricity, but simply to warm things. Let me cite a homely example. Where I live (in Santa Fe, NM), some buildings are heated entirely by passive solar energy (i.e. by that direct warming). My house is about 50 percent solar, simply by virtue of its southern orientation, large windows, adjustable shades, a brick floor in the sun room, and a concrete sub-floor. It catches and stores the sun's warmth and enjoys great natural light. We use less than half as much energy per square foot as our neighbors' more conventional houses.

It will be hard to match that solar role in places less sunny than Santa Fe, but there would be substantial national savings – and some hope of staying warmer in cold winters – if we encouraged solar house design. A south-facing design, with overhangs, adjustable awnings, good insulation and ventilation keeps houses cooler in the summer and warmer in the winter.

Such a massive change in our house design and the layout of our towns and cities will be an investment far beyond any initiative we have ever undertaken. The U.S. Interstate highway system has been called the largest single civil project ever, but this proposal would dwarf it – and we will be undertaking it even as we must begin to rethink our commercial energy infrastructure, our living patterns and our transportation system, including those Interstate highways themselves.

** Zoning laws and building codes should encourage street layouts that promote the south-facing orientation of buildings, shade trees, solar design and better insulation.*

We have an immense investment in the housing and communities already in place, and it turns over slowly. With the present prospect for population growth, we will need to spend our money to expand our entire infrastructure.

** With a population diminishing in size, the demand for new infrastructure would go far down, and more money would be available to deal with the energy transition. In housing, we would be able to concentrate on the solarization of the existing buildings best suited for it, and to use the sturdiest and best insulated of the existing stock, retiring the others.*

– Storing Intermittent Energy. As fossil fuels decline, most of our energy will be erratic or intermittent. We must learn to live with daily "blackouts" and "brownouts", and with windless and cloudy periods. It will be miserable. We can live with it, as people already do in emergencies, but life will be much different. Our descendants will learn to use power when it is available, and to rethink their work, their food storage, their lighting, their communications and their lives to get by when it is not. Transportation and industry will have to learn to use more interruptible power, to figure out which operations can be interrupted without damage and which cannot.

At some point, ways of storing energy that are now uneconomic will become attractive. Batteries can play only a tiny part, but a dramatic one, in keeping radios, television, emergency lighting, 'phone systems and even short-range transportation going. There are ways of using intermittent power sources to smooth out the energy supply. Pumped storage in reservoirs — to run through the generators again — and electrolytic sequestration of

hydrogen come to mind. Both are known technologies (though we are far from figuring out how best to use the hydrogen), and both could be dramatically expanded using wind and solar power that would otherwise be excess to our momentary demand for electricity. It has been proposed to store the excess heat from thermal electric plants in salt, to keep the generators running longer when the sun is not shining. Variability of power supply can be reduced by connecting into grids over large areas, in the expectation that the wind will be blowing or the sun shining somewhere in that area. Scientists will probably develop other useful proposals. The cost – in money and energy – of trying to eliminate the unreliability of the supply would be almost unimaginable. At best, we may hope that the fluctuations can be ameliorated.

** At present energy prices, these technologies will need deliberate encouragement, since they require the construction of wind turbines and solar farms beyond present needs and they are not yet competitive in price with fossil energy, but we need to be ready to move in that direction, because the prices are likely to move swiftly when they move, and it takes 50 years or more to build and amortize an energy system.*

** Any amount that we can store will go farther with a smaller population.*

Climate Change.[10] The climate is changing faster than the experts expected. The ocean is warming and sea levels are rising. West Antarctic and Greenland ice caps are losing 93 cubic miles of water to the sea each year, by one report, and glaciers are accelerating their movement to the sea.[11] Icebergs from the Ross Ice Shelf in Antarctica are floating past New Zealand. The Arctic sea ice is thinning, breaking up and retreating. (That's the reason for the current proposals to designate the polar bear as a threatened species.) The Arctic Sea will probably be ice free in summer before the end of the century. Eleven of the twelve hottest years on record, world-wide, have occurred since 1995. Much of the world has experienced unusually severe weather in the past decade: prolonged droughts, floods and more severe storms. The major hurricanes in 2004 and 2005 convinced many Americans that something is indeed happening. All of these phenomena are consistent with models of anthropogenic climate warming, though swifter than anticipated.

VALEDICTORY: **The Age of Overshoot**

The IPCC has been studying climate change since 1990. Its fourth assessment is being published in 2007, and Chapter 1 is available.[12] It calls the evidence of climate warming "unequivocal" and is 90 percent confident that human activity is causing it – in effect strengthening earlier IPCC assessments. It confirms a continuing rise in CO_2 and methane emissions, and in their concentration in the atmosphere. It offers different scenarios leading to global surface temperature warming of 1.1 degrees C to 6.4 degrees C (2 to 11.5 degrees F) in this century, with larger increases in the Arctic.

Recent sea level rise works out to about 0.31 meters (12 inches) a century, and the scenarios lead to a rise of 0.18 to 0.59 meters (7 to 23 inches) by 2100, though the IPCC cannot exclude a "substantially higher" rise, because the panel has not had time to absorb the new information about the movement of the great ice sheets.

Some scientists are talking of a rise of more than one meter in world sea levels in this century, accelerating later. This reflects the new discoveries about the ice sheets and the realization that past climate changes have occurred much more swiftly than we had thought. There is a respectable theory that there was an immense flood out of the Gulf of St. Lawrence in the early Holocene when the ice dams from the melting Laurentian ice shield gave way and released the stored water. This is said to tie in with evidence of a sudden freshening of the North Atlantic, which affected ocean circulation patterns.

The IPCC focuses on this century, and it is a conservative consensus forum. It notes that "... anthropogenic warming and sea level rise would continue for centuries... even if greenhouse gas concentrations were to be stabilized." We must plan both for the long term and for the likelihood – which is getting likelier – that things will happen faster than the IPCC predictions.

Some of the present patterns are synergistic. The loss of Arctic ice and snow fields will lower the albedo (reflectivity) of the Earth, further accelerating the warming trend. Melting of the tundra releases methane, a major greenhouse gas. Some consequences are counter-intuitive. Freshening of the north Atlantic from melting Greenland ice could slow the Gulf Stream, which would make Europe's climate much like Labrador's – even while it warmed the mid-Atlantic, which in turn would spawn more severe hurricanes

in the Caribbean and the southeastern United States. (The IPCC detected evidence of such a slowing already happening, but it considered a dramatic change unlikely in this century.)

What does this mean for mankind? The catalogue of projected changes is voluminous. Some things are pretty clear. Others, particularly the regional impacts, are much more uncertain.

The effects of rising sea levels are predictable, although the rate of rise is in doubt. Katrina is just a foretaste. (More than one expert has suggested that New Orleans should not be rebuilt except for its port, which connects heartland America with the world.) That is just the beginning. If the Greenland ice sheet melts, it will raise sea level some 6 or 7 meters. The Antarctic ice sheet would add another 59 meters or so – which would put the U.S. capitol dome in Washington under water and bring the U.S. coastline to the foot of the Blue Ridge Mountains. Low lying areas will be threatened by the rising waters, and even larger areas will suffer occasional storm surges. Much of the U.S. and world populations live in the threatened areas.

The United States' population density is relatively low, and we have some room to accommodate those displaced by rising sea levels, though it will obviously be much easier if the population is falling, rather than rising. For more densely packed countries such as Britain, the problem is much worse. It will be critical for low-lying countries such as The Netherlands, Bangladesh and some of the island countries of the Pacific and Indian Oceans. For them, migration may be the only way to survive. One can entertain such an idea for Europe – with its population starting to decline – but not elsewhere, because the uplands throughout those regions are already densely populated. (I will return to this point.)

Worldwide food production is expected to go down because of the warming and in many areas the more frequent droughts. The first IPCC predictions for temperate zone agriculture suggested that output might rise because of the increased CO_2, which plants metabolize. Since then, the negative impacts are becoming more obvious –

- rising sea level itself will flood much of the farmland,
- experiments have shown that major crop plants can make less use than anticipated of heightened CO_2,
- more droughts, floods and windstorms will damage those

crops,
– there will be dislocations as the climate changes and the best areas for crops move northward, and
– irrigated crops depend on mountain runoff in many places. Warmer temperatures are already causing the runoff to be earlier and swifter, and therefore unsuited to agricultural needs. And more dams are not the solution.

As a 2000 study of the United States warned: "it is likely that some aspects and impacts of climate change will be totally unanticipated as complex systems respond to ongoing climate change in unforeseeable ways."[13]

**The ways to ameliorate climate change are largely the actions we must take in the energy sector. If we are to do anything about a looming catastrophe, we must take actions such as I have catalogued above. In so far as we fail, our descendants must learn to accommodate.*

The European Commission has proposed sweeping reforms to lower greenhouse gas emissions (see Free Trade below). Separately, the United Kingdom has launched a study as to how to minimize the damage from rising ocean levels. The United States has been notoriously slow to address climate change. We are the principal holdout from the Kyoto Protocol, which was meant to encourage the industrial nations to lower their greenhouse gas emissions.[14] And we remain resistant to serious unilateral action on climate change. If we, the largest source of the changes, remain passive about them, we will all face the consequences.

** Pressures are mounting on the United States to abandon its passivity. Even some states and cities are developing their own rules to limit CO_2 emissions. One can only hope that the Federal government will begin to move, but neither the President's State of the Union address in January 2006 nor the Congressional responses suggested any readiness to take actions commensurate with the problem. The developing countries are still not addressing global warming. This puts demand limitation – population reduction – in the residual role as a potential solution. Even the European proposals probably rely too much on wind and solar energy, but Europe's population decline (below) makes their problem more manageable.*

The Demand for Fresh Water.[15] In the worst situations, water shortage can affect the availability for direct human consumption, but the principal impact is on crop production. It takes, for one example, 1000 tons of water to grow a ton of corn. That ratio becomes particularly important in irrigated agriculture.

Worldwide, about 70 percent of freshwater use by humans is for irrigation. In turn, irrigation, although it occupies only 20 percent of arable land, produces about 40 percent of the world's food crops. The ratios in the United States are about 10 and 20 percent. Because of the demand of rising populations for food and fiber, irrigation has increased, to the point where many rivers, especially those in dry areas, are actually pumped dry in the growing season, long before they reach the sea. Examples are the Yellow River in China, the Indus in Pakistan and the Rio Grande and Colorado Rivers in the United States and Mexico.

Groundwater is a major source of water for irrigation and municipal and household supplies. Rising use is drawing down aquifers. Total freshwater consumption in the United States has actually declined slightly in the past twenty years, primarily because of dropping water tables in the southern part of the great Ogallala aquifer, which underlies much of the Plains states. Lower water tables, together with rising energy prices, have made it unprofitable for farmers in those areas to pump the aquifer. Nationwide, groundwater use is estimated to be about 125 percent of annual recharge, and many water tables are dropping.

The fate of forests will make a huge difference to the availability of freshwater, because of their role in holding and managing runoff. As of now, forest cover is increasing in the United States and generally stable in Canada and Russia, because fossil fuels have replaced fuel wood. This may change with increasing reliance on biofuels or with climate change. In our Southeastern states, drier conditions are expected to force a gradual change from pine woodlands to open savannah. The world's great forests are in Brazil, the Congo and Indonesia, and they are being cut down for sale or to clear land for agriculture. In short, forests help increase and sustain water flow, but they are declining because of commercial and population pressures.

Much of the tropics and subtropics is already suffering water shortages ranging from mild to desperate, and that problem will worsen with the growth

of population and demand.

The United States used to be relatively well endowed with water. Rising demand has already created water shortages and, on balance, we can expect them to get worse. Conflicts over water have long been endemic in the West, and have now spread to the East – conflicts between states, between cities and farmers, between cities, power plants and industries, between conservationists protecting fish and all the above.

** Some improvements in efficiency can be made in household, urban, and industrial use, but agriculture is the key, and there we are approaching the limits, worldwide, of getting more water. Drip irrigation would allow us to use it more efficiently, but would require enormous investments.*

** The future of population change will dictate the future of the forests. What we can do about population, worldwide, will determine whether forests can continue to play their role in water management.*

** Desalination of seawater or brackish water would multiply the amount of water available, but the cost would be some multiple of present water costs, depending on location and the salt concentration. We encounter here an interaction between energy and water. Desalinating is energy-intensive, in a world moving into increasing energy shortages.*

** Here again, a reduction in demand – population – is the single straightforward solution.*

Food & Agriculture. What will happen to food supplies? This is where the population issue becomes critical. Yields and output are now essentially static in the United States and other industrial countries. The official data for the developing world show a continuing rise in per capita food production.[16] That may reflect progress in bringing overall yields up toward those theoretically attainable, or it may be statistical error, or falsification by governments, or some of all three. Experimental yields have not increased in two decades, which leads experts to anticipate a decline in the growth of world food production.

The United States is better off than most – we still have about three

times the arable land per capita as Europe and six times as much as China [17] – but a combination of factors has stopped or slowed the growth in yields and will probably bring food production sharply down here and elsewhere during this century.

– Fertilizer use reached saturation levels and has declined for a decade. Heavier applications in response to rising profits would produce little or no increase in overall yields. Witness Japan: with an artificial rice price ten times world levels, it uses 40 % less fertilizer per hectare than it did 20 years ago. When oil and gas are effectively finished, nitrogen fertilizer can be made from coal. (The prototype IGCC plant is now producing urea fertilizer, at a profit.) When coal declines, so will commercial nitrogen fertilizers. Future farmers will need to revert to older practices: manuring and green maturing, and periodic fallow cycles. That is good for the soil, but it means much lower yields. For example, U.S. corn yields early in the 20th Century were about one-quarter current yields.

– Increased irrigation supported the remarkable yield increases of the 1960s-1980s, but we have exhausted that source of growth. Water has already been shifted from agriculture to urban use in California. There are few new dam sites for reservoirs to store water, and river flows in dry areas are generally committed or over committed. Ground water is being overdrawn (see above.)

– The "miracle varieties" that raised yields in the less developed countries and the U.S. are dependent on massive inputs of fertilizer and water. The agronomists will now have to turn to developing varieties that conserve both and are heat tolerant to deal with climate change, but they will probably have lower yields.

– Desertification is causing major declines in arable acreage in Africa, the Middle East and China, and may affect us. Similarly, urbanization has reduced arable acreage in crowded regions including Europe. It is taking some of the best land in the United States.

– Climate change will substantially reduce food production in the tropics and subtropics, and probably in the United States (above).

–The use of arable land for biomass and chemical feedstocks is already under way, and they compete with food for arable land.

– In about a century, when we are really out of fossil fuels, draft animals will again become economic for many farm uses. They provide fertilizer, but they need pastures and feedgrains for their support. About a quarter of U.S. cropland a century ago was used to raise feed for draft animals. They will be needed again, and that – along with green manuring –

means less land for food production.

On the other side of the picture, the only real innovation in sight is genetic crop modification (GM). This should not be dismissed. Most U.S. corn is now GM corn, and our corn yields in 2004 set a record (though they declined again in 2005 and 2006). The Holy Grail of the agronomists and agricultural geneticists is to develop grain crops with symbiotic bacteria that will fix nitrogen, as legumes do. We must consider this a wild card, as nuclear fusion is in energy, but in both cases a half century of scientific effort has yet to show that it will happen.

** That suggests certain directions for research policy. Among them are research on the possibility of nitrogen fixing grains, salt water tolerant rice, perennial grains that do not divert much of their energy to the annual growth of the plant, and new low-input miracle crops that may not produce like the old ones but will serve us better in the new conditions.*

** Agriculture is particularly sensitive to the problems we face in energy, climate and water. Progress in dealing with those problems will help us avoid calamity in agriculture, but only biomass and green manuring offer assured sources of nitrogen fertilizer. The problem is circular, because only with smaller populations can we free the land for those uses.*

How many Americans can U.S. agriculture support? Right now, we eat a rich diet and still are able to export nearly one-fifth of our grain production; but this is counterbalanced by our import of specialty foods, and our agricultural trade balance is coming down toward zero. If production and per capita consumption stay where they are, and U.S. population continues to grow at the present rate, we will be consuming all the grain we produce in less than two decades, and running a deficit in agricultural trade. From then on, we will face mounting shortages. The problems I described above will accelerate that schedule.

Food consumption is a relatively inelastic variable. Even the richest can consume only about four times as much as the poorest. (Compare that to the spread in U.S. incomes.) Americans (and their livestock) consume about 800 kilograms of grain per capita a year. We would be healthier with a less meat-intensive diet. Italy, Japan and Taiwan are good models. They consume about 400 kg/year. At that level, we could extend our self-

sufficiency in grain by some decades – I hesitate to guess how many – but we are on a path toward real hunger in this century.

** Our food habits are already changing, and 400 kg/capita/year of grain consumption may be attainable. Promote range cattle and aging milk cows as our source of beef, not feedlots, and we will also get another benefit: fodder-fed cows are better for us than grain-fed animals.*

After fossil fuels, the prospect becomes murkier, and even bleaker if we do not reverse population growth. Perhaps the best starting point is the early 20th Century corn yield I mentioned: 25 % of the present. At that time, we were supporting a growing population of about 100 million, compared with today's 300 plus million. By the 1950s, we were mechanizing and beginning to use commercial fertilizers in quantity. Yields were up to 40% of the present yields, and our population had passed 150 million.

We tend to forget just how important food is, because agriculture and forestry are now such a tiny fraction of GNP. But they supply one of the three basic human survival needs – food, clothing and shelter – and part of the other two.

** Meeting those basic needs in the post-fossil fuel era will be uniquely dependent upon reversing the astonishing population growth of recent decades. I would suggest a target U.S. population for the post-fossil era of somewhere in the range of 125 to 150 million. This would take into account both the things we have learned in a century and the factors depressing production. It is just that: a target, not a solid number, and it will change – upward or more likely downward. If population is to stay in some sort of balance with food production, the target must be reached well before the end of this century.*

I have pointed out that the developing world, Europe and Japan face more difficulties, for various reasons. I will touch upon their situations later in discussing Solutions on the Demand Side. Before moving on to them, however, I will briefly dismiss one illusion: people say "let 'em eat fish." Fish provide less than three percent of human food intake, worldwide. The world's wild fishery has already peaked, and the remaining stocks are heavily stressed. Aquaculture (fish farming) has grown, mostly in Asia. It is not an addition to food supply. It is a form of livestock. It competes with other uses

for grain or (in the case of valuable fish like salmon) fish meal.

The agriculture I am describing can perhaps be described as "back to 1900, with modern innovations." By necessity, it will rely more on animal power and perhaps human labor. It will be more local than global, because transportation will be much slower and more expensive. It will be extensive rather than intensive – an idea that Europe is already experimenting with. It will be manageable – but only if the demands on it are scaled back

Summary: Ask yourself: would the problems I described be better met with a larger population, or a smaller one? For that matter, are there any issues facing the world and the nation that population growth would help to meet? The problems I have described are all the product of past and continuing growth in demand, and population is the fundamental driver. The potential solutions are limited by that same growth.

– The energy transition is a result of that growing demand, and the potential solutions are hostage to continuing growth. We cannot use biomass to replace fossil fuels, because we need the land for food. The adjustment to solar and wind energy is made harder because of the demands of a growing population.

– Anthropogenic climate change is the result of rising human demands, and our ability to adjust is limited by the size of our population.

– The loss of fossil energy will cripple modern agriculture and could indeed lead to starvation in the poor countries and hunger in the United States. With lower yields, more arable land will be needed per capita to grow enough food, and that can be done only by lowering population, because of the limits on potentially arable land.

The common thread in these issues is the need to systematically reduce the immense human impact on global systems, which is a function of recent population growth. How do we do it? I will discuss below the ways to bring population into harmony with the Earth's resources.

SOLUTION ON THE DEMAND SIDE

Let me spell out how we can influence population change.

The first step toward a solution is to recognize that there is a problem. People have become habituated to growth. We must convince policy makers that the scientists' discoveries are real. That argument may be starting to get more traction.

The second step is tougher. If we are to try to manipulate demand – consumption, human fertility and migration – for social ends, we come directly into conflict with the individualistic side of human nature: "Society has no right to tell me what I can do." This is a basic conflict in human societies. It now comes into focus because we are at a point where we must find ways to rescue whole civilizations from overshoot and from the trap we have gotten into because we failed to recognize the limits to growth.

We must identify and use all the solutions we can: 1. technology, 2. consumption patterns and 3. population change.

1. We already look to technology for solutions.

2. We are divided about consumption. Environmentalists call for lower consumption, while mainstream economists call for more of it. And we do little or nothing to control it. To some degree, consumption may be self-limiting as resource limitations drive up real prices, but poverty is hardly a solution.

Some conservation may be a fairly painless escape from wasteful habits. Consider Europe and Japan, which live very well with per capita energy consumption about half ours. We can make more efficient use of resources in satisfying the same wants. Think of all the houses that regularly run their air conditioners even when the outdoor temperature is delightful. Or the electric clothes dryers that replaced clotheslines. Or the proliferation of giant SUVs, most of them carrying one lonely person. People who live near good public transportation frequently discover that it is pleasanter than driving, because they can read, or work, or ruminate, which they can't do in

traffic. These ideas may spread, with a little education, an ongoing increase in energy prices, and better public transport, but human habits die hard. We live in a consumer society dedicated to creating wants. Consider the exhortations from government to consume more to boost the economy, the blandishments from the advertising industry, and the credit cards that make consumer debt very easy.

3. Policy makers do not deal with population at all. It now ranks lower in the national consciousness than it did three decades ago.

With fewer people, we could protect a decent level of per capita consumption even as total consumption declines. Our political leadership has completely ignored the role that smaller populations could play, yet that is the most fundamental part of the solution – and the cheapest.

Population. The Cross Cutting Solution. The world is divided into three very different demographic groupings.

1. All of Europe, Japan, South Korea, Taiwan, Singapore, Thailand, Georgia and some tiny Caribbean island states are on the fast track to diminishing populations. Most of their governments are urging women to have more children, for fear that their societies will disappear or be replaced by immigrants if they don't get back to replacement level fertility – and those policies are justified. Italy, for example, has a population of 57 million and a total fertility rate (TFR) of 1.2 children per woman. It will be moving downward past 8 million by 2100, barring immigration, if its fertility does not rise. If it gets back to replacement level by 2020, the non-immigrant population will continue to sink until it stabilizes around 23 million. That might be a good population level, intrinsically, but one wonders if the space created would not simply be occupied by migrants.[18]

European and Japanese women's low fertility may simply be the product of exuberance at newfound freedom and economic independence. It may also reflect their awareness of the energy transition and the knowledge that their countries are already densely populated, with limited arable land per capita, with little fossil energy and relatively poor prospects for renewables. They are right, but nobody knows whether the mood will change before those civilizations fade away.

It is popular right now to talk about the "birth dearth." This fear is focused on those societies, which are a very small fraction of world population. The fear of aging has become an obsession for some, with the question: "Who will support the old?" That is a legitimate question, though it is secondary to the bigger issue: how will they live within their resources after the fossil era? I think the dependency problem is overstated. There are ways of softening the shift. Both Europeans and Japanese retire very early. They will probably have to go back to an earlier pattern when they worked for more of their lives. Putting more of the "working age" population to work is another solution. Half time work and shared jobs for the older workers are others. The aging problem will in any case last in extreme form for only a generation, until the population age distribution settles in a new pattern. [19]

The energy transition will still affect those societies. Solar energy, for instance, offers very little promise for northern Europe and Japan. However, those are cohesive and educated societies, and they will probably make the best use they can of their resources.

We must expect a certain level of protectionism to be part of the solution. Europe and Japan will not be able to afford free trade. They have not been as wedded to free trade as the United States is (at least in theory), and their demographic future will make it unbearable. With some of the best salaries and perks in the world, and with aging and declining work forces made productive by mechanization, their labor force and their social stability would be threatened if thrown into unmanaged competition with younger developing world labor working for a fraction of their wages.

There may be a lesson there for the United States, as our population grows and ages.

A number of developing countries are within sight of entering the "developed" stage. They are succeeding in bringing fertility down, usually with a combination of access to contraceptives, educating women, giving them the right to hold jobs and property, and – in some countries – successful micro-loan programs to give them the money to start home industries. With some more progress on fertility, some of them will eventually approach the same sort of age distribution as Europe and Japan, and they will probably react in similar fashion as their societies age. They need to get away from the United States model of economic development. They face differing

energy prospects, severe environmental and pollution problems and, for the most part, highly unfavorable land:people ratios, but those countries at least have hope, and they include the most populous developing countries such as India (TFR=3.0), Indonesia (TFR=2.6), Bangladesh (TFR=3.0) and Brazil (TFR=2.4).

China, has an official TFR of 1.6 (though the real number is probably somewhat higher.) It could be considered a full member of the developed group, except for several considerations. It is still more than half a peasant society. It has brought fertility down through government policy rather than individual choice. Recognizing that it is succeeding, it is now softening the "one child" policy. It does not face the European problem of individuals choosing extremely low fertility, whether or not the government wants them to. With any luck, it should be able to allow fertility to rise again to something near replacement level – particularly given its large rural population – without governmental prodding. Even with its monumental environmental problems, it is probably among the more hopeful of the states on the verge of entering group one.

2. The Poorest Countries. Sub-Saharan Africa has more than quadrupled from 168 million people in 1950 to 752 million now, and the UN Medium Projection would have it more than double again, to 1.7 billion, by 2050. It won't happen; it can't happen. To that beleaguered continent, add Haiti, Guatemala, Honduras, 11 Arab and Asian countries, and six tiny Pacific Ocean island states. All of them have fertility above 4.0, and it has changed little in two generations. This group roughly approximates the United Nations' 48 "least developed countries". They face the classical population growth crisis that was much discussed a generation ago but is seldom talked about now. To be blunt and brief: they face desperate futures, and their problems will probably affect us. To have any chance of escaping into a better life, they would need a sudden and dramatic decline in fertility to bring their populations far below their present levels. If that doesn't happen, they will go through a population collapse driven by rising mortality. If it does happen, such a fertility decline would eventually cause a population aging far more sudden and serious than anything Europe will experience.

Still, we must help them if we can, out of humanity and self-interest. At least, many of them recognize their problem, even if we don't recognize ours.

If you seek underlying causes for current world crises, note that Palestine, Afghanistan and Pakistan are all in this group. So are Iraq and Saudi Arabia, though they have a temporary cushion of oil revenues if they can learn how to use them.

3. The United States is all by itself: the only industrial nation going through rapid and sustained population growth.

The Census Bureau projects a 40% growth, to 420 million, by 2050, most of it resulting from immigrants and their children. If earlier Census projections are any guide, that projection will turn out much too low. At current growth rates, we will have passed 500 million by then. That figure is quite possible, particularly if we adopt the amnesty measures currently being proposed by both Democrats and Republicans.[20] That, I might note, is close to China's population in 1955.

Our growth is not the result of native fertility. The total fertility rate (TFR) for the country is 2.054, somewhat less than replacement level.[21] For non-Hispanic U.S. whites, it is 1.844 and declining, for non-Hispanic Blacks it is 2.019 and steady, and for American Indians it is 1.749. At those three rates, our population would reverse its growth within decades.

Hispanic fertility is much higher: 2.877 and rising. Mexican-Americans' fertility is 2.96. In that zone, populations rise 50% or more every 50 years, even without immigration. That fertility is substantially higher than Mexican fertility in Mexico. I surmise that the causes are several: its roots are in highly fertile, uneducated rural populations in Mexico; it is enjoying an unprecedented level of prosperity since migrating, and there may be some statistical bias in the calculation (See Note 21).

Whatever the cause, U.S. growth is presently driven largely by Hispanic immigration and fertility.

I hope I have made the case that a growing population is the worst possible way to go into the energy transition. The highest priority, then, for our demographic policy – and one of the most urgent of all national tasks – is to bring down both that immigration and that very high fertility. And it must be done in a non-selective way. In other words, we must reach the Hispanic audience (and others such as Filipino immigrants), but the proposed

remedies must be generally applicable and non-discriminatory.

– Immigration. Perhaps the most succinct statement of the policies that would bring immigration under control are these proposals contained in NPG's Proposed National Population Policy:

* Sustained, regular enforcement of existing rules and penalties to significantly curb illegal immigration.

* Mandatory imposition of fines and/or jail terms — for illegal entry, illegal presence, document and visa fraud, and knowingly hiring illegal aliens — would hasten the end of illegal immigration.

* More physical and technical barriers to entry, with sufficient manpower to maintain and police them.

* A streamlined process of deportation, which is now mired in interminable appeals.

* Regular verification of legal immigration status during transactions with government, banking, health care and real estate sectors to detect illegal aliens and ensure their removal.

* Sizable increases in the number of investigators, border patrol agents, federal attorneys, judges, and more detention space and personnel to make these steps work.

* Systematic enlistment of local and state law enforcement agencies to cooperate with the Federal government in identifying and turning over illegal aliens to the DHS (Department of Homeland Security).

To stop the chain migration snowball and immigrant-fed population growth, legal immigration should be cut to not more than 200,000 per year, a level supportive of eventual reduction of U.S. population. An 80% cut will mean eventually ending all family reunification.

* The new ceiling of 200,000 admissions should be used to satisfy core U.S. national interests. They would be allocated as follows:

a) Humanitarian – Up to 30,000 for permanent humanitarian admission of the most endangered refugees and asylees. All other humanitarian admissions would be for short terms only.

b) Work – 110,000 for skilled professionals, technicians, artists and entrepreneurs and their immediate families. There would be no admissions of semi-skilled or unskilled workers.

c) Special Needs – Up to 10,000 slots to cover an array of special immigrant allocations, such as religious ministers, rare specialty workers, military recruits, and foreign employees of the U.S. government.

d) Existing so-called "temporary" visas for workers and professionals – These now account for 220,000 "quasi-legal" immigrants a year. They should be abolished and skilled labor needs met under the 200,000 limit.

e) Transitioning Away from Family Reunification – Family reunification should be phased out. Petitions of U.S. citizens for nuclear families approved before enactment would be honored. For five years thereafter 50,000 slots a year would be allotted for qualified spouses and minor children of U.S. citizens under strict eligibility rules. Afterward, the 50,000 numbers would be prorated among the three permanent categories.

* An absolute ban on amnesties and Mariel-type mass "emergency" admissions.

* An end to citizenship by birth for "anchor babies" born here to illegal and temporary visa aliens, now seen as required by the 14th Amendment. Anchor babies born to illegal alien parents accounted for 380,000 births in 2004, nearly 40% of all births to immigrants. Bills regularly introduced in Congress would end automatic citizenship with a clarifying statute. If legislation fails, the constitution should be amended.

The change of emphasis to use immigration numbers mostly for skilled immigrants will contribute much more to the economy than the present priority for "family reunification" (which itself is a euphemism, since the families were united in the old country before one of them migrated.) There will be another positive benefit: most of the immigrants in the skilled and professional categories are educated and prosperous, and their fertility is much lower than the unskilled people now dominating the movement.

People object that you cannot suddenly deport 10 to 15 million people. The point is that it would not be necessary with the above policies in effect. They would make the United States less attractive as a place to find a job, and they would make it more difficult to stay here. The result would be reduction of the problem, not by a mass deportation such as we did in the 1950s, but by attrition.

Fertility. The TFR numbers show that fertility among most Americans is below replacement level, and it is drifting downward. Under the slogan "The Two Child Family", I have pointed out for years that a two-child maximum would result in a TFR of about 1.5. This level could be combined with 200,000 net annual immigration and still result in a U.S. population drifting down to 150 million in this century. The "net" is important, because it corresponds with the detailed gross immigration proposals above and yet it still allows room for some slippage without imperiling the chance of reaching the target.

Here are some specific proposals for encouraging lower fertility, from the same paper:

* Endorsement of the two-child family by political leaders.
* Education of parents and children in the immediate and long-term benefits of smaller families.
* Educational programs aimed at helping young women enter the work force with the

job skills needed to make a decent living.

* Ensuring that birth control information and materials are universally available. That should include, as a last resort, the availability of abortion as embodied in Roe vs.Wade.
* Advocacy of abstinence by government, social and religious groups, on practical and moral grounds as appropriate, to discourage teen pregnancies.
* The elimination of tax benefits for children beyond the second child.
* Priority in public housing programs for families with fewer than three children.

Given the progress already under way, and the European experience that, once started, young women may carry their fertility too far down, these measures seem likely to achieve the population reduction I propose here. They could be toughened if they don't work, or rescinded if we approached 150 million, decided it was a good target figure, and wanted to stop the downward drift.

THE ECONOMISTS' MYTHS

There are two major impediments to addressing population policy: the faith in growth; and the hope for simple, usually technical solutions. First, the faith in growth.

The capitalist economists should not be blamed too harshly for the tenacity of their mind-set. After all, their formulas worked pretty well for 200 years, at least for those who run the system – but in a less populous and consuming world. They believe they know about economics. They should reciprocate and acknowledge that scientists know more about natural systems than they do. They pretend that efficiency and new technologies will make continuing growth benign, but that belief rests on faith, not proof. They need to learn about sustainability from those who study it. Macroeconomics is not the appropriate discipline for understanding the consequences of growth.

Growth: the Capitalist Mindset. John Maynard Keynes, the arch-druid of modern economics, looked forward in a 1930 essay to a day when people will "once more value ends above means and prefer the good to the useful..." But he went on to argue that "The time for all this is not yet. For at

least another hundred years we must pretend to ourselves and to every one that fair is foul and foul is fair; for foul is useful and fair is not. Avarice and usury and precaution must be our gods for a little longer still. For only they can lead us out of the tunnel of economic necessity into daylight."[22] In other words, the system is based on greed, but we cannot escape it for the foreseeable future.

Keynes' followers have ignored his moral qualms and latched on to his cynical tactical advice as to how to make the economy grow. There is no theory of limits in post-Keynesian economics. The economy is considered healthy only when it is growing at 3 or 4% a year. That means a doubling of GNP about every two decades. It takes only a few doublings for the scale to reach the absurd, in a finite country on a finite planet, but growth proponents don't look that far ahead.

We see here, baldly, the conflict between an implacable human urge and the calculations of science. To say which approach is rational is not to predict the likely winner. The scientists are wrestling with an 800-pound gorilla: greed.

Theoretically, it is immaterial to the macroeconomists whether growth comes from larger numbers or increased individual consumption. Either way, growth benefits the successful entrepreneurs. To watch big business and investors in the modern United States, one must assume that they prefer the larger population approach, since they are the most intense advocates of mass immigration, which furnishes cheap labor, at the price of massive population growth.

The result is an increasingly frantic and crowded nation. I would submit that we have lost more than we have gained as we have lost the sense of space and silence that the country once enjoyed. Crowding detracts from human well-being, and crowding is a function of sheer numbers, of consumption levels, and of income distribution. The best and most space has always gone to the powerful and the rich, but it was perhaps less important when humans were less crowded and there was more space to go around.

There seems to be no limit to the appetite of the powerful for more money. So far, the working classes have put up with that appetite, in the United States, because of the widespread hope that they, too, can enter the

gilded minority. In Europe, and apparently now in Latin America, they are not so forgiving, and that has given rise to populist governments and demands for redistribution. We should take heed. There is a strong moral case against the widening gap between the wage earners and the super-rich.[23] To give a more pragmatic argument: the energy transition will inevitably be a period of retrenchment. If we go into that transition encumbered by class hostility and struggle, we will find it much harder to make the sacrifices necessary for the common good.

GNP as Myth. The growth goal is usually stated in terms of Gross National Product (GNP) or Gross Domestic Product (GDP), both of which ostensibly measure a nation's total output of goods and services. But they measure only those activities that enter the money economy. They put a value on cutting down a forest, but no value on the forest that is destroyed.[24] They inflate growth by measuring the investments in irrigation systems to supplement the rain, but they do not measure the value of the rain. They record with magisterial indifference the creation of pollution and the expenditures on its control. They ignore production for home use, including subsistence farming. If China's GNP accounting follows those rules, its remarkable recent GNP growth is thus in part an artifact. It documents what is happening to the modern sector but not to the resource base, or to the majority of Chinese who are down on the farm, except insofar as they send their young people off to work in factories.

There is no necessary connection between rising GNP and rising well-being. Very little money moved in pre-modern agriculture, but it could be quite prosperous if there was enough good land per person. The term "subsistence economy" has a bad name right now, but that is partly a function of the paucity of resources per capita. And the larger the population, the less land per capita.

On the other hand, GNP includes many things that offer no pleasure in themselves but are necessary in complex societies – things such as urban infrastructure costs, parking meters, superhighways, highway police and security systems. Taken together, the things we don't really enjoy but must have in a modern society probably constitute a good portion of the whole – including the cost of governments that intrude in every part of our lives, in order to manage the tensions that come with crowding.

The economists argue that we are getting more efficient, and that GNP growth does not require equivalent growth in energy and resource use. Partly true, but not true enough. In the United States, we have cut our energy use per dollar of GNP as we move from heavy industry to a service economy and let the rising nations have the heavy industry. But that is not a particularly meaningful statement. China and India are growing nearly 10% per year – doubling every 7-10 years, and it is energy-intensive. In the United States, energy use per capita has risen steadily and swiftly for more than a century. Now, facing the energy transition, it is poised to drop, slowly at first and then precipitously through this century.[25]

The argument for fewer people and a smaller economy is driven by that energy calculation, but it also becomes attractive if we recognize that, in the prosperous nations, we don't need a rising GNP except as a way of making more growth tolerable.

The developing countries, on the other hand, need to escape from poverty. They want to do it the way we have, with massive consumption, but most of them missed the free ride of the fossil fuel era, and they may need to content themselves with a more modest definition of well-being, even as a goal.

Infinite Substitutability. This term embodies the conventional economists' would-be answer to limits. Sure, substitutability works, up to a point. We can all think of substitutes that came into use when the original resource declined or became too expensive. Some substitutes (such as plastics for metals) may or may not be as good as the original. Others (such as particle board for heart pine) are a long step down. But the "infinite" is the hooker. Name a substitute for water. Or energy. Or food. Or, at a more sophisticated level, consider the unorthodox economist Herman Daly's point that different inputs are more likely to be complementary than substitutes. When a forest is cut down, you cannot maintain lumber production by adding sawmills.

Free Trade. This is traditionally a tenet of the powerful, not the weak. It justifies their demand for open markets, investment opportunities abroad, and access to resources. If there were no constraints on resources, it could be good for both trading partners, through the doctrine of comparative advantage. But comparative advantage no longer works when the powerful

are free to move capital and know-how to the place where production costs are cheapest, and when they can then sell without restraint in any market, using their deep pockets and marketing machinery to drive out local competitors. When that happens, it drives wages everywhere toward the level of the lowest labor cost. This hurts labor and generates social unrest in the richer countries. It does not help the poorer countries when the capitalist suddenly shifts his production to a cheaper country. Witness what has been happening to Mexican labor as U.S. industrialists have closed the Maquiladora factories and moved on to other countries with cheaper labor costs.

The "free trade" slogan is used cynically, and it may not reflect reality. The NAFTA document is hundreds of pages long, most of which are devoted to maximizing U.S. business' operating freedom in Mexico rather than to free trade itself. The Doha Round of GATT has been stalled as Europe protects its agricultural exports and the United States protects its intellectual property. And it doesn't work when exports are subsidized (as are U.S. agricultural exports), or when there are serious scarcities. In recent decades, the United States has banned soybean exports to protect domestic producers in a bad year, and the European Union has done the same for wheat.

Now, OPEC and the principal oil exporters are coming to recognize that they have the whip hand in the petroleum market. In Bolivia, we are running into increased protectionism for its gas resources. Mexico nationalized its oil in 1938, and Saudi Arabia in the 1950s. I wonder what will happen to free trade when we become the Saudi Arabia of coal.

"Free trade" has become the cover for the effort to obtain others' resources. But we are in idiots' heaven if we think it will work. Russia has become increasingly assertive about squeezing out foreign oil companies and using its gas and oil resources for political ends. Witness its negotiations with the Ukraine, Georgia, and now Byelorussia. In its talks with the European Union about continuing its gas sales, it has made the EU increasingly nervous about being dependent on such a threatening neighbor for the gas supplies that are essential to run their economies and even to keep warm.

The European Commission, as a consequence, has formulated a dramatic set of policies to promote renewables and reduce its dependence on gas and oil. They are tough policies, and the European electorates may not

be willing to swallow the medicine, but Europe at least is far ahead of the United States in its willingness to talk about real and sweeping changes to meet the problem, rather than offering palliatives.

"Free trade" may for a time purchase cheap goods at the expense of devalued workers here and abroad, and at the cost of destroying our manufacturing base. It is not a justification for growth beyond our means, since it offers no real access to resources beyond our own control. A century and more ago, because of the costs of transportation, countries (or regions) tended to be self-sufficient in the essentials such as food and energy. In terms of basic security, if not of growth, there is much to be said for that condition.

"Economic Man" is the myth used to justify brutal labor policies in the pursuit of growth and more profits. Modern economics is betting on the wrong horse. It promotes efficiency – which means fewer jobs to do the same work – at the same time that it imports cheap labor, drives wages down and exports jobs. To justify these policies, it posits "economic man", who moves easily and swiftly into another, better job when the one he had disappears.

The real world doesn't work that way. Various recent studies of displaced workers have found that more than half eventually find new jobs, but most of them must accept lower wages and fewer benefits.

The loss of income forces a reduction in living standards. There is a widening inequality between wages and the income of the rich, and between workers' productivity and their wages. In the United States, supposedly the model of successful capitalism, hourly wages have stagnated for three decades. To see the impact of free trade on wages and benefits, look at the agonies the U.S. automobile industry is presently going through as its wages, medical benefits and retirement plans are under assault from foreign and non-union domestic competition.

Japan apparently is entering the same condition of soaring profits and stagnant wages.[26]

Even that is perhaps less important than the loss of a job. Humans tend to find their identity in their work. Joblessness leads to hopelessness,

frustration and anger. Our official unemployment statistics conceal the real level of joblessness. They show about 5% of the labor force as unemployed, but about 33% of the civilian "non-institutional population" (i.e. not in prison or school) 16 and over is not in the labor force. (They don't even show up as "unemployed.") For young minority members, the proportion can run over 50%. Some of those people don't want to work. Many do, but they have dropped out of the hiring halls and other measures of "seeking work." This is the real measure of wasted people.

Modern economics, in short, promotes policies that benefit the entrepreneur but not the laborer. It does not serve the working class, but it wins acquiescence by offering the evanescent benefit of cheap goods.

The economists' own law of supply and demand suggests that a smaller work force, relative to the economy, would earn better wages, but that does not happen if free trade serves to drive wages downward. A diminishing population would profit from that law, but it is hardly the mainstream economists' choice.

Our pattern of mass immigration drives down the price of U.S. labor, but unlike free trade, it also perpetuates the problem into the future. Because most of the immigrants we choose to allow in (legally or otherwise) are from the more fertile components of traditionally fertile societies, immigration policy is accelerating U.S. population growth.

Taken together, the capitalist economists' myths may reassure them and their followers that they are not immoral, but they are internally inconsistent and they do nothing to address the problems of limits I have described.

If I seem to have spent an inordinate amount of time beating up on the macroeconomists, it is because they are the most persistent and effective advocates of growth and of the immigration that drives it, and we must learn to rebut their vision if we are to escape the fate toward which they would lead us.

TUNNEL VISION AND ITS SOURCES

The problem is made worse by tunnel vision. My granddaughter sent me a bubbly letter from college. She had heard a well-known speaker about energy. "He was so optimistic!", she said. Well, yes and no. His specialty is simple fixes such as mini-fluorescent bulbs and "the hydrogen economy." It sounds very simple. He is a favorite of business because he seems to say "adopt these painless solutions, and our problems will go away."

Beware such simplistic solutions. Compared to incandescent bulbs, mini-fluorescents do indeed cut the energy cost by three-quarters for the same amount of light, and LEDs may soon do even better. But lighting, along with communications, are two areas where technical fixes work best. Overall, they are one of a multitude of technological contributions that we may use to deal with the energy transition, but they are a small part of the whole.

The White House. The President's enthusiasm for corn ethanol and for a "hydrogen economy" are examples of hasty efforts to find a simple solution to a deep problem. Hydrogen is not an energy source. It is a potential way of storing and carrying energy, but it is at best decades away. Such efforts to find a simple panacea at least recognize that there is a problem, but they don't do anything to solve it.

Facile optimism is a snare if it diverts us from starting to make deeper changes. We are teetering at the edge of overshoot. BandAids are not enough; we must make some fundamental changes to adjust our demand to match our resources. That may be truer optimism than a faith in palliatives.

Environmentalists. Even the environmentalists who propose to do something about our resource and environmental problems are usually dealing with only one small problem. Their solutions may aggravate other problems. They are hacking at the branches of evil (to borrow Thoreau's phrase) while ignoring its roots. The Sierra Club, for example, fights furiously against new proposals for a mine or gas well or logging operation, but will not address population growth or the uncontrolled mass migration that drives it in the United States. If we promote population growth, we will need more ores, gas and lumber, and we will generate more problems, but the Club seems to

be mesmerized by the fear of addressing the real issue.

The Sierra Club is not alone, and the tunnel vision has gotten worse. Other national environmental groups display the same myopia. In 1988, the Club was among the 18 major U.S. environmental organizations that drafted *Blueprint for the Environment, Advice to the President-Elect from America's Environmental Community*. That advice said that "*Population growth* is a major contributor to all these global environmental problems. *U.S. population pressures* threaten the environment all across our nation...(p.6) *The President should establish an official population policy for the United States, and encourage all other nations to do the same." (p.28*; italics in original) Since then, those organizations have all lapsed into silence on population growth, while the nation has grown by 55 million.

The Press. That same myopia surfaces in the editorial pages of major papers such as the *New York Times*. In its editorials on immigration, it regularly emphasizes the interests of illegal immigrants and sides with those who would legalize them, but I have never seen it recognize the population dimension of mass immigration.

Scientists. Scientists themselves are guilty of tunnel vision and often blind to the demand side. Some scientists are among the most passionate and distinguished writers about the dangers of population growth, but not all. The new Chair of the AAAS (American Association for the Advancement of Science) has described 38 "Grand Challenges and Great Opportunities in Science, Technology and Public Policy."[27] Many of them were addressed to environmental and health problems. None of them touched upon population or consumption as sources of the problem or potential solutions.

Perhaps the most dangerous of all tunnel vision is the scientific enthusiasm for engineering solutions to make more growth possible. One example is the proposal to sow the oceans with iron. It is a limiting deficiency in wild fish production, and the proposal would remove that limit. Its proponents do not ask "what else happens when we change the chemical composition of seawater?"

Other sweeping technical "solutions" have been proposed. One proposal would generate solar energy by floating giant amorphous silicon generating carpets in stationary orbit, 23,000 miles above the Earth, and

beaming the power down to Earth, thus freeing solar energy of both clouds and night. Another proposal is to counteract global warming by creating artificial smog in the upper atmosphere to dim the sunlight reaching Earth. Fortunately, skepticism and their own impracticality have stopped most of those ideas. The skeptics recognize that, as a species, we tend to think of the benefits of new ideas before we think of the problems. We have done a very poor job of managing our environment so far. There is little reason to think these ideas would do better.

Try considering the solutions on the demand side. We might just save the Earth for human habitation.

The reluctance to address population growth arises from an aversion to dealing with its causes. I have suggested that the unwillingness to take on mass immigration arises from narrow self-interest on the part of those who profit from cheap labor, combined with generous and humanitarian feelings among some idealists. The idealists are being manipulated by the greedy and by some ethnic politicians, but still it is a powerful combination. Some countries have tried with varying success to manage fertility for social ends, and we have tried to help them, but here again there is a powerful roadblock. It is a new and frightening idea to some, and vocal women's rights organizations oppose any interference with "women's right to control their own bodies" in the pursuit of social goals.[28]

Our potential allies must realize that the solution to their specific issues may lie outside their own specialized areas, in a broader effort to bring demand into balance with resource and environmental realities. And that will require a transition over the next century into a society very different from this one.

CONCLUSION: AN OLD AND NEW SOCIETY?

Requiem for the Big Bonanza. Fossil energy has given us quite a ride. The society dimly visible (above) may well be a better society, but it will be smaller, less mobile, with a level of energy use closer to 1900 than to 2007.

The Towering Obstacles Before Us. I have described the sources of opposition to population reduction in the United States. I should add two more; (1) inertia and ingrained habits; and (2) the Vatican's opposition to family planning, which is a major obstacle among many U.S. Hispanics, in Latin America, the Philippines and parts of Africa. Moslem attitudes are much more divided, and there is no single center to impose doctrine.

The United States is better prepared than most countries to weather the energy transition, if we take farmland or coal reserves per capita as the measure, but we share the planet with others, and there is much conflict latent in a world of tightening resources, rising competition, different fertility and growth rates. Those differences suggest a grim prospect of terrorism, wars and more migration as groups fight for scraps of a diminishing pie and growing populations become desperate in the search for a living. It would be surprising if that turmoil did not threaten an orderly transition from the petroleum era.

The tensions with and within the Arab world reflect populations full of young men without the prospect of meaningful civil employment, and we have learned that they are capable of throwing a bomb, literally, into our midst.

Africa is the exemplar of the poorest countries with rapidly growing populations. The struggles in Africa are a product in part of the competition of growing numbers of people for limited and deteriorating farmland. I haven't tried to write prescriptions for a successful future for Africa, because I can think of none. The one thought I can offer is that, insofar as we can help them bring the beast of runaway population growth under control, we will improve their prospects. And a less turbulent world will in the long run serve our interests, too.

Perhaps they too will adopt the militant Arab model. Or maybe they will eventually find stability in a return to lower population levels resulting from rising mortality. They may then be able to achieve modest living standards, or they may find themselves living close to subsistence levels, disabused of the dream of the American 20th Century model. It will not be a pleasant experience for them or us, and it will be worse if dictators continue to escape that fate, personally, by enriching themselves at the expense of the poor. It is difficult to be of help in such circumstances.

Guarded Optimism, or Whistling in the Dark? Do we, the developed and the truly developing nations have enough time to make the changes that we need, before the stresses we are putting on the natural world tip us into overshoot and calamities? A macroeconomist might say, with Mr. Micawber, "something will turn up." A pessimist – and perhaps a realist – would say "probably not, humans have never undergone major changes without turmoil, and these proposed changes are without precedent in scale and speed." An optimist would minimize the obstacles and point out that, theoretically, the adjustments are possible, and – in the richer nations – doable without major calamities.

An activist would say "let's give it a try; we have little to lose except a few years of overconsumption", and he would point out that, if we succeed, we may actually create a world that has conquered the Darwinian trap that has applied to all successful species: the genetic imperative of excess fertility. It could be a world in balance, with population and consumption at sustainable levels, and a genuine international community rather than the historical world of national and class warfare, perpetual conflict and endless competition for finite and limited resources.

I will go with the activist, but we really cannot tell who will turn out right. Can *homo sapiens* – self-styled – have the wisdom to learn to manage fertility for the common good? It is a unique experiment. We have examples of other species being too successful in isolated situations such as islands, impoverishing the environment and eventually diminishing in numbers through starvation. We have similar examples in the human experience, but we have no such experience for the species as a whole, spanning oceans and historically warring cultures. I cannot imagine social regulation – except in an Orwellian state – becoming so perfect that the human race actually reaches an optimum level and stays there, but a future of population fluctuations around a moving optimum level would be much better than we now have.

The point of this paper is that that level is indeed moving – downward. Human activity is already degrading the environment and its resources. There are now too many of us to live decently on the impoverished resource base toward which we are moving. It is not enough to hope that "something will turn up." That view betrays a vitalistic view of history. Nothing is likely to turn up by itself.

NOTES

1. For a history of several such civilizations, and a few that escaped that fate, see Jared Diamond, *Collapse* (New York: Viking, 2004). I would add the ancient Ceylonese city-states of Polonnuruwa and Anuradhapura.

2. More detailed treatment of these issues will be found in my books *Juggernaut: Growth on a Finite Planet (1996), Too Many People (2000), and The Collapsing Bubble: Growth and Fossil Energy (2005)*, all published by Seven Locks Press.

3. *Scientific American,* September 2006, pp. 46-114 provide a broad general survey of the energy picture, a bit loaded perhaps with the authors' enthusiasm for their own specialties. *Science* on 2-7-2007 (p. 737 & 781-813) carried an editorial by AAAS President John P. Holdren and a series of articles on "Sustainability and Energy" focused mostly on technical issues and solutions.

4. DOE/EIA (U.S. Department of Energy/Energy Information Administration) *International Petroleum Monthly,* online, Tables 1.7 & 4.1c.

5. IPCC Special Report "Carbon Dioxide Capture and Storage" (9-2005). The report states that its estimate of potential storage areas is based on "partial data... (and) may change." Solidifying CO_2 into silicate materials is "very slow (and)... energy intensive" and still at the research stage, as is the possibility of ocean storage. The study was premised on a target atmospheric range of 450-750 ppm; the higher figure is twice the present level. And it said that "by 2050... around 20-40% of global fossil fuel CO_2 emission could be technically suitable for capture." That is a very modest goal.

6. "Taking Control of Electric Bill, Hour by Hour", *New York Times, 1-8-07.*

7. There are frequent enthusiastic reports about the great possibilities for tides, waves, ocean currents, ocean temperature differentials and geothermal heat as "limitless" energy sources. Most of these tend to be limited – see *The Collapsing Bubble*, Chapter 3. For instance, efforts to mine geothermal energy in the absence of massive water in the heated zone – the so-called "dry hot rocks" technology – go back to an international experiment led by the Los Alamos laboratory in the mid-1970s, which failed because the introduced water dissipated in rock fissures. Ocean temperature differentials are still a hypothetical source; whether they would work, and at what scale, is still unknown.

8. *The Collapsing Bubble*, op cit, pp. 49-51. The 5% figure assumes an annual harvest of 3 tons/ha, which is about average for woodlands but probably optimistic for the lands available for biomass harvesting. For a discussion of the connection with climate warming, see *Juggernaut*, pp. 69-77.

9. As with other potential energy sources, there are occasional "can do" articles extolling the potential of supposedly unused land. See for instance David Tilman et al, "Carbon-

Negative Biofuels from Low-Input High-Diversity Grassland Biomass", *Science*, 12-8-2006, pp.1598-1600. This may be the product of an experiment on still-undegraded soils. Hillsides in the tropics and sub-tropics may be burned over annually and then harvested for grass for cooking, but it is a low-value use of marginal land.

10. Some readers may have been misled by the campaign by major corporations, particularly Exxon, to pay "think tanks" that dismiss global warming. Obviously, this can make headlines, but not science. Al Gore's documentary *An Inconvenient Truth* quotes a literature review reported in *Science,* which found that of 928 peer-reviewed scientific articles from 1993-2003 on climate change, none challenged the idea that human activity plays a role. On the other hand, of hundreds of popular articles on the subject, more than half dismissed that role.

11. There are varying estimates of the changes, but agreement that the ice loss is dramatically accelerating. See, for example, ENS Boulder, CO, report 9-21-06, H.K. Chen et al, "Satellite Gravity Measurements Confirm Accelerated Melting of Greenland Ice Sheet", *Science*, 9-29-06, pp. 1958-1960 and A. Cazenovia, "How Fast Are the Ice Sheets Melting?", *Science*, 11-26-2006, pp. 1250-1252.

12. IPCC, *Climate Change 2007: The Physical Science Basis. "Summary for Policymakers."* (2-2-07) www.ipcc.ch/SPM2feb07.pdf.

13. National Assessment Synthesis Team of the IPCC, *Climate Change Impacts on the United States* (Washington: U.S. Global Change Research Program, 2000.)

14. The Kyoto proposals are far from sufficient to arrest climate warming, and they suffer from their limitation to industrial countries. (China and India led the third world refusal to be bound by any targets.) They are, however, the most serious effort so far to address a major world problem on an international scale, and the EU is making strenuous efforts to comply with it.

15. See the UN *Second World Water Development Report*, March 2006 for an exhaustive treatment of water issues.

16. Food & Agriculture Organisation (FAO), FAOStat Agricultural Production data at http://faostat.fao.org/site/339/default.aspx. FAO relies primarily on official country data, which may be weak in many developing nations, or distorted for political reasons.

17. In this case, I use the European Union 15 as proxy for our usual definition of Europe. The comparison with China is only approximate. The official figure for China's arable acreage has risen from 96.9 million hectares in 1980 to 142.6 million hectares in 2003. That is a 47 percent increase, in the face of desertification in the North and Northwest and the loss of land to industry, urbanization and new reservoirs. The increase, in an already overcrowded land, is certainly an artifact. It reflects historical differences between the Ministry of Agriculture and the State Statistical Bureau, plus the perpetual tug-of war between local and provincial officials, who benefit from an undercount, and the central government. May that be a warning about Chinese – and many other – statistics.

18. Lindsey Grant, *Too Many People*, op cit, p.75-80.

19. Lindsey Grant, "Social Security and the Fear of Aging", NPG FORUM, 2005.

20. The growth rate projected is the annual rate of 1.12% between the 1990 and 2000 census. Jack Martin & Stanley Fogel reach the same 500 total with a cohort model. See *Projecting the U.S. Population to 2050: Four Immigration Scenarios* (Washington: Federation for American Immigration Reform, March 2006.) Both calculations assume that fertility by race will remain constant. We may hope that, as a result of national policy or women's volition, that assumption will be wrong, and that immigration, fertility and population growth will be lower.

21. All TFR rates are from NCHS Health Preliminary Birth Statistics 2005, Table 1, and National Vital Statistics Report Vol. 54 #2, 9-8-05, Tables 4 & 9. Note that NCHS uses official Census estimates of total populations. Particularly in the case of Hispanics, those estimates may be too low, which would raise the apparent fertility level, since we can count births more easily than total population. If they have undercounted, the real population will be higher, but the fertility lower, which is a worse situation right now but a less threatening picture of future growth.

22. From E.F. Schumacher, *Small is Beautiful. Economics as if People Mattered* (New York: Harper & Row, 1973), p. 24. This paragraph was quoted in *Juggernaut*, op cit.

23. The *New York Times* (4-9-06) and even the *Wall Street Journal* (1-19-06), that bastion of capitalism, have recently carried articles critical of the widening income spread.

24. Be it said that a few economists, with the United Nations' blessing, are trying to develop a measure that includes the increase or decrease in national resources.

25. See Graph 1, *The Collapsing Bubble*, op cit.

26. Yuka Hayashi, "Japan's Profits Rise, but Wages Stagnate", *Wall Street Journal, 1-16-07, p. A2.*

27. Gilbert S. Omenn, *Science*, 12/15/06, pp. 1696-1704.

28. See *Juggernaut*, op cit, Chapters 15-17.

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