Perilous Optimism

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I

Human beings thrive on hope. Without some sense that our individual deliberate effort brings us closer to a fulfillment of our personal goals, we simply cannot function from one day to the next.

And yet, hope often betrays us, as it blinds us to clear and evident danger and leads us to courses of action and inaction that will eventually result in the loss of our property, our livelihood, our liberty, and even our very lives.

Pangloss is admired, and Cassandra is despised and ignored. But as the Trojans were to learn to their sorrow, Cassandra was right, and had she been heeded, the toil of appropriate preparation for the coming adversity would have been insignificant measured against the devastation that followed a brief season of blissful and ignorant optimism.

Throughout history, and most recently in the mid-Twentieth century, millions have perished due to stubborn and ill-advised optimism. For example, Hitler made his intentions brutally clear in *Mein Kampf,* yet neither the British nor American governments took heed until the Wehrmacht crossed the Polish border.

Today, Cassandra holds advanced degrees in biology, ecology, climatology, and other theoretical and applied environmental sciences. In a vast library of published book and papers, these scientists warn us that if civilization continues on its present course, unspeakable devastation awaits us or our near descendants. Turning away from that "present course" toward "sustainability," will be difficult, costly and uncertain, but far preferable to a continuation of "business (and policy) as usual."

As a discomforted public, and their chosen political leaders, cry out "say it isn't so!," there is no shortage of reassuring optimists to tell us, "don't worry be happy."

We sincerely wish that we could believe them. But brute scientific facts, and the weakness of the Panglosian arguments, forbid. And so, in this paper we will confront some of the arguments of the optimists, and sadly conclude that their reassurances can not stand up against scientific evidence, fundamental natural laws, logical scrutiny, or even plain common sense. While the optimists are numerous and their reassurances familiar, we will focus our attention primarily on two individuals: the late economist, Julian Simon, and the philosopher, Mark Sagoff.

First of all, Julian Simon makes the following hopeful, yet highly controversial, claims:

- "The supply of natural resources [is] really infinite!"
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- "There is no reason to believe that at any given moment in the future the available quantity of any natural resource or service at present prices will be much smaller than it is now, or non-existent." (Simon, 1981, 48).
- "We now have in our hands in our libraries, really the technology to feed, clothe, and supply energy to an ever-growing population for the next 7 billion years... We [are] able to go on increasing forever." (Myers and Simon, 1994, 65).

- "Even the total weight of the earth is not a theoretical limit to the amount of copper that might be available to earthlings in the future. Only the total weight of the universe..." (Simon, 1980a, 1435). [After all, alchemy is said to be] "preposterous because it is impractical now. But ... so was electricity considered impractical a century ago." (Simon, 1980b, 1306). "In the end, copper and oil come out of our minds. That's really where they are." (Myers and Simon, 1994, 100).
- "Population density does not damage health or psychological and social well-being." [2]
- "There is no statistical evidence for rapid loss of species in next two decades." (Simon, 1984, 14).
- "The climate does not show signs of unusual and threatening changes." (Simon, 1984, 14).
- "For most relevant matters, aggregate global and U.S. [environmental] trends are improving." (Simon, 1984, p. 15).

In short: *There is only one scarcity: Human brain power* -- *"The Ultimate Resource."*

Simon writes:

> "The main fuel to speed the world's progress is the stock of human knowledge. And the ultimate resource is skilled, spirited, hopeful people, exerting their wills and imaginations to provide for themselves and their families, thereby inevitably contributing to the benefit of every one." (Myers and Simon, 1994, 33)

It then follows that *population growth rates are not a problem,* except possibly in the sense of being too slow.

Similarly, Mark Sagoff believes that human ingenuity, what Simon calls "The Ultimate Resource," combined with accumulated information and technological advancement, will overcome any and all resource and consumption limits in the near or distant future.

"The idea that increasing consumption will inevitably lead to depletion and scarcity, however, plausible, is mistaken, both in principle and in fact. From a global point of view, raw materials have grown more abundant and prices for them have fallen, in spite of an expanding economy and growing world population. Food is more plentiful and less expensive on international markets today than at any time in history. Similarly, proven reserves of non-renewable resources, such as metals and petroleum, have generally increased, not decreased, with consumption, and [recently] real prices for these commodities have declined. Shortages of raw materials tend to be local and temporary and [do not result] from physical limits nature sets." [3] (Sagoff, 1997, 2).

In sum, Sagoff assures us that "... technology can deliver greater and greater abundance...." and that "the endless expansion of the global economy is physically possible..." (Sagoff, 1997, 29). In addition: "if there is a limiting factor in economic production, it is knowledge, and ... as long as knowledge advances, the economy can expand."[4]
(Sagoff, 1995, 610) In brief, both Sagoff and Simon are confident that knowledge and human ingenuity, combined with market incentives, will suffice to meet any upcoming environmental emergencies.

"Endless expansion?" And yet, on an average day at the turn of this new century, 63 million tons of CO_2 are added to the atmosphere (UNEP, p.24), 95 square kilometers of agricultural land are lost to desertification (Hauchler & Messner, 1999), and 410 square kilometers of forests are razed – an annual loss (at 150,000 sq. km.) almost twice the area of Austria (83,000 sq. km.). (Myers and Simon, 1994, 74). On this average day, an estimated 74 species will become extinct (Wilson, 1992, p. 280). And on this ordinary day, human population will score a net gain of 210,000 (World Watch, 2000b, p. 99), which adds up to more than seventy million a year – about 90% of the population of Germany.

Add to this, the fact that since 1950, the world's population has more than doubled, while at the same time, twelve million square kilometers of land (the combined area of China and India) have been seriously degraded (World Resources Institute, 1992, Ch 8), and since 1960 twenty percent of the world's tropical forests have been lost

(Bryant, 1992, 14) Since the onset of the industrial revolution, atmospheric carbon dioxide (the major "greenhouse gas") has increased by more than thirty percent. (IPCC, 2001, 4) E. O. Wilson expresses the conventional wisdom among environmental scholars and activists: "Because Earth is finite in many resources that determine the quality of life including arable soil, nutrients, fresh water and space for natural ecosystems doubling of consumption ... can bring disaster with shocking suddenness." (Wilson, 1993)

If the optimistic view of Simon and Sagoff is overwhelmingly rejected by informed scientific opinion, why should anyone take the optimists seriously? Should we not, instead, ignore them as we move ahead with the serious business of establishing a sustainable world economy, in harmony with the physical and biotic limitations of the Earth?

We should take the optimists seriously, and carefully answer and refute their arguments, for the simple reason that the political-economic paradigm of endless resources and constant growth dominates the thinking of those who establish and implement governmental and corporate policies throughout the developed world. We will return to an examination of this dominant economic paradigm near the end of the paper.

In the section that follows immediately, we will critically examine Mark Sagoff's optimistic claims and projections regarding natural resources. In the third and final section, we will explicate and scrutinize the fundamental tenets and presuppositions of Julian Simon's defense of endless constant growth.

II

All the basic resources that support industrial civilization, Mark Sagoff argues, are abundant now and will remain so into the foreseeable future. In all cases, I reply, his optimism is unfounded. (World Watch, 1999, 2000a, 2000b).[6]

Food

Can we feed the world population, believed by the United Nations estimates to grow from eight to eleven billion in the next half-century? (World Resources Institute, 1998, 143) Sagoff assures us that "the trends are favorable. Global output of cereal crops has more than tripled over the last 40 years, largely as a result of greater yields, while agricultural output generally rose 160 percent, outpacing population growth." (Sagoff, 1997, 10)

How have we managed this? Through "better seeds, more irrigation, multicropping, and additional use of fertilizer..." (Sagoff, 1997, 10) He further points out that new strains and methods promise to triple per-acre cassava production in Africa, and triple corn yields in America.

Simply put, we have traded a rather inefficient but sustainable system of solar to biomass energy (by means of animal power and manure fertilization), for an intensive system that draws on the capital of fossil fuels (supplying both machinery fuel and fertilizers), with a byproduct of greenhouse gases. In a very real sense, industrial man eats petroleum. Consequently, land formerly used to produce food for the draft animals, is converted to food production, reforestation or urbanization. However, this, says ecologist, Kenneth Watt, is a gamble.

> Between 1950 and [1970] a final 11 million horses have been taken out of American agriculture and replaced by tractors powered by crude oil. Since it takes very roughly four times the acreage to support one horse as a person, this means that we have been able to add 44 million people to the American population [in those twenty years] for that one cause alone, because of a fossil fuel subsidy...
>
> Mankind is embarked on an absolutely immense gamble. We are letting the population build up and up and up, by

increasing the carrying capacity of the Earth for people, using a crude-oil energy subsidy, on the assumption that there's no inherent danger in this because when the need arises we'll be able to get ultimate sources of energy...

The world can probably support between one and four billion people at the absolute outside without a fossil-fuel energy subsidy...By the time we run out of this fossil fuel energy subsidy, there will be 10 to 20 billion people in the world... (Watt, 1970, 9-11).

This fossil fuel subsidy accounts for the tripling per-acre yield that Sagoff refers to. Improved seeds and genetic engineering may increase per-acre yield still more -- perhaps even enough to feed the world population of ten billion projected for this century. But surely there must be an upper limit to all this. Or are we to believe that yields can triple again, and then again? Surely available nutrients and solar energy, not "knowledge," are that upper limit. And yet, as we noted, Sagoff promises that 'the endless expansion of the global economy is physically possible.'" (Sagoff, 1995, p.610).

Meanwhile, we have discovered that industrial agriculture is vulnerable agriculture, as monocultures are assaulted by ever-more resistant pests, which are then attacked by every more toxic pesticides. All the while, soil is lost and ground water degraded by the massive importation of chemical pesticides and fertilizers. A further loss of "natural capital." (Brown, 1999, 115)

Forests

What, then, of our forests and timber supply? Once again, Sagoff is reassuring:

Timber prices stood at an all-time low in 1991... [The] eastern United States, which loggers and farmers in the 18th and 19th centuries had nearly denuded of trees, has become reforested during this century.... India now plants four trees for every one it commercially harvests. (Sagoff, 1997, 12-3).

Notice, however, that Sagoff cites the Indian forestry practice in terms of numbers of trees, not biomass: i.e., the weight of a harvested tree against the weight of four seedlings. If my neighbor were caught cutting down and hauling away the ancient oak tree on my front lawn, I would not be compensated with four acorns. Moreover, every tree cut and hauled away carries with it the nutrients which, in a natural forest, are recycled through the death and decay of the old trees. Still more drain on the "natural capital." Forest industry advertisements to the contrary notwithstanding, industrial forestry is not sustainable.

Sagoff writes that "the US is far more wooded today that it was 50 and 100 years ago." (Sagoff, 1997, 13) True enough: "wooded," but not "forested." There is an important difference, such that if the total area of woods and forests increases as the ratio of woods to forests also increases, our wealth in "natural capital" may decrease significantly. The difference can be seen at a glance. In the pacific northwest of the United States, you will find logging trucks bearing a single 6-foot diameter 400 year old log. In northern Wisconsin, recently my home of four years, the logs are stacked crosswise, eight feet long and rarely more than a foot in diameter. The pacific logs are from non-renewable old-growth forests such as we had in Wisconsin two hundred years ago. In my former Wisconsin neighborhood, today's harvest is not from "forests," but from second growth "woods," and even worse, from "tree farms" monocultural stands of trees, of identical size, age and species, arrayed in rows like cornstalks in Iowa, and in a landscape just about as interesting aesthetically or diverse biotically. Not a fair trade for the northern forest that the voyageurs found there three-hundred years ago.

If timber is so plentiful, then why is there a demand to take the remaining old-growth forests. Why don't those "tree farms" suffice? The wood is plentiful, precisely because timber interests have finagled the North American governments to give away the store i.e., the natural capital: witness the amputation of the Tongas National Forest. Sagoff tells is that "forests now provide the largest harvests in history." (Sagoff, 1997, 12) I have no reason to doubt this. But somehow, I take no comfort in it, for it is a non-sustainable "provision."

Water

Why should we be worried about water? After all, Sagoff reassures us, water, like all matter, "is neither created nor destroyed: there is just as much water now as there was 10,000 years ago."[7]

He is right, of course: none of the water that enters my house is, strictly speaking, *destroyed.* But believe me when I tell you that it is *altered!*
There is more to that water when it leaves than when it enters, and that "more" is economically less. Thus, while I would willingly dip a ladle in to the inflow I would not do so to the outflow. And what would it take to make that outflow a useful resource again? *Energy,*
of course the same "ultimate resource" required to restore any natural capital (by reducing *entropy*). And the more intensively we "use" water, the more polluted the outflow, the greater the loss in natural capital, and the more energy required to restore it.

Unfortunately, we don't restore it all, and so we all continue to go down the entropy escalator. Thankfully, nature does manage a few steps up the down escalator through the simple expedient of solar energy: evaporation, atmospheric circulation, and precipitation. What both nature and humans fail to restore as natural capital is "waste" e.g., groundwater contamination, relocation of fossil ground water to the atmosphere, water pollution.[8]

Energy

"The bottom of the oil barrel," Sagoff assures us, "is fading from view. No shortages of hydrocarbon fuels are in sight. (Sagoff, 1997, 16) In defense of this claim, Sagoff repeats the oft-stated report that, "the world's proven recoverable reserves of oil and gas have grown" eight-fold. (Sagoff, 1997, 6). His optimism rests upon a careless disregard of those qualifiers, "proven" and "recoverable." Those qualifiers state what no ecologist has ever disputed; namely that new deposits will be discovered, and that the techniques of extraction will be improved. Yet that same "increase" suggests what no informed person can, on reflection, truly believe; namely, that the Earth is replenishing its fossil fuel supply on a time scale that is of any use to us. And yet this myth of "infinite supply" is implicit in public policy debates. For example, in the recent US Presidential campaign, neither major party has addressed the question, "When will we finally run out of petroleum, and what will we do then?"

Even so, the stubborn fact persists: the remaining supply of fossil fuels can only be depleted. And since oil consumption has doubled each generation, this means that we have extracted, each generation, an amount equal to all that has been extracted before. A superficial appreciation of the sequence of powers of two tells us that this trend is not sustainable. Thus one must devoutly hope that Sagoff is correct when he assures us that the demand for oil is leveling out. But with the vast majority of the world's population, and most significantly the populations of China and India, aspiring to imitate our high-consumption life-style, one must wonder.

Because the earth is not producing any more coal or oil, the qualified term, "proven recoverable reserves" testifies to our expanding technological capabilities, not to the an infinite supply, and eventually that technology must encounter the limit of that supply. When it does, there will still be petroleum and coal in the ground, but the price of extraction will be greater than its market price a price considerably higher than it is today.

However, I suspect that the limit on the use of fossil fuels will be dictated, not by the amount of "reserves," but by the capacity of the atmosphere to absorb their combustion products. On this point, Sagoff and I agree, though he seems a bit more sanguine about this problem than I am. Plant ecologists that I have read have warned that while the added dose of atmospheric CO2 might stimulate plant biomass production, this appears to be better news to weeds than to cash crops. Furthermore, there is experimental evidence that global warming may precipitate still more release of carbon dioxide from organic soils. (Harte, et al., 1995) Furthermore, sudden climatic changes can make large areas inhospitable to the previously established species. Some of us might be able to move north when the planet heats up. But our forests and ecosystems can not. (Kerr, 1995, 731)

The Pricing Argument

In defense of the claim that essential resources are abundant now and into the foreseeable future, both Sagoff and Simon cite falling prices for these resources. Recall our opening quotation from Sagoff: "From a global point of view, raw materials have grown more abundant and prices for them have fallen, in spite of an expanding economy and growing world population." (Sagoff, 1997, 2)

This citation of global resource prices is not reassuring. In point of fact, commodity and resource prices reflect the willingness to pay of those who are in the market, now. That willingness to pay is reflected in cash amounts, and thus those amounts are subject to all the moral limitations that cash is heir to limitations that Sagoff has explicated elsewhere with great cogency and eloquence. (Sagoff, 1988, Chapters 2 and 3).

Most significantly, the falling prices of resources reflects, not their enduring value, but rather prices at the present moment. However, due to the arithmetic of pricing, in particular "the discount rate," resource and environmental costs deferred into the remote future (e.g., costs incurred from radwaste, loss of biodiversity, global warming, etc.), need not factor significantly into the cost-benefit analyses of investors or, for that matter, economically oriented policy-makers. This is because, from the point of view of the present time, the absolute value of money (i.e., at zero interest) diminishes through time, (which is why a decision to save money must be rewarded with a "bonus," which we know of as "the interest rate.").[9]

Thus, for example, with a modest return on investment of five percent, an entrepreneur can accept a doubling of resource costs (e.g. of timber of crude oil) in fourteen years, and in a lifetime of seventy years, a cost increase multiplied by thirty-two. With a not-so modest return of ten percent, the present value of today's constant dollar (at zero interest) is worth less than a penny in fifty years. Little incentive here for the investor to provide for the remote future.

In light of this, consider: Sagoff cites John Holdren's estimates that oil and natural gas reserves extend several decades into the future. If so, the delayed costs of global warming resulting from the consumption of those fuels will be paid by our successors who are centuries and millennia in the future. According to the arithmetic of discounting from the perspective of time present, those remaining decades matter very little, and those deprived future generations centuries and millennia into the future matter not at all.

Furthermore, competitive advantage goes to the firm that returns on investments now, not in the lifetimes of our children and grandchildren. Because investors shop around for the returns that are both "the first and the most," the markets further "bid down" the value of the future.

Resource prices are depressed by the current squandering of "natural capital" by policies which "externalize" costs (in terms of eventually depleted resources) to our descendants. The depletion of "natural capital" is rarely factored into conventional economic analysis or into markets, since we insufficiently understand or appreciate the extent of "natural services." The ecological "service" of the stratospheric ozone layer, and the depletion of this "capital" by CFCs, is a case in point.[10]

"And what will we do when we finally run out of fossil fuels and petrochemicals?" "How are our grandchildren supposed to deal with global warming, or UV radiation, or radwaste?" Answer: "We, correction, *they,* will think of something we know not what." More bluntly, "that's their problem, not ours."

Resource prices are often artificially low due to "politically arranged" government subsidies the virtual "free gift" of national forest timber to private corporations, and oil depletion allowances are cases in point.

Excluded from the markets, thus having no voice in the determination of prices, are the ever-growing hordes of the destitute, as well as other species, and future generations.

In short, the cost reductions in resources that Sagoff quotes are systemically myopic.[11]

Assessing our global "wealth" in terms of our consumption is comparable to judging an individual's wealth in terms of his possessions. Both global and personal wealth are misleading, if they fail to take into account the security of the "capital" on which that wealth is based. (For example, a profligate "playboy" who cashes in blue-chip stocks to purchase a yacht, increases his "apparent wealth" as he decreases his "real wealth"). If the bio-scientists are to be believed, the security of "natural capital" -- the capacity of the Earth's physico-chemical-biotic systems to sustain the impact of industrial civilization -- is tenuous.

The apparent global "resource wealth" that Sagoff describes is, I submit, comparable to the apparent wealth of the consumer, surrounded by material goods and immersed in consumer debt, and the apparent increase in that wealth is accomplished through the expenditure of our natural resource capital a quantity, incidentally, not factored into standard economic analyses.. We are on a resource spree, with little regard for the discounted future.

In Dispraise of "Warehouse Earth"

For all it's good cheer and reassurances, Sagoff's argument is more interesting for what it excludes. There is a brief mention of thermodynamics, but not of *entropy,*
which is that aspect of thermodynamics most subversive of his thesis. In addition, one rarely encounters the word, "ecology," and yet the ecologist's view of the systemic web of our biotic and physical life support stand in sharp contrast to the picture of "warehouse earth" that one gains from reading this essay.

Despite alleged the opportunities for unlimited growth, Sagoff insists (and I agree) that we should curb growth and consumption so as to preserve "the beauty and spontaneity of the natural world (4) ... [and] the intrinsically wonderful aspects of Creation." (Sagoff, 1997, 4-5) Quoting John Muir, Henry David Thoreau, Steven Jay Gould and E. O. Wilson, he cites the fascination, mystery, and miracle of nature meaning, I take it, the ultimate inscrutability of nature.

Yet the nature that I read about in the first part of this paper is a nature that is all too "scrutable." So scrutable, in fact, that we can devise a global info-economy whereby our knowledge of the workings of nature can expand to virtually usurp the place of the other factors in economic well-being, hitherto thought indispensable: resources and energy. It is, in brief, a nature that we could, if we wanted to, totally artificialize and then competently manage. We could, he says, but of course we really shouldn't.

However, I would insist that this very mystery and miracle of nature those qualities that give it its intrinsic value confound the conceit that nature is "manageable," and will permit perpetual growth and artificialization by whatever amount of knowledge that we can come by. For any attempt to artificialize and manage nature produces new management problems, requiring still more knowledge in short, the quest for "total management" suggests a race to overtake our own shadow, as the solution of immediate problems produces still more problems. We seem to believe that we can catch up, if only we just run a little bit faster.

The reason why mysterious nature is, in principle, less than fully manageable is no mystery: the reason is *entropy*.

Sagoff refers to the Second Thermodynamic law, but only by pointing out that in a closed system "free energy" can be transformed into "bound energy," but not the reverse that you can't burn a lump of coal twice. Far more important is the rule that, absent the importation of energy from outside a system, nature moves from conditions of low to high probability, from order to disorder, from complexity to simplicity, from high to low potential toward increased entropy. Localized negentropy (as in organic evolution, or the designing of a city, or in scientific research and development) can only be accomplished through the importation of energy and information from outside. And the net result will be an increase in entropy outside the system. Thus the price of order here is disorder there, of complexity is simplification, of utilized energy is less available energy. "There is no such thing as a free lunch." And that is why "total management" of nature will forever elude us.

We will have much more to say about *entropy* near the close of this essay.

In the final analysis, entropy and ecology are the undoing of the info-economy that Sagoff says we can but should not have. A library of ecological horror stories affirm those most basic of ecological laws: 'you can't do just one thing," and "there is no 'away'." Public health measures explode the population, pest control "selects" super-pests, the stuff that cools our food erodes the ozone, and so on. Virtually all our environmental problems turn out to be the results of prior environmental "solutions." (Natural disasters are excluded from this observation). Touch a strand, and trouble the web. "The law of unintended consequences" reigns supreme.

It is true that there are promising prospects ahead for utilizing solar energy, perhaps the only acceptable long-term fuel to drive the global economy.. The technological wizardry that Sagoff describes, along with the short-term drop in resource prices that it has promoted, have bought us some time. But if we use that time to continue our spree, with no thought for the long-term morrow, then we are merely climbing higher up the cliff from which we will fall. And when we are about to fall, the aesthetic and spiritual values of wild nature that Mark Sagoff celebrates will be a distant memory, sacrificed to our insatiable appetite for "more, still more."

III

Julian Simon's Cornucopism: The Elements

The late Julian Simon's essential thesis is that there are no physical limitations on economic growth or human population growth. The only resource shortage, he claims, is human knowledge and ingenuity: "The Ultimate Resource" which, in adequate supply, is capable of solving any and all resource problems.

Prof. Simon's ideas have been universally dismissed by environmental scientists as crackpot, and yet he was something of a hero among libertarians, neo-orthodox economists, and their political disciples. Because the latter group is far more influential in the articulation and implementation of national and international environmental and economic policies, Simon's ideas should be taken very seriously, and scrupulously examined and rebutted.[12]

As we noted at the beginning, these are the fundamental tenets of Julian Simon's position:

The supply of natural resources is infinite.
Almost all trends in environmental quality are positive.
History is a reliable guide to future possibilities.
There is only one scarcity: Human brain power "The Ultimate Resource."[13]

Accordingly, population growth rates are not a problem, except possibly in the sense of being too slow.

What is interesting about Simon's position is that the data that he cites in its defense are for the most part correct. The trouble is that these data are either irrelevant or partial, and as a result, do not sustain his cheerful world-view.[14]
However, that world view is supported by several presuppositions which are occasionally stated or hinted at, but more often unacknowledged. And some of the more salient of these presuppositions can be inferred, not by the pattern of evidence that he cites, but by the patterns of significant information that he disregards.

The superficial plausibility of Simon's position is gained much more through his *exclusion* than through his citing of data. As we shall see, missing from Simon's cheerful prognoses is any acknowledgment or apparent comprehension of such fundamental ecological principles as nutrient cycling, feedback mechanisms, and limiting factors, or even that very foundation of physical science: *thermodynamics* and *entropy*. His perspective is confined to his own field of market economics.[15]

Julian Simon's Cornucopism: The Presuppositions

This remarkable collection of assertions describes a world-view radically at odds with that of most biological and physical scientists. It is a view which, if true, would seem to rest upon a number of presuppositions equally at odds with "establishment science." In this section, I will sketch what appear to me to be the presuppositions that are both most crucial to the cornucopian world view, and most vulnerable to scientific and conceptual criticism. The task of refuting these assumptions will occupy us throughout the remainder of this paper.

Many or most of these assumptions would be rejected by Simon and the cornucopians. But if I've done my work effectively, that rejection is so much the worse for cornucopism, since a rejection of these presuppositions entails a rejection of their world view. So the challenge of this analysis is simply this: can the cornucopians carry forth their cheerful view of the world without the baggage of the seemingly absurd assumptions on which they rest? I submit that they can not.

The supply of natural resources is infinite

Closer inspection reveals that Simon means by this that "the supply of natural resources in not finite in any economic sense." (Simon, 1981, 42) If shortages appear and prices begin to rise, "human ingenuity" gets to work and finds cheaper ways to extract or recycle the resource, or else finds alternative resources that provide the same "service" -- e.g., coal for whale oil, thence petroleum for coal. (Simon, 1984, 15) In the future there is no practical limit to what human brain power will provide, not even, as we noted above, *alchemy:* the transmutation of elements.

Not content with this rather straightforward explanation of "non-finitude," Simon boldly ventures beyond the fringe. "Finitude," he reminds us, is a concept which "originates in mathematics." He then proceeds with an argument so strange that it must be quoted at some length, if we are to believe that he really means what his is saying:

> The length of a one-inch line is finite in the sense that it is bounded at both ends. But the line within the endpoints contains an infinite number of points; these points cannot be counted, because they have no defined size. Therefore, the number of points in a one-inch segment [of a line] is not finite. *Similarly,* the quantity of copper that will ever by available to us is not finite, because there is no method (even in principle) of making an appropriate count of it... (My italic, EP) (Simon, 1981, 47)

Note that word, "similarly." Clearly, Simon wishes to draw an inference from mathematics to the "real world." Unfortunately, such an inference is invalid, since:

> ... in the context of mathematics ... all propositions are tautologous definitions... But scientific subjects are empirical rather than definitional... [Thus] mathematics is not a science in the ordinary sense because it does not deal with facts other than the stuff of mathematics itself, and hence such terms as "finite" do not have the same meaning elsewhere that they do in mathematics.

This quotation is wholly consistent with the view of mathematics that is generally accepted by scientists, mathematicians and philosophers today as well as by Julian Simon, who is the author. (Simon, 1981, 48) In fact, of the two quotations just cited, the second appears just one page after the first. Remarkably, Simon seems quite unaware that he has thus totally demolished the conclusion that he painstakingly attempted to establish just three paragraphs previously.

But there is worse to come. In that same "points in a line" example, Simon equates (without supporting argument)

the concepts of "indeterminate" and "not finite" (which he is willing to treat as "infinite"). Continuing: "The quantity of a natural resource that might be available to us ... can never be known even in principle, just as the number of points in a one-inch line can never be counted even in principle... Hence resources are not 'finite' in any meaningful sense."

I should find this very reassuring: for if the day of my death is indeterminate, then by Simon's reckoning I can assume that I am immortal. And since that drill hole on my property, left from a failed attempt at oil exploration, is of indeterminate depth, I can assume that it is infinitely deep. Absurd? Of course! But what else could he mean by his inference from "indeterminate" to "infinite"?

History assures us that human progress is perpetual. The essential parameters of historical development are invariable, and thus there are no essential discontinuities in history. Accordingly, since history discloses that human ingenuity has always eventually triumphed over environmental adversity in the past, there is no reason to doubt that it will do so in the future.

The question of what, if any, meaning and lessons might be drawn from history, is one of the most profound and intractable issues in both philosophy and historical scholarship. And that very fact undermines much of the cornucopian argument, which requires a naive and simplistic belief that history is a *reliable* predictor of the future.

The cornucopian argument rests, not only upon a false reading of history, but also on an over simplistic notion of induction: namely, that the long history of successful human "coping" with nature gives us inductive warrant to assume more of the same in the future.

By way of refutation, environmental alarmists like to tell the story of the optimist who falls off a high building, and who reflects, two-thirds of the way down, "well, so far, so good!" I prefer another tale told by Bertrand Russell, which concerns a certain farmer and his turkey. From the point of view of the reflective turkey, the farmer will *always*
greet him in the morning with a bucket of grain. Why? Because, by simple inductive reasoning, it follows that the more often this happens, the more secure he is in the belief that it will happen again until, one morning, the farmer appears with an axe. Now from the farmer's better informed point of view, he knows that the more often the turkey gets the grain, the *less*
likely it is that he will survive another day. Similarly, life underwriters adopt the farmer's point of view.

Eco-scientists, like the farmer, have the better informed point of view. They understand all too well that "business as usual," celebrated by the cornucopians, is undermining the physical-biotic structure that supports that "business," and that the more our industrial "business as usual" continues as it has, the less likely it is that we will be able to continue. We are, as eco-scientists like to put it, "living off our biotic capital." All this is due to conditions in the real world well known to, and exhaustively studied by, these scientists conditions systematically discounted and ignored by the cornucopians.

Whatever problems may appear, human ingenuity will be equal to it. We've always solved our problems in the past, and we'll continue to do so long into the future.

This is, of course, a corollary to the previous assumption: that history is a reliable guide to future possibilities. However, this assertion brings to mind an epistemological observation, prefaced by a personal recollection.

Several years ago, I was engaged in a debate with a fundamentalist preacher. To his claims of the virtual existence of a heaven and hell, I protested that he was offering no evidence to support his claim. He replied, "just you wait -- you are eventually going to encounter plenty of evidence, when you meet your Maker!"

His retort was not particularly useful at the time.

I submit that this oft-reiterated claim, "human ingenuity will be equal to the task" is super-empirical hand-waving of the same type. It is simply a "secular eschatology" -- a kind of "cargo cultism," which attempts to answer scientifically validated challenges with unverifiable promises.

In the meantime, "human ingenuity" *has*
been at work and in the very biotic, atmospheric and other sciences that the cornucopians summarily dismiss. The cornucopian confidence in "gray matter," thus appears to be curiously selective. Never mind, they tell us, what "ingenious humans" in the sciences are telling us now, and kindly disregard the weight of evidence and the strength of inference amassed through this applied "ingenuity." The cornucopians have faith that somehow, sometime, some other "ingenious humans" will eventually come along to prove that they are right. "Just you wait!"

Nature is just inert "stuff," a warehouse of resources, on which we act and from which we take, but about which we need not give special notice. If nature causes us problems, we simply assemble our "best minds" and they will take care of it.

Prof. Simon's "nature" is a very strange place almost a caricature of George Berkeley's subjective idealism; it exists only when we take note of it. "To be is to be a commodity." (More fairly: "to be of any concern to us, is to be a commodity"). Complete your transaction, turn your attention elsewhere, and nature will, for all practical purposes, just disappear until you next find need of it -- infinitely and perpetually available. Moreover, Nature is also an infinite "sink." When we throw something "away," it is really "away" -- it never comes back. The chain of causation, which is very useful to us when we want resources from nature, somehow just stops when we cease taking note of it.

The Berkeleyan world view goes even further: "to be is to be intended." It then follows that there are no "unintended consequences." In other words, after we enjoy the desired effect, there are no further causes. Pesticide residues "go away," never to appear again. The CO2 produced by the burning of fossil fuels is of no further concern to us. Nor are the pesticides after they kill the pests, and are thus miraculously rendered innocuous to song birds.

Of course, the cornucopians will retort that this is an unfair caricature and of course they are right. And yet, they act as if this caricature were so. Cornucopians pay almost no attention to the complications and costs of "unintended consequences" (called "externalities" by economists) and they are quite unimpressed by the findings, even less the warnings, of scientists who study ongoing phenomena in "uncommodified nature." And if the cornucopians admit that causation continues unnoticed, they will then claim, "well never mind, we can fix all that don't underestimate the power of human ingenuity, especially when motivated by profit."

In short, cornucopians seem to be totally unconcerned by "Hardin's Law:" *You can't do just one thing*. (Hardin, 1970, 17) And they rarely bother to ask Hardin's query: *And **then** what?* (Hardin, 1976, 122) All this is surpassingly strange since, despite their allegiance to free market theory, the cornucopians thus conveniently ignore that most fundamental of economic maxims: "there is no such thing as a free lunch."

Nature (and, in particular the biosphere) is a mechanical order, not a systemic order of mutually interacting components.

This axiom of the cornucopian world-view is challenged by the late economist, Nicholas Georgescu-Roegen, who writes:

> "... the founders of the neoclassical school set out to erect an economic science after the pattern of mechanics.... [and thus], analytic pieces that adorn the standard economic literature ... reduce the economic process to a self-sustained mechanical analogue. The patent fact that between the economic process and the material environment there exists a continuous mutual influence which is history making carries no weight with the standard economist." (Georgescu-Roegen, 1993, 75).

But while the "pattern of mechanics" is implicit in neo-classical economic theory, it is contrary to the principles of thermodynamics: "The opposition between the entropy law with its unidirectional qualitative change and mechanics where everything can move either forward of backward while remaining self-identical is accepted

without reservation by every physicist and philosopher of science." (Georgescu-Roegen, 1993, 87-8) Georgescu-Roegen's enduring legacy is his demonstration that *entropy,* the cornerstone of physical science, challenges the very foundations of classical economic theory even more, the reassurances of the cornucopians. We will have much more to say about *entropy* shortly.

Simon's mechanistic view of physical reality is nowhere more evident than in his dismissal of concerns about "global warming."

> ... no threatening trend in *human welfare* has been connected to [global warming]... It may even be that a greenhouse effect would benefit us on balance by warming some areas we'd like warmer, and by increasing the carbon dioxide to agriculture... [Moreover], we now have large and ever-increasing capabilities to reverse such trends if they are proven to be dangerous, and at costs that are manageable.[16] (Simon's italics). (Myers and Simon, 1994, 18-9)

Unfortunately, Simon offers not a word to identify these putative "capabilities" with which we will unscramble the atmospheric omelet.

Simon's view here of global atmospheric processes is astonishingly ill-informed. Brushing aside whole libraries of scientific data, he chooses to regard "global warming" as "global warming -- *period.*" He acknowledges no changes in "warehouse Earth" except that *everywhere*
things are a bit warmer. To Simon, "warming" the Earth, is essentially no different that turning up the thermostat and "warming up the house." He thus fails to recognize that the global climate is a *system.* Accordingly, global warming *in toto*, would mean that some regions might in fact be cooler, some much hotter, some dryer, some wetter, some subject to more violent tropical storms, and so on, far beyond our reckoning. Ocean currents would likely change with dramatic consequences; for example just a slight change of direction in the Gulf Stream could condemn Great Britain to a climate comparable to its latitudinal opposite, Labrador. (Of course, as we have seen, if scientists tell us that "we don't know the full effects" of something, Simon routinely interprets this to mean, "there are no effects"). Also, Simon typically fails to comprehend the sensitivity of established ecosystems to such sudden climatic changes. For example, whole forest ecosystems, unable to "migrate" to more favorable climates, would collapse. (Kerr, 1995, 731)[17]

Because elementary matter can not be destroyed, we'll never run out of resources. The dumps and sinks of today are the mines of tomorrow.

This seems to make superficial sense to the mechanist mind-set of reversible processes favored by the cornucopians. However, elemental resources that are scattered as "garbage" are often woefully beyond recovery. This is so due to some fundamental thermodynamic principles, to which we will return.

In particular, nature can be successfully managed. So-called "biological services" (such as insect pollination) are fully replicable if not dispensable, once we put our engineering skills to the task.

"Biological services," like so many basic concepts of the life and physical sciences, are totally ignored in Julian Simon's writings. Small wonder. To acknowledge these services, is to admit that it just might be possible that management of the natural order which created and nurtured our species, might be forever beyond our capabilities. Yet such capabilities are implicit in Simon's cavalier assumption that any problems that might arise can be handled by "human ingenuity."

Very well, cornucopians, "manage" this!

The "biotic services" that we can cite are endless. (Daily, 1997; Costanza et al., 1997b; Baskin, 1997) I will settle for two examples of such "services." First, the oceanic phytoplankton, whose production of atmospheric oxygen is

greater than that of the tropical rain forests. (Myers, 1984) Next, consider permanent removal of CO2 from the atmosphere by zooplankton, coral and mollusks (which convert it into carbonates and eventually into limestone). And plankton, of course, is the base of the oceanic ecosystem, and thus utterly necessary of we are to be fed from the seas. And yet, the plankton are threatened by ultra-violet radiation from ozone depletion. (Häder, 1995) Not to worry, Simon reassures us, since that increased UV radiation might improve our vitamin D intake, and the harmful effects might be overcome by wearing hats, and anyway, says Simon, "if human interaction is causing the change, then human intervention can reverse it." (Myers and Simon, 1994, 63)

Unfortunately, hats are not of much use to the plankton.

Then there the are micro-invertebrates such as mites and worms, along with the bacteria -- what E. O. Wilson calls, "the little things that run the world" -- that transform "dirt" into *soil,* and which transforms the waste of completed life into nutrients for new life. Of these "little things," Wilson notes that we need invertebrates but they don't need us... If invertebrates were to disappear, I doubt that the human species could last more than a few months... The earth would rot. As dead vegetation piled up and dried out, narrowing and closing the channels of the nutrient cycles, other complex forms of vegetation would die off, and with them the last remnants of the vertebrates. The remaining fungi, after enjoying a population explosion of stupendous proportions, would also perish. Within a few decades, the world would return to the state of a billion years ago, composed primarily of bacteria, algae, and a few other very simple multicellular plants. (Wilson, 1987, 344)

There is literally no end to an accounting of our debt to the other life forms which maintain the physical-chemical-biotic nexus that is the ecosphere -- *Gaia.* But in Julian Simon's writings, there is scarcely a beginning of an acknowledgment of that debt.

Recently, the incapacity of human ingenuity to "manage" an ecosystem was vividly demonstrated by the spectacular failure of "Biosphere II." This two-hundred million dollar project attempted to establish a totally isolated and enclosed ecosystem which, like natural systems, could sustain the eight human "ecospherians" indefinitely. Instead, reports Paul Ehrlich and associates,

> ... the experiment ended early in failure: atmospheric oxygen concentration had dropped [from 20] to 14 percent (a level typical of elevations of 17,500 feet); carbon dioxide spiked erratically; nitrous-oxide concentrations rose to levels that can impair brain functions; nineteen of twenty-five vertebrate species went extinct; all pollinators went extinct thereby dooming to eventual extinction most of the plant species; aggressive vines and algal mats overgrew other vegetation and polluted the water, crazy ants, cockroaches and katydids ran rampant. Not even heroic efforts on the part of the system's desperate inhabitants could suffice to make the system viable. (Ehrlich, et al., 1997, 101).

In fact, we cannot "manage the Earth," precisely because the planet is not an "inert warehouse;" rather, it is a lively place, more complex and "wonderful" (literally "full of wonders") than we can ever know or even imagine. It is all this, because it is, first and foremost, *systemic*, and thus it displays these features:

- *energy* which *flows* and *nutrients* which *cycle*
  through the life forms of the trophic pyramids -- from plants to herbivores to carnivores.
- biotic and atmospheric action is *synergistic,*
  in ways that constantly surprise us and thus are out of our control. For example, photochemical smog, we have found, is more than just a "soup" of component air pollutants. It is a substance "cooked" into existence by those substances, through the catalytic action of sunlight.
- the biosphere displays numerous *"feedback effects:"* positive feedbacks which initiate "runaway sequences," such as "red tides" or possibly, for that matter, the greenhouse effects; and negative feedbacks which are characteristic of stable ecosystems.
- we must also cope with *time-lag effects,*
  such as the eventual release of "geologically stored" toxic and radiological materials, or the slow spread of pollutants through aquifers.

- we are constantly surprised by *threshold effects*
  or "tipping effects," such as when a forest or a lake appears capable of absorbing pollutants without harm, until eventually a slight increase causes massive die-offs or eutrophication. (In popular parlance, this phenomenon is known as "the final straw that breaks the back).

Because of these mechanisms, and many more, the biosphere is, to paraphrase J. D. S. Haldane, not only more mysterious that we suppose, but more mysterious than we can suppose. Accordingly, the biosphere is *not* reliably "manageable."

"The Facts speak for themselves."

To the anticipated criticism, "but what about the other side's data?", Simon boldly replies, "there are no other data." He continues, "I invite you to test for yourself this assertion that the conditions of humanity have gotten better." And he then refers the readers to the Census Bureau's *Statistical Abstract of the United States*. He concludes, "every single measure shows a trend of improvement rather than the deterioration that the doomsayers claim has occurred." (Myers and Simon, 1994, 64)

No data? Perhaps he just has not bothered to look. Simon claims that "There is no documentation of further data produced by biologists since 1979 to demonstrate what Norman Myers was saying" about mass extinctions. Myers replies, "during those thirteen years, the number of papers published on the mass extinction crisis is over three hundred... No documentation, no data, Professor Simon?" (Myers and Simon, 1994, 129)

Simply put, Simon counts as "data," what he wants to use as "data." The rest, he simply disregards. As we stated at the outset, the problem with Simon's argument is not that the data which he cites is not factual, but that it is partial or irrelevant. And it is that vast body of unacknowledged fact and theory that demolishes the cornucopian view.

"The facts speak for themselves" is the first refuge of the huckster posing as a scientist.[18]

But as anyone even casually familiar with the philosophy of science knows full well, "facts" only speak to us *in context* of other facts, and guided by theory. This is what distinguishes sound scientific theory and *ad hoc* caricatures such as "creation science" and, I submit, cornucopism. In the case of science, theory arises out of observation of facts, effectively classified and organized as the result of prior investigations (thus enabling the scientist, in his subsequent investigations, to distinguish "relevant" from "irrelevant" data). Reciprocally, a developing theory refines "the investigator's eye" as he returns to further explore the "facts" with a sharper sense of "relevance." Thus, in principle, all components of a sound scientific system (theory and facts) are "fair game" for reassessment. All scientific assertions, that is to say, are vulnerable to "the falsifiability principle:" i.e., the principle that scientific theories must yield implications that can clearly and unequivocally be shown to be otherwise, if the world is not what the theory describes it to be.

In the case of pseudo-science, a preconceived dogma selects facts and pre-determines what is to count as a "fact" and as "evidence," all the while this "preconceived dogma" remains outside the realm of "permissible inquiry," not amenable to reassessment in the light of new factual information, which is to say "the non-falsifiable in principle." In the present case, Julian Simon offers us the non-falsifiable, "super-empirical" reassurance that somehow, sometime in the future, economic incentive combined with human ingenuity is capable of solving any environmental problems that may arise, by means we cannot even guess at today.

"Facts do *not* speak for themselves." Give someone a *carte blanche* license both to pick any "facts" that he chooses and to disregard any others that he may find inconvenient, and he will be able to claim a "demonstration" of virtually any strange notion under the sun. However, by violating the "falsifiability rule," this self-concocted "ability" to "prove anything whatever" amounts to a capacity to prove nothing at all.

The preponderance of scientific opinion and theory, in the relevant disciplines of ecology, atmospherics, soils, demographics, and even physics, is simply wrong. Julian Simon and his friends know better. Furthermore, the well-known pessimism of environmental scientists is suspiciously motivated.

With this claim the cornucopians, quite frankly, display colossal *chutzpah*. For they contend, in effect, that the consensus opinion of entire fields of established sciences ecology, atmospheric chemistry and climatology, demographics, agronomy, etc. are fundamentally in error. All this scientific investigation and expertise is casually brushed aside in favor of historical analogies ("trends"), selected anecdotes, and abstract economic modeling. Still worse, at the close of his *Science* and *Bulletin of the Atomic Scientists* articles, and throughout the two books examined herein, Professor Simon practices unlicensed psychotherapy as he claims that the pessimism of "established science" is a conspiracy, motivated by careerism, competitive grantsmanship, a public fascination with bad news, and willingness to exaggerate in order to mobilize public activism.[19] (Simon, 1981a, 1436-7, and 1983, 16)

The Entropy Trap[20]

Throughout this essay, we have referred to the thermodynamic laws, and in particular *the entropy principle,* and have promised to explain how *entropy*
is the most fundamental and decisive refutation of cornucopian optimism. It is time, now, to fulfill that promise.

While thermodynamics, in the minutiae of mathematical elaboration, can only be comprehended by advanced students and practitioners of physics, in its general, non-quantitative formulation, the second law is quite simple: *closed physical systems move from states of free to bound energy, from high to low probability, and from order to disorder.*
These progressions can only be reversed in localized systems by the importation of information and energy (i.e., by "opening" the closed system). In the words of Nicholas Georgescu-Roegen, "the free ["useful"] heat-energy of a closed system continuously and irrevocably degrades itself into bound ["useless"] energy... Entropy (i.e., the amount of bound energy) of a closed system continuously increases or ... the order of such a system steadily turns into disorder."[21] (Georgescu-Roegen, 1993, 78).

Ehrlich, Ehrlich and Holdren express the second thermodynamic law as follows: "all physical processes, natural and technological, proceed in such a way that the availability of the energy involved decreases... What is consumed when we use energy ... is not energy itself but its availability for doing useful work."

They then spell out five significant implications of the second law:

1. "In any transformation of energy, some of the energy is degraded [from useful "free" to useless "bound" energy. EP].
2. "No process is possible whose sole result is the conversion of a given quantity of heat (thermal energy) into an *equal* amount of useful work. [Thus "perpetual motion machines" are physically impossible. EP].
3. "No process is possible whose sole result is the flow of heat from a colder body to a hotter one.
4. "The availability of a given quantity of energy can only be used once; that is, the property of convertibility into useful work cannot be "recycled."
5. "In spontaneous processes, concentrations (of anything) tend to disperse, structure tends to disappear, order becomes disorder." (Ehrlich, Ehrlich, Holdren, 1993, 71).

This final formulation, linking *work and heat to structure, order and probability,* is the most puzzling implication of the second law, and the implication which bears most heavily on the cornucopian world view. An elaboration is in order.

The most memorable explanation, to my mind, comes from Isaac Asimov.[22] Consider a typical child's bedroom.

When clean, it is orderly and improbable. Then entropy sets in, and it becomes disorderly and more probable. Why "probable?" Because, for example, dirty sox belong in just one place -- the laundry basket -- but instead end up "anywhere else," which is a more "probable" location than the basket. A made-up bed is just one improbable condition of numerous states of the bed; "unmade" is all the others.

Then mother sees the entropic mess, and says "no dinner for you, young man, until you clean this up!" So what does it take to reverse entropy and achieve the improbably neat condition? Knowledge of where things belong (information) and *energy*.

Next, consider "dispersion" and "probability:" The tea in the tea bag disperses into the cup of hot water. Never does the tea in the cup return to the leaves. Every pool game begins with a "break" of a racked triangle of fifteen balls. No game has ever succeeded in returning the scattered balls to a triangle. For that you need "outside" information and energy a player "racking them up." You will never shuffle a deck of cards into the order of suits. (Conceivably possible but virtually impossible). In the natural world, any organism deprived of nourishment (energy input) will die, and its constituent matter will disintegrate and dissipate -- i.e., entropically degrade from a complex and organized state, to a simple and chaotic condition. Once again, "all physical processes proceed in such a way that the entropy of the universe increases." Accordingly, as one wit put it: "We can't win, we can't break even, and we can't get out of the game." (Ehrlich, Ehrlich, Holdren, 1993, 72).

In the realm of deliberate action, this means that *order, concentration and useful energy within a system is purchased at the cost of greater disorder, dispersion and lost potential from outside the system.* Physical-chemical processes are irreversible: You can't unscramble an egg. You can't strike a match twice (the "free energy" has been "bound" after the first strike). Water pressure behind a dam, having turned a turbine, cannot turn it again, until external solar energy has evaporated it, turned into rain again and dropped it on the upstream watershed.

But if the natural tendency of systems is toward dispersal, disorder and simplicity, how then did life on Earth evolve over millions of years toward greater complexity from probable to improbable states? And what accounts for the regenerative forces, upon which the very phenomenon of life depends ? All this came about and continues simply because the Earth's climate and ecosystems are not "closed systems." The energy that drives the negentropy that is life and evolution, comes to us from an external source: the sun a thermonuclear furnace that "binds" (i.e., transforms to a useless and degraded form) -- free energy through nuclear fusion, on a time scale of billions of years. That radiant thermonuclear energy is then captured by photosynthesis and converted into chemical energy (carbohydrates), and the scattered nutrients from earlier death and decay gathered, reassembled and reorganized into complex organisms. In individual organisms, this captured energy is directed to a struggle for survival, and through this competition and natural selection, more complex organisms evolve.[23]

Eventually, in the species *homo sapiens*
reflective intelligence, knowledge and technical capacity have emerged, and with them moral agency and responsibility.

In short: the biosphere and human culture are "entropy pumps" powered by "imported" solar energy (in the case of human culture, solar energy "stored" in biomass and fossil fuels) -- i.e., localized eddies of increasing complexity and decreasing probability, against the universal entropic current flowing toward dispersion, simplicity and disorder.[24]

The implication for environmental policy and management is stark: *most if not all anthropogenic environmental "problems" are the result of prior "solutions"!*
(By "anthropogenic" w mean to exclude from this rule environmental problems of natural origin such as earthquakes, volcanoes, tsunamis, etc.). Think about it! The "solution" of premature death has resulted in the population explosion. The "solution" to mass transportation has led to air pollution. The "solution" to intensive agriculture has caused nitrate pollution of ground water and the eutrophication of streams.

This "undoing" of our good intentions has received popular notice in Edward Tenner's book, *Why Things Bite Back: Technology and the Revenge of Unintended Consequences.* (Tenner, 1996) In his review of the book in

Science, Landgon Winner cites some of these "unintended consequences:

> Antibiotics marshaled against disease have spawned new varieties of highly virulent drug-resistant bacteria that pose new threats to human health. Methods for preventing forest fires have been so effective in preserving the dry underbrush that wildfires are now enormous conflagrations... Cleverly engineered structures that have altered the contours of rivers and beaches have unwittingly contributed to the lethal force of "natural disasters" that now vex civilization. (Winner, 1996, 1052)

Herein lies the fatal flaw in the cornucopians' attempt to extrapolate into the future, favorable trends (i.e., increased wealth and resources) from the past. While, in the past, we have "exported" our "entropy cost" to the environment as pollution, we have managed so far to "get away with it." For, true to the traditional pioneer spirit, we have been able to "use it up, then move on." But now, with the expanding population, there is no more "on" to "move" to, and still worse, the pollution sink that is the environment, is nearing saturation, whereby the synergisms, feedbacks and threshold effects begin to kick in. In fact, this has already happened in the Grand Banks fisheries, and is likely happening in the atmosphere with ozone depletion and global warming. But don't expect the cornucopians to recognize any of this. "Entropy" and "thermodynamics" (along with the additional physical principles, "synergism," "threshold," and "feedback") are missing from the indexes of the two Simon books on my desk, and I cannot recall encountering any of these concepts anywhere in Simon's writings.[25]

Finally, the principle that "order (negentropy) is purchased at the price of greater disorder (entropy)" may be the undoing of Simon's "secular eschatology." i.e., the faith that "we'll think of something don't underestimate the ingenuity of human beings." It is the irreparable hole in the cornucopia, since however we might manage to "fix" (reverse the entropy of) developing environmental problems, these "fixes" are very likely to create still more problems (entropy).

The rule that "every man-made environmental problem we now have is the result of a prior solution" appears to counsel despair: The rules of the thermodynamic game seem to forbid ultimate success: "we can't win, we can't break even, we can't leave the game." There is, however, an acceptable option -- quite possibly the only option -- and that is to cherish and preserve the natural system that brought us here in the first place, namely the biosphere. If so, we must, like the ecosystem itself, recycle basic resources and charge the entropy bill to the sun's account. The more we maintain the complexity of the global ecosystem and the civilized condition by drawing from solar entropy, and the less we maintain this complexity at the cost of polluting our air, water and nutrients, and depleting upon non-renewable energy sources, the longer we will be able to sustain the advantages of industrial civilization. So long as we keep the entropy that drives our sustainable civilization at a safe distance of one-hundred forty million kilometers, we might achieve a plus-sum technology: at long last, "solutions" that do not bring about still greater problems. Finding and following that path toward sustainability is the task of ecologically informed scientific research, technological development, and public policy-making.

That enlightened policy will not be forthcoming from the cornucopians, whose world-view takes no account of the laws of thermodynamics and the entropy principle. Since these laws are at the foundation of modern physics and thus "no exception to [the thermodynamic laws] has every been observed," (Ehrlich, Ehrlich, Holdren, 1993, 69) it follows that the cornucopians must be positing a different physical universe than the one we happen to reside in. Any economic and industrial policy based upon a belief in this fanciful universe is fated to fail.

A Triumph of Theory over Realism, *"An analysis of far-out examples is a useful and favorite trick of economists...*" Julian Simon (1981, 43). *"The Theory is Beautiful; It's Reality that has me baffled.*" (Source Unknown).

How can intelligent and well educated individuals such as Julian Simon arrive at such bizarre conclusions? They do so by adopting a world-view that is an ontology in a Kantian sense: it is *a priori,* and thus not the product of empirical investigation of the world, but rather a theoretical construct that imposes a view upon the world, thus dictating what will and will not count as evidence as to the nature of the world. And since that "world view" is pre-supposed, and refuting evidence is excluded *a priori*, this is an "ontology" that violates the most fundamental

requirement of scientific inquiry, *falsifiability*; namely, the requirement that all scientific hypotheses clearly indicate the type of evidence that would prove it false. In simple terms, nothing will budge Simon's world view, since he declares, at the outset, that nothing will be allowed to do so.

Clearly, Simon's ontology is derived from a dominant paradigm of his discipline of economics: *the perfect market.* In theory, *the "perfect market"* has these qualities:

- An infinite (or very large) pool of potential buyers and sellers ("agents").
- Radical autonomy: i.e., no collusion among the potential agents.
- All relevant information available to the agents.
- No transaction costs.
- No externalities, positive or negative, resulting from the transactions.
- Transactions, once completed, are final.
- All transactions are completely voluntary.
- "Pareto Optimality:" no transactions that leave a party worse off.
- All agents are solely motivated to maximize their personal utility, or "preference satisfaction." (I.e., all parties are so-called "economic men"
  [26]).

"The perfect market" thus aggregates autonomous agents, prepared to exchange discrete items such as cash, goods, services, resources. It is this theoretical construct that describes the mechanistic and atomistic "world" of Simon's "ontology. It is also, let us note, a "world" wherein "market incentives" activate the "human ingenuity" which, Simon believes, can in principle overcome all obstacles be they ecological or even thermodynamic.

As all economists (including Simon) will readily agree, the theoretical "perfect market" comprised of "economic agents" is an "ideal type," nowhere found in "the real world." However, like "ideal types" in physics such as "frictionless machine," "absolute zero" and "perfect vacuum" (also nowhere exemplified in nature), the "perfect market" and "economic man" are essential to the abstract quantified modeling that characterizes modern economic theory.[27]

This abstract world-view of autonomous, utility-maximizing rational agents is replicated in the political ideology of *libertarianism,* with its fundamental and inviolable rights to *life, liberty* and *property,* and its concomitant denial of "welfare rights" and "social duties." Accordingly, to the libertarian, the only legitimate functions of government are the protection of life, liberty and property from external threats (the military), internal threat (the police), and civil disputes (the courts). To the libertarian, all else -- education, welfare, promotion of the arts, protection of the environment, etc. -- are solely the concern of private individuals, and no business of the government. Thus the libertarian repeats in his political theory, what the classical economist describes in his central paradigm: an aggregate of discrete, autonomous individuals, each owning items and parcels of property, totally encapsulated by title and well-defined boundary lines. To both, "society" is like a "swap meet," comprised of self-serving "economic persons," all mutual strangers meeting on inert "Newtonian space" (which, *qua* "inert," is totally unaffected by what transpires upon it).[28]

Classical, free-market economic theory, then, appears to be the foundation of Simon's atomistic world-view of autonomous individuals, inviolable property lines, and discrete events. From this *idee fixee* of "the perfect market" he moves outward to a theory of politics, *libertarianism,* and thence to a theory of physical reality a view of a world of infinite resources, infinite possibilities, infinite growth, all this unhampered by such limitations and complications as feedbacks, synergisms, time lag effects, and above all, *entropy*. In this Simonized world, "nature" is a passive theater whereupon we seek to maximize our individual utilities, all the while absorbing our assaults without consequences. By this account, in nature, just as in the market, when a transaction is agreed to and the exchange is made, then that's the end of it. All acts are disconnected.

You *can* "do just one thing!" No need to ask "Hardin's query: "... and then what?"

To Julian Simon, then, *economics*
is the "queen of sciences," according to which human endeavor and even physical reality is best interpreted. This point of view is not unique to Simon: for example, A. Myrick Freeman writes that " to the economist, the environment is a scarce resource which contributes to human welfare." (Freeman, 1983) And William Baxter:

> All our environmental problems are, in essence, specific instances of a problem of great familiarity: how can we arrange our society so as to make the most effective use of our resources... To assert that there is ... an environmental problem is to assert, at least implicitly, that one or more resources is not being used so as to maximize human satisfactions.... Environmental problems are economic problems, and better insight can be gained by economic analysis. (Baxter, 1974, 15-17)

In short, in an audacious reversal of Copernicus, these economists are proposing to place humanity, and in particular "consumer preferences," back at the center of the physical universe. In contradistinction, the economist Georgescu-Roegen insists that "the economic process is solidly anchored to a material base which is subject to definite constraints." (Georgescu-Roegen, 1993, 81) Gaylord Nelson puts the matter more bluntly: "the economy is a wholly owned subsidiary of the environment."[29] (Nelson, 1994)

Unfortunately, Julian Simon's "ontology" simply does not describe the world that we live in, since it is articulated with a fundamental disregard of basic ecological (which is to say natural) laws not to mention the findings of behavioral science and the insights of moral philosophy (which we cannot elaborate in this space).[30] The surveyor can plot a property line within a centimeter, but that line has no meaning or significance to the conditions of nature which give that property its value which, for that matter, sustain our very lives.

The atmosphere, the ocean, cycling nutrients, migrating birds, insects and spores, global pollution sinks and heat sinks none of these are the least aware of property lines. None can be meaningfully contained within the confines, and thus within the concept, of "inviolable private property."

While Julian Simon's "ontology" selects, *a priori,* what is to count as data and evidence, it does not enjoy *a priori* immunity from the challenge of scientific facts. Nature, as discovered and articulated in the body of modern bio-science, "talks back" to Simon's "ontology." Simon's reductive/atomistic world view entails claims that are empirically falsifiable (thus scientifically meaningful), and furthermore, demonstrably false (thus scientifically refuted). Simply put, "human ingenuity," exemplified by modern science, has persuasively demonstrated that in the "real world," energy flows up trophic pyramids, nutrients recycle through and back into ecosystems, and entropy reigns supreme, and thus each ingenious "solution" generates new problems. Furthermore, science has taught us that the atmosphere, the oceans and the soil, which support our lives, are in fact *systems,* and not infinitely large and inert "dumps." In short, life (including human life), and its supporting mechanisms are simply not what Julian Simon claims them to be. *Hardin's Law*
"you can't do just one thing" is more than a slogan: it is a demonstrable fact.

It is a cheerful universe that Prof. Simon describes for us. Unfortunately, as Richard Feynman used to remind his students, it is not the universe that we happen to live in, and for reasons that physicists like Feynman are especially well qualified to demonstrate.

Why, then, are Julian Simon and the cornucopians taken seriously?

The dominant paradigm in the industrialized world requires "constant growth." One might call this the "shark economy" since, like many sharks, the global economy as currently constituted has to move constantly in order to stay alive. Quiescence means death. The engine of modern economy is "return on investment," i.e., *growth.* In contrast, in natural ecosystems there are limits to population growth, resources are recycled, and there is a constant tendency (never fully realized) toward system stability and homeostasis.[31]

Thus the economists' choice is simple and stark: either devise and defend a new economic theory that

accommodates itself to the basic conditions of life as articulated by the life sciences (e.g., ecosystemic stability and population limits) and the physical sciences (e.g., thermodynamic laws), or else simply choose to ignore these facts and deal instead with a fanciful world. Clearly, Simon has chosen the latter course and, in the face of both common sense and scientific evidence, has posited, as he must, a world of infinite resources that is supportive of perpetual growth.

I once heard Paul Ehrlich remark that if an engineer proposed a design for an aircraft with a constantly expanding crew, we would think him mad. And yet, when an economist defends a theory that posits a perpetually growing global economy, he is awarded a Nobel Prize. Notwithstanding that, "perpetual growth" is unknown in the natural world. In the words of the novelist Edward Abbey, "the ideology of constant growth is the ideology of the cancer cell." It is an ideology that leads to the death both of the cancer and its host.

While I have argued that there are severe limitations to the applicability of economic theory to the natural world, economic theory might nonetheless help to explain the successful promulgation of Prof. Simon's ideas: There is a demand, lavishly rewarded, for an *apologia*
for classical economic practice, for a justification of global industrial "business as usual," and thus for a dismissal of the eco-scientists' warnings. Julian Simon has met that demand with extraordinary wit and cleverness.

In short, if there were no Julian Simon he would have to be invented.

But Simon posits a world-view and proposes a policy that can only lead to ruin. To paraphrase the wise and much-lamented physicist, Richard Feynman "For a successful environmental policy, reality must take precedence over wishful thinking, for nature cannot be fooled."[32]

Notes

1. I take this to be a fair paraphrase, since it is taken from the title of Chapter 3 of Simon's book, *The Ultimate Resource,* "Can the Supply of Natural Resources Really be Infinite? Yes!"(1981).

2. Another chapter title (Chapter 18) in *The Ultimate Resource,* (Simon, 1981).

3. This is the essential message of Simon's book, *The Ultimate Resource* (1981), of his paper in *Science* (1980a) and indeed most of his writings. In the anthology, *The Resourceful Earth...,* co-edited with Herman Kahn, he writes: "If present trends continue the world in 2000 will be *less* crowded (though more populated), *less* polluted, *more* stable ecologically, and *less*
vulnerable to resource-supply disruption than the world we live in now. Stresses involving population, resources, and environment will be *less in the future than now..."* (Simon, 1984, 14)

4. Mark Sagoff, "Do We Consume Too Much," full unpublished manuscript (52 p.), of which pp 29-39 were read by Prof. Sagoff at the conference, *Environmental Challenges to Business,* April 4-6, 1997, University of Virginia. A later version under the same title appeared in *Environmental Challenges to Business,* ed. Joel Reichart and Patricia Werhane, Society for Business Ethics, Bowling Green, OH: Philosophy Documentation Center, 2000. All citations below from the unpublished conference manuscript.

5. Sagoff, 1995, 610. Sagoff also quotes Peter Drucker, who argues that where there is effective management, "that is, the application of knowledge to knowledge, we can always obtain the other resources.' He adds: 'The basic resource -- "the means of production", to use the economist's term -- is no longer capital, nor natural resources... It is and will be knowledge.'"

6. State of the World 1999, State of the World 2000, Vital Signs 2000, The Worldwatch Institute. I cite these excellent anthologies, not only as direct confirmation of my claims about the limitations of natural resources, but also as "gateways" that cite hundreds of publications and studies that also substantiate these claims.

7. Private correspondence, Mark Sagoff to Ernest Partridge, March 30, 1997.

8. Herman Daly makes the point supremely well: "The matter/energy we return [to the environment] is not the same as the matter/energy we take in. If it were, we could simply use it again and again in a closed circular flow. Common observation tells us, however, and the entropy law confirms, that waste matter/energy is qualitatively different from raw materials. We irrevocably use up not only the value we add to matter, but also the value that was added by nature before we imported it into the economic sub-system, and that was necessary for it to be considered a resource in the first place. (Daly, 1975, 6).

9. Accordingly, the loss of "present value" through time ("the discount rate") is the mathematical reciprocal of the added value required to motivate saving ("the interest rate"). The equation for the discount rate is as follows:
Present Value = $FV/(1 + i)^t$
– where "FV" = Future Value; i = annual interest rate; and t = time in years. Accordingly, the "present value" of $100 in fourteen years ("future value"), at an interest rate of 5% is $50.50. The present value of $1 in fifty years at a 10% discount (interest rate) is, according to the formula, less than a penny (.85 cents). For a more detailed examination of "the discounted future" and its moral and environmental implications, see my "In Search of Sustainable Values" (Partridge, 2001).

10. For two recent and influential works that take "natural capital" very seriously and which adopt an appropriately lon-grange approach to economic policy, see Gretchen Daily, *Nature's Services* (1997) and Hawkin, Lovins and Lovins, *Natural Capitalism* (1999). In the flyleaf to the latter, we find: "Traditional capitalism ... has always neglected to assign monetary value to its largest stock of capital -- namely, the natural resources and ecosystem services that make possible all economic activity, and all life. Natural capitalism, in contrast, takes a proper accounting of these costs."

11. For a careful argument against "using money to signal resource scarcity or natural capital depletion," see Rees and Wackernagel, (1996, 42-47).

12. For instance, Simon's cornucopism is believed to deserve a hearing by such prestigious publications as *Science,*
which published "Resources, Population, Environment: An Oversupply of False Bad News, (1980, and also the *Bulletin of the Atomic Scientists* "Bright Global Future," (1984), and *New Scientist* "Disappearing Species, Deforestation and Data," (1986). And his influential book, *The Ultimate Resource,* was considered significant enough to be published by Princeton University Press (1981). This is not to say that these esteemed publications erred in choosing to publish Simon's papers. These papers are important for the significant policies that they support and for the display of a fallacies assembled in support of what, to many, appear to be plausible conclusions. Equally valuable as these papers were the abundant criticisms that were to follow in the "Letters" section of these publications.

13. Philosopher Jan Narveson fully concurs: "Sustainability has become the buzz-word, the implication being that life as we currently know it and enjoy it is not sustainable.... Should we be impressed by that? ... [T]he answer is no. Future generations will consist, after all, of rational animals, resourceful people like our ancestors and (I hope!) ourselves. They will be able to cope. The human species has made a decent or better than decent life for itself in an incredible variety of "ecologies" ... It is astonishing how contemporary humans can overlook the resourcefulness of their fellows in all of this recent cant about ecology.... There is ... no resource problem of consequence for the globe." (Narveson, 1993, 24).

14. As an example of a *non-sequitur,*
consider Simon's dismissal of governmental concern about soil erosion concern, which he charges is a "fraud." On the contrary, he says (perhaps correctly) that soil loss has decreased by all of 6% (from 5.1 tons/acre to 4.8 tons/acre). But it does not follow from this that it is of no concern. Quite the contrary, he cites and does not contest Al Gore's observation that "eight acres of prime topsoil floats past Memphis every hour" and that half of the topsoil of Iowa has been lost to erosion. So the question he should ask, and doesn't, is whether this allegedly "reduced" loss still constitutes a problem. If so, then what is the "fraud?" (Myers and Simon, 1994, p. 53).

(Analogously, the FBI reports a 15% drop in murder rates last year. According to Prof. Simon's logic, it then follows that murder is no longer a problem in the US).

15. Herein is the trap that caught no less of a bio-scientist than Paul Ehrlich, who, in 1980, carelessly consented to "wager" Simon that pending shortages in five designated metals would cause a rise in their prices during the next decade. Simon won that wager. Ehrlich's mistake was to consent to "play the game" according to the rules of Simon's discipline of economics. Recently, Ehrlich and his colleague, Stephen Schneider, challenged Simon to a new wager, this time utilizing indexes derived from atmospheric and soil science, and also involving supplies of rice, wheat and firewood, and additional factors such as AIDS mortality, ocean fisheries, male sperm counts and species extinctions. Simon refused the offer, on the grounds that these indicators, based upon the biological and physical conditions, "have only indirect effects on people." Charles Petit, "Two Stanford Scholars Take on Rosy Economist," *San Francisco Chronicle*, May 18, 1995, p. A-15. The final quotation is from Petit, not Simon.

16. Myers & Simon, *op. cit.*, 18-9. Simon is referring here to acid rain and ozone depletion as well as the greenhouse effect. However, our focus of concern here is on global warming. About the ozone layer, Simon reports that "there has been no increase in skin cancers from ozone." (Ibid.) I doubt that he would be able to convince the Australians of this. A computer search (in "Google") of "Australia" and "skin cancer" and "ultraviolet" (Boolean sum) yielded 5370 hits. Note the following from the National Cancer Institute, a U. S. government agency: "Ultraviolet radiation from the sun is the main cause of skin cancer... Worldwide, the highest rates of skin cancer are found in South Africa and Australia, areas that receive the highest amounts of ultraviolet radiation." (NIH, 1998. See also, D. Leffell and D. Brash, "Sunlight and Skin Cancer" in the September, 1996 issue of *Scientific American*).

17. Working Group II of IPCC (1995) concludes that with approximately 5E C. warming, "midlatitude climate zones ... would shift northward by a hefty 550 kilometers over the next century. At that rate, some species of trees might not be able to keep up and might imply die out. In eastern North America, the panel says, a high-end warming would wipe out much of the eastern hardwood forest, opening the way for grassland and scrubland." (Quoting Kerr, 1995, 731).

18. As an example, consider the 1996 NBC Television program on "The Mysterious Origins of Man," which has attracted the ire of *Science*
magazine and the AAAS. In this strange compendium of kookery, we were told that dinosaurs and humans co-existed, that the sphinx was built 25,000 years ago, and that the site of Atlantis is now under a mile of Antarctic Ice. At the close, the "host," actor Charlton Heston, urged us to "keep an open mind," and reminded us that "the facts speak for themselves."

19. "The conspiracy of establishment science" is a recurrent theme amongst creationists, UFO-logists, and other pseudo-scientific groups. The charge of "establishment conspiracy" was particularly prominent in the NBC-TV program, "The Mysterious Origins of Man," cited in the preceding note.

20. The title is "borrowed" from Kenneth Boulding, *The Meaning of the Twentieth Century,* 1965, Ch. VII. I can think of no better way to describe the significance of the concept of *entropy* to environmental policy.

21. Nicholas Georgescu-Roegen (1993, 78) Herman Daly and Kenneth Boulding are among the few economists to take entropy seriously.

22. I have long-since forgotten just where I read this. However, I am quite (though not totally) certain, that the source of this example is Isaac Asimov.

23. Thermodynamics provides the "creationists" with one of their favorite arguments against the theory of Evolution. According to the principle of entropy, they claim, it is impossible for complex life forms to "evolve" from simpler forms. They conveniently ignore the further stipulation that this rule applies to "closed systems." The Earth's biosphere, however, is not a closed system. Evolution is "powered" by solar energy. And when that energy flux is shut off by comet or asteroid impacts (most recently, 60 million years ago), the global ecosystem is

severely "set back" to a simpler and more probable state. Recovery from these "extinction spasms" is accomplished through the availability of "improbably" complex information (negentropy) stored in the genes of the surviving organisms.

24. The terms "pumps" and "eddies" are, of course, metaphors, intended to illustrate the localized "reversal" of surrounding universal processes. For example, a hand pump draws water "up" contrary the universal downward pull of gravity. And an eddy is a localized current that flows upstream alongside the primary downstream flow of a river's current. Both pumps and eddies function only through the importation of external energy.

25. The contrast between the economists' and the physicists treatment of "heat" is instructive. In the taxonomy of classical economics, heat is a subset of "energy," which in turn is a subset of the category of "economic resources;" i.e., "heat "is just one of many economic "goods." To the physicist studying the potentiality of all physical activity, heat is virtually everything. All work proceeds from heat differential ("free energy"), and the end product of all useful activity is useless or "bound" heat. In other words, according to the second law of thermodynamics, without heat differential, nothing happens.

26. While I would prefer the politically correct "economic person," the term "man" is used here to reflect an historically established gender preference: "economic man" (*homo economicus)*.

27. If the physicist uses "ideal types" to advantage, then why not the economist? Because the difference between the disciplines is crucial: In physics, these "ideal types" are derived, "one at a time," from carefully conducted experiments and measurements, and they are asymptotic extrapolations from "near perfect" laboratory conditions -- "end points" of precisely measured empirical functions. And finally, in physics, unlike economics, these "ideal types, when employed in the "hypothetical-deductive" methodology of physical science, yield falsifiable predictions and thence experimental verifications.

None of this is true of the economists' "ideal types." They are not extrapolated to zero, they are not the single controlled variables of experiments, but rather are "bundled together" in theoretical constructs. Furthermore, they "posit" as irrelevant to their theory, conditions which are in fact inalienable to human motives and economic activity: such things as transaction costs, externalities, collusion, restricted access, imperfect information, distributive injustice, self-transcending motivation and communal loyalty.

28. For a more developed critique of libertarianism, see my "Environmental Justice and Shared Fate...," *Human Ecology Review,*
Winter/Spring, 1996, 2:2. pp. 138-147, and my unpublished "With Liberty and Justice for Some." (2000) My dissatisfactions with neo-classical economic theory, and its application to public policy, may be found in my papers, "In Search of Sustainable Values," (2001) forthcoming in *the International Journal of Sustainable Development*, and my unpublished *Twentieth Century Alchemy.*

29. For a further critique of the neo-classical economic approach to public policy, see my "With Liberty and Justice for Some" (Partridge, 2000a) and "In Search of Sustainable Values" Partridge, 2001). Also, Mark Sagoff, The Economy of the Earth. (1988)

30. But let this much suffice: First of all, human beings are in fact inalienably *social animals,* and not the egoistic autonomous agents of the classical economic paradigm. Well ordered societies can only exist and endure if the members thereof have concerns which transcend their personal "utility maximization." (I have developed this notion at length in my paper, "Why Care About the Future?," in *Responsibilities to Future Generations,* ed. Partridge, Buffalo, Prometheus Books, 1981. See also, Mark Sagoff, *The Economy of the Earth,* Cambridge University Press, 1988, Chs. 2 & 3). Furthermore, "perfect free market transactions," far from being exemplars of "rational decision-making," often have little to do with "rationality." We do not regard "willingness to pay" as relevant in the criminal or civil justice systems. Nor is this relevant in national defense or in education. Scientific and scholarly papers are not evaluated by pricing at the margin, nor are mathematical proofs or even economic theories. And moral issues are not properly settled by the "free market," otherwise we would still condone slavery. Clearly, the life of *homo economicus* is neither healthy, nor moral, nor even, in the final analysis, *"rational."*.

(Partridge, 2000, 2001).

31. This qualification, "never fully realized," is crucial. Thus I mention a "tendency" toward stability, while deliberately avoiding more traditional terms "balance of nature" and "equilibrium." These terms have been largely discarded by contemporary ecologists. My position occupies a middle ground between the "balance of nature" view and the more radical "disequilibrium" theories that are currently fashionable. See my "Reconstructing Ecology" (2000b).

The "New Ecologists" correctly point out that "population limits" vary according to constantly changing ecological conditions. Also, populations can fluctuate dramatically within an ecosystem: the population variations between Canadian Lynx (predator) and Hare (prey) is a classical example. However, that there are *some* ultimate limits to the growth of a species population in a region seems beyond dispute. A population can not exceed the food supply or a "limiting factor" nutrient ("Liebig's Law").

As for recycling, there is a popular slogan among environmentalists that "in nature, there is no such thing as garbage," meaning that the "waste" of one life form is a resource to another. It is a good point, *almost* completely true. In fact, some nutrients are lost to "geological deposit" (e.g., by sinking to ocean depths), while others are released from geological "stores" (e.g., through erosion and volcanic activity). Still, the "economy" of nature found in the numerous "nutrient cycles" stands in noteworthy contrast to the "throughput" (from raw material to commodity to garbage and pollution) that is found in industrial societies.

32. Originally, "for a successful technology, reality must take precedence over public relations, for nature cannot be fooled." This remark appeared at the close of Feynman's dissent from the report of the Congressional Select Committee investigating the Challenger Shuttle Disaster.

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