The Unsustainability of Economic Growth

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Introduction

In its World Development Report 1999/2000, the World Bank expounds on its Comprehensive Development Framework (CDF). This framework is posed as a new, holistic approach to development in which greater effectiveness in fighting poverty is achieved through a diverse set of strategies (World Bank, 2000: 21). Given the complexity of our global society and the diversity of its social problems, the World Bank is to be commended for adopting an approach that recognizes complex relationships and the need for multifaceted solutions instead of panaceas (World Bank, 2000: 2). Further, the idea of sustainable development is noted many times, indicating an appreciation of the need to pursue ways of improving the human condition which can remain successful through the long term.

All of this is suggestive of the ecological perspective, in which the science of ecology, itself the study of relationships within living systems, is used as a framework to study subjects which it may or may not traditionally cover. However, one of the crucial findings to come out of the ecological perspective undermines the CDF as currently formulated. Despite the fact that the report notes, in the very first paragraph of its forward, that “development must move beyond economic growth to encompass social goals” (World Bank, 2000: iii), the World Bank bases nearly every aspect of its CDF on economic growth — a growth which I argue is not sustainable.

In many ways, growth is desirable, yielding incredible improvements for many populations, from necessities like health-related infrastructure and food to conveniences and luxuries. Along with these benefits, its historical feasibility has made it appear to be simply a matter of common sense that growth should be the hallmark of a healthy economy. However, its success has blinded us to the fact of its unsustainability. It is only within the last two centuries that the science relevant to this analysis was developed. Further, it is only during the 20th century that the analysis itself arose and that we have begun to witness most of the negative unintended consequences of growth.

The foundation of this analysis involves understanding exactly what the human economy is. Herman E. Daly, an economist who himself worked at the World Bank from 1988 to 1994, suggests that our understanding of the economy is limited by what Joseph Schumpeter called a preanalytic vision. Since analysis must start with something to analyze, the something is given by a preanalytic cognitive act Schumpeter called "Vision." Whatever is omitted from this cannot be recaptured by subsequent analysis (Daly, 1996: 46). Daly suggests that our traditional economic preanalytic vision is of an isolated, closed system in which there is a circular flow of goods and services from firms to households and of factors of production from households back to firms (Daly, 1996: 47).

Such a preanalytic vision ignores the physical dimension of that which flows within the circle, allowing for the possibility, even desirability, of unlimited growth. However, only abstract exchange value flows in the closed circle. Completely ignored is that to which value is added (Daly, 1996: 62). At its root, "to produce is to metabolize natural physical energy into energy useful to man" (Deléage, 1989 / 1994: 43). Without a resource base, there would be nothing with which to do anything within the circle: "Adding value is more like multiplication than addition — we multiply the value of 'stuff' by labor and capital. But multiplying a zero always gives zero" (Daly, 1996: 64).

To account for physical material, one needs a different preanalytic vision, one that sees the economy as an open subsystem within the larger system that is the Earth. Since the Earth is finite, the human economy can grow, at most, only up to the size of the Earth itself (Daly, 1996: 47-49). The human economy is thus, as with any species, simply our ecological niche, the sum total of the Earth's resources used by humanity. Indeed, as the science of ecology has developed, it is this view that appears more and more to represent common sense. Further, it is only through this perspective that the idea of sustainable development makes any sense, for if the economy was not limited by a larger system, it would not need to worry about what activities could not be sustained (Daly, 1996: 7).

Arguments about the ephemeral nature of finance, services and information may be made in an attempt to circumvent the idea material limits to our economy. However, it should be abundantly clear that even these rely on material resources. Without material, not only would there be nothing with which to create currency or store information but there would be nothing to purchase, nothing to live on. Indeed, there would be no people to provide or purchase services or products. In the end, no matter how an economy is measured or what innovations may arise, it must have a material basis (Altvater, 1989 / 1994: 78; Daly, 1996: 28, 42, 64; Dryzek, 1992 / 1994: 178).

According to the World Bank itself, "A development path is sustainable only if it ensures that the stock of overall capital assets remains constant or increases over time" (World Bank, 2000: 28). While other definitions may be given, this appears as good as any, literally suggesting the *sustaining* of one's *ability* to achieve success in both the present and the indefinite future. Anything that reduces long-term ability, though it may provide temporary successes, cannot be said to sustain.

In this paper, I will argue that economic growth is thermodynamically unsustainable because it hinges upon increasing resource use which, in a finite world and in contrast to the World Bank's own definition, ensures that the stock of overall capital assets decreases over time. Further, growth is ecologically unsustainable because, long before resources ever approach depletion, it disrupts ecosystems upon which humans depend. Thus, while growth may provide short-term benefits, sustainable economic growth is a genuine contradiction in terms and therefore cannot provide a long-term basis for development, i.e., the improvement of the human condition. The unsustainability of growth also points to several problems in economics itself.

Basic population ecology models will show that population growth is simply an epiphenomenon of a particular kind of economic growth, the increase of our food supply. Ecologically speaking, population growth is thus not a sustainability problem in and of itself but only inasmuch as it is caused by, and leads to, increasing resource use. Theories of organization and state formation, however, show that a growing population generates hierarchy within a social structure. Thus, economically and politically, population growth systematically generates inequality, perpetuating poverty even in conditions of material abundance.

All of this demonstrates that the World Bank sabotages its own good intentions by basing its Comprehensive Development Framework on economic growth. That said, it must also be noted that proscriptions posed by those with ecological concerns are often as unfounded as the idealization of economic growth. A truly ecological perspective yields a surprisingly optimistic approach toward achieving the related results of sustainability and a fairer distribution of resources.

Thermodynamic Irreversibility

The Earth is technically an open system. It receives energy from the sun (and, to a much lesser extent, other cosmic sources) and emits heat into space. Of course, the Earth is extremely dynamic within, making any number of uses of the energy it receives from space before it emitting the equal value back out. However, since the flow of energy into the Earth is non-growing and energetic equilibrium with respect to the rest of the universe is maintained (Hardin, 1993: 76), the Earth is effectively a closed system. Eventually, when the sun burns out, even this equilibrium will be lost.

Per the ecological preanalytic vision, the human economy is one of many open systems within the closed system of the Earth. In principle, its size can increase to no larger than that of the supersystem itself. The subsystem relies on the supersystem as both tap and sink, a source of material inputs and a disposal area for waste outputs.

Thermodynamics and entropy therefore become crucial. The first law of thermodynamics is that the conversion of energy into work is never efficient, with some energy always being lost in the process. From this is derived the law of the conservation of energy, denying the possibility of perpetual motion. The second law of thermodynamics is that energy always flows downhill, from high-energy objects to low-energy ones. Entropy is the amount of disorderliness in a system, and higher temperatures are said to introduce disorder. Thus, high-energy sources are said to have low entropy, since, when they are put to use, they will give off heat, resulting in less energy available for future work and thus higher entropy in the system (Barnes-Svarney, 1995: 283-4). Thus, the second law of thermodynamics also states that entropy increases in an isolated system.

While the model of the circular flow of value added is consistent with the first law of thermodynamics, involving only transformations of matter, it completely ignores the second law of thermodynamics (Daly, 1996: 65). The Earth is both the supplier of high-energy, low-entropy raw materials and the recipient of low-energy, high-entropy wastes (Daly, 1996: 33). The sun is the only significant source of energy for the Earth and thus the foundation for the creation of all low-entropy resources on the Earth. If energy on Earth is used at a rate higher than that at which the sun replenishes it, the Earth's entropy increases irreversibly, making it ever more difficult to find energy to accomplish work: "By definition, the overall increase of entropy associated with any process of production is always greater than the local decrease in entropy corresponding to this process" (Deléage, 1989 / 1994, 42).

Such a view of resource use was developed right along with thermodynamics itself, with the 19th century thermodynamicists viewing nature not as boundless but always threatened with exhaustion (M. O'Connor, 1994: 3). That economics has not yet come around to incorporating this knowledge makes it no less true. To study our economy without acknowledging its environment is like studying physiology in terms of the circulatory system without ever mentioning the digestive tract:

> An animal with an isolated circulatory system and no digestive tract would be a perpetual motion machine. Unlike this imaginary circular-flow animal, real animals have digestive tracts that connect them to their environment at both ends. They continuously take in low-entropy matter/energy and give back high-entropy matter/energy. An organism cannot recycle its own waste products. (Daly, 1996: 193)

An economy does the very same thing.

Just as growth traditionally seemed to provide only benefits, the possibility of continued growth was not unreasonable when environmental taps and sinks were much larger in comparison with the human economy (Daly, 1996: 34). As the economy grows, however, it becomes ever clearer that what used to seem unlimited is not after all. Sustainable growth is a thermodynamic contradiction in terms. To ignore an economy's exchange with its environment is to treat it as if it were a perpetual motion machine (Daly, 1996: 34).

Tap, Sink and Biodiversity

Human exceptionalism cannot keep us from the effects of thermodynamics. But what if it could? Would unlimited growth then be possible? An understanding of the workings of ecosystems shows that the answer would still be no.

In 1868, German biologist Ernst Haeckel coined the term and founded the discipline of ecology, the study of the relationships between a species and its inorganic and organic environment. Eventually, the discovery of whole ecosystems yielded an expansion of the ecological perspective to the mutual dependence and balance among all inhabitants of an ecosystem (Enzensberger, 1974 / 1996: 17). As living systems, ecosystems are marked by an extraordinary internal complexity, with countless relationships, interdependencies and subsystems. As such, one hallmark of ecology is the existence of cycles, in which by-products from one process become the raw materials for another. An important concern for any production process, then, whether photosynthesis or microchip manufacture, is the way in which it attaches to the larger ecosystem. It receives its inputs from taps of resources which must be regenerated, and it places its output in sinks which must be able to absorb wastes (Daly, 1996: 3).

Organic resources tend to be renewable, because they are part of systems in which they regenerate, while inorganic resources tend to be non-renewable. Renewables, though, can be exploited to extinction, while non-renewables may regenerate over extremely long periods of time (Daly, 1996: 80). The key is simply that any resource used at a rate greater than its rate of regeneration will be depleted. Further, ecosystems have particular absorptive capacities, amounts of wastes they can withstand while maintaining normal function. The more our production processes create by-products which are not easily assimilated back into ecological cycles, the more we tend to exceed ecosystemic absorptive capacities, reducing regeneration rates and putting further stresses on the material inputs themselves.

Another important issue is that we make efforts to *alter* our taps, most obviously and significantly in our pursuit of agriculture and silviculture. By attempting to harvest as much as possible, our processes tend toward the use of heavy machinery and chemicals, whose own production is ecologically stressful. Simultaneously, the cultivation endeavors themselves encourage monoculture and genetic uniformity, increasing crop vulnerability to pests, disease and other shocks (Altvater, 1989: 83; Deléage, 1989 / 1994: 41). All of this contributes to ecosystem destabilization. Indeed, figures for the United States and Europe in the 1960s and 1970s show between six and nine calories worth of fossil fuel being expended to produce just one calorie of food (Deléage, 1989 / 1994: 40). Such a ratio is thermodynamically unsustainable on top of the purely ecological effects.

Beyond stresses on tap and sink is the biodiversity factor. Crucial to regeneration and maintenance of ecosystems as a whole is the ability of its varied constituent parts, its many species, to be able to regenerate and maintain themselves and play their roles within complex ecological relationships. Insufficiencies in parts of the system can weaken the whole and even lead to collapse. When the World Bank's millennial development report (*WB2K*) notes that the estimated marginal value of some species' existence may be as low as $44 (World Bank, 2000: 103), it is clear that they have little understanding of the complex interdependencies within ecosystems, in which those seemingly worthless species' stability may be crucial to the existence of other species presently given a much higher value. To truly understand the importance of biodiversity, one must literally see the forest for the trees, looking beyond individual species and their immediate values for people to see the big picture.

The field of island biogeography attempts to account for the number of species within a given discrete area, a real or conceptual island. In the 1960s, Robert H. MacArthur and Edward O. Wilson developed the equilibrium model of island biogeography, which holds that the number of species that can stably coexist on an island of a given size represents a balance between immigration of new species onto the island and recurrent extinction of resident species (Gotelli, 1998: 159). One can scale this model up to analyze the Earth as a whole, in which there would be an optimum number of species capable of coexisting worldwide. Extinction rate remains in the equation, but immigration would be replaced with species generation through evolution, while the number of species in the source pool becomes the number of species on the Earth at a given time. This application of the model actually has a hidden benefit in that the standard model must ignore evolution (Gotelli, 1998: 166), while the global version specifically incorporates it.

It is easy to imagine, indeed borne out by fact, that, for the largest part of global history, the evolutionary generation rate was greater than the extinction rate, yielding increasing global biodiversity. The MacArthur-Wilson model predicts that the Earth would eventually contain a quantity of species whose diversity was optimal for its size. There would continue to be a turnover between new and old species, but this equilibrium level of overall biodiversity would be maintained. In general, the larger the island the lower its extinction rate, and the more isolated the island the lower its immigration rate (Gotelli, 1998: 164-165). Applied to the global model, in which the Earth is a maximally large and isolated island, equilibrium should yield relatively low rates of both generation and extinction. In the end, biodiversity should only ever increase or be maintained at an optimum level; only extenuating circumstances should lead to a decreasing trend.

An important phenomenon that can occur in population ecology is the paradox of enrichment, in which a predator with a low death rate and a high conversion efficiency, i.e., the efficiency with which it consumes prey species and converts them into more predators, ends up overexploiting its prey, drives them to extinction, then starves (Gotelli, 1998: 140). *WB2K* itself notes that even the lower estimates of global extinction rate are approximately 1,000 times the natural rate (World Bank, 2000: 102). If persistent economic growth exploits non-human species, directly or indirectly, so as to yield such a paradox, it must at some point increase the global extinction rate to outweigh evolutionary generation. Whether or not the Earth had yet reached its optimal biodiversity when human economic growth began, and it certainly may not have, it seems clear that such an increase in the extinction rate would drag diversity down further and further away from equilibrium. This would continue until the paradox of enrichment kicked in, extinguishing the source of overexploitation. Note that the situation worsens when one considers that the extinction of non-prey species, ignored by the paradox, also reduces biodiversity and destabilizes ecosystems.

A species that grows ceaselessly will thus not only extinguish many other species in the process of growth but also creates the conditions for its own extinction. Indeed, with the exception of a few microorganisms, the odds are that a species that pursued this strategy would not be remotely the last to go extinct. After such a species disappeared, global biodiversity would increase again, eventually up to its optimal level. Damaging as we may be, then, the world is in no danger of ceasing to exist as a habitat for life in general since, whatever destruction we may cause, we would hardly be able to destroy all life. The notion of "saving the world" ends up meaning simply saving the world as a human habitat (Quinn, 1999: 6). If we are to accomplish this goal, its success lies in ceasing our systematic reduction of biodiversity, thus in reducing our impact on the global extinction rate. Luckily, adamant economic growth is a cultural trait, so its extinction need not coincide with the extinction of *Homo sapiens*.

In theory, the human economy can grow to no more than the size of its supersystem, the Earth. In practice, a species constantly expanding its niche would stress its taps and sinks, as well as the pervading biodiversity, to such an extent that it would degrade the ecosystems on which it depends long before it ever even approached the size of the supersystem. Even if it was thermodynamically sustainable (which it isn't), growth is thus not ecologically sustainable. Understanding the complete workings of all ecosystems, even if possible, would not provide a path out of this situation, since any attempt to work within ecosystemic requirements, e.g., management to maximize the existence of species and other resources on which humans depend, would place limits on growth.

The only possible pathway out might be alchemy, the knowledge of how to convert the worthless into the valuable. Instead of lead into gold, ecological alchemy would convert wastes, pollution and degraded sources into viable raw materials, bypassing ecosystemic processes that do this automatically. In other words, alchemy would be the ultimate form of recycling. But even this is problematic, for entropy prevents complete recycling (Daly, 1996: 33). Not only would alchemy only take us so far, but the heat lost during the never completely efficient recycling processes must go somewhere. It would merely become yet another anthropogenic cause of global temperature increase (Dryzek, 1992 / 1994: 178), one of the key destabilizers of the biosphere.

Economics and Sustainability

Microeconomics suggests an optimum size beyond which an enterprise should not grow, but traditional macroeconomics allows for the aggregate of all microeconomic units to grow indefinitely (Daly, 1996: 27). As we have seen, though, the macroeconomy, i.e., the global human economy, cannot do this. In a finite world, the law of diminishing returns — which yields the existence of diseconomies of scale, of antieconomic growth — is as certain at the macro level as the micro (Hardin, 1993: 98-100), and one of the ways in which this becomes evident is when growth increases environmental costs faster than it increases production benefits (Daly, 1996: 166). Whatever the effects of environmental degradation, an extinction of humanity brought about by our growth-driven paradox of enrichment would be an event that occurs far beyond the point at which environmental costs outweighed production benefits. In the end, the macroeconomy must, like microeconomies, also be viewed with respect to optimization (Daly, 1996: 51). As a result of its ignorance of this fact, there are a number of ways in which the field of economics is not presently equipped to deal with sustainability. Foremost is its failure to realize that, since growth is unsustainable, economic health must be found in a condition of material equilibrium.

The idea of an economy based on equilibrium as opposed to growth has a long history, going back at least as far as John Stuart Mill's discussion of the stationary state, in which population and physical stock do not grow (Hardin, 1993: 117; Daly, 1996: 3). Most classical economists thought that the economy would end up in such a state, which they dreaded as the end of progress. Yet Mill welcomed it, as there was no reason to suggest an end to qualitative improvement (Daly, 1996: 3): “The steady state is by no means static” (Daly, 1996: 31). Indeed, this directly parallels the notion of ongoing species turnover within a global evolutionary equilibrium. Thus, there is no reason to abandon the idea of progress along with growth.

Kenneth Boulding argued that we obtain satisfaction from the capital stock itself, not from additions to it (production) or subtractions from it (consumption). A sensible economy would thus be founded on maximizing maintenance efficiency rather than production or consumption, both of which should be minimized (Daly, 1996: 68). It is Boulding’s concept of throughput that provides a clear idea of exactly what economic growth is: an increase in the total amount of matter/energy that passes through an economy (Daly, 1996: 31). Phrased one way or another, these ideas about the physical basis of economics and the importance of entropy have also been dealt with by Sergei Podolinsky, Frederick Soddy, Nicholas Georgescu-Roegen and many others, but these ideas have yet to enter mainstream economic thought, due simply to the stranglehold of growth ideology.

Daly was at the World Bank during the writing of their World Development Report 1992: Development and the Environment. Though not on the project, he had opportunities to comment on early drafts, which suggested that the world was “full of ‘win-win’ opportunities for both increasing growth as usual and improving the environment,” failing to address the key cause of environmental degradation, i.e., ecological limits (Daly, 1996: 6). However, as long as growth is held to be the solution to poverty, the World Bank simply cannot acknowledge such limits, because the possibility of endless growth would be denied (Daly, 1996: 7) and key economic concepts would need to be revised. Among these concepts are the idealization of the free market and our present methods of keeping national accounts.

One important problem with market prices is that they externalize many costs, both social and physical (Beckenbach, 1989 / 1994: 92). Indeed, decreasing microeconomic costs and increasing social costs are two sides of the same process (Beckenbach, 1989 / 1994: 96), e.g., as when a company keeps prices down through production mechanisms which may be unsafe for the worker or which pollute the environment, only to have a community's bills rise for health services and environmental clean-up. In principal, all costs could be internalized, resulting in an undistorted, "perfect" market. But since the possibility of accidents and unintended consequences remains present in any economic process, and since certain damages may be irreversible, the idea that externalized costs can ever be fully internalized is unrealistic (M. O'Connor, 1993 / 1994: 143). Another crucial flaw is that, even in a perfect market, sustainability is not guaranteed by market forces, since prices measure only the relative scarcity of individual resources, not the absolute scarcity of resources in general. The market may yield an optimal allocation of resources but has no idea how to gauge its scale relative to the Earth (Daly, 1996: 32).

Free marketeers who oppose any limit to the size of the economy simply increase the chance that their opponents may be successful in instituting the very central economic planning that they abhor (Daly, 1996: 59). Ecologically speaking, though, there are compelling arguments against central planning. Centrally planned economies have had little success, while ecosystems took care of themselves prior to unbridled economic growth (Daly, 1996: 59). Further, ecosystemic complexity also seems to rule out the possibility of obtaining sufficient knowledge for comprehensive planning. The idea, then, is to oppose free trade only to the extent that sustainability is encouraged and press no further.

Free trade monotonizes the world's nations, making them less able to act differently from everyone else, indeed, making it impossible *not* to trade. This reduces cultural and socioeconomic diversity, creating global economic vulnerabilities in the same way that reduced biodiversity destabilizes ecosystems (Demirović, 1989 / 1994: 264). Policies for sustainability may thus involve economic strengthening at levels below the global, perhaps taking the form of nations internalizing external environmental and social costs. There is, however, no guarantee that all nations will adopt and abide by equivalent policies. Free trade means that those countries that institute such policies will be at a comparative disadvantage to those which do not, because, having internalized, their prices will go up. Thus, protective tariffs of a certain kind would be desirable, protecting not an inefficient domestic industry from competing with efficient foreign firms but an efficient national policy of cost internalization against standards-lowering — and thus price-loweing — competition from less efficient countries (Daly, 1996: 147).

The Gross National Product was created to measure national accounts and indicate the size of a nation's economy. Its endless growth is seen as a good. However, even beyond the refutation of endless growth, the GNP has several flaws. First, GNP conflates growth (quantitative increase) with development (qualitative improvement), making it more difficult to distinguish what is actually better from what is merely more (Daly, 1996: 69). More importantly, it conflates three incongruous factors, adding services (a benefit), throughput (a cost) and net accumulation (simply a change in capital stock and funds) (Daly, 1996: 112). Further, it does not include benefits arising from non-monetary sources, such as domestic labor or environmental amenities. Also, externalized costs are, by definition, left out (Beckenbach, 1989 / 1994: 101).

It make no sense to add apples, oranges and pears, and to leave out some apples and oranges at that. More egregiously, though, GNP includes costs and considers them *to be* benefits. For example, non-renewable resources are liquidated wealth (Daly, 1996: 82), but their use is incorporated into GNP. Further, environmental cleanup costs, rather than being counted as a cost of unsustainable economic practices, are simply added to the GNP as products and services purchased (Daly, 1996: 112). Deducting for depreciation of capital in order to keep productive capacity intact is an accepted principle in accounting income (Daly, 1996: 16) yet is completely ignored when calculating GNP.

In the end, GNP does not tell us whether we are living off income or capital, interest or principal (Daly, 1996: 40). Even the most traditional economist knows that costs must be compared, not added, to benefits and that you cannot live off your principal without depleting it. Further, it is "not only a passive mismeasure but also an actively distorting influence on the very reality that it aims only to reflect," inasmuch as it merely encourages more of the unsustainable growth which it measures (Daly, 1996: 41). Daly and others have endeavored to create alternate measures, but even these are imperfect, and Daly suggests that we would be better off with no measure than a faulty one (Daly, 1996: 115).

To describe the overall state of economic theory, Daly makes an apt analogy:

> Neoclassical economics, like classical physics, is relevant to a special case that assumes that we are far from limits — far from the limiting speed of light or the limiting smallness of an elementary particle in physics — and far from the biophysical limits of the earth's carrying capacity and the ethicosocial limits of satiety in economics. Just as in physics, so in economics: the classical theories do not work well in regions close to limits. A more general theory is needed to embrace both normal and limiting cases. In economics this need becomes greater with time because the ethic of growth itself guarantees that the close-to-the-limits case becomes more and more the norm. (Daly, 1996: 37)

Basic economic theory must therefore undergo some significant changes to accommodate the fact of growth's unsustainability (Daly, 1996: 193-197). However, much would remain unchanged. As Elmer Alvater says, "without scarcity, there is no need for economics" (Altvater, 1989 / 1994: 84). The only difference is in what we identify as scarce. Economic logic would remain focused on economizing on the limiting factor, simply acknowledging a shift of the limiting factor from man-made capital to natural capital, “from fishing boats to the populations of fish remaining in the sea” (Daly, 1996: 8). As Daly says, “This is not ‘new economics,’ but new behavior consistent with ‘old economics’ in a world with a new pattern of scarcity” (Daly, 1996: 78). To continue maximizing man-made capital would be genuinely antieconomic.

One other key notion which does not need to change is the Hicksian definition of income as the maximum amount that a community consume over a given time period and still be as well off at the end of that period as at the beginning (Daly, 1996: 75). Indeed, this is the very essence of sustainability.

Population: A Very Special Case of Economic Growth

One important facet of economic growth is population growth. Indeed, when non-human species are modeled, population size is most often used as the indicator of the size of their niche, their economy. The human population size is not the best index for the size of our global economy, since resource use per capita varies widely in subpopulations around the world. However, though there may be much disagreement about how to analyze the situation, more attention has been given historically to our growing population than to most any other aspect of our niche expansion. Often posed as a great problem in and of itself, with solutions ranging from the controversial to the more controversial, it is crucial to understand the ecological dynamics behind our population size.

Population growth is simply assumed to be an inherent characteristic of our species, its cause seldom sought. Basic population ecology concepts can shed light on this as well, most notably the models of competition and predation developed in the 1920s and 1930s by Alfred J. Lotka and Vito Volterra.

To understand these models, we need to grasp the notion of a species' carrying capacity. Rather than simply being tree-hugger rhetoric, this concept has a concrete mathematical basis, calculated from a species' birth rate, death rate and constants for each of these rates representing their degree of density dependence, i.e., the extent to which these factors are affected as the population size itself changes. Resources are depleted incrementally as crowding increases so that the birth rate gradually decreases and the death rate gradually increases. Eventually, a population reaches a level at which birth and death rates are equal, and the population is maintained at the maximum level at which it can achieve sustainability (Gotelli, 1998: 26-28).

The carrying capacity, however, is *not* a constant for any given species, as revealed by the Lotka-Volterra models of competition and predation. The competition models give competition coefficients to each species, indicating the effect that each species has on the growth of the other (Gotelli, 1998: 102). Similarly, the predation models incorporate the conversion efficiencies mentioned earlier (Gotelli, 1998: 128). The carrying capacity is shown to be variable, determined only in relation to the carrying capacities of other species (Gotelli, 1998: 102-103). Thus, tree-huggers who demand that we respect carrying capacity and pro-natalists who claim its meaningless share an incorrect idea of just what carrying capacity even is. The Lotka-Volterra models reveal that a species can increase its carrying capacity at the expense of other species. Competition and predation are, at their base, a channeling of carrying capacity, of population potential, from one species to another.

Economic growth appears to be the very definition of increasing carrying capacity. Engaged in this pursuit on a global scale, we do not simply prove ourselves more successful than other species. Instead, we enter into the most extreme possible form of interference competition, i.e., behavior that reduces the exploitation efficiency of other populations (Gotelli, 1998: 100), consciously commandeering global resources under the auspices of species self-improvement, natural right, etc. Combining our high conversion efficiency and growth rate with a low death rate, various conclusions arise. Solving for equilibrium predator population, we find that high conversion efficiency means fewer people are needed to control other species' populations (Gotelli, 1998: 129). Our large and growing numbers must then overcontrol our victims, contributing to a reduction in biodiversity. Conversely, increasing food production, i.e., victim populations, as an attempt to fend off starvation simply ends up requiring greater numbers of predators, i.e., people, to control the victim populations (Gotelli, 1998: 129). Basic population ecology thus shows that, rather than contributing to any alleviation of hunger, constantly increasing food production is the very engine that drives population growth.

These conclusions are supported by the paradox of enrichment. Victims may find refuges from predation, helping alleviate their overexploitation (Gotelli, 1998: 142-3), but humans programmatically seek and destroy such refuges. An extra bird in the hand now, though, means none in the bush later, per the paradox. Finally, the cycle rate between predator and victim populations, i.e., the rate at which cyclic variations occur in their population sizes, slows as both prey growth rate and predator death rate decline (Gotelli, 1998: 133). Thus, as we overexploit other species and decrease our own susceptibility toward death, the fluctuation cycle may slow to a rate too low for us to recognize, making us ever less able to acknowledge our connection to other species.

Thomas Malthus may have been wrong about food production increasing arithmetically while population increases exponentially, but his basic claims hold: there is a relationship between food and population (a causal one which he didn't expect), and population growth can outrun food production. Garrett Hardin gleans what he refers to as a demostat, describing essentially the same phenomenon as the cycle rate in the Lotka-Volterra predation model, from Malthus. The demostat is a simple negative feedback loop which acts on population in the same way that a thermostat acts on the temperature of a room. The set point is the population's carrying capacity, and an increase in population above this level causes density-dependent variables to kick in and bring the population back down to carrying capacity. The population continues to shrink to somewhat below the carrying capacity, when those same density-dependent variables then create circumstances in which the population can thrive a bit more, bringing the population up and starting the cycle over again. The population is maintained in dynamic equilibrium, cycling around the carrying capacity just as temperature is maintained around the set point of a room's thermostat (Hardin, 1993: 104-106). This view is extremely consistent with the above analysis in that a population's set point, just as with a thermostat, can be changed. Hardin poses a set of demographic revolutions, in which the technological innovations of tool making, agriculture and the development of modern science and industry each served to increase the human population's global carrying capacity (Hardin, 1993: 112-114).

Contrast this analysis with the most common discussions of human population growth, such as the one published by the *New York Times* anticipating the occasion of the birth of the six-billionth person (Crossette, 1999). Charts show that our population will level off at just under 10 billion around the year 2200 (Crossette, 1999: 5). This kind of prediction employs the logistic model of population growth, assuming that there is simply some inherent growth rate and some inherent carrying capacity toward which we will grow and then level off (Gotelli, 1998: 26-30). A sidebar derides Malthus' claim that population growth will outpace food production as "more than plain wrong... an enduring source of error and self-bamboozlement," since technological improvements "sidestep limits" (Wade, 1999: 5).

Both the forecast and the refutation of Malthus are completely oblivious to the true cause of population growth and thus the true nature of carrying capacity as a relative variable. Again, Malthus was wrong about the rates of change but not about the food-population relationship itself. Limits are not sidestepped, they are increased. Further, a smooth leveling off of population, known as monotonic damping, is not the only end predicted by this model. A key variable is the lag between the increase in a population and the time at which density-dependence evokes a response. This time lag combines with the growth rate to indicate just how the logistic model plays itself out. For a species with a high growth rate and a large time lag, such as humans, the population will greatly overshoot carrying capacity before beginning a phase of decline (Gotelli, 1998: 32-4). Whether we have already exceeded our carrying capacity or not is highly complicated by the fact that we are constantly increasing that variable along with food production.

Of course, food production, like all resource usage, cannot grow without end. This is, of course, due to the earlier mentioned thermodynamic and, most significantly due to the possibility of extinction, ecological limits to growth. Even *WB2K* acknowledges that further increases to the food supply will be difficult, especially if they are to be sustainable (World Bank, 2000: 28). But as long as we continue to produce more food, we will continue to produce more people. As

Daniel Quinn puts it, posing the escalation of a "food race" to parallel the nuclear arms race, every win on the food side is answered by a win on the population side (Quinn, 1999: 113). The level at which we stop being able to continue increasing food production is unlikely to be sustainable and would thus emphatically *not* be a carrying capacity. Food production would then take a sudden drop, and along with it would go our carrying capacity and our population, having overshot our optimum as predicted. Indeed, given that social and ecological ills appear to grow along with our population, it is hard to believe that anything above our current numbers could represent some "natural," stable equilibrium population size for our species.

In a materially finite world, the refutation of Bentham and Mill's notion of the greatest good for the greatest number should be obvious. While one can be maximized or both can be optimized, it is logically impossible to maximize both (Daly, 1996: 220; Hardin, 1993: 264). As the population increases, the amount of resources available per capita must be reduced. This is made all the more dramatic by the fact that a significant portion of the Earth's resources are actually used in *creating* the larger population, with the biomass of the planet gradually being turned into human mass (Quinn, 1999: 113).

Strictly speaking, though, a growing population is not harmful in and of itself. It is only a problem because of the increased strain on natural resources. There are many species with populations much greater than six billion that nevertheless do not face our resource problems because their rate of resource use is much smaller than ours and is not ceaselessly growing.

In a very real sense, population growth is simply a side effect of economic growth, of the commandeering of ever greater quantities of resources. Everything boils down to a consumption crisis, in which the total amount of resources we use reduces the survivability of other species, many of which we depend on, degrading ecosystems, many of which we depend on. All of this brings us closer and closer to extirpating ourselves long before all the resources on the planet run out due to thermodynamic irreversibility.

Increasing food production may channel some extra food to people currently starving, but it also drives population growth, assuring that there will be less to go around later and thus providing no real solution to hunger. Likewise, other forms of economic growth provide no final solution to quality of life in the so-called developing countries. Economic development may provide amenities now and may reduce population growth (though even this is debatable), but the huge increases in per capita consumption of a smaller, developed population can actually do more ecological damage than lower consumption in a larger, undeveloped population. The idea of the demographic transition, which in any case was only ever a descriptive model and not a deterministic process (Hardin, 1993: 182), holds no benefit in the quest for sustainability. Pursuing economic growth, we are caught between the Scylla of population growth and the Charybdis of increased per capita resource use, for these two factors multiply to yield to total size of our unsustainably growing economy.

Growth and Hierarchy

Perpetual motion doesn't work because of thermodynamics. Alchemy doesn't work because of both ecological instability and thermodynamics. Food production drives population growth. But we can ask one more "what if" question: what if humanity really was exempt from these biophysical laws of nature? Would everything work out? Unfortunately, the answer is still no. Even if we could consume as much as we wanted and have as many people as we wanted, one key factor remains in our analysis of our situation. There is a way in which there is a population crisis beyond the issue of limited resources, and to understand this we need to look at theories of organization and state formation.

The study of state formation attempts to understand how simple, egalitarian social structures like tribes evolved into the complex, hierarchical, inegalitarian structures that pervade the world today. State in this sense refer not to government but to nation-state or city-state, forms of social organization that include all the members of its population. Inasmuch as these organizations are managed as single entities, governments naturally follow, with only a few of the state's members wielding power at the top of its political hierarchy.

Many theories of cultural evolution and state formation propose a unilineal path, an inexorable movement from "primitive" tribes, increasing complexity to eventually form nation-states and, in the social structural sense of the word, civilization. An inherent drive toward complexity in cultural evolution seems like a dubious claim at best. Theories of state formation provide support that the complication of social structure, as globally widespread as it is today, has specific causes and is, in fact, a truly rare phenomenon. John Langton cites Robert L. Carneiro: "At the start of the Neolithic, the world contained roughly eight million people but several hundred thousand small, autonomous societies... Today, more than five billion people crowd the planet, but only about 160 sovereign societies (i.e., nation-states) survive, most of which are large, complex, and powerful" (Langton, 1988: 493).

Though it has evoked many criticisms, one of the most widely accepted theories of state formation is Carneiro's circumscription theory, which Robert M. Schacht sums up in one sentence: "In areas of circumscribed agricultural land, population pressure led to warfare that resulted in the evolution of the state" (Schacht, 1988: 439). Carneiro himself, though, suggests that it should be possible for states to arise in uncircumscribed areas, where overcrowding may occur if population growth is fast enough (Carneiro, 1988: 499; Schacht, 1988: 439). That Carneiro is willing to concede this has made some of his critics suggest that the environmental factor of circumscribed arable land should not be considered essential to the theory at all. In response, Carneiro claims that "The thesis advanced here is not that societies become more complex *only* by growing larger, or that as they grow larger they *invariably* become more complex. Rather, the contention is that if a society does increase significantly in size, and if at the same time it remains unified and integrated, it must elaborate its organization" (Carneiro, 1967: 360).

For Carneiro, though, the cause of population growth is unimportant, yielding probably the most widespread criticisms of his theory. He uses the exponential model for unconstrained population growth, explicitly rejecting models involving equilibria or limits (Schacht, 1988: 440). This is especially surprising given that the nature of circumscription theory is to show how various constraining factors affect cultural change. George L. Cowgill has been particularly vociferous on this issue, saying that "Population growth is not an automatic tendency of either ancient or contemporary agrarian societies. It is not an automatic 'prime mover' which accounts for development episodes" (Cowgill, 1974: 505), and that "We can never simply assume that stress or the threat of stress will automatically or even typically generate social or cultural development" (Cowgill, 1974: 507). To this, Carneiro claims that it is not up to his theory to explain the rate of population increase, but "simply takes this increase as *given*, and uses it as one element in accounting for state formation" (Carneiro, 1988: 503). Though not obliged, he is generous enough to offer a suggestion for the high growth rate, posing that sedentism made possible by agriculture permitted a reduction in the practice of infanticide and other forms of population limitation (Carneiro, 1988: 504). In effect, "with the coming of agriculture, the cork was out of the bottle" (Carneiro, 1988: 505).

Cowgill also poses an opposite consequence of population pressure: "If there is serious stress due to resource shortages that can only be overcome by intense conflict with other groups, the response will be to halt population growth *unless* something other than inelastic fertility is stimulating that growth" (Cowgill, 1974: 517). Indeed, Malcolm C. Webb's sentiment is extremely pertinent here: "It is doubtful that so significant a cultural evolutionary step as the birth of civilization was the consequence of a final struggle of desperate, impoverished, teeming masses" (Webb, 1988: 451). But Carneiro defies the notion of self-constraint, logical as it may seem: "In theory, they might have done so; in practice, they did not. Examine any major area of the world where states arose and you will find [population growth]" (Carneiro, 1988: 504).

Of course, Carneiro commits a logical flaw here, putting the cart before the horse by suggesting that, because all states arose from (among other things) population growth, population growth (among other things) leads to the state. However, we can resolve this dispute with our knowledge of population biology. Though Carneiro does not feel the need to explain the cause of population growth, he is right in suggesting that agriculture uncorked the bottle, increasing humanity's set point as suggested by Hardin's demographic revolutions. Thus, while Cowgill is perfectly correct that population growth cannot be, and indeed is not, a given for all human populations since no species actually grows according to the exponential model, human population growth has, since the agricultural revolution, approximated this model. The upshot of this is that, while Carneiro is practically justified in granting exponential growth, population ecology models disprove his theory: as Cowgill suggests, populations do not grow when food production is constrained. It is food production itself which has enabled the exponential-like growth of humans over the last 10,000 years.

However, Carneiro could not be more correct in claiming that a society, *if it is to remain unified and integrated*, must elaborate its organization to accommodate population growth. Whether political, economic, religious or otherwise, any entity that grows and wishes to keep in tact without fissioning must make its organizational structure more complex and hierarchical, and hierarchy brings, by definition, inequality. To paraphrase George Orwell, some hierarchies may be more equal than others, as democracy may be compared to dictatorship, but the fundamental inequality never disappears. Indeed, hierarchy arises not just among people within an organization but among organizations in supraorganizational entities, e.g., departments within a company, companies within in an industry, industries within an economy and even, in a truer sense of the Orwellian paraphrase, economies within the global market. Disparity in resources — wealth, power, status, etc. — is endemic to the management of large systems. The poverty of the lower class compared to the upper is as assured as that of the Third World compared to the First.

Not only is increasing inequality inherent in such a system but increasing complexity is, in a way distinct from yet related to that of economic growth, unsustainable. Increasing social complexity, like economic growth, faces limits of its own in a closed system like the Earth. The growth which causes complexity would first reach a physical circumference past which it could not expand. At this point, complexity could continue to increase within the system but there is likely to be a limit here as well, caused possibly by limits of information processing capacity.

Increasing complexity in such a circumstance will lead to, as Langton suggests, a single world state, the ultimate level of earthbound social complexity (Langton, 1988: 495).

Long ago, the initial effect of increased complexity would have been to increase the carrying capacity of an area and so reduce absolute population pressure, an advantageous development which is consistent with Carneiro's circumscription theory. However, Webb says it would only do so "at the cost of increasing the *fragility* of subsistence thus *increasing the necessity of staying in place and maintaining the social and economic status quo*" (Webb, 1988: 455). Norman Yoffee cites Rappaport as believing that complex systems are profoundly maladaptive since, instead of maintaining flexible responses to stress, their many interconnections mean that change in one component is likely to have a ripple effect, changing the whole system: diversity and flexibility diminish, and a failure in one element must spread (Yoffee, 1988: 5). Thus, while at first the state is strong, successful and seemingly adaptive, like economic growth, it becomes vulnerable in the long run. Driven complexity pushes itself toward two limits: the breach of one yields explosion; the other, implosion. Fissioning, an option long ago left behind, becomes the only choice left to evade collapse. The localization trend pointed out by *WB2K*, though it may not be an urgent response to potential collapse, represents precisely this sort of dissolution of complex systems.

Bruce H. Mayhew points out that the "seeds of their own destruction" attitude toward certain social systems is usually marked by the grave defect that it is usually discussed as a purely internal flaw, something inherently wrong with the structure itself or with an ideology involved. But he acknowledges that population systems nevertheless can generate the conditions of their own demise, arising from an environmental relation, not an internal one (Mayhew, 1982: 137-8).

Looking at a few of Mayhew's population system propositions, we can see more specifically why driven complexity thrives at first and then brings about its own end.

System proposition 4 says that "The higher the rate of change in information and/or energy transactions (resulting in an increase toward the system's upper processing limit) the greater the probability that the structural change in the system will be destruction of the system" (Mayhew, 1982: 140). Thus, with driven complexity, the rate of change not only increases but accelerates, so there is a geometric approach to the always-possible moment when further change is likely to destroy the system. That possible moment, though, is made less possible by propositions 7 through 9, which state that the upper limit on information and energy capacity will increase along with a social system's population size, functional differentiation and complexity of material technology (Mayhew, 1982: 140). In other words, "The larger a system becomes, the greater the environmental change required to destroy it" (Mayhew, 1982: 148). Hence driven complexity truly does succeed at first, but only at first because even success is bound to catch up with the system, due to propositions 10 through 12. These suggest that the lower limit will also increase, meaning that more and more information and energy are required at minimum to continue the system's operation (Mayhew, 1982: 141): "Functional and technical complexity thus place powerful constraints on operation, requiring even more stringent schedules of activity and systematic coordination" (Mayhew, 1982: 153). In other word, the larger something grows, the greater are its maintenance costs (Daly, 1996: 68). The eventual failure becomes just as likely as the initial success, for there must come a time when complexity accelerates faster than the ability of the system's managers to remain in control — and the ability of the Earth to provide energy inputs.

This sort of limit need not only occur after state formation. Discussing the Melanesian Big-Man phenomenon, Joseph A. Tainter says, "... as resources are allocated to expanding a faction, those available to retain previous loyalties must decline. As a Big-Man attempts to expand his sphere of influence, he is likely to lose the springboard that makes this possible. Big-Man systems contain thus a built-in, structural limitation on their scope, extent, and durability" (Tainter, 1988: 25). Paul B. Roscoe concurs, elaborating on Big-Man politics with more universal implications:

> Since agricultural populations are committed to stored resources and to a relatively heavy investment in sowed fields, relocation will have its costs, and this fact will tend to promote the hegemony of big-men and chiefs. If subsistence is also dependent on irrigation systems, then... the population will be 'tied down' yet further... elite power can rise to greater levels under intensive than under extensive subsistence regimes... For, if labor- and capital-intensive agriculture makes relocation unappealing, then environmental circumscription, social circumscription, and resource concentration render it more so. (Roscoe, 1988: 480)

Indeed, the phenomenon is universal. Webb suggests that warfare occurred in Egypt "not because of overpopulation or... land shortage, but simply because their dependence on irrigation and exchange networks forced them to stay in place and deal with the conflicts that, for a variety of reasons, inevitably rose among them" (Webb, 1988: 455).

While we have already seen that circumscription theory is flawed, Roscoe suggests adding a new layer may improve it: "A gradual continentwide growth in technology..., by stimulating population growth and necessitating continuous attachment to more complex — and demanding — economic networks, eventually would create a condition that one might characterize as *technoeconomic* circumscription" (Roscoe, 1988: 457). Yet another level of circumscription is proposed by D. Bruce Dickson, who suggests that the thesis "be amended to include changing patterns of 'artificial' circumscription brought about by anthropogenic environmental destruction" (Dickson, 1987: 709). In this light, the circumscription process itself can be seen as "a complex dialectical one — in which social units, competing with each other... created ever more constricting and circumscribed agricultural environments for themselves" (Dickson, 1987: 715).

It should be abundantly clear by now just how economic growth, population growth and social complexity relate to problems of ecological degradation and unsustainability. Just as a socioeconomic system like ours creates, in effect, massive inequities between humans and the rest of nature, inequities among humans and groups are created within. Similarly, just as we as a civilization find growth difficult to give up, those in the upper levels of social hierarchies have a great interest in keeping their power and resources and thus in maintaining the system. All of this ensures that the situation will worsen. Ecological degradation certainly has direct impact on human societies through feedback mechanisms, but through this analysis of social structure we see direct support for the idea that economic growth and the domination of nature are destructive not only of ecosystems but of the purely social aspects humanity as well (M. O'Connor, 1994: 5).

We may never reach the world state suggested as the inevitable end of increasing complexity, since economic growth could very well reach the limits of unsustainability sooner than complication, bringing a premature end to the complication process. Additionally, nationalism and the free market ideology may prevent such a final unification. Of course, there is an alternative to a world state as such. As Langton suggests, after having described how the United States allows for organization at a federal level while maintaining a certain degree of freedom at lower levels, "the transformation of the American state also suggests that some form of federalism, combined with a system of governmental checks and balances, might serve as the political structure of a world state capable of solving humanity's common problems without despotism or the destruction of cultural diversity" (Langton, 1988: 495). Supranational entities, such as the United Nations, the World Bank, the IMF and the WTO, suggest just this sort of development. While this might happen in theory, though, the fact that the United States has not succeeded in solving its own problems after more than two centuries of federalism could be held as just cause for pessimism in applying the system on a global level.

Our hierarchical civilization proves maladaptive through the vulnerability of maximum complexity and minimum variety: there are more parts that can go wrong and fewer unique features to respond to problems. John S. Dryzek echoes this, suggesting that large, highly hierarchical administrative mechanisms cannot cope with truly complex, multifaceted problems, because division of labor tends toward disaggregation of problems into components which become artificially separated from each other (Dryzek, 1992 / 1994: 181). The problems of a system like ours, whose analysis requires knowledge from such varied fields as physics, ecology, economics, demography and anthropology, are precisely the kinds of problems such systems are least able to solve. Perhaps it is no coincidence that such a system is unable to follow the classical dictum to Know Thyself, since, if it did, it would be forced give itself up. Our system's failure to acknowledge the causes of some of its main problems amounts to a cultural version of psychological denial.

In the end, economic growth yields population growth, which in turns generates social complication and hierarchicalization, whose many forms include governmental expansion and centralization, urbanization and market globalization. These conspire not only toward ecological destruction but systematic inequality and organizational implosion. This complex, multifaceted process is the flip side of the growth coin and the reason why its endless pursuit is impossible.

Conclusions

Daly grants that the World Bank's environmental standards are generally higher than those of most of its member countries (Daly, 1996: 9). Indeed, *WB2K*'s discussion of protecting the global commons is relatively sensible, acknowledging the importance of biodiversity and both the devastating potential and primarily anthropogenic cause of ozone depletion and severe climate change. The main problem is simply that they only appear willing to address symptoms rather than causes, yielding low potential for creating lasting solutions.

Beyond the mere three symptoms explored in detail, a handful of other issues briefly mentioned in a sidebar (World Bank, 2000: 88) come no closer to root causes. About the closest *WB2K* gets to addressing the true basis of unsustainability is the following uninspired statement: "In the long term, renewable energy sources may play a more important role in production, but wind and solar energy are not yet feasible economic substitutes for fossil fuels on a large scale" (World Bank, 2000: 97). Sustainability is precisely about what is renewable and what is not. Renewable sources *must* play a more important role in production because non-renewable energy sources are, in fact, *non-renewable*! The ridiculousness of this redundancy is in direct proportion to the World Bank's misguidedness.

The very suggestion that there are natural limits to human activity is often seen as a turn-off. Yet even Stephen Jay Gould, who famously stood against the suggestion of limits to human potential in the debate over sociobiology, notes that there are many cases of humans coming up against limits, such as practitioners of the performing arts, including musicians and athletes, who likely "stand close to the right walls of human limitation" (Gould, 1996: 225). Further, those involved in the creative arts, such as writers and composers, may even have reached the limit, e.g., Gould believes that we are not likely to produce a writer greater than Shakespeare or a composer superior to Mozart (Gould, 1996: 228-9).

Most natural laws are statements of impossibility (Daly, 1996: 104), postulates of impotence, as E.T. Whittaker has called them (Hardin, 1993: 42). It is impossible to create or destroy matter/energy; it is impossible to make a perpetual motion machine; it is impossible to travel faster than the speed of light; it is impossible to simultaneously measure a subatomic particle's position and momentum. It is through understanding physical laws, so often involving limits, that we have been able to make such great strides in science and technology. Biological or ecological laws, though, seem to hit too close to home and we fail to see how understanding them can be empowering rather than limiting, for "if we know that something is impossible then we can save an infinite amount of time and money by not trying to do it" (Daly, 1996: 104).

Ideologically tied to certain socioeconomic practices and beliefs, people on both sides of the ecological argument often jump to proscriptive conclusions upon hearing assessments of limits. But proscription does not always follow from assessment. Continued pursuit of the ecological perspective reveals that many possible courses of action often mentioned as responses to these issues are actually flawed. It is far beyond the scope of this paper to provide a complete discussion about the positive approaches to human improvement that can come from the ecological perspective, but a few key examples demonstrate that the apparent gloominess of an assessment of unsustainability should not entail the pessimism with which it is so often attributed.

Daly provides some cursory calculations to demonstrate the impossibility of bringing the world population up to U.S. consumption levels, i.e., of "developing" everyone (Daly, 1996: 104-106). Indeed, as both U.S. consumption levels and world population increase, the prospects continue to decrease. This evokes the possibility of "overdevelopment" as a correlate of "underdevelopment." Daly defines an overdeveloped country as one whose level of per capita resource use would be unsustainable if generalized to all countries. An underdeveloped country, therefore, rather than simply being a country that has not industrialized, would be one whose per capita resource consumption is less than what could be sustained indefinitely if generalized to the world (Daly, 1996: 106).

On average, a more modest level of living than that of the U.S. is simply required for the human species to continue to exist for any significant amount of time. This does not mean, though, that we must abandon all production and live in poverty. On the contrary, it means only that maximized use of resources cannot be held as an ideal to which all people should aspire. The world's nations, on average, simply cannot be overdeveloped, but nor would they have to remain underdeveloped. On average, we just need to use resources at a rate no greater than that of their regeneration.

Too often, we are led down a Luddite path abhorring science and technology, or even a Deep Ecologist path which suggests that people are inherently bad for the planet. We are told that we must be environmental saints. Admittedly, we could stand to do a great deal better than we currently do. Economic growth, though, in the strictest sense, is precisely how all species live. The species or individual that does not take resources from its environment dies. However, so does the one that takes too much. All we need to recognize is that growth beyond some optimum is antieconomic, yields results we truly do not desire. Further, humans are not even the only polluter of the environment, as many of the substances that we consider pollutants also have non-human sources (Barnes-Svarney, 1995: 470). Here, all we need to recognize is that levels of pollution or waste disposal beyond an ecosystem's absorptive capacity is antieconomic. Recognizing a limit to a certain factor does not mean we must drop the factor to zero. Heeding limits is precisely what allows us to proceed confidently in our activity.

Population control proposals also seem to go hand in hand with environmental solutions. Boulding, Daly, Hardin and many other proponents of the ecological perspective believe that, in the absence of growth as a solution to poverty, population control and wealth redistribution schemes are the keys to alleviating poverty in a sustainable world. However, neither of these actions necessarily follow from our population crisis. These are merely management techniques, addressing symptoms and not causes. Both may have their place but neither can provide stable, lasting solutions.

What is perhaps the most threatening idea expressed in this paper, that of the relationship between food and production, actually provides a path out of this. Since the principles of population dynamics apply equally to humans as to other species, solutions to population management "problems" might be applied equally without falling prey to the double standards of human exceptionalism. In managing non-human species, bottom-up measures, involving regulation of the inputs to a system, appear to yield much more stable solutions than top-down measures, which usually involve simply killing off either "overrepresented" species or the predators of "underrepresented" ones. For humans, then, top-down efforts, from birth control to the even more controversial tactics of euthanasia, infanticide, genocide and eugenics, could never yield stable solutions to human overpopulation. On the other hand, just as economic progress will go along with regulating the material inputs to our economy, we should find success with our population dynamics by following the same strategy.

Amartya Sen rightly points out that our problem is not that we have too little food but that our entitlement schemes yield insufficient distribution (Sen, 1981: 7). Rather than institute massive redistribution schemes, requiring great effort while evoking resistance from our hierarchies, an approach that may provide real solutions would be to start to alter the system which creates the inequalities in the first place. Since we know that increasing food production merely contributes to population growth which then contributes to inegalitarian social structures, we simply need to, little by little, reduce, or at least stabilize, the amount of food being produced. In addition to discouraging growth and therefore hierarchy, doing so will also lead away from industrial agriculture. Reducing our dependence on chemicals, genetically engineered crops, heavy machinery and monoculture, agriculture would become easier and would generate healthier, more robust foods.

Another path toward de-hierarchicalization is localization, the assertion of self-determination among subnational entities. This phenomenon is met by *WB2K* with decentralization, an effort by states to reassert control even as certain functions are granted local control. Allowing genuine localization, though, helps transform hierarchical structures into flatter, more equal ones. Municipalities and regions can still come together for whatever endeavors they wish to pursue in common while taking control over the issues they want under their own purview.

Quinn suggests one way in which these two concepts can be brought together, posing that farmers can enter an agreement with their communities or regions. They would provide enough food for the stable maintenance of the area's population. In return, the farmer would receive all the necessary forms of non-food support, obviating the need for the farmer to charge per unit and thus the incentive produce ever more (Quinn & Thornhill, 1999). This is not meant to be a single solution applicable everywhere but merely representative of the kind of thinking that can come from the ecological perspective. Bottom-up endeavors are not likely to be put into place overnight or to immediately produce astonishing results, but they have a strong likelihood of providing stable, viable solutions for the long run.

Daly reminds us that the World Bank exists to serve the interests of its member nations,

> not individuals, not corporations, not even NGOs... It has no charter to serve the one-world-without-borders cosmopolitan view of global integration — of converting many relatively independent national economies, loosely dependent on international trade, into one tightly integrated world economic network upon which the weakened nations depend for even basic survival. (Daly, 1996: 92)

A growth economy strains ecosystems to the point of degradation. A faulty understanding of the relationship between food and population leads to an ever-growing population, ensuring hierarchy with social organizations. These factors combine to make almost inevitable the existence of areas where populations, or at least subpopulations, find scarcity and increased risks of disease; where, in short, they simply cannot live healthy lives. But the fact that we cannot grow indefinitely in no way suggests that it is impossible to improve the human condition, i.e., to *develop*. Indeed, it is only through understanding sustainability that the alleviation of these problems becomes possible, thus only through sustainability that the World Bank can fulfill its mission.

On growth and development, Daly says:

> The two processes are distinct — sometimes linked, sometimes not. For example, a child grows and develops simultaneously; a snowball or a cancer grows without developing; the planet Earth develops without growing. Economies frequently grow and develop at the same time but can do either separately. But since the economy is a subsystem of a finite and non-growing ecosystem, then as growth leads it to incorporate an ever larger fraction of the total system into itself, its behavior must more and more approximate the behavior of the total system, which is development without growth. (Daly, 1996: 167)

Even the World Bank admits, on the first page of the *WB2K* overview, that growth does not trickle down and that development must address human needs directly (World Bank, 2000: 1). By viewing development as qualitative improvement rather than quantitative expansion (Daly, 1996: 1), we can start to find ways to get more of what we want, rather than just more (Quinn, 1999: 89). None of this suggests that using resources is inherently bad, or that we must all live in poverty at some minimal level of resource use. There is no reason to think we can't have sewerage, sanitation or even vehicles and movie theatres. For all the need to acknowledge limits, sustainability really has one simple requirement: that, on average, the human economy not pull resources out of the Earth at a faster rate than the Earth can replenish those resources. Within this simple guideline, anything else is possible. In the end, seeking sustainability is not about what humanity has to give up, but what we stand to gain (Quinn, 1999: 86).

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