The 'Malthusian Dilemma' Revisited

Excessive human numbers in a world of finite limits

J. Kenneth Smail

Abstract

In this essay I call attention to the growing disconnect between reasonably accurate demographic projections of future global population growth (to more than 9 billion by mid-twenty-first century) *versus* prudent scientific estimates of the Earth's likely long-term sustainable human carrying capacity (perhaps no more than 2 billion at a modest first-world standard of living). In addition to identifying the recent emergence of several other critical global challenges, I speculate about the nature of the profound evolutionary, ecological, and sociocultural consequences that could well appear during the twenty-first century. In essence, I argue that an important emergent phenomenon has become increasingly likely: namely, the growing potential for a global "synchronous failure," a cascading political, economic, social, environmental, and demographic breakdown (or generalized collapse) stimulated by the mutually reinforcing convergence of multiple "inconvenient truths." This poses a fundamental existential question. Unless significant mitigating steps are soon undertaken, could the future of modern agricultural/industrial/technological civilization, as well as the lives of several billion human beings, be at considerable risk?

Stretch a bow to the very full
and you will wish you had stopped in time.
—Lao-Tse

Introduction

It has become increasingly apparent over the past half-century that there is a growing tension between two seemingly irreconcilable trends. On one hand, moderate to conservative demographic projections indicate that global human numbers—ca. 7.6 billion (as of 2018)—will almost certainly reach 9.5 billion or more by mid-twenty-first century, less than two generations from the present. On the other hand, prudent and increasingly reliable scientific estimates suggest that the Earth's long-term sustainable human carrying capacity—at what might be defined as a "minimally adequate" to "moderately comfortable" developed-world standard of living—may not be much greater than 2 billion. It may in fact be considerably less, perhaps in the 1 billion range, particularly if the normative life-style (level of consumption) aspired to is anywhere close to that currently characterizing North America.

Consider the following thought experiments. Examine any late twentieth/early twenty-first century problem, whether environmental, economic, political, social, or moral, and ask whether its solution would be made easier—or more difficult—by a steadily growing population. Or conversely, imagine trying to resolve, or at least accommodate, these same problems in a context where population size—whether global or local—has either stabilized or slowly begun to decline. Or consider the following challenge posed by Bartlett (1998): "Can you think of any problem, on any scale, from microscopic to global, whose long-term solution is in any demonstrable way aided, assisted, or advanced by having larger populations at the local level, the state level, the national level, or globally?" Or finally, might it be legitimate to ask whether the Earth suffers not so much from a "shortage" of resources as it does from a "longage" (or surfeit) of people (Hardin 1999)?

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In what follows, I take the position that increasingly rapid population growth during the past century has played a central role in causing, or at least in further exacerbating, the numerous systemic problems—ecological, economic, political, social, and moral—that currently face our species. Although recognition of this fundamental fact has been slow in coming, there is now a growing realization that "demographic fatigue" can not only overwhelm the efforts of many less-developed nations, particularly those whose populations and corresponding infra-structural needs double (or more) every generation, but can also sap the strength of even the most robust and stable political and economic systems (Brown et al. 1999).

In fact, the magnitude and rapidity of this rampant and seemingly unregulated demographic expansion, particularly since the mid-twentieth century, have led some researchers to see certain fundamental similarities between the spread of the human species and the growth of a malignant melanoma (or other cancer). Consider the following criteria for identifying a cancerous malignancy (Gregg 1955; Hern 1993; 1999):

(1) rapid, uncontrolled tissue growth;
(2) invasion and destruction of adjacent normal tissue;
(3) de-differentiation: loss of functional (adaptive) distinctiveness of individual tissue components;
(4) metastasis: dissemination to and/or invasion of distant tissue sites; and
(5) production of toxic metabolites.

Notwithstanding a difference in scale of several orders of magnitude, humanity:

(1) has also grown explosively;
(2) has invaded, destabilized, and simplified numerous adjacent ecosystems;
(3) has become increasingly amalgamated into a single, undifferentiated global phenomenon (agro/techno/urban civilization);
(4) has now metastasized into a monocultural "juggernaut" (Grant 1996) in the process of spreading to (colonizing) all corners of the Earth;
(5) typically accompanied by an excessive production of dangerous waste and pollution.

In short, one could argue that the human species has now become a growing cancer—a malignant ecotumor—on the planet, and further that this cancerous process has increasingly been reinforced by what has become a runaway (positive feedback) relationship between continued population growth and ongoing cultural/technological elaboration (Hern 1993). In simplest terms, this human cancer has the potential to significantly, and perhaps permanently, destabilize the planetary ecosystem.

GLOBAL POPULATION REDUCTION

I thus begin with the following general propositions:

(1) that there are indeed finite limits to global human numbers;
(2) that these limits have not only been reached, but already exceeded; and
(3) that population stabilization and subsequent significant decline are not only desirable, but almost certainly inevitable.

However, as is usually the case, the devil is in the details, and there is obviously considerable disagreement about appropriate means to this end. While some have tended to focus on rapid population growth as the primary causal mechanism underlying many (if not most) of our current global difficulties, others have preferred to explain these critical challenges (including population growth) as the consequence, or outcome, of the combined operation of various other factors. As with so many problems of this nature, particularly those dealing with complex and non-linear adaptive systems, the reality of course is probably somewhere in between, the synergistic result of numerous feedback mechanisms, both positive and negative, operating in a complex causal network.

At any rate, as a consequence of this modern-day "Malthusian dilemma," it seems reasonable to suggest that it is now time—indeed, past time—to think boldly about the midrange future, and to consider alternatives that go beyond merely slowing the growth, or even achieving the stabilization, of global human numbers. In this partly hortatory essay, I take the position that it has now become necessary for the human species to develop and implement, as quickly as possible, a well-conceived, clearly articulated, flexibly designed, broadly equitable, and internationally coordinated program focused on bringing about a *very significant reduction in global human numbers* over the next two or more centuries.

In simple quantitative terms, given the above-mentioned "irreconcilable numbers," this will likely require a global population "shrinkage" of at least 75 to 80 percent, from a probable mid-to-late twenty-first century "peak" in the 10 to 11 billion range to a future (twenty-second century and beyond) "population optimum" of not more than 2 billion, or perhaps even fewer. While these tentative target figures may at first glance seem draconian, it is surely worth remembering that global human numbers only passed the 1 billion mark in the early nineteenth century, barely two centuries ago, and only reached the 2 billion mark in the late 1920s, a time still within living memory.

Obviously, a demographic change of this magnitude, whether brought about by conscious human design

or ultimately by forces beyond human control, will require a major reorientation of human thought, values, expectations, and lifestyle(s). Unfortunately, there is no guarantee that such a program will be successful. Moreover, if humanity fails in this effort, it seems likely that nature's even harsher realities will almost certainly be imposed. Speaking as a professional physical anthropologist/human evolutionary biologist, it is entirely possible that this rapidly metastasizing—yet still partly hidden—demographic and environmental crisis could emerge as the greatest evolutionary/ecological "bottleneck" that our species has yet encountered.

To the best of my knowledge, any claim to originality on my part stems primarily from my willingness, in several published essays and papers over the past two decades, to speak more openly and candidly than most about *the next logical step beyond global population stabilization* (Smail 1995; 1997a,b,c; 2002a,b; 2003a,b; 2004; 2008). Specifically, I refer here to my central argument: *first*, that a significant *decrease* in global human numbers is now a necessary—and probably inevitable—consequence of a century-long period of "explosive" population growth that now shows numerous signs of having already exceeded the Earth's long-term optimal human carrying capacity; and *second*, that the unsustainable "tensions" resulting from this complex dynamic could potentially lead to the fragmentation and eventual collapse of modern agricultural/ industrial/ technological civilization, perhaps *within* the lifetimes of those now living.

VALIDATING THE HYPOTHESIS

It is important to recognize that this admittedly controversial proposition—that there must be a very significant reduction in global human numbers over the next one or two centuries—is presented here in the form of a testable scientific hypothesis, one that is amenable not only to continued empirical confirmation, but also to potential falsification. In other words, this hypothesis may be quickly and easily *rejected* (i.e., empirically falsified) if it can clearly be demonstrated that ongoing estimates for global population size over the next few hundred years *will not exceed* what will presumably be increasingly accurate projections of both current and future optimal human carrying capacities. For the purposes of this essay, an "optimal" carrying capacity may be defined as a population size, typically *less than* the sustainable maximum, that is most likely to produce a good and sustainable (i.e., broadly acceptable) quality of life for its members, without adversely affecting the quality of life of people who live elsewhere or of people who will live in future times.

However, this hypothesis is *confirmed* if future global population size *continues to exceed* (by a significant margin) these same carrying capacity estimates. Moreover, such confirmation would be true regardless of whether human numbers continue to grow at current rates, grow more slowly, stabilize, or even begin to decline. For example, even if future research shows that the 2 billion (or smaller) optimal carrying capacity utilized in this essay has been significantly underestimated (i.e., is "off-target" by a factor of two or more), the argument put forth here loses little if any of its persuasive power, nor is the above hypothesis in any way invalidated. The reason for this is simple. Even a global population optimum of 4 to 5 billion, more than double the figure recommended here, would still necessitate a very substantial reduction (of some 50 percent or more) from the 10 to 11 billion currently projected for the late twenty-first century.

Notwithstanding the numerous difficulties in addressing a problem of such complexity, it is nonetheless surprising how little scientific and public attention has been directed toward establishing empirically quantifiable, scientifically testable, and socioculturally agreed-upon parameters for what the Earth's long-term human carrying capacity—or flexibly defined "optimal population range"—might actually be. Unfortunately, with only a few notable exceptions, many otherwise well-qualified scientific investigators and public policy analysts have been rather hesitant to take a clear and forthright position on this profoundly important matter, certainly destined to become the overarching issue of the current century.

It is difficult to say whether this unfortunate reticence is due to ingrained investigatory caution, concerns about professional reputation and advancement (particularly among younger investigators), the increasingly specialized structure of both the scientific and political enterprises, personal qualms about reaching conclusions that have potentially unpalatable social and political ramifications, or other unspecified (and perhaps deeply rooted) ideological, moral, or religious reservations (Beck and Kolankiewicz 2000). Or perhaps, given its global nature and seemingly endless ramifications, the chief difficulty in dealing with the complex population/ environment/carrying capacity conundrum represents little more than a manifestation of "scale paralysis," that enervating sense of individual and collective powerlessness when confronted by problems whose magnitude seems overwhelming.

Certainly the rough approximations of global human carrying capacity put forth during the past century show considerable variation, ranging from fewer than 1 billion to well beyond 20 billion, an order of magnitude or more (Cohen 1995). It is, however, important to note that over the past three decades a growing number of investigators (and organizations) have articulated

reasonably well-thought-out positions on future global population optimums. Interestingly enough, most of these estimates have clustered in the 1 to 3 billion range. This is an important development, since it is patently obvious that it will be difficult to engender any sort of effective public response to the above-mentioned global crisis if future population goals (i.e., desired demographic optimums) continue to be imperfectly understood and poorly articulated.

MULTIPLE CHALLENGES

Quite frankly, I hope the above hypothesis is wrong and that various demographic optimists are correct in their claims that, thanks to a number of significant recent developments—from effective and inexpensive contraceptive techniques to advances in women's education and empowerment—human numbers will begin to show a "natural" stabilization and subsequent decline somewhat sooner than expected. Presumably, when this welcome demographic trend is coupled with enhanced efficiencies in energy production, resource utilization, and materials conservation, and is further reinforced by efforts toward significantly reduced per capita consumption levels (particularly in the more developed world), it might allow for somewhat larger carrying capacities, or optimal population sizes, than we currently imagine.

But this sort of optimism is warranted only by corroborative data; that is, only if the above-mentioned "irreconcilable numbers" show unmistakable evidence of coming into much closer congruence. For it is now increasingly apparent that any such optimism should be tempered by an honest and full consideration of the problems surrounding a broad range of rapidly emerging (and converging) "inconvenient truths,"—global phenomena whose powerful downstream effects will undoubtedly become manifest within the next few decades, if they have not done so already. In addition to the overpopulation/carrying capacity conundrum, the two "truths" that have thus far generated the most public interest and controversy, both scientific and political, are of course:

(1) Unpredictable climatic trends: or the broad-scale ecological, economic, political, and cultural consequences of ongoing "climate change," or increasing "climatic instability" (or more popularly, anthropogenic "global warming"). Based on the evidence now provided by extensive scientific research and analysis over the past three decades, these wide-ranging climatic phenomena and longer-term trends are empirically quite well documented, certainly resting on a strong "preponderance of evidence" as they increasingly approach the level of "clear and convincing" and perhaps (for some) "beyond all reasonable doubt."

(2) Post-peak fossil energy supplies: or the unpredictable consequences—including the potential for wide-scale political, economic, and social destabilization—of passing the global "production peak" of oil, coal, and natural gas. For it seems increasingly likely that the "post-carbon" world will soon be engaged in a massive struggle to adapt to a long-term and significant decline in the availability of cheap and abundant energy from fossil fuels, the aptly named "ancient sunlight" that for the past two centuries has fueled the exuberant growth of modern agricultural/industrial/technological civilization (Hartmann 2004; Heinberg 2005; Greer 2008; Klare 2012).

More specifically, the evidence from recent "peak energy" research and analysis increasingly suggests that by the middle of the present century humanity will be faced with a global population of some 9-plus billion, struggling to maintain—or in many instances still trying to acquire—some semblance of modern first-world civilization on but 1/3 to 1/2 of the non-renewable energy (particularly oil and gas) the world *currently* produces, exacerbated still further by a notable deficit of "proven" or "environmentally benign" energy substitutes (renewable or otherwise) on anywhere near the scale that would be necessary.

This of course is in addition to dealing with the growing constraints and pressures due to a broad range of other important "limiting factors," most of which have been the subject of considerable scientific study, public concern, and increased political attention over the past generation and more. Chief among these multiple and complexly interconnected "critical challenges" are:

(1) continuing rapid population growth, particularly in the less-developed world
(2) the diminishing availability of fresh water, particularly for agricultural use
(3) the ongoing degradation of topsoil, both in terms of fertility declines and erosional losses
(4) maintaining an adequate food supply (plant, animal, and fish protein) for growing populations
(5) growing shortages of, and geopolitical competition for, essential minerals and materials
(6) the steady constriction of wilderness areas and reduced global biodiversity
(7) the warming and increasing acidification of the oceans (ca. 70 percent of the Earth's surface)
(8) growing stresses on public health due to breakdowns in the epidemiological environment
(9) the increasingly sclerotic malfunctioning of basic political, economic, and social institutions
(10) a pervasive economic mindset based on the fallacy of unlimited growth in a finite world
(11) the growing potential for a major collapse of the world's debt-based financial system

(12) the growing power and influence of non-state actors (criminal gangs, terrorist groups, etc.)
(13) ongoing and uncontrolled mass migration, not only cross-border but also within-border
(14) the ever-present danger posed by weapons of mass destruction (nuclear, chemical, biological)
(15) and surely others that the reader might identify....

ACKNOWLEDGING OUR DILEMMA

Given the above, it is obvious that assertions that the Earth might be able to support a population of 10 to 15 billion people for an indefinite period of time at a standard of living similar to or superior to the present are not only cruelly misleading but almost certainly false. Notwithstanding our current addiction to continued and uninterrupted economic growth, surely the dominant political mantra of the twentieth and early twenty-first centuries (what some have aptly termed "growth-mania"), it is essential for humanity to recognize that there are, in fact, *finite physical, biological, and ecological limits to the Earth's long-term sustainable carrying capacity* (i.e., the "natural capital" that supports us). And to recognize further that we are now drawing down on the principal, as well as the interest, of these precious "capital assets," as many of these finite limits have already been reached (and in a number of instances surpassed).

Consequently, because at some point in the not-too-distant future the negative ramifications and ecological damage stemming from the mutually reinforcing effects of excessive human reproduction and over-consumption of resources could well become irreversible, and since there is only one Earth with which to experiment, it would undoubtedly be better for our species to err on the side of prudence, exercising wherever possible a cautious and careful stewardship.

Surely it is time to suggest that the burden of proof on these matters, so long shouldered by so-called "neo-Malthusian pessimists," be increasingly shifted to the "cornucopian optimists." In other words, for those who might be inclined to ignore (or summarily reject) the hypothesis put forth here, the *scientific* "burden of proof" should be quite clear: *What is the evidence that the Earth can withstand—without irreparable damage—another two or more centuries during which global human numbers and per capita consumption greatly exceed the Earth's optimal (sustainable) carrying capacity?*

In any event, having established in this essay an empirically "quantifiable" and "falsifiable" frame of reference, it seems obvious that it is now time to go one step further, and at the very least begin to make the case that current rhetoric about "slowing the growth," or even achieving the "stabilization," of global human numbers *is clearly insufficient to the task that lies before us*. Quite simply, both the empirical data and inexorable logic suggest with increasing clarity that what will be required for the foreseeable future—the "default position" for the next two or three centuries—is a *very significant reduction* in global human numbers.

Admittedly, this presents a vexing "temporal disconnect," an existential dilemma that may be difficult (perhaps even impossible) to resolve, particularly in a manner that will be perceived as equitable, voluntary, and humane. It seems all too likely that the period of time—*at least two centuries*—that will be minimally necessary for initial population stabilization and subsequent reduction, eventually to a desired global optimum in the 1 to 2 billion range, is clearly inconsistent with the much more "restricted" time frame that is suggested by the swelling chorus of those who project significant fossil-energy production declines, steadily growing problems associated with global climatic change, and the high probability of increasing food shortages, all appearing much more rapidly (within the next generation or two).

I refer here to the distinct possibility of an environmental "critical threshold," or quasi-evolutionary "bottleneck," or cascading political, economic, and social "breakdown," or global "synchronous failure," all emerging over the *next several decades* (by mid- twenty-first century or before), while demographic momentum remains an active force and global human numbers continue to increase.

I am therefore only cautiously optimistic that the human species will be able successfully to confront the complex and interrelated problems we have managed to create for ourselves—what some have begun to characterize as an ecological, demographic, economic, political, sociocultural, and moral "perfect storm." In fact, when I see how little traction various mitigating (or ameliorative) efforts have gained over the past 30 to 40 years, I have become increasingly pessimistic that humanity—potentially some 9-plus billion of us within our children's and grandchildren's lifetimes—will be successful in staving off some very difficult times over the next several generations.

COLLAPSE SCENARIOS

Given this, it is certainly time—indeed, past time—to give serious consideration to steps that might avert, or at least to some extent mitigate, the growing possibility of a partial-to-full collapse of what we have come to know as modern agricultural/industrial/technological civilization. A number of reasonably well-articulated "collapse scenarios" have been recently put forth, ranging from gradual to rapid. Though hardly an exhaustive overview, the following examples are representative:

(1) *A slow and inexorable decline* (i.e., gradual societal destabilization, fragmentation, and breakdown) over a considerable period of time; what some have termed a "long emergency," eventually resulting in much smaller—as well as more "localized" and "resilient"—political, economic, and social units; a more-or-less "soft landing" collapse, extending over multiple generations and several centuries.

(2) *A gradual but "step-wise" collapse*, characterized by repeated periods of societal conflict and decline that alternate with temporary—but ultimately unsuccessful—attempts at reintegration and stability at lower levels; a pattern of ongoing "de-industrialization" that some have characterized as a "catabolic" process, inevitably resulting in ever greater economic, political, social, technological, and demographic "simplification" over an extended period (i.e., centuries).

(3) *A much more rapid breakdown*, with little advance warning and/or prior preparation, as modern agricultural/industrial/technological civilization rather quickly (and unexpectedly) crosses over the edge of a partly unforeseen precipice—most likely a "finite energy and resources" threshold—with severe-to-chaotic political, economic, social, and demographic consequences; a "hard landing" collapse that develops over several years to at most a few decades.

(4) *A sudden and total systemic collapse*, most likely resulting from an all-encompassing and rapidly expanding global "territorial and resource war" involving the use of nuclear, chemical, and/or biological weapons of mass destruction; complete devastation and unimaginable social chaos, with deaths probably in the billions; an "irreversible" political, economic, and societal collapse occurring within a few days to at most a few weeks.

It goes without saying that each of the above collapse scenarios would be characterized by—indeed, would undoubtedly necessitate—a very significant decrease in global human numbers, almost certainly numbering in the hundreds of millions (if not several billions). This would happen irrespective of whether such a reduction would be sudden (a catastrophic mass "die-off") or develop somewhat more gradually (and, one hopes, rather more humanely).

For a more detailed discussion and analysis of the causes and consequences of civilizational collapse, as well as providing several points of entry into the recent literature describing a broad range of collapse scenarios (both historical and contemporary), the interested reader may wish to consult the following: Catton 1980; 2009; Tainter 1988; Hardin 1993; Smith et al. 1998; Meadows et al. 2004; Grant 2005; Diamond 2005; Homer-Dixon 2006; Ponting 2007; Greer 2008; 2016; Kunstler 2005; Heinberg 2005; 2007; Orlov 2008; Ahmed 2010; Dilworth 2010; Ophuls 2012; Ehrlich and Ehrlich 2013; Oreskes and Conway 2014; Youngquist 2016.

In sum, the *synergistic combination* of the previously mentioned "critical challenges," when considered together with any of the just-described "collapse scenarios," surely represents a toxic brew. Succinctly stated in the language of systems theory, Ophuls argues that:

> In fact, the potential for catastrophe is ever present in chaotic systems. The gradual accumulation of small changes can push a system over an unseen threshold and thereby precipitate rapid and radical change...(and) the very fact that complex systems [civilizations] have key links and nodes connected by multiple feedback loops means that they are vulnerable to a cascade of failure. To put it another way, systems that are too tightly coupled or too efficient are fragile; they lack resilience....When formerly separate problems coalesce into a problematique, [a civilization] does not face one or two discrete challenges, as in simpler times, but instead a swarm of simultaneous challenges that can overwhelm its capacity to respond, thereby provoking a general collapse (i.e., a catastrophe that propagates rapidly across a globe that is ever more tightly coupled) (Ophuls 2012, 39).
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> Civilizations are (thus) trapped in a vicious circle. They must keep solving the problems of complexity, for that is the price of civilized existence, but every solution creates new, ever more difficult problems, which then require new, ever more demanding solutions. Thus complexity breeds more of the same, and each increase in complexity makes it harder to cope, while at the same time escalating the penalty for failure. In effect, civilizations enact a tragedy in which their raison d'etre—the use of energy to foster the complexity that has raised them above the hunter-gatherer level of subsistence—becomes the agent of their ultimate downfall (Ophuls 2012, 36).

And it certainly doesn't help that our current deteriorating state of affairs—with a few notable exceptions—has been further exacerbated by a generalized lack of political, economic, social, and moral foresight and cooperation on both a national and global level, not to mention an underlying and recalcitrant human nature all too prone to both individual and collective denial. Nevertheless, to the extent that humans universally share a deep-rooted and powerful "investment in immortality," however we might individually or collectively choose to define it, it is essential that we keep trying to bias the future in a positive direction.

CONSUMPTION AND EQUITY CONCERNS

Even though I have previously referred to the significance of global (and per capita) energy and resource consumption, this matter undoubtedly deserves further discussion and elaboration. To a certain extent, the *quantitative* importance of consumption to the population/environment dynamic can easily be demonstrated by the following manipulation of variables in the well-known I = PCT equation: *Impact = Population X Consumption X Technology* (Holdren and Ehrlich 1974). Even if considerably enhanced technological and other conservation-oriented efficiencies (T) could reduce global energy usage and "waste and pollution" by as much as 50 percent, these gains would quickly be canceled out by a doubling of population (P). To many observers, this suggests that the most effective short-term means of reducing humankind's "total impact" (I) on the global environment would be to focus on significantly reducing per capita consumption (C). This not only could, but undoubtedly should, include efforts to reduce (or minimize) as much as possible the very large (and in some instances growing) "affluence differentials" between the developed and less-developed worlds.

Put another way, this suggests that the developed world also has a population problem of significant proportions, particularly when one considers that *per capita* consumption rates (and corresponding ecosystem impacts) in so-called "rich" nations may be 5, 10, 25, 50, or even 100 times greater than in those nations designated as materially "poor." Therefore, it should not be surprising to anyone that the less-developed world's typical response to suggestions that they significantly curtail their "rampant" population growth is an equally emphatic call for developed nations to greatly reduce their "profligate" consumption levels, or population, or both!

Given this current impasse, let me make a few additional observations on matters pertaining to population growth, per capita consumption levels, and ongoing attempts to minimize as much as possible the above-mentioned "disparities" between rich and poor. Certainly, if greater fairness or balance in the distribution and utilization of the Earth's finite resources (i.e., enhanced global equity) is to be coupled with a considerably enhanced standard of living (quality of life) for the mildly-to-severely "disadvantaged 80 percent" of the world's peoples, something has simply "got to give." For example, according to Myers (1997, 212):

> Per capita consumption worldwide has increased by 3 percent per year during the past quarter century, so it is reasonable to suppose that people in the future will want it to increase by at least 2 percent per year (provided it can be sustainable). Per capita consumption would then double in 35 years, quadruple in 70 years, and increase eightfold by 2100....Were global population to reach 11 billion people by 2100, total consumption would (then) expand 15 times—an amount surely unsustainable given available stocks of nonrenewable natural resources and given the Earth's limited capacity to absorb pollution among other forms of waste. Even a low-variant projection for global population, 6.0 billion by 2100 (albeit after a mid-century peak of 8.0 billion), would leave consumption soaring 8.4 times.

In short, it seems increasingly evident that even greatly enhanced technological efficiencies (on a worldwide scale) and considerably reduced per capita consumption (by nations in the developed world) *will not be enough by themselves* to bring about the oft-articulated and presumably desirable goals of greater equity and justice, particularly in a world that seems destined to add another 3 billion people within the next two or three generations. And if one further argues that humanity's fundamental goal—indeed, ethical first principle—must necessarily be to preserve the stability and resilience of the Earth's integrated ecosystem(s), the logical (and pragmatic) consequence seems both obvious and irrefutable: *Only a global human population "optimized" at a considerably reduced size will provide the opportunity to build a much better quality of life for everyone.*

Finally, a few closing comments about equity concerns may also be relevant. I fully agree that a cooperative global effort to resolve humanity's current crises, in terms of population and otherwise, will require both the perception and the reality of an honest movement toward equity of all kinds (gender, class, ethnic, religious, economic, educational, etc.). But it is important to note that in addition to enhanced equity for those currently alive (what might be defined as *intra-generational* or "spatial" equity), there is also the equally important matter of equity for future generations (*inter-generational* or "temporal" equity), and to recognize further that these two imperatives may frequently come into conflict.

In fact, given the inevitability of increasing tensions in the ongoing dynamic between present and future generations, so much in evidence already, it is of crucial importance that we develop the political and moral courage *now* to make the kinds of decisions that will maintain or enhance an acceptable quality of life *later on* (for our descendants). Suffice it to say that none of these decisions will be easy, especially those concerned with matters pertaining to the beginnings of life (e.g., encouraging voluntary and equitable limits on fertility) or those concerned with issues at life's end (e.g., developing ethically acceptable limits on the use of "extraordinary measures" to marginally prolong life).

Last but not necessarily least, as many have eloquently described, there is yet another balance that must be maintained. For the lack of a better term, this might be described as a "geo-biological equity," establishing a balance not only between our species and numerous other life forms via biodiversity and wilderness preservation, but also with the Earth itself via conservation of the varied components of the geosphere (Cafaro and Crist 2012). Simply stated, humanity will surely be better able to confront these issues if we can collectively come to regard ourselves more as the Earth's long-term stewards rather than its absolute masters (Wilson 1992).

ONGOING UNCERTAINTIES

I fully realize that population projections are not predictions and, as mentioned earlier, very much hope that continuation of recent worldwide fertility declines suggests that global human numbers could "peak" (stabilize) somewhere in the 9 to 10 billion range during the mid/late twenty-first century, and then begin a slow but steady decline. Much of this guarded optimism is based on the assumption—but not the assurance—that certain inferences based on the demographic transition model are empirically justified, particularly the claim that there is a strong positive correlation between increased economic, social, physical, and sexual well-being and steadily decreasing fertility levels. But it is entirely possible that these assumptions and correlations are also "projections" rather than "predictions," leaving at least three possibilities insufficiently addressed.

*Firs*t, what sorts of unpredictable and potentially deleterious instabilities might be introduced in the meantime, as both the Earth and humanity attempt to cope with the increasingly severe twenty-first century political, economic, environmental, sociocultural, and moral "difficulties and discontinuities" discussed earlier? And what effect, if any, will the "dislocations" stimulated by these problems, most likely resulting in a *decrease* in economic, social, and physical well-being, have on the above-mentioned declining fertility rates, or for that matter on mortality rates?

Second, even if the demographic transition model does have predictive value, will global fertility rates necessarily keep declining to levels below ZPG (zero population growth), as any attempt at significant population reduction requires? Or might they stabilize at levels that are considerably smaller than at present yet still modestly positive (perhaps in the 2.2 to 2.5 range)? In other words, will the demographic trajectories observed in the developed world over the past century necessarily be the case for nations in the developing world over the next half-century?

Third, just how large a "shrinkage" (population reduction) should there be, assuming we are indeed fortunate enough to reach that critical turning point? This of course is a matter which has very much to do with a set of even more difficult projections, not so much about changes in population size but rather about the Earth's long-term optimal and sustainable carrying capacity. Until convincing evidence is presented to the contrary, it would seem prudent to adhere to the rather conservative 1 to 2 billion "global optimum" articulated throughout this essay.

COORDINATING THE EFFORT

This leads to a crucial final point—the ineluctable fact that in our multinational and politically fragmented world, solutions cannot be imposed from without. Ultimately, both individually and collectively, the people of each sovereign state must come to terms with, and subsequently resolve, their own unique demographic and consumption problems, motivated not only by an increasing awareness of global realities but even more by their local consequences. In this regard, given the limited time available and the excruciatingly difficult decisions that must be made, it is daunting to realize that population problems are often the most pronounced in areas of the world where national sovereignty—and the requisite political, economic, and social stability—is most tenuous (Kaplan 1994; Connelly and Kennedy 1994; Weisman 2013).

However, at no point do I make the case—nor do I recommend—that the political means toward the goal of significantly reduced global human numbers necessarily involves collective, interventionist, centrally administered, rigidly target-oriented, or draconian top-down measures implemented by some sort of supra-national world government. Rather, such measures that are employed should be essentially voluntary, broadly equitable, flexibly designed, locally focused (bottom-up), primarily educational, and appropriately sensitive to various cultural, ethnic, gender, and religious considerations (as well as the strong likelihood of deeply rooted biological inclinations and propensities).

To be sure, these measures would need to be coordinated over a lengthy period of time (several generations) by some sort of international clearing house whose primary function would be to provide all relevant political and other "entities"—including, and most especially, various non-governmental organizations (NGOs) and public interest groups—with accurate, internally coherent, and consistent information, both scientific and sociopolitical. Such information would be designed to address each entity's particular and unique demographic situation, all within the broader context (generalized goal) of moving toward a considerably smaller and increasingly optimal world population that might provide a better quality of life for all.

I do not at this time see the likelihood of going much beyond this level of international cooperation and coordination, the basic framework of which already exists. Whether this sort of structure and/or strategy will be sufficient for the enormity of the task, however, I am not prepared to answer. What I do know is that humanity does not need any further delay in educating itself about—and subsequently confronting—these critically important issues. Our "window of opportunity" may not be open much longer.

Because of these (and other) difficulties, it remains to be seen whether humanity will be capable of mounting a unified and lasting effort toward population limitation and subsequent reduction. Clearly this will be an unprecedented undertaking, a broad-ranging effort that must be conducted on a species-wide scale, and an endeavor that by its very nature must be sustained for a century or more. While posterity demands that we be successful, I am only cautiously optimistic that such success can be achieved by rational human forethought, or by means compatible with contemporary social, political, and ethical norms. One can only hope that these ongoing doubts about our capacity to successfully confront these problems will somehow serve to strengthen our resolve.

FINAL THOUGHTS

And so, the critical question: Is it naive to suggest that the evidence is now sufficiently convincing to encourage a "critical mass" of knowledgeable, concerned, and motivated investigators to quickly begin to put together a serious, legitimate, and empirically well-documented case for averting what appears to be a rapidly emerging global catastrophe? If so, it would certainly become much easier—or more "palatable"—for still other scientists, as well as environmentalists, politicians, economists, moralists, and other concerned citizens of the planet, to speak forthrightly and with ever greater confidence about humanity's responsibility to rapidly and resolutely address this burgeoning existential crisis.

Surely it is essential that elected public officials, civil servants at all levels of government, academics from a broad range of disciplines, representatives of the news media, religious leaders from all the major faith traditions, and spokespersons for national and international environmental organizations, should not feel as though they are committing political, professional, or moral suicide by bringing these matters to public attention. For time is becoming increasingly precious, and the above-mentioned "window of opportunity" for effective remedial action may shortly be closing, if it has not already done so.

I very much hope that this all-too-brief and partly hortatory essay has helped to clarify an important and often underappreciated point: that ongoing population growth has a significant influence on, or connection with, nearly every other critical issue that humanity currently faces. I hope it is also obvious that this influence is both reciprocal and mutually reinforcing, resulting in numerous and interconnected positive feedback (or deviation amplifying) systems and subsystems, many of which are imperfectly understood. It may thus be entirely appropriate to characterize the twentieth and early twenty-first centuries' rapid and continuing population expansion as *the critical factor* that not only undergirds, but also reinforces many if not most of our species' growing political, economic, social, environmental, and moral difficulties.

Until demonstrated otherwise, *I would therefore suggest that unchecked or "insufficiently restrained" population growth should be considered the single most important feature in an admittedly complex (and synergistic) physical, ecological, biocultural, and sociopolitical landscape*. More than two centuries after the publication of *An Essay on the Principle of Population*, it is surely worth remembering that, except for not fully anticipating the subsequent human capacity to overcome—if only temporarily—certain "checks" on population expansion, the Reverend Thomas Malthus' (2004 [1798]: 20) analysis of the "strong and constantly operating check on population [emerging] from the difficulty of subsistence" may have been right on target!

In any event, it should by now be unassailable that the limitation of human population size, and subsequently confronting the numerous problems that will be engendered by its eventual and inevitable contraction, should occupy a central position within the "modern problematique," and as such should be dealt with much more forthrightly, and much more promptly, than has heretofore been the case.

More than half a century ago, at the dawn of the nuclear age, Albert Einstein suggested that we shall require a new manner of thinking, if humankind is to survive. Even though the aptly named "population explosion" is neither as instantaneous nor as spectacular as its nuclear counterpart, its ultimate consequences may be just as real (and potentially just as devastating) as the so-called "nuclear winter" scenarios promulgated in the early 1980s (Turco et al. 1983).

That there will be a large-scale reduction in global human numbers over the next two or more centuries appears to be inevitable. The primary issue may well be whether this lengthy and difficult process will be moderately benign or unpredictably chaotic. More specifically, is modern humanity capable of a comprehensive organized effort to compassionately reduce global human numbers, or will brutal self-interest prevail—either haphazardly or selectively—resulting in an unprecedented

toll of human lives, not to mention the growing likelihood of a global civilizational collapse? Clearly we must begin our "new manner of thinking" about this critically important issue *now*, so that Einstein's prescient and very legitimate concerns about human and civilizational survival into the twenty-first century and beyond may be addressed as rapidly, as fully, and as humanely as possible. ■

> *Assuming then, my postulata as granted, I say that the power of population is indefinitely greater than the power in the earth to produce subsistence for man.*
>
> —Thomas Malthus (2004 [1798])

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