Population and Environment: Of *Doomsayers* and *Truth Tellers*

T. Abrajano*

The Assyrian Tablet

> *"The Earth is degenerating today. Bribery and corruption abound. Children no longer obey their parents, every man wants to write a book, and it is evident that the end of the world is fast approaching."*
>
> — Assyrian Tablet, c. 2800 BC

There are several reasons why I decided to open up my discussion on population and environment with the forgoing passage from an Assyrian Tablet. First, it is clear that we are not the first generation to contemplate our planet's eventual demise. Doom saying is an old business. Indeed it can be argued that part of the reason that we are still here discussing the issues of population and environment is that previous venerable prognosticators have made predictions that were eventually proven to be inaccurate. In 1798, the Reverend Thomas R. Malthus forecasted that the world's population will be limited by food shortages. In 1960, Paul R. Ehrlich noted that "The battle to feed humanity is over. In the 1970s the world will undergo famines - hundreds of millions of people are going to starve to death" and that up to four billion people would die during the 1980s. Some would contend that our inability to make accurate predictions of the future means that discussion of the type we are having today is pointless. Of course, none of us would be here today if we thought that this is the case.

* Professor, Rensselaer Polytechnic Institute, New York, and Program Director, Geobiology and Low-Temperature Geochemistry, The National Sciences Foundation, Virginia, USA. He presented this paper at the University of the Philippine Alumni Association Council Meeting on June 23, 2006.

But discussions of impending doom sell tickets. Doomsayers fascinate and interest the public and that is all the media need to know. I recall the recent hoopla and uproar caused by a speech delivered by former Vice President Al Gore here in the Philippines (February, 2006) (also see, *An Inconvenient Truth*). The banner headline of the *Philippine Daily Inquirer* on the speech reads: "Gore: Earth is now at risk, let's save it, 2M need relocation if Manila Bay overflows". Visions of fleeing people from a great deluge reminiscent of the flood of Gilgamesh and Noah's flood played in the minds of many. Some say it was a credible warning from one who had dealt with the major issues associated with global warming at the highest levels. Some, including a number of scientists from the University of the Philippines, reacted with disgust. "Here we go again," they said, a foreign celebrity bringing in the 'hype' and the country's leaders buying it hook, line and sinker, while our government constantly ignores more realistic predictions on flooding and other hazards in the Philippines.

On a grander scale, the Intergovernmental Panel on Climate Change (IPCC), the world's leading assembly of experts on climate change and impact, has been accused of doom saying on a global scale. Emerging at the nexus of legitimate criticisms and political attacks on the IPCC Report is a 515-page account of the real state of the world by Danish statistician Bjorn Lomborg (*The Skeptical Environmentalist: Measuring the Real State of the World*). In his book, Lomborg contends that the world's global temperature will increase much less than maximum IPCC estimates and the cost of the impact is far outweighed by the proposed cost of mitigation. Many others have advanced similar positions, hence the debate on the future impacts of global warming continues unabated, and the Kyoto Protocol remains to this day a hollow document.

Another reason that I lifted the above Assyrian tablet quote is that it conveys a sense that confusion is very much at the core of every doomsday claim. Discussions of population and environment are prone to such uncertainty because when people's lives, personal beliefs and livelihoods are affected, there is little space for objectivity and a gigantic hallway for biased perceptions from all involved, scientists included. The current debate on global warming and sea-level rise has reputable scientists on both sides. It doesn't take much math to figure out that a big fraction of those involved in these discussions would be wrong. The Earth's terrestrial, oceanic and atmospheric systems are complex systems part or whole, so it is not surprising that even very good scientists could disagree. Add to that the socio-political dimension, and it is not hard to imagine how disagreements can arise even from well-meaning individuals. How can humankind look at this problem the same way if there are different levels of responsibility for causality (e.g., disparity of past and present green house inputs) and drastic differences in the resources and means available for each in mitigating possible impacts (e.g., developed versus developing economies)?

Yet, there are mistakes and there are "mistakes". All good scientific work begins with a hypothesis that could either be right or wrong. Errors in the scientific methods employed or

honest misconception of limits and uncertainties of data could lead to errors of conclusion. These are all parts of the normal business of science. What has alarmed a great many including myself, however, are "deliberate mistakes" driven by agenda beyond the normal realm of the scientific process. A popular writer, Michael Crichton, recently suggested that science has been corrupted, and scientists have become another form of raw political power "tricked out on special claims of objectivity." In this way, Crichton warns that science may soon become no better than any other human undertaking. But here, one has to make a distinction between science and the practitioners of science. Scientists are humans who, indeed, can be corrupted. But science itself is the method to the madness of the world around us, and I submit that it will continue to be the one reliable tool needed to address environmental issues facing humanity. I hope this digression in 'the essence of science' did not come across as a tangential issue to our discussions of population and environment. It is a crucial point that has to be brought to the surface, as we contemplate translating scientific observations and inferences to useful policies. Scientists are fallible, but the scientific process must continue to play a part in devising the necessary answers. The bad news is that scientific charlatans are still out there on the loose; the good news is "In the long run, it is impossible to stand in the way of the exploration of truth. Someone will learn, somewhere, sometime" (Philip Handler, President of the National Academy of Sciences, 1969-1981).

Earth On The Brink?

So, is Earth on the brink? The Assyrian tablet quoted earlier, and apparently former Vice President Gore, suggest that the Earth is on the brink of destruction. Credible television documentaries, a hoard of old and recent movies and very reputable journals and magazines have said as much. As an Earth scientist, keenly aware of 4.5 billion years of sometimes tumultuous record of Earth's existence, let me assure you at the outset that the Earth is not nearly on the brink of destruction. This planet was born of and shaped by violent events in planetary history. It has seen extremes of hot and cold easily beyond those contemplated by the most dire predictions global climate models. Earth's history was punctuated by planetary collisions, bolide impacts, massive volcanic eruptions and global mass extinctions. Yet, the total biomass has grown and diversified with time. Members of the domain bacteria and archaea have been around for billions of years and now comfortably thrive in the coldest ice, the saltiest seas, the warmest hot springs, and deep beneath the ground. This planet and the resilient life on it will survive as they have always done so in the past, in much the same way that Ecclesiastes (1:4) has proclaimed, "One generation passes away, and another generation comes; but the earth abides forever...". Stephen Jay Gould (*The Golden Rule – A Proper Scale for Our Environmental Crisis*) points out that human impact on this planet is indeed vastly overrated. Certainly, the sum total of what we do has the potential to challenge humanity's

existence, but that is a far cry from the destruction of Earth and life on it. Global warming and the litany of other environmental issues facing us threaten not the Earth itself, but the quality of human existence on it. Environmental and population stress leads to greater and greater exposure of humans to risks because, as Gould best puts it, "Humans ought to treat nature as they would want to be treated by nature" (i.e., the Golden Rule).

Even granting that the Earth is not on the brink of destruction, however, there are reasons to think that these are special times. The predictions of Malthus and Ehrlich on the impact of growing populations were certainly off in timing, but the jury is out on the eventual outcome. It is evident that the failure of their predictions on the extent and impact of population growth came about because they failed to take full account of human adaptability and ingenuity. The way humanity has avoided or postponed the predictions of great famine is to improve food production technology and expand arable land. This meant shrinking natural ecological systems by expanding agriculture, increasing the use of fertilizers, pesticides, herbicides and genetically-engineered crops to improve yields, growing more and more domesticated animals at the expense of the world's grasslands and forests, and encroaching and exploiting some of the world's most sensitive marine and terrestrial ecosystems and seats of major biodiversity. Ehrlich and Ehrlich described it as "turning the Earth into a giant human feedlot". But what about the world's oceans and atmosphere? About two centuries ago, Lord Byron (1788-1824) remarked "Roll on, deep and dark blue ocean, roll ... Man marks the earth with ruin, but his control stops with the shore." Oh, how sweet the past, when no one was noticing the large-scale perturbations that humans can make. But ignorance isn't bliss. Alas, the finiteness of the oceans has caught up with us as the cod stock of the Northwest Atlantic collapsed towards the end of the millennium, and fisheries throughout the world are failing today because of over-fishing. The finiteness of the atmosphere can't be more clearly demonstrated by the colossal holes in the ozone layer of the stratosphere and unabated concentration increases in green house and noxious gases in the lower atmosphere. El Nino and La Niña frequency and intensity may have likewise been influenced by human activity. Malthus and Ehrlich may have failed to take full account of human adaptability and ingenuity, but let us also not make the mistake of underestimating the scale of human's destructive impact.

But that's not all, increasing human population, especially in developing countries, means that human dwellings must encroach land and coastal environments that may be at risk from either natural or human-induced hazards. Examples of this tragedy are fresh in the minds of Filipinos, especially the residents of St. Bernard, Southern Leyte. People throughout the world that inhabit natural river floodplains and artificially propped up deltas (e.g., New Orleans) are at risk. The combination of increasing environmental stress and greater demand for basic necessities of food and drinking water also has led to human-induced disasters of food poisoning, drinking water contamination by chemicals and pathogens, and spread of

diseases. Increasing population and increasing environmental hazards are not that difficult to connect. Thus, humanity may have escaped the dire predictions of doomsayers past, but at what cost? Did we prove them wrong or did we just buy ourselves some time?

Human Carrying Capacity of the Earth: Myths and Realities

How many people can the Earth sustain indefinitely? Ecologists define "carrying capacity" as "the population of a given species that can be supported indefinitely in a defined habitat without permanently damaging the ecosystem upon which it is dependent". Clearly, this question is difficult enough to answer for individual habitats, given that the environmental impact of organisms on their surrounding depends not only on their number but also on the manner that the organisms interact with their environments. If we cannot comfortably do it for individual ecosystems, how can we do it for the whole Earth? But there are certain useful metrics for what the Earth can physically provide. For example, humans presently appropriate anywhere from 10 to 50 percent of the annual net primary production from terrestrial vegetation (Rojstaczer et al., *Science*, 2001), with Stanford biologist Peter Vitousek putting his best estimate at 38.8 percent. This number is staggering even for those who might insist the Earth's ability to provide is limitless. The fact we will likely see upwards of three billion additional humans on the planet by the middle of this century and the land, soil and water resources will continue to be strained to support additional production (e.g., surface soil losses, salt build up, water supply requirements of agriculture, chemical input to land and water) stoke lingering Malthusian concerns. Recent events in the continent of Africa may have political components to it (e.g., failure to bring aid to starving people), but the underlying problem of the biophysical limits of the land should not be underemphasized.

Taking a different approach, we could ask what amount of resources each individual on the planet need to go on with our business as usual. When put in terms of acreage of land needed to support an individual that follows a specific life style, we can then speak of his/her ecological footprint. The latter, it turned out, may be an easier estimate to make: the total useful land space on Earth and the total number of people means there are only between 1.5 to 2 hectares available per capita to draw sustenance from (~1.7 hectares is used as a benchmark); by this measure the U.S. lifestyle requiring ~10.3 ha/capita is clearly over consuming and the people of Bangladesh who require ~0.5 ha/capita is under consuming at the opposite end of the spectrum (http://www.ecouncil.ac.cr/rio/focus/report/english/footprint/). Note that the Philippines has an estimated ecological footprint of 1.5 ha/capita. Of course, these estimates carry a healthy dose of uncertainty, yet the overall picture is revealing. Affluent lifestyles need larger and larger acreage of land to sustain.

Hardin (Science, 1968) in *Tragedy of the Commons* pointed out that the only way to sustain our lifestyle is for population to stop growing. Human existence needs a finite resource in a

finite Earth. If another three billion people were to be added to the planet by the middle of this century, then the finite resource available for everyone must be reduced by about a third. If affluent nations sustain their lifestyles in the same scenario, then the world's poorest nations must proportionately accommodate even more reduced resources per capita. Human ingenuity may yet improve the Earth's ability to produce food, but even this is unlikely to sustain future population growth (Pimentel et al, AAAS, 1996). The last three decades have seen increased food production upwards of 20 percent, yet close to a billion people worldwide still go hungry each day. Furthermore, as human ingenuity and adaptability pushes the limits of food production and provision of other needs (e.g., energy, drinking water, clothing, habitation), then the finite environment must sustain the required additional stress. If affluent regions of the world can escape the perils of such environmental impact (e.g., through stricter enforcement of environmental regulations, waste trading), then the rest of the world will have to take on disproportionately greater risks from environmental degradation. Thus, Hardin (1968) correctly concludes, there is no technical solution to the problem of global sustainability. The answer must also include reforming human attitudes and behavior.

The Philippines Context

Within the Philippine context, the increasing population requires resources of food, water, jobs, dwelling and waste disposal. Whereas the lifestyle of Filipinos is sustainable by world standards (i.e., ecological footprint < 1.7 ha/capita), our immediate environment is degrading at a non-sustainable rate. This apparent paradox can be reconciled if we take two considerations into account: (1) agriculture, mining, forestry and other industries in the Philippines impose on the local environment yet a large part of its production supports lifestyles of people elsewhere, and (2) national ecological footprint estimates average the collective lifestyles of whole nations, yet a wide range of lifestyles and behavior exists within each country including the Philippines. With respect to the first point, it is demonstrable that the Philippines and many other poor countries are net importers of "environmental degradation". Such importation can be direct such as the disposal and "reprocessing" of developed countries' waste in willing (for the right price) developing countries. Indirect effects span the range of local environmental degradation to support other countries' appetite for food (e.g., marine produce and agriculture), leisure (e.g., exotic plant and animal trade) or raw materials (e.g., mining). With respect to the second point, disadvantaged regions and neighborhoods within the country likewise are importers of "environmental degradation" relative to their wealthier counterparts. Such disparity can come in the form of selective citing disposal sites, transportation depot, toxic-emitting factories, etc. in poorer neighborhoods, all captured in the phrase "environmental injustice". Rich and poor (both countries and people) indeed live in "different worlds". But even that has limits. The ability

of various Earth compartments' (e.g., atmosphere, surface and groundwater, ocean) to absorb pollution will eventually be approached, and it will be increasingly difficult even for the privileged to escape wholesale environmental impact.

In order to provide the basic needs of growing populations in the Philippines and abroad, more and more Filipinos, especially its poorest, will be exposed to greater and greater risks, both man-made and natural, in the future. What are these major risks?

- Too many people, too much garbage, and no plan. Solid municipal wastes are overwhelming existing non-sustainable disposal sites, and there is no agreed strategy for waste reduction, waste disposal and impact mitigation. Filipinos annually produce upwards of eight million tons of garbage nationwide, with unlined open waste dumps being the primary disposal option. The largest per-capita producers of municipal waste in the world are the Americans who produce upwards of 230 million metric tons of garbage every year (2003 figure). In contrast to the Philippine dilemma, the U.S. has a clear, if uncomfortable, strategy that includes 72 million tons removed from the waste stream by recycling, 0.1 million metric tons reduced by incineration, and the remainder disposed of using lined and regulated/monitored landfills. So, the good news is Filipinos produce only about 0.5 lbs to Americans 4.0 lbs of garbage per capita. The bad news is the Philippines does not have a workable waste reduction program, our open dumps expose the population to greater health risk and physical hazard, and the Philippine land area is a factor of 30 smaller than the U.S. The "economic analysis" of waste reduction and disposal cost should not end with the cost of the waste strategy alone, but must factor in the cost savings of reducing the long term beneficial impact on human health and quality of life for citizens and visitors to the country.
- Deteriorating air quality in Philippine urban centers from combustion of over 120 million equivalent barrels of oil each year (including coal use). This also results in the emission of green house gases approaching 20 million metric tons of carbon per year. The Metro Manila area has developed a reputation for possessing Asia's dirtiest air. A concerted strategy of efficient transport system, emission control, air quality monitoring and improvement and effective approaches to commuter reduction is key.
- Existing reduction or disposal strategy for rapidly accumulating industrial waste remains ineffective. The Philippines lacks the required infrastructure for the handling of toxic industrial waste spawned by over 20,000 hazardous (waste) generators. For comparison, Americans produce 7.6 billion tons of highly hazardous waste, but these are strictly regulated at the state and tribal levels. Likewise, there is now worldwide concerted effort to recycle large fractions of industrial wastes generated by specific waste producers. Programs such as Denmark's Kalunborg "eco-industrial park" allows for virtually complete recycling and resource sharing amongst an oil refinery,

pharmaceuticals, wall board producer, power company. For example, the power plant scrubs sulfur dioxide from their smoke stack and sells it to the wallboard company that needs it as raw material. Biotechnology (biodegradation, biobeneficiation, recycling biomass to paper, etc.) and the emerging application of designer nano-technology are key ingredients of the U.S. strategy. The Philippines is best served by strictly implementing existing hazardous waste regulations, improving ineffectual ones, and keeping abreast of more recent but implementable waste reduction and reduction strategies.

- Water contamination and water treatment problems resulting from inadequate facilities for the management and treatment of sludge generated by over 120,000 industries, mine wastes and tailing, agricultural contaminants, and residential septic systems. The infrastructure for the treatment of municipal sewage from 15 million households is woefully insufficient, groundwater supplies are vulnerable to leachates produced by the continued operation of open dumps, and inadequate availability of remediation technologies to rehabilitate contaminated surface (lakes and marine environments) and groundwater systems. Clear strategy for contaminant prevention and treatment are keys to getting a handle of this emerging problem.
- Water supply problems associated with increasing urban population with accompanying water demand pressure from industries and agriculture. Massive groundwater utilization are leading to drawdown effects including land subsidence and saline water intrusion.
- Expansion of land used for human work and habitation to areas prone to natural (e.g., flooding, land slide, lahar flows, volcanic eruption, and earth quakes) and anthropogenic hazards (e.g., water contamination, pathogens, and infectious diseases). The arithmetic is simple, a growing population will be forced to live and work in higher-risk terranes and locations. A government that opts not to seriously address the issue of a growing population is morally bound to protect this growing population from avoidable risks. Conversely, human habitation and economic activities are also enhancing the likelihood of environmental disasters. For example, deforestation and other human activities (e.g., housing development, mining) can dramatically impact flooding and land slide risks and groundwater extraction affects land subsidence and flooding risks.
- Finally, the same expansion of land used for human work and habitation to ecologically sensitive areas can lead to the destruction of tremendous biodiversity on tropical rain forests (<10 percent virgin forest), mangroves (<20 percent of original mangrove) and coral reefs (<5 percent in excellent condition) in the Philippines. Apart from the utilitarian reasons for preserving biodiversity, the protection of endangered species has moral, cultural and spiritual dimensions that must be considered.

Concluding Statements: Approaching a Balance

Whenever there is doom and confusion, there is indeed a great temptation to write a book or pontificate, as I am doing now. My hope is we can do a little bit better than just sound off and complain. Part of our task, if this gathering is to have meaning beyond just another good U.P. alumni symposium, is to confront issues honestly first and foremost, separate the "hype" from the "real threats", identify realistic approaches to mitigate those threats, and most importantly come to our own conclusion, as to what each of us in this room today is prepared to do individually or collectively. If today's gathering is to have real impact, it must be such that each of us will be moved to action. I am an academic, but I did not come here for intellectual amusement, either mine or yours. The organizers of this symposium did not put this event together to fill in your time, and I do not suppose any of you came here to do only that either. I urge each of you critically listen to the subsequent presentations, weigh the facts and opinions we have put before you and participate in the subsequent discussion so that you can resolve for yourself why it is or it isn't important that we change the way we live our daily lives.

The scientific and technologic community should continue to strive to better characterize emerging environmental and other hazard concerns and find appropriate mitigation measures once such concerns are identified. Whereas individual institutions and foundations will continue to conduct such studies on the basis of the priorities identified by each, the scale of threats and impact often warrants a longer term, larger scale and unified strategy. Outcomes of national or international concerted effort identifying the preeminent environmental problems facing the country/region should be paid attention to, and countries like the Philippines in particular must identify workable locally-viable responses. Past environmental policies and their implementation have been largely reactionary, with short-lived initiatives and "stop-gap" approaches being the norm. Yet it is clear that such an approach has not gotten us too far, with millions of Filipinos continuing to face unnecessary risks daily.

The cost and organization of a concerted environmental approach have often been a deterrent in its forward implementation. A cost-benefit analysis of implementing a national strategy for environmental and hazard mitigation is doable, and likely to show a net benefit not counting the number of human lives that will be spared. This utilitarian justification can be crystallized by putting cost of life, property, business losses, in the same currency as the cost of mitigation. The destruction of the environment has cost that can enter the basic spread sheet of normal economic analysis. But a purely utilitarian approach cannot be the sole basis for deciding our actions. Aldo Leopold, widely acknowledged as the father of wildlife ecology, pointed out that we have no qualms building an aesthetically pleasing house even though it is seldom "profitable" to do so. While we have long acknowledged that we are prepared to put value on the pleasantness, quality of life or safety of our individual

dwellings, we have thus far failed to extend the same to the rest of the space we live in. On the question of government bureaucracy, the traditional approach of "boxes and arrows" amongst balkanized government bureaucracies have not worked in the past. This is not surprising, given that existing bureaucracies are designed to address only parts of an otherwise intricately interlinked set of issues. Such multi-headed beasts must be taken by the horns, and it may be appropriate to elevate an environmental and natural disaster czar to take on a holistic leadership role (unless the President herself wants to take this on). Any approach, either new or patterned after successful approaches in other countries, must be aimed at formulating an integrated national strategy based on thorough risk identification and assessment, and implementing mitigation or relocation measures accordingly. Indeed, environmental considerations must become a regular part of the larger planning of governments, as it deals with economic strategies and eradication of poverty.

Environmental governance cannot be fully entrusted to governments alone. At the very least, a perception of "conflict of interest" is inevitable when a government bent on economic development and returns is entrusted with the responsibility of environmental protection. The imperative of the proactive approach advocated to above extends beyond government, scientists, engineers, urban planners, etc. into the larger society and each individual. All of us will be much better off with a more proactive approach to our individual actions and as well as the actions we goad our government into. Those amongst us who are very spiritual profess weekly that we will live our daily lives in a manner that will do the most good to ourselves and our neighbors, in the service of God. The church has indeed already recognized our spiritual responsibilities to that environment wherein we live. Some of us view this simply as a moral imperative that we owe our children and grandchildren who will inherit the Earth. All of us will be helped by clearly distinguishing those that are "*immediately gratifying*" to those that are "*eternally beneficial*" in our daily actions. Aldo Leopold said it best : "It is hard to make a man, by pressure of law or money, do a thing which does not spring naturally from his own personal sense of right and wrong."

Environmental governance must be a shared responsibility. A preeminent environmentalist, Prof. Edward Wilson, advocates a partnership format in the form of an "iron triangle" among governments, private sector and scientists. The private sector in this case includes non-government organizations, the business sector and society as a whole. I believe that representation from these groups of stakeholders, perhaps presided over by an environmental czar, could bring about real and constructive reform in environmental governance in the Philippines and worldwide. At its core, such an "iron triangle" must be formulated in a cooperative environment, with clear "governance rules" of its own and clear enforcement mechanisms (e.g., monitoring, sanctions, arbitration). Such an entity must have the capacity (e.g., financial resource, knowledge and infrastructure) to develop policies and act on those policies. Such partnership entity could be the negotiating venue for conflicting interests, guided

by credible data that is openly accessible. Finally, such an entity must engender on the citizenry a fuller understanding of environmental and related issues (e.g., health, economic) through education and outreach, so as to foster public confidence and participation.

Some would say that this discourse focused too much on what the environmental problems are, how we perceive and articulate them, and how we can begin to think of possible solutions. Perhaps I could have expended more effort examining the root causes of these environmental concerns – population and poverty, consumerism, technology and the present market system. Perhaps, that is true. But what I have put forward are things that must be understood and addressed, regardless of our collective ability or inability to affect the "driving forces" of environmental degradation. Ambitious as some of the suggestions may seem, I have no doubt that they are doable now. The great Mohandas Gandhi said it best: "The difference between what we do and what we are capable of doing would suffice to solve most of the world's problems."

References

Assyrian Tablet, c. 2800 BC. Quoted from L.B. Williams, *Encyclopedia of Wit, Humor and Wisdom,* 299, 1949.

Crichton, M. (2003). *Aliens Cause Global Warming.* http://www.crichton-official.com/speeches/speeches_quote04.html

Ehrlich , P.R. (1968). *The Population Bomb.* Ballantine Press, New York.

Ehrlich , P.R. and Ehrlich, A.H. (1990). *The Population Explosion,* Simon & Schuster, New York.

Gore, A. (2006). *An Inconvenient Truth,* Rodale, New York

Hardin, G. (1968). *The Tragedy of the Commons,* Science, v 162, 1243-1248.

Intergovernmental Panel on Climate Change (IPCC). (2001). Climate Change 2001: The Scientific Basis (http://www.grida.no/climate/ipcc_tar/wg1/index.htm) , UNEP-WMO.

Lomborg, B.. (2001). *The Skeptical Environmentalist: Measuring the Real State of the Worl.* Cambridge University Press, London.

Malthus, T.R.. (1798). *An Essay on the Principle of Population* (1798 1st edition, plus excerpts 1803 2nd edition), Introduction by Philip Appleman and other commentaries on Malthus edited by Appleman. Norton Critical Editions.

Pimentel, D., Huang, X., Cordova, A. and Pimentel, M. (1996). The Impact of Population Growth on Food Supplies and Environment. Presented at American Association for Advancement of Science, Annual Meeting, Baltimore, Maryland, 9 February 1996.

Rojstaczer et al. (2001). Human Appropriation of Photosynthesis Products. *Science* 21,Vol. 294. no. 5551, pp. 2549 - 2552

Stephen Jay Gould, S.J. (1997). The Golden Rule – A Proper Scale for Our Environmental Crisis, in Pojman, L. J. *Environmental Ethics: Readings in Theory and Application.* 2nd ed., Wadsworth Publishing Company, Belmont, CA.

Vitousek, P.M., Mooney, J., Lubchenco, J. M. Melillo. (1997). Human Domination of Earth's Ecosystems, Science 277, 494.