Neo-Malthusians and Cornucopians put to the test:

Global 2000 and The Resourceful Earth revisited

Jonathan Chenoweth,^{*} Center for Environmental Strategy, University of Surrey, Guildford, Surrey, GU2 7XH, UK.

Email: j.chenoweth@surrey.ac.uk

Eran Feitelson, Department of Geography, Hebrew University of Jerusalem, Mt. Scopus, Jerusalem, 91905, Israel.

Email: msfeitel@mscc.huji.ac.il

Abstract: There is an on-going debate between neo-Malthusians and Cornucopians about the state and trends of the world's environment. Two key contributions to this debate were *The Global 2000 Report to the President* and, *The Resourceful Earth*, both published at the beginning of the 1980s and looking forward to the year 2000. This paper compares the predictions and analysis of the two reports with the situation in the year 2000 to ascertain their accuracy. In terms of predicting the future, *The Resourceful Earth* relied heavily upon examining past trends as giving the best indication of the future; *Global 2000* gave somewhat less emphasis to past trends and also tried to analyze directly the factors that it saw as being likely to influence the future. Broadly speaking, *Global 2000* was overly pessimistic, while *The Resourceful Earth* was more accurate in predicting that with many basic parameters relating to human existence the trends of improvement of earlier years would continue. Neither report dealt adequately with questions relating to adaptive capacity and its impact on predictions of the future.

Key words: *Neo-Malthusian, cornucopian, environmental trends, development.*

^{*} Corresponding author

Introduction

There is an on-going debate about whether or not the human situation is improving or becoming more unstable as population growth and economic development continue in most areas of the world. A current example of this debate is the discussion that has been generated by Lomborg's *The Skeptical Environmentalist* [1]. In this book Lomborg examines, using the best available data, whether or not human existence on earth is becoming more or less precarious and whether or not quality of life and the environment, broadly speaking, are improving or deteriorating. Lomborg's book sparked a fierce debate in the literature about the validity of his findings. *Nature* [2], *Science* [3], and *Scientific American* [4] published critical or highly critical reviews, while *The Economist* [5] and *Le Scienze* [6] published in favor of Lomborg's work.

This debate, however, is just one round between two opposing world views, often labeled as the cornucopians and the neo-Malthusians [7].¹ The Cornucopian perspective holds that natural resources are not in short supply, as human ability to adapt is generally able to compensate for shortages that do appear in relation to particular resources.² The opposing Neo-Malthusian perspective holds that there are severe limits to growth and resource use which are further aggravated by pollution and subsequent resource degradation.³ Essentially it argues that, unchecked, population growth will exceed the earth's carrying capacity thereby leading to

¹ There are other approaches, such as those outlined by Dryzek [8]. Still the two that generate the most vehement debate are the cornucopians and the neo-Malthusians.

² Other names used to label the Cornucopian perspective include techno-fix and promethean.

³ The Neo-Malthusian's viewpoint is also referred to as the Cassandra perspective, a self labeled term.

disaster. Table 1 lists some of the major contributions to the Cornucopian / neo-Malthusian debate over the last 40 years.⁴

{table 1 about here}

As can be seen in Table 1, one of the crescendos of the debate occurred in the early 1980s. At this time two landmark studies were published: Julian Simon's *The Ultimate Resource*, and *The Global 2000 Report to the President*. Simon [8] when looking at long term trends stated that the situation of humanity is improving, thanks to human ingenuity and hence human capital is the ultimate resource. *Global 2000* was a study undertaken by US Federal agencies at the behest of President Carter to assess the likely problems humanity would face in the future, specifically the next 20 years. To this end an interactive multi-agency forecasting and deliberative process was initiated, that drew upon the skills of some of the US's top scientists. The final report suggested that humanity was likely to face serious hardships. In particular, it forecasted stresses relating to the interaction between population, resources and environment, with life for many people being more precarious as a result. The report was, however, meant to be a policy relevant document that would promote and guide governmental and public action rather than a purely objective scientific prediction of the year 2000. Due in part to its ideological outlook, its findings were subsequently rejected by the Regan administration.

In response to this report, Simon and Kahn [9] asked a number of distinguished scientists to assess the assumption and forecasts of *Global 2000*. Their critique entitled *The Resourceful Earth* came out in 1984 and argued that *Global 2000* was wrong in its forecasts. As with *Global 2000*, this critique also had its own policy-orientated agenda, thus the critique was also not a purely objective scientific prediction of 2000. This was one of the few times in the history of

⁴ Due to large number of publications relating to this debate, only some of the key contributions can be listed here due to space limitations.

this debate that a comprehensive forecast was undertaken and critically reviewed almost concurrently. As most of the debate has focused on the future only limited attention has been given to systematic appraisals of past forecasts. Yet systematic appraisals of past forecasts are critical though both in terms of assessing the validity of the arguments of both sides but also to provide an indication of how useful and accurate current predictions relating to the global environment and human well-being are likely to be.

The debate between the Cornucopians and neo-Malthusians has progressed over time, with the focus shifting from a debate largely about the adequacy of natural resources for meeting human needs to a focus on the ability of the biosphere to cope with growing human impacts. *Global 2000* captured the early stages of this shift by examining each of its resource predictions in terms of the likely effect on the environment, with this environmental analysis taking up almost half of the section on future predictions. Unfortunately, however, much of this environmental analysis largely repeated what was said in the earlier chapters of the report. The *Resourceful Earth*, being a multi-edited book, varied considerably in the focus of each chapter. As a whole, it was, as its name suggests, focused upon resource issues but it did deal with ecological and environmental consequences of increased resource use, and the chapters on long-run trends in environmental quality, and air and water quality both focused almost entirely upon environmental quality trends rather than resources adequacy.

This paper compares the predictions and analysis of *Global 2000* for the year 2000 with the present to ascertain how accurate was the report, and why. The criticisms of *Global 2000* given in *The Resourceful Earth* are then examined to ascertain their validity. Because of the length of the two reports together with their repetitiveness in places, only the key predictions and analysis are examined. As a result the presentations given in this paper are brief and cannot do justice to any issue in depth. The paper concludes with an examination of the two reports as a whole to deduce whether the relatively pessimistic conclusions of *Global 2000* compared to the more

optimistic conclusions of *The Resourceful Earth* presented a more accurate vision of what the year 2000 was actually like, and what implications this has for the cornucopian – neo-Malthusian debate twenty years on.

It should be noted from the start that there are serious methodological difficulties associated with long term forecasts, including problems relating to the data upon which the predictions are based, problems of scale, of aggregation, and of assumptions about the linearity of ecological and socio-economic processes. Being clear about the methodological difficulties of forecasts is important when making predictions, but to some scientists, any long term forecast, whatever its direction is rendered virtually useless by such difficulties. Nonetheless, forecasts continue to be made and their validity discussed.

In preparing this paper careful attention was paid to ensure that similar or compatible data sources were used for the year 2000 to those data used by *Global 2000* and *The Resourceful Earth*. Thus where possible, data from the same (or equivalent) US government agency or international organization was used for comparison, at times supplemented with data or information from the general scientific literature where appropriate. Despite, this, data definitions have varied over time and by source, particularly with resources such as forests. In such cases where compatibility is doubtful, it can be more appropriate to look how rates of exploitation or growth have changed compared to predictions in order to avoid being misled by absolute figures.

The Global 2000 Report to the President and The Resourceful Earth: An overview

Global 2000 largely based its trend projections that were used to form its conclusions on the long-term data and models developed by the US government federal agencies. Because the

models of the different federal agencies were not designed to be used in an interactive manner, interaction between the models was limited to developing projections sequentially. Population and Gross National Product (GNP) projections were used to estimate demand in the resource sectors, and all of these projections were then used to prepare the environment projections [10]. While this sequential process allowed limited interaction among the elements of the study, continuous interaction and feedbacks between the models employed was not possible. It was possible, however, for the different agencies involved to comment upon the results prepared from other agencies and this feedback to be incorporated back into the modeling process.

Global 2000 begins its major findings and conclusions chapter by stating that:

If present trends continue, the world in 2000 will be more crowded, more polluted, less stable ecologically, and more vulnerable to disruption than the world we live in now. Serious stresses involving population, resources, and environment are clearly visible ahead. Despite greater material output, the world's people will be poorer in many ways than they are today.

For hundreds of millions of the desperately poor, the outlook for food and other necessities of life will be no better. For many it will be worse. Barring revolutionary advances in technology, life for most people on earth will be more precarious in 2000 than it is now – unless the nations of the world act decisively to alter current trends.

[10] (p1 of Volume 1)

Global 2000 went on in subsequent paragraphs to outline in greater detail what global conditions would be like in the year 2000. Specifically, it said that there would be continuing

rapid population growth, slightly lower in percentage terms but greater in absolute numbers than in 1975 [10]. Economic growth would continue in most countries, but at the same time, in most less developed countries Gross National Product (GNP) per capita would remain very low. While food production was projected to increase on a per capita basis, most of that increase was predicted to go to countries with relatively high per capita consumption, while per capita consumption in many less developed regions of the world was expected to scarcely improve or even decline. Real food prices were expected to double. Global oil production was predicted to peak in the 1990s. While richer industrialized nations were expected to be able to cope with the associated energy price increases that were expected, many less developed nations were predicted to have increasing difficulties meeting their energy needs, and for the quarter of the human population dependent on wood for fuel, the outlook was seen as being bleak.

On a slightly more positive note, *Global 2000* suggested that non-fuel mineral resources were sufficient to meet demands through to the year 2000, although disproportionate use by industrialized countries would continue [10]. However, regional water shortages were expected to worsen, global deforestation would continue at an alarming rate, as would plant and animal extinctions and agricultural land degradation. Radioactive and other hazardous materials would present increasing health and safety problems in a growing number of countries.

Despite such serious problems, *Global 2000* did conclude that the situation was not hopeless since the study's projections were based on the assumption that relevant national policies and programs would remain essentially unchanged through to the year 2000, even though policies were already beginning to change [10]. Such changes, so far however, were not seen as being adequate, with the report saying that a period of unprecedented co-operation and commitment between nations was essential. Without prompt and vigorous changes in public policy around the world, *Global 2000* suggested that the world's problems would become unmanageable, with any delay likely to seriously reduce options for effective action.

In *The Resourceful Earth* no attempt was made to reach an agreed upon synthesis of all chapters. There is no formal conclusion or summary chapter of key findings. However, in the introduction a broad outline and summary is given. To highlight the difference between the two reports in the clearest possible terms, the first two paragraphs of *Global 2000*, as quoted above, were reworded in this introduction in the light of what was presented in the subsequent pages of *The Resourceful Earth*:

If present trends continue, the world in 2000 will be *less crowded* (though more populated), *less polluted, more stable ecologically*, and *less vulnerable to resource-supply disruption* than the world we live in now. Stresses involving population, resources, and environment *will be less in the future than now...* The world's people will be *richer* in most ways than they are today... The outlook for food and other necessities of life will be *better...* life for most of the people on earth will be *less precarious* economically than it is now.

[9] (p1-2: italics and shortenings in original)

Simon and Kahn [9] went on to state that the then present global trends in life expectancy, birth rates, food supply, deforestation, and availability of oil and mineral resources were generally improving rather than worsening, while problems relating to matters such as climate change, water scarcity and species loss were much less significant than was frequently suggested. They argued that although all was not necessarily well then nor would everything necessarily be well in the future, global trends which indicated that things were generally improving rather than deteriorating could be expected to continue in the future as humans, both individually and collectively, continued to address the problems they face.

Perhaps the most important point of divergence between the two works is in their assumptions regarding the endogeneity of policy responses. *Global 2000* qualifies its findings with an assumption that current policies will continue. In contrast, Simon and Kahn [30] argue that throughout history individuals and communities have always responded and adapted to changes in their environment and so basing predictions on past trends implies that this adaptation will continue and hence policies will be modified. In *The Resourceful Earth*, each of the major conclusions of *Global 2000* is challenged by showing either that the statement itself is meaningless because it is too vague or value laden, that there is no evidence to back up the claim, or that global trends clearly imply the opposite.

Did *Global 2000*'s projections materialize ?

As noted in the introduction to *The Resourceful Earth*, much of the language used in the introduction to *Global 2000* was vague at key points, making it difficult to evaluate in a quantifiable way [9]. To assess the accuracy of *Global 2000*, the projections specified within it that are most closely connected to the report's overall conclusions are compared in the following subsections with what the year 2000 (or which ever year prior to that was chosen as the target year for a prediction) was actually like. The results of this comparison allow an evaluation also of the critique provided by *The Resourceful Earth*. The years 1980 through to 2000 are referred to below as the study period.

Population projections:

In *Global 2000* high, medium and low population projections were given with the high and low projections "representing the highest and lowest population counts that may reasonably be expected to occur" and the medium representing "reasonable" projections [10]. World population was predicted to increase from around 4 billion in 1975 to 6.35 billion in 2000, an

increase of more than fifty percent.⁵ The high medium and low population projections for the world and a select range of countries are given in Table 2.

{ table 2 about here }

The total fertility rates estimated by the Bureau of Census for the year 2000 for its high, medium and low population projections were 3.9, 3.3, and 2.8 respectively [10]. The actual estimated total fertility rate in 2000 was 2.7 [11], thus slightly below the low estimate of fertility. Overall, world population reached 6.08 billion in 2000, which is near to the lower end of the range included in *Global 2000*'s projections and 4.5 percent below the medium projection. This may validate Perlman's [12] observation that such projections have rarely stood the test of time. Perlman goes on to argue in *The Resourceful Earth* that population projections in themselves are not very relevant to the main concerns of *Global 2000*, since the empirical evidence indicates no negative correlation between the rate of population growth and the standard of living, and thus no negative effect upon the state of natural resource availability. This contention can only be tested by looking at the other subjects dealt with in *Global 2000*.

Food and agricultural projections

Global 2000 included three scenarios in its projections for the food and agricultural situation of the world in 2000. Alternative 1 was the base line projection, while alternatives 2 and 3

⁵ Two sets of population projections were given in *Global 2000*, one set prepared by the US Bureau of the Census, the other by the US Community and Family Study Center. In the Major Findings and Conclusions chapter, only the set prepared by the Bureau of Census is referred to, indicating that this set is the primary population projection of the report. The population projections do not take into consideration international migration, with this factor likely to explain the relatively low projections of the US population in 2000 compared to reality.

represented the upper optimistic and lower pessimistic bounds of their projections in terms of population and income growth rates. While all the scenarios painted for developed countries were relatively optimistic, with more than adequate food supplies continuing, even in the optimistic projection for less developed countries in per capita food consumption suggested that gains were likely to be small and unevenly distributed. In the pessimistic projection per capita levels were not projected to grow at all [10].

The *Global 2000* report does not state clearly how food production was defined and thus it is difficult to ensure that any comparison with the present is entirely consistent. Nonetheless, the Food and Agriculture Organization (FAO) includes a food production index on its internet site that allows temporal comparisons within the database, thus ensuring some degree of consistency. A comparison between the basic projections given in *Global 2000* and the actual production is shown in Table 3.

{ table 3 about here }

Table 3 shows that the overall food production projections in *Global 2000* were relatively accurate, but at the same time, they were spectacularly incorrect for some individual countries or regions. Production in the former Soviet Union was less than half the projection, while that of China was more than twice the projection. Given the significant proportion of the human population which is concentrated in China, China's unexpectedly good performance is very significant to the world's overall food situation. The inability to accurately predict the food situation in these two countries perhaps highlights the importance of effective social systems and adaptive capacity relative to the basic natural resources endowment and population size.

Reality was considerably better than implied by overall food production. Not only was total food production slightly higher than predicted by *Global 2000* but given that population growth

was slower than predicted (that is, the medium projection which was considered the most likely) global per capita food production was much higher than expected.

Global 2000 also prepared two scenarios of daily per capita calorie consumption (tables 6-8, 6-9 and 13-17 of report). Scenario A assumed that the real price of energy would remain constant, low population growth, high income growth, and favorable weather would occur. Scenario B assumed that the real price of energy would increase, there would be high population growth, low income growth and less favorable weather.⁶ In Figure 1 a summary of these projections is compared to the average daily per capita calorie consumption in 1997-99 (the most recent year for which data are available). It shows that reality turned out to be significantly better than even the optimistic scenario predicted. While the average for less developed countries was 93 percent of the FAO recommended minimum calorie requirement in 1973-74, by 1997-99 this had risen to 117 percent. The optimistic scenario predicted by *Global 2000* only had this rising to 104 percent, while the pessimistic scenario only expected a one percent rise to 94 percent. By 1997-99 the only region with a daily calorie consumption below the recommended level was sub-Saharan Africa, at 94 percent of the daily recommended intake and even this region was ahead of the average for less developed countries in 1973-74.

{Figure 1 about here}

It is important to note when evaluating Figure 1 that achieving an average daily per capita consumption of 100 per cent of the FAO recommended level in a country will still mean that a large number of people in that country may be malnourished. Skewed caloric consumption means that average daily per capita consumption needs to be 110-125 percent of the minimum to ensure that all income classes are consuming above the minimum recommended level [10].

⁶ On page 85 of *Global 2000*, the authors expressed the view that energy prices were certain to increase.

Because of this, even *Global 2000*'s optimistic scenario, which predicted that the daily calorie consumption in less developed countries would rise to 104 percent of needs, suggested significant malnutrition would remain in the developing world. Conversely, caloric consumption does not continue to rise indefinitely as incomes rise. Once a certain level is reached consumption will plateau, as has occurred in the developed world.

The Resourceful Earth painted a more optimistic picture of the state of the world's food resources in the year 2000 than did *Global 2000*. In its chapter on world food and agriculture, Johnson [13] noted that there had been modest improvements in per capita food supplies in low income countries in the previous three decades and that real prices of major foods had been declining. An increasing rate of growth of per capita food production in developing countries was thought to be likely. International trade in grain had grown rapidly during the 1970s and a world food system had developed which had substantially reduced the risks of food shortages, famine, and hunger resulting from natural disasters, with most people in the world being expected to be able to participate in this system by the end of the century [13].

The analysis presented in *The Resourceful Earth* showed that despite considerable variability over the short term, real price trends of most major agricultural commodities had declined over the previous century due largely to rising productivity [13]. Johnson [13] was particularly critical of the conclusions put forward in *Global 2000* that there would be large increases in the real price of food by the year 2000 together with a substantial increase in the share of the world's resources committed to food production, arguing that the available evidence suggested that such conclusions were simply not possible. Data for the year 2000, shows that Johnson's [13] criticism was well founded. The World Bank commodity price index for food shows a peak in the mid-1970s followed by a steady and dramatic decline. When the 1990 global food price is equal to 100, then the price of food fell from 223 in 1975 to 193 in 1980, 126 in 1985, 98 in 1995, and 84 in 2000 [14]. However, global food prices are heavily affected by agricultural

subsidies, meaning that ascertaining whether the real cost of producing food is increasing or decreasing over time is very difficult, even if these figures do show a dramatic decline in prices and thus suggest falling costs.

In the environmental section of *Global 2000* there was discussion relating to impacts on the environment of increasing food production. It was argued that agricultural and grazing lands of parts of Africa, Asia, the Middle East and Latin America could not be expected to retain their then present productivity with another two decades of intensifying pressures, with population growth making major loss of biological life support capacity virtually inevitable [10]. *Global 2000* predicted that without major policy change, there would be a general worldwide deterioration of soils quality that would significantly interfere with achieving the production levels projected. There is no reliable worldwide estimate of the condition of soils thus it is not possible to assess *Global 2000*'s predictions directly. Rozanov et al [15], for example, estimate that the amount of lands whose soils have been severely damaged or rendered useless for agriculture exceeds the surface area that is currently cultivated. Their estimate, however, considers losses and degradation over the past 300 years and was made less than half way through the study period. Given the food production increases that were achieved during the study period together with the falling real price of food that has occurred over the same period, *Global 2000* was either unduly pessimistic about the environmental impacts of agriculture, or else those impacts were better managed and the effects of those impacts were less than expected.

Fishery projections

Global 2000 stated that naturally produced fish leveled off in the 1970s at about 70 million tonnes a year, 60 million tonnes from marine fisheries, and 10 million tonnes from freshwater fisheries, with no-further sustainable increase likely. In 1975, around 6 million tonnes of food

was produced by aquaculture each year according to *Global 2000*, with *Global 2000* indicating that there was significant scope for this to be expanded over the coming decades, citing the conclusion of a Food and Agriculture Organization (FAO) conference on aquaculture which stated that a 5-10 fold increase in production would be possible by the year 2000.

According to the FAO [16] approximately 86 million tonnes of fish were produced from marine fisheries, and around 9 million tonnes from fresh water fisheries in 2000. The total fisheries catch was around 95 million tonnes. Thirty-six million tonnes of food was also being produced by aquaculture in 2000. Based on this FAO data it would appear that *Global 2000* was unduly pessimistic with regards to the world's potential fisheries, although relatively accurate with regards to aquaculture.

In *The Resourceful Earth* it was stated that marine fisheries would probably grow over the coming twenty years and reach 100-120 million tonnes a year of conventional species around the turn of the century. Aquaculture was not thought likely to increase its contribution to the world food supply very much by the year 2000, with other options for increasing natural fisheries likely to be able to produce food at lower cost. Given that the marine fish catch was around 86 million tonnes in 2000 and aquaculture produced around 36 million tonnes of food, it would seem that *The Resourceful Earth* was unduly optimistic with regards to marine fisheries and unduly pessimistic with regards to aquaculture.

One of the problems with the data of fish production produced by the FAO, the source of the data used by *Global 2000* and *The Resourceful Earth*, and hence for present day comparisons, is that the FAO as an international organization must rely upon the data supplied to it by member countries, even when those data are of doubtful quality [17]. Watson and Pauly [17] note that global fish catches were widely expected to plateau in the 1990s at around 80 million tonnes and yet catches reported by the FAO continued to increase, largely driven by catch reports from

China. Comparison of expected fish catches that were produced by modeling world fisheries with reported fish catches revealed significant differences in areas along the Chinese coast, with the large absolute value of these catches strongly affecting the global total. Watson and Pauly [17] believe that the reason for the over-reporting by China of its fisheries output is a result of having the same state entities which monitor the economy also being responsible for increasing its output, whereas in most countries under-reporting tends to be more of a problem. By substituting more realistic estimates of the Chinese fishing catch into the FAO statistics, a declining rather than increasing trend in fisheries catches since 1988 is revealed. According to Botsford et al [18] nearly half of world's individual fish stocks are fully exploited and a further 22 percent are over exploited. Therefore, given that world fisheries are in slight decline at present and there is significant over exploitation of some fish stocks, it appears that *Global 2000* was nearer to reality than *The Resourceful Earth* in its analysis and predictions. Furthermore, global totals fail to consider the quality of fisheries and whether or not more desirable species are being over fished, with desirable species over time being replaced in catches by less desirable species.

Forestry and Biodiversity Projections

In *Global 2000* it was estimated that the global forest cover would shrink from one-fifth of the world's land area (2,655 million hectares) in 1978 to one-sixth of the land area in the year 2000. While checking this estimate is difficult due to variations in the definition of what constitutes a forest, this estimate was based upon the annual deforestation rate remaining constant at between 18 and 20 million hectares. *Global 2000* stated that land use for forests versus agriculture was approximately in equilibrium in the industrialized countries of the world, meaning that most of the net deforestation would take place in developing countries, much of it in tropical rainforests [10].

According to the FAO, the net global deforestation rate between 1990 and 2000 was only 9.4 million hectares [19]. The loss of natural forest in tropical areas was 15.2 million hectares and was compensated partly by the afforestation and the conversion of forests to plantations, as well as the natural expansion of forests, particularly in temperate areas. Furthermore, the FAO estimated that the total forest area of the world in 2000 was 3869 million hectares [19]. That this figure is much higher than the estimate given in *Global 2000* twenty-two years earlier is due to different definitions of what constitutes a forest; a less stringent definition which results in a much larger percentage of the world's land area being forested logically should suggest that all things being equal, statistically speaking a higher deforestation rate will be recorded simply because there is more forest area potentially available for deforestation. The FAO's data, therefore, suggests that current deforestation rates are significantly lower than those predicted in *Global 2000*. Global totals, however, say nothing about the biological health and diversity of the forested area.

In its discussion relating to deforestation, *Global 2000* commented on a number of problems arising from deforestation, including the acceleration of runoff and erosion, siltation, loss of ecological diversity, micro-climate changes, and permanent loss of genetic resources [10]. Between 437,000 and 1,875,000 species were predicted to be lost during the study period, depending upon the rate of deforestation and other factors, with this being as much as 20 percent of the three to ten million species thought to be present on Earth at that time [10].

The Resourceful Earth presented a more optimistic analysis of the world's forests than was presented in *Global 2000*. Sedjo and Clawson [20] argued that there was little to suggest that major regions of the world would be denuded of their forests in any reasonable time horizon, although in some regions excessive deforestation was occurring. They saw serious environmental damage from forest utilization as a local rather than global problem since there

was little danger of the wholesale destruction of the world's virgin tropical forests in the foreseeable future, with the risk of serious loss of genetic resources being exaggerated.

Estimating the actual loss of genetic resources over period of 1980 to 2000 is very difficult due to the level of uncertainty regarding number of species and their extinction rates. Habitat loss in some of the world's most biologically rich areas suggests that extinction rates must be high, and extinction rates have been made for a few intensively studies species groups such as mammals. However, extrapolating from one group, such as mammals relies upon these rates being representative of completely different taxa [21]. Hence with the paucity of reliable data few global estimates of species loss based upon methodologically sound research are available.

Estimates of both background (natural) extinction rates and current extinction rates remain highly uncertain [21]. Estimates also vary due to uncertainty about the total number of species present on Earth, together with uncertainty about the precise distribution of those species. Hughes et al [22] state that assuming that there are 14 million species globally and that two-thirds of all species exist in tropical forests, then between 14,000 and 40,000 species are being lost each year. While this estimate is comparable to the figures stated in *Global 2000*, in reality it suggests a much lower rate than that given in *Global 2000* because this current estimate depends upon a much greater estimate of the total number of species and hence the total percentage of species lost is much lower. Woodruff [23] estimates that at least 250,000 species went extinct in the twentieth century, an estimate that is between 13 and 57 percent of that given in *Global 2000* for just the last twenty years of the twentieth century. Given the high level of uncertainty about the total number of species present in the world and current rates of species loss, it is impossible to know with any certainty how accurate *Global 2000*'s estimate of loss of genetic diversity actually was, even if the estimates given above suggest that that of *Global 2000* was unduly high.

The Resourceful Earth noted in its discussion on species loss that estimates of previous or then current extinction rates, which were little more than guesses anyway, were very low (up to 100 species per year) and yet *Global 2000* suggested that this rate would suddenly increase to around 40,000 species per year [24]. Simon and Wildavsky [24] argued that such a sudden deviation from the past should not normally be taken except on very strong empirical evidence and yet this evidence was lacking.

Regardless of the exact rate of extinctions there is little doubt that the world is in the midst of a major extinction interval that is not sustainable since it is well above background extinction rates [21] although probably not unprecedented in the Earth's history [23]. On a different note, Nee and May [25] argue that even when 95 percent of species are lost, approximately 80 percent of evolutionary history is preserved, with the proportion of evolutionary history surviving being relatively insensitive to whether the saved species are chosen randomly or optimally. They note, however, that conservation concerns relate not just to the preservation of evolutionary history but also to other factors such as ecosystem functioning or the potential usefulness of lost species, hence this does not necessarily significantly diminish concern relating to species loss.

Water Projections

Global 2000 predicted a general deterioration of the global aquatic environment in its environmental projections chapter. *Global 2000*'s major projection for the state of the world's freshwater resources for 2000 was derived from a 1971 estimate of water supply per capita, whereby the water supply per capita was then re-estimated for 2000 based upon *Global 2000*'s population projections. In other words, the projection of the state of the water resources in 2000 was based upon a population per unit of resource index that did not take into account of the state of the resource nor the ability of countries to adapt to their water resource situation. *Global*

2000 predictions of the water situation in the year 2000 were thus no more than an extension of the report's population projections.

The Resourceful Earth, comments that such an estimate of water availability presented in *Global 2000* may have little relevance to the actual situation and may even promote action in unproductive directions [26]. *The Resourceful Earth* points out that things are much more complicated than a population per unit of resource type index suggests. The criticisms given in *The Resourceful Earth* have been supported by subsequent trends in the water indicator literature where alternative methodologies have been suggested. For example, the methodology of defining water resources adequacy in terms of the relative size of each country's water resource has been criticized by Raskin et al [27] because it does not reflect differences in patterns of use. A country's per capita water use is a reflection of its level of development, economic structure, climatic situation, and cultural practices. Any two countries with similar levels of per capita water resources may have significantly different levels of usage which could mean that one is suffering from water stress while the other is not.

Alternatives have been suggested for measuring the adequacy of water resources. Raskin et al [27] suggest an index for assessing the adequacy of a nation's water resources based upon the percentage of available water resources within a country which are being withdrawn for different uses. This better reflects the variety in water use patterns between countries than the methodology used in *Global 2000*, but it does not account for multiple in-stream usage. Feitelson and Chenoweth [28] propose an index which measures the adequacy of a nation's water resources using economic terms since this allows the internalization of both inter-generational and intra-generational issues in a defensible manner. The index they propose is based upon cost of supplying a sufficient volume (for domestic and industrial needs) of clean sustainable water and sanitation to all the people of a country at all times compared to the nation's gross national product. Feitelson and Chenoweth [28] suggest that affordability of

water supply is the real issue when assessing the adequacy of a nation's water resources, as additional clean water can be had in most cases, at a cost. However, this issue was not addressed in either *Global 2000* or *The Resourceful Earth*.

Energy

Energy projections for the coming twenty years were a major component of *Global 2000* as these projections influenced many other factors, such as food and non-fuel mineral prices.

Global 2000's most detailed energy projects were for the years 1985 and 1990. Table 4 compares the energy use projections given in *Global 2000* for the year 1990 with the energy use in that year. This table shows that oil use and total energy use were significantly lower than predicted, while coal and natural gas usage was higher, both in absolute terms and as a percentage of total energy use.

{Table 4 about here}

Global 2000 listed three different projections of US energy consumption for the year 2000, each calculated using different methodologies and with two of these projections listing multiple scenarios. Total US domestic energy consumption was predicted to be between 115.4 and 146.1 Zettajoules⁷ [10]. In reality, total US domestic consumption in 2000 was 104.2 Zettajoules⁸, or 25 percent of the total world energy consumption [29]. *Global 2000* predicted that total world

⁷ In original, 109.4 and 138.5 quadrillion Btu where one quadrillion Btu is equal to 0.476 million barrels of oil per day.

⁸ 98.8 quadrillion Btu

energy demand in 2000 would range between 557 and 663 Zettajoules⁹ [10]. In reality, the total world primary energy output in 1999 was 401 Zettajoules¹⁰ [30].

Global 2000 expressed a high degree of certainty that an increase in energy prices was to be expected. Therefore, a real price increase of five percent per annum was adopted as the basis of several calculations in *Global 2000*. However, between 1975-78, the period for which data were available when *Global 2000* was prepared, the price of oil averaged just below \$13 / barrel in current dollars, that is just below \$36 / barrel in constant 1999 US dollars [31]. The figure of \$13 / barrel (constant 1975 dollars) was adopted as the basis of calculations in *Global 2000*. While the price of oil rose very significantly but temporarily around 1980, it declined afterwards, averaging around \$18.50 (constant 1999 \$) in the second half of the 1990s. Clearly, energy prices actually declined in the 1990s, contrary to predictions, and the O.P.E.C. oil shocks had little lasting effect on prices.¹¹

In *The Resourceful Earth* the discussion focused on the way global energy markets operate, and the effects of prices. It was noted, for example, that it is impossible for the world to “run out of oil” as demand outstrips supply since the consumption of oil must always equal supply, with the balance being achieved by prices [32]. Singer [32] argued that the oil price rises around 1980 would lead to a decline in oil consumption in the OECD if all economic replacements to oil

⁹ 528 and 628 quadrillion Btu

¹⁰ 380 quadrillion Btu

¹¹ Oil consuming countries diversified supplied away from O.P.E.C. countries following the oil shock of 1980 thus reducing the influence of O.P.E.C. on prices through developing alternative supplies. According to the [29] the location of the world’s proven crude oil reserves is far more concentrated than current production, with non-OPEC oil reserves being depleted far more rapidly than those of the OPEC countries, thus implying in the long term that OPEC will increase its domination of oil production contrary to the trends of the last twenty years.

were put into effect. While oil consumption did rise during the study period, it rose much more slowly than previous trends indicated it would, thus suggesting that the oil price rises of 1973 and 1980 did indeed hinder the growth in oil consumption.

Atmospheric problems

Atmospheric problems such as global warming or the depletion of the ozone layer were not the issues of global prominence at the time *Global 2000* or *The Resourceful Earth* were written that they later on went on to become. As with many environmental issues, the agenda has changed over time as new problems are identified and then research is conducted to investigate that nature of these problems and their seriousness. Simultaneously, other once prominent issues will fade from the agenda as solutions are found and implemented or the problem was found to be less serious than initially suspected. In the late 1970s and early 1980s knowledge about global warming or depletion of the ozone layer was very limited compared to today. For example, *Global 2000* contained three climatological scenarios, namely no change, global warming, and global cooling, each of which was considered to be of equal probability [10]. *Global 2000* did not predict, however, that any substantial climate change would occur before the year 2000 [10].

In relation to the possibility of global warming, *Global 2000* noted the increasing level of carbon dioxide in the atmosphere and its long term potential to cause significant global warming, stating that a doubling of atmospheric carbon dioxide would have very serious consequences, with some scientists predicting that such a doubling was likely to occur during the first half of the twenty-first century. *Global 2000* suggested that it might have been warranted when considering future energy policies to take into consideration the carbon-dioxide balance of the atmosphere. Because of the vagueness of the *Global 2000*'s predictions in relation to global climate change, it is not possible to assess their accuracy other than to note

that *Global 2000* did note the potential significance of the build up of carbon dioxide in the atmosphere.

The Resourceful Earth in its discussion of global climatic trends highlighted the fact that global climate has shown significant inter-annual and inter-decadinal variation well before there was any human induced build increase in atmospheric carbon dioxide concentrations [33].

Landsberg [33] also noted the large variation and uncertainty relating to climate predictions of global warming due to increasing carbon dioxide concentrations in the atmosphere together with the long time scales involved, with both of these factors reducing the likelihood of policy action. Like *Global 2000*, *The Resourceful Earth* did not predict any significant climate change prior to the year 2000, and expected climate to stay within the range of previously observed values and events.

The sections of *Global 2000* and *The Resourceful Earth* on climate change appear to be, broadly speaking, sound given the knowledge available at the time they were written although neither predicted the warming trend that occurred during the study period. From the mid-1940s until the mid 1970s the earth went through a period of mild cooling, but since 1976 (and the period from 1910 to 1945) there has been a global temperature increase of 0.15° C per decade and since the late nineteenth century the global average surface temperature has increased 0.6° C [34]. Nineteen-ninety-eight was the warmest year in the instrumental record since 1861.

Global 2000 also remarked upon the depletion of the ozone layer, noting that there are a number of anthropocentric causes of ozone depletion, even if the relative magnitude of the different anthropocentric causes was uncertain at the time [10]. While the date at which significant ozone depletion could take was unknown, it was thought that at the 1974 rate of the use of chlorofluoromethanes, global ozone would be reduced by 14 percent over fifty years [10].

The Resourceful Earth said relatively little about the depletion of the ozone layer. Landsberg [33] stated that with the stratospheric ozone reduction expected no appreciable alteration of climate at the earth's surface was expected while assessing the medical problems due to increased risk of skin cancer went beyond the scope of his study.

According to the United Nations Environment Program [35], current ozone losses are at six percent in northern mid-latitudes in winter and spring, and five percent in southern mid-latitudes all year around. Ozone losses are 50 percent in the Antarctic spring, and 15 percent in the Arctic spring. Due to the implementation of the Montreal Protocol there has been a marked decrease in the consumption of ozone depleting substances and recovery in the ozone layer is expected to begin shortly [35]. While *Global 2000* ozone depletion predictions for mid-latitudes appear reasonable with hindsight, the depletion seen over Antarctica and the Arctic was unexpected.

Both climate change and ozone depletion were seen as problems relating to the global commons, thus making them both important but difficult problems to solve. While it appears that the problem of ozone layer depletion has been reasonably successfully dealt with (on a long term basis at least) during the study period, the build up of carbon dioxide gas in the atmosphere has yet to be adequately addressed even though *Global 2000* described them both as atmospheric problems of great consequence over the long term. Other atmospheric problems, such as the emission of sulfur and nitrogen oxides leading to acid rain, were mentioned in *Global 2000* but were seen primarily as regional rather than global atmospheric problems [10].

Discussion and Conclusions

In the late 1970s *Global 2000* projected a very worrisome picture of the world in the year 2000, suggesting that the world's problems could become unmanageable by then if prompt action was not immediately taken. Conversely, *The Resourceful Earth* argued that global conditions were generally slowly improving as human ingenuity and technological development allowed society to deal with the problems that it faced. The positive global trends of recent history, *The Resourceful Earth* argued, were likely to continue through to the year 2000. To some extent, different politics and values were the major driving force of the original *Global 2000* – *The Resourceful Earth* debate.

It is impossible to measure the precise impact of *Global 2000* on policy making over the period from 1980 to 2000 as it is impossible to check what the situation would now be like if it had never been published. Focusing policy and decision makers' attention, as well as that of the general public, on major issues of concern by presenting alarming scenarios for the future may have played some role in leading to the policy changes that then prevented these alarming scenarios from actually being realized. Thus, the projections may well have been doomed to be inaccurate by their very existence. However, it is difficult to believe that *Global 2000* or *The Resourceful Earth*, either separately or together, could have had a major impact on the many of problems described. This is due to the fact that they were global problems whose management depended upon the actions of thousand, millions or in some cases billions of people worldwide. For example, it would be difficult to argue that global food production increased as dramatically as it did simply because *Global 2000* focused the attention of certain policy makers on this issue twenty years ago. Furthermore, the Carter administration in the US was replaced by the Regan administration soon after *Global 2000* was released, with the new administration largely rejecting the reports findings and the policy intentions behind the report.

Now that the year 2000 has come to pass, it appears that *The Resourceful Earth* was closer to reality than *Global 2000* in most, but not all fields, even if the level of improvement in some areas was less than it predicted. Globally in terms of basic indicators of human well being, things generally got better rather than worse between 1980 and 2000 as global trends generally continued as *The Resourceful Earth* predicted they would. Specifically, in the case of fisheries, however, *Global 2000* was more accurate. At the same time many environmental problems have been less severe than predicted in *Global 2000*, as was also expected by *The Resourceful Earth*. On a more negative note, some major problems with long term implications that were highlighted by *Global 2000* but were played down in importance in *The Resourceful Earth*, such as the loss of genetic resources, continue to be of major concern even if they are unfolding more slowly than predicted by *Global 2000*. However, humanity has proved remarkably adept at achieving the seemingly impossible, such as the near doubling of global food production within a 30 year period so that, on average, six billion people are now being better fed than were four billion 25 years earlier, even if this achievement has come at significant environmental cost in some areas.

In some cases the indices used in *Global 2000* and *The Resourceful Earth* were inappropriate, as with the water indices, while in other cases, such as in relation to atmospheric problems, the emphasis in the discourse has now shifted. In terms of predicting the future, *The Resourceful Earth* relied heavily upon examining past trends as giving the best indication of the future. *Global 2000* gave somewhat less emphasis to past trends and also tried to analyze directly the factors that it saw as being likely to influence the future. An example of this is the analysis of non-fuel minerals. *Global 2000*, while noting that the real price of most mineral commodities had been constant or declining for many years argued that, despite such trends, in the coming two decades real prices were likely to rise due to increasing energy costs, declining ore grades, and increased requirements for environmental protection [10]. As predicted by *The Resourceful Earth*, however, mineral price declines continued. (See Table 5.) The effectiveness of reliance

on past trends for providing the best indication of the future, together with the fact that the key indicators of human welfare show that globally things are improving lends support to the Cornucopian rather than neo-Malthusian perspective in the on-going debate about the state of the world and its direction.

{Table 5 about here}

It should be noted that the conclusion that as a whole *The Resourceful Earth* was more accurate than *Global 2000* is based only upon the data available relating to the global situation in the year 2000. *Global 2000*'s predictions may (or may not) still come about in the future but both *Global 2000* and *The Resourceful Earth* were specifically focused upon the year 2000 and thus it is in relation to that year which they must be judged. It should also be noted that the conclusion that as a whole *The Resourceful Earth* was the more accurate of the two reports requires certain value judgments. For example, when concluding that as a whole *The Resourceful Earth* was more accurate, the overall improvements predicted by *The Resourceful Earth* in relation to global food resources must be weighed against *Global 2000*'s prediction that global fisheries as a whole were already fully exploited. Thus other conclusions based on different value judgments are not necessarily excluded.

While past global trends may be able to give some assurance for the future, they also have significant limitations. Synergetic effects can mean that a small change in one area can have a big effect in other areas, and individual regions can differ significantly from global projections and be much higher or lower. In many cases this can be the result of geo-political upheavals that are by their nature very difficult to forecast. Neither *Global 2000* nor *The Resourceful Earth*

predicted the decline that has been experienced in the former USSR¹², nor that the trend of increasing life expectancy would be reversed in sub-Saharan Africa due to the unforeseen effects of AIDS. Similarly, threshold effects bringing sudden and severe changes could prove significant in relation to certain environmental problems, such as climate change, meaning that the analysis of past trends may provide a very poor indication of the future in some cases. Furthermore, sudden changes due to threshold effects, or unpredictable events with acute impacts could severely limit humanity's ability to adapt by their very suddenness. Nonetheless, when the predictions of *Global 2000* and *The Resourceful Earth* are compared to reality, it suggests that perhaps it is possible to be cautiously optimistic for the future. Just as *The Resourceful Earth* argued that there was no reason to believe that the positive trends of the previous few decades were likely to suddenly reverse in most cases, as was argued in *Global 2000*, perhaps the same can be said now. That is not to say, however, that humanity is not facing formidable challenges now and into the foreseeable future that will very likely stretch humanity to its limits of ingenuity in order to deal with them, but rather, that past evidence suggests that in most cases humanity will manage to deal adequately with the more pressing of these problems.¹³ As such, this review of a major predictive neo-Malthusians report and the associated Cornucopian report together with the actual data for the period in question suggests that Cornucopian report has better stood the test of time.

Cornucopian and neo-Malthusian perspectives are two polar views on the state of the global environment. The main difference between these two perspectives lies in their attitude towards

¹² In the case of the former USSR this decline can be attributed to economic and social breakdown, and thus paradoxically may support Simon's [8] view that human ingenuity (and the ability of society to tap that ingenuity) rather than absolute numbers is what is most important.

¹³ Major unresolved issues that require urgent attention include global warming, the provision of clean potable water and sanitation services, developing sustainable fisheries, and the preservation of biodiversity.

adaptive capacity although adaptive capacity is exogenous to them both. Adaptive capacity, as defined by Ohlsson [36] consists of a structural component that includes both institutional and intellectual capital for the generation of alternative solutions by technocratic elites, and a social component that consists of the willingness and ability of society to accept such solutions as being both reasonable and legitimate. Both components may be found amongst local populations although this is sometimes overlooked when making predictions about the future.

Neither *Global 2000* nor *The Resourceful Earth* dealt adequately with the question of adaptive capacity and the use of natural resources and the environment. The predictions of *Global 2000*, for example, were based upon the assumption that there would be no significant change in national policies regarding natural resources management and the environment over the study period [10], and many of the predictions in the report indicate that no allowance was made for the ability of individuals or nations to react to changing prices or technological developments by adapting production techniques or consumption patterns. Conversely, in *The Resourceful Earth* Simon and Kahn [9] argued that human adaptation to changes in the supply of natural resources was incorporated into the long run trends of supply and cost themselves and thus extrapolating these trends in the future assumed that such adaptation would continue. Empirically it can be seen that there is great variation in adaptive capacity between countries and regions, and over time. Thus, the real question for the forward-looking environmental discourse may not be the cornucopian – neo-Malthusian debate in terms of resource use or the extent of human impacts on the environment, but rather, assessing how global human society adapts to environmental (and other) challenges together with understanding what adaptation mechanisms are adopted and why.

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Tables and Figures:

Table 1: Major contributions to the Cornucopian / neo-Malthusian debate over the last 40 years

Author(s)	Book / Report title	Year	Perspective
H.J. Barnett C. Morse	<i>Scarcity and Growth: The Economics of Natural Resource Availability</i>	1963	Cornucopian
D.H. Meadows D.L. Meadows J. Randers W.W. Behrens	<i>The Limits to Growth: A report for the Club of Rome's Project on the Predicament of Mankind</i>	1972	Neo-Malthusian
W. Beckerman	<i>In Defense of Economic Growth</i>	1974	Cornucopian
G.O. Barney	<i>The Global 2000 Report to the President: Entering the Twenty-first Century</i>	1980	Neo-Malthusian
J.L. Simon	<i>The Ultimate Resource</i>	1981	Cornucopian
J.L. Simon H Kahn (eds)	<i>The Resourceful Earth</i>	1984	Cornucopian
L.R. Brown	<i>State of the World</i>	Annually since 1984	Neo-Malthusian
P.R. Ehrlich J.P. Holdren (eds)	<i>The Cassandra Conference: Resources and the Human Predicament</i>	1988	Neo-Malthusian
L.R. Brown C. Flavin S. Postel	<i>Saving the Planet</i>	1991	Neo-Malthusian
DH Meadows DL Meadows J Randers	<i>Beyond the limits: Global collapse or a sustainable future</i>	1992	Neo-Malthusian
R. Bailey (ed)	<i>The True State of the Planet</i>	1995	Cornucopian
J.L. Simon	<i>The State of Humanity</i>	1995	Cornucopian

Table 2: The high, medium and low population projects given in *Global 2000* compared with the actual population levels in the year 2000. Source [10] p20-22; Actual figures for 2000 from [11]

Country / Region	Low population projection : 2000 (in millions)	Percentage difference of projection to actual population	Medium population projection: 2000 (in millions)	Percentage difference of projection to actual population	High population projection: 2000 (in millions)	Percentage difference of projection to actual population	Actual estimated population in 2000 (in millions) ¹⁴
World	5921.75	-2.58	6351.07	4.48	6797.50	11.83	6078.68
<i>China</i>	1175.76	-6.87	1328.65	5.24	1467.86	16.27	1262.47
<i>India</i>	974.28	-2.83	1020.92	1.82	1141.90	13.88	1002.70
<i>Philippines</i>	66.79	-16.25	73.23	-8.17	79.77	0.04	79.74
<i>Thailand</i>	69.38	11.28	75.24	20.67	80.81	29.60	62.35
<i>Egypt</i>	58.80	-16.58	65.38	-7.25	70.53	0.06	70.49
<i>Nigeria</i>	128.75	4.04	134.68	8.83	136.93	10.65	123.75
<i>Brazil</i>	213.84	21.81	225.90	28.68	241.44	37.53	175.55
<i>Mexico</i>	110.60	10.21	131.32	30.86	142.02	41.53	100.35
<i>USA</i>	234.33	-17.00	248.37	-12.03	270.17	-4.31	282.33
<i>Japan</i>	128.89	1.75	132.95	4.96	135.31	6.82	126.67
<i>South Korea</i>	53.55	13.31	56.98	20.57	61.54	30.20	47.26

¹⁴ From [11].

Table 3: Total food production as projected by Global 2000 for the year 2000, versus actual global food production in 2000. Sources: [10] (p80-81); [37].

Country / Region	Total projected food production in 2000 (1969-1971=100) ¹⁵	Total actual food production in 2000 (1970=100)	Percentage difference of actual food production from projected
World	192.5	199.2	3.48
Western Europe	124.1	138.8594	11.89
USSR / former USSR	172.7	79.10448	-54.20
South Asia	219.3	232.5581	6.05
Latin America	282	240.3846	-14.76
Sub-Saharan Africa	201	191.8639	-4.55
China	169	405.7737	140.10
Japan	128.3	109.3713	-14.75
USA	181.4	177.7461	-2.01

¹⁵ Data are taken from the Grain and Total Food Production, Consumption and Trade, Actual and Projected (Alternative I) table on pages 80-81 in *Global 2000*. They are the medium projection of the report. Where a range of data are given for the projection, the average is taken.

Table 4: A comparison of the world energy consumption predicted by *Global 2000* for 1990 compared to actual consumption in 1990. Source: [10]; [30]. Note: 1 Zettajoule = 1×10^{18} Joules or 1.055 quadrillion Btu.

	1975		1990 Predicted		1990 Actual	
	Zettajoules	Percent of total	Zettajoules	Percent of total	Zettajoules	Percent of total
Oil	119	46	189	47	142	39
Coal	72	28	81	20	95	26
Natural gas	49	19	70	17	79	22
Nuclear and Hydro	20	8	65	16	44	12
Total	260	100	405	100	364	100

Table 5: The price of a range of minerals in 1976, in both 1976 US \$ and 1998 US \$, compared to the price of the same minerals in 1998, in 1998 US \$. Source: [38].

Mineral Commodity	1976 Price (1976 US \$ per metric ton)	1976 Price (1998 US \$ per metric ton)	1998 Price (1998 US \$ per metric ton)
Aluminum	910	2600	1400
Chromium ore	435	1245	817
Copper, refined	1530	4393	1734
Lead	509	1458	992
Silver	139900	400500	164000
Steel	313.3	897.3	625.2
Tin	8370	23980	8230
Zinc	816	2337	1130

Figure 1: Daily per capita calorie consumption in 1973-73, projected for 2000 by Global 2000 (Scenarios 1 and 2), and actual level in 1997-99 compared to FAO recommended minimum requirement. Source: [10] p275; [39]