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Environmental Impacts, Human Population Size, and Related Ecological Issues

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Nature is commanded by obeying her – Francis Bacon

Abstract

Despite the fact that ecosystems underwrite human existence, we are now changing and degrading them at local and global scales; neither Earth nor Australia is ecologically sustainable. This situation is largely caused by the rapid economic and population growth of the last century. Despite this there are universal pressures for more economic growth and, in Australia, calls for faster population growth from business leaders but not from scientists. Such outcomes will intensify pressures on biodiversity and ecosystems. This paper discusses some key ecological issues and their nexus with environmental impacts and human population size. If the societal goal of sustained wellbeing for all people is to be attained, primacy in policy setting and management must shift to the ecological sphere and, ultimately, fewer and/or smaller human ecological footprints will be required. Failure to achieve these paradigm shifts will further degrade life-support systems and increase the likelihood of a future collapse in human numbers.

Alan Jones, Environmental Impacts, Human Population Size, and Related Ecological Issues

Introduction

What might be the pre-eminent goals for humanity? Surely the survival of our species and the permanently sustained wellbeing for all people would qualify. When considering strategies for achieving such goals, it is crucial to understand that ecosystems provide the goods and services that underwrite human survival and wellbeing. Unfortunately, this fact has had little influence on the management of our affairs. As made clear by the World Resources Institute (2000), we are now degrading our environment at global scales via atmospheric changes, deforestation, species extinctions, soil erosion and salinisation, eutrophication of waterways, depletion of groundwater, desertification, bioinvasions and coral reef decline. Human effects are felt by every ecosystem on earth. The sheer magnitude of change leads to the 'inescapable conclusion that human activities have begun to threaten the ability of Earth to support even current human life-styles and populations.' (Risser *et al.* 1991). Indeed, halting this environmental decline may be the greatest challenge humanity has ever faced (World Resources Institute 2000).

While the immediate causes of these environmental impacts are well known (e.g., burning fossil fuels, clearing vegetation, pollution), there is debate over the relative importance of the underlying causes. These are summarised in the equation $I = PLOT$ where I = environmental impact, P = population size, L = lifestyle (consumption), O = social organisation and T = technology (CSIRO 1994). This equation can be simplified into $I = \text{per capita impact} \times P$. The significance of P is that it is a multiplier; more people necessarily cause greater environmental impact if the L , O and T factors remain constant.

The global threat posed by population increases was recognised by the 1994 United Nations meeting in Cairo and by the UN Secretary General, Kofi Annan, who said in 1999 that nothing could be more important than helping the world's people control their numbers. United Nations programmes are helping to slow growth in the global population which may peak at about nine billion, 50% greater than now. In Australia, however, there is a strong pro-growth lobby (the boosters) who claim that environmental degradation is not caused by population but by other factors. For example, Bone (2000:18) asserted that 'it is not the size of the population, but what that population does, that matters.' Of course both factors matter because of the multiplicative relationship described above.

Further, it is asserted that most Australian environmental damage was done in the first century of European settlement when the population was much smaller (Nieuwenhuysen 1999). Hence, inappropriate technology was to blame rather than numbers. However, this assertion is false concerning the key issues of vegetation clearance, land degradation and water diversion, all of which are far larger now than before 1900 (SoEAC 1996).

The boosters are primarily business people, politicians and journalists (e.g., contributors to the 'Australia Unlimited' conference, Melbourne 1998) who assert, with little evidence, that more people are needed for economic growth and national

security. They are technological optimists who believe that emerging problems can be rectified by human ingenuity. They do not dwell on our dependence on nature or on the growing deluge of negative environmental findings (World Resources Institute 2000, SoEAC 1996). On the other hand, natural scientists are strongly opposed to population growth (Risser *et al.* 1991, Atiyah and Press 1992, Australian Academy of Sciences 1995). Recently, 763 scientists from 27 countries signed a letter of concern about 'population growth and related environmental degradation.' (<http://climate.konza.ksu.edu/~popres>).

Scientists are alarmed because of the documented evidence of degradation and unsustainability. They understand that, at base, these are ecological issues and acknowledge the links to population size. They also know that 'human demands on ecosystems have never been higher, and yet these demands are likely to increase dramatically, especially in developing countries, as rising populations mean more and more people seeking better lives.' (World Resources Institute 2000).

In addressing the goals of wellbeing and sustainability, it is central to establish a) the sort of environment we desire and how to achieve it (Stocker and Eckersley 1994, Cocks 1996, Wackernagel and Rees 1996), b) the amount of ecological capital we need for survival (Pimental *et al.* 1994) and c) the structure and function of ecosystems and their responses to human intervention (Lubchenko *et al.* 1991).

The first question is largely values based. It was addressed in 1992, by the Council of Australian Governments who laid down the essential goals and principles of ecologically sustainable development (ESD). The other questions are science based but answers are slow in coming, largely because of the sheer complexity of ecosystems (Dovers *et al.* 1996). It thus becomes a prime challenge for the 21st century to understand the vulnerability and resilience of ecosystems and to apply that knowledge in the joint interests of humans and ecosystems.

This paper sketches an overview of the state of the environment and the causative pressures, outlines some related ecological issues, and discusses the nexus between these and human population size.

Environmental State and Pressures

Every year, globally, approximately 26 billion tonnes of topsoil are lost, 17 million hectares of forest are cleared, deserts expand by six million hectares (Wackernagel and Rees 1996) and probably >10,000 species become extinct (May *et al.* 1995). Many more species have suffered large population declines. Freshwaters and forests are particularly vulnerable with one fifth of all freshwater species being extinct or endangered and one tenth of tree species at risk of extinction and (World Resources Institute 2000).

During the last century, half the world's wetlands were lost, nearly 40,000 large dams were built affecting 60% of the largest rivers, and the quality and quantity of available surface water and ground water are falling (World Resources Institute 2000). Two-thirds of the world's agricultural lands suffer soil degradation (40% seriously) and

70% of the world's major fisheries are fully fished or overfished (World Resources Institute 2000). As well, the greenhouse effect has been enhanced, ozone depleted and ecological complexity decreased with numerous ecosystems suffering worsening degradation (World Resources Institute 2000).

Nor is Australia free of similar trends (SoEAC 1996). Indeed, concerning the loss of biodiversity, clearing of vegetation, and degradation of productive lands and waterways, we are the worst performer of all developed countries (Krockenberger 2000).

In short, the fundamentals of life support are being eroded both globally and nationally. Humans are living on ecological capital rather than interest, a process inherently unsustainable.

Causing these ecological changes is the unprecedented 20th century growth in human economies and populations. Since 1900, the gross world product has multiplied by 20 and fossil fuel consumption by 12 (both 1987 estimates) and, between 1860 and 1985, energy throughput grew by a factor of 60 (Meadows *et al.* 1992). Between 1975 and 1990, pesticide sales rose 10 times, the United States spent US\$100 billion on wastewater treatment facilities and, every year, one billion tonnes of hazardous wastes are produced (Meadows *et al.* 1992).

Growth in the human population has also been spectacular. It increased from two billion in 1927 to six billion in 2000 and is currently growing by about 78 million people per year. Humans consume, divert or waste 40% of terrestrial net primary production (Vitousek *et al.* 1986) and appropriate 54% of accessible freshwater runoff (Postel *et al.* 1996). Productive land per capita has fallen from >5 hectares in 1900 to <1.5 hectares in 1995 and the total human ecological footprint (demand for resources) exceeds natural income by a factor of 1.3 (Wackernagel and Rees 1996).

These great economic and demographic changes have consequences for our life-support systems and sustained wellbeing that can scarcely be overstated. Indeed, 'the lavish partying by the wealthy today means a hefty bill for everyone tomorrow' (Wackernagel and Rees 1996:90). Unfortunately, human economic accounting methods have heavily discounted ecological goods and services. Their annual value has been estimated at an amazing US\$33 trillion globally (Costanza *et al.* 1997) - nearly twice the gross world product - and A\$1327 billion for Australia (Jones and Pittock 1997) - about x4 GNP. While these estimates may be crude, they highlight the economic and opportunity costs associated with large-scale ecosystem degradation.

Ecological Issues

1. Laws of Thermodynamics

Fundamental to living systems is the transformation of energy whose accounting is governed by the first and second laws of thermodynamics. The first law asserts that energy can neither be created nor destroyed although its form, distribution and availability may change. Its availability in high-grade form (e.g., food, fuel) has particular relevance for both natural and human systems because as high-grade energy

is used to do work, it becomes less concentrated and is dispersed as heat loss and is thus less available. This is the essence of the second law, which states that all processes are accompanied by an increase in entropy (= disorder, a measure of unavailability of energy).

How then do ecosystems generate and maintain their order and complexity if entropy is always increasing? In fact, the laws apply to closed systems (e.g., the universe) but ecosystems are open because of the free flow of energy they receive from the sun. This energy enables plants to photosynthesise complex, energy-rich molecules from simpler components. This process reduces entropy locally in open ecosystems but increases overall entropy in the closed universe.

These laws explain why a) organisms need continuous energy to maintain their order and complexity, b) plants are essential for ecosystem complexity and maintenance, c) the use of high-grade energy by humans causes warming, d) large carnivores, being high on the food chain, have little energy available to them and are relatively few and, similarly, e) why the human carrying capacity is greater for vegetarians than meat-eaters. Moreover, these laws place ultimate limits on the biophysical carrying capacity of Earth (Fremlin, 1964). They also undermine unqualified claims that economic growth is necessary to achieve sound environmental management because every step in economic energy transformation creates more entropy, not less. Consequently, unless economic growth can be uncoupled from the environment, it is not a panacea for environmental restoration. (Arrow *et al.* 1995, Ekins 1993).

2. *Interconnectedness of Nature*

Ecosystems are characterised by interconnectedness and interdependencies among their various living and non-living components. For example, some sets of species have mutualistic relationships and some may act as keystone species which strongly influence others (Paine 1969). More generally, the functional interconnectedness of ecosystems depends on energy capture and photosynthesis by autotrophs and materials recycling involving complementary trophic groups. Such cycling is obviously necessary for ecological sustainability in a materially finite world. Unfortunately, the appreciation of recycling and material limits is not a central imperative of human economies.

Another strong connecting agent in ecosystems is water. Apart from being, as Leonardo da Vinci put it, 'the driving force of all nature,' water moves through the hydrological cycle and connects waterways with their catchments via its ability to transport materials (Ricklefs *et al.* 1984). Consequently, waterways are vulnerable to burgeoning human catchment activities (Jones 1995) that have led to severe degradation (World Resources Institute 2000, SoEAC 1996).

These interactive characteristics of ecosystems have an important consequence for humans - we can never do merely one thing, sometimes called Hardin's first law of human ecology (Hardin 1993) and termed 'nature's boomerang' by Webb (1973). All human activities have unintended consequences because of interconnectedness. Prominent examples include the enhanced greenhouse effect from burning fossil fuels and the spread of schistosomiasis, serious coastal erosion at Alexandria and the

collapse of the Mediterranean sardine fishery, all caused by the Aswan High Dam (Aleem 1972). In Australia, vast areas of formerly productive land have been salinised by tree clearing and irrigation. Other examples abound and all are a product of increasing human demands, either to meet the wants of the first world or the genuine needs of poor and increasing populations elsewhere.

3. *Maintenance of Biodiversity*

Biodiversity is defined as the variety present in living systems and is usually considered at three hierarchical levels – genes, species and ecosystems. Although the protection of biodiversity is usually included in government ESD strategies, there is much concern about the continuing loss of biodiversity at all three levels (SoEAC 1996). Particular attention is paid to the extinction of species, but the links among the three levels should be recognised. For example the survival of any species depends on, *inter alia*, sufficient habitat and resources to maintain a viable population size. This issue is particularly relevant to species with narrow geographical ranges such as the 38 snail species found in a single stream (Ponder *et al.* 1993). For viability, a population must be big enough to include sufficient genetic variation to retain evolutionary and ecological potential i.e., the ability to adapt or acclimate to change.

Genetic variation and its consequent adaptive potential are increasingly important as rates of anthropogenic environmental change accelerate (SoEAC 1996). For example, synthetic chemicals now enter the environment at a rate of 3-5 new chemicals per day with less than 1% undergoing toxicological testing (Meadows *et al.* 1992). Consequently, the risks of causing unacceptable change are usually unknown.

Estimates of rates of contemporary global extinction vary enormously but 10,000 species per year may be a conservative figure which probably exceeds the current rate of speciation and the background rate of extinction by four orders of magnitude (May *et al.* 1995). While these large estimates derive substantially from tropical deforestation, Australia's record concerning extinction and biodiversity loss is very poor (SoEAC 1996, Krockenberger 2000).

While the prime immediate causes of extinction are loss and fragmentation of habitat (Office of the Chief Scientist 1992), the underlying cause is 'the effect of human population and consumption' (SoEAC 1996:ES-14). Moreover, 'the situation continues to deteriorate as population and demands on natural resources increase.' (SoEAC 1996:ES-14).

4. *Assimilative Capacity*

Assimilative capacity is defined as the ability of a natural system to absorb various materials, including anthropogenic wastes, at certain concentrations without itself being degraded (Cairns 1977). As such it is a valuable ecosystem service. Although the term was first used by engineers concerning the processing by waterways of organic wastes in sewage, ecosystems can also render harmless some other contaminants such as metals, pesticides, hydrocarbons and excess nutrients.

Unfortunately, assimilative capacities are limited and 'large human populations made it obvious that the assimilative capacity of streams for organic wastes could be exceeded and that this overuse could have unpleasant consequences.' (Cairns 1999: 259). These consequences include constraints on the alternative uses of waterways by rendering them unfit for drinking, fishing or recreation. These constraints have become familiar to numerous people worldwide including those in the Sydney region. Indeed, it is likely that the optimum population of the Hawkesbury-Nepean River catchment has been exceeded despite huge expense on technological treatment of sewage (Jones and Pearson 1995).

5. *Functional Redundancy*

A key question involves the relationship between ecological structure and function – how much variation in structure (biodiversity) is required to maintain the production of ecosystem goods and services that underwrite human survival and wellbeing? If ecosystem processes are dependent on functional groups whose member species are equivalent, then some species are redundant. In the case of human nutrition, few species are apparently necessary i.e., redundancy is high. Only 20 species of plants and five animals account for over 90% of all human sustenance and international commerce in foodstuffs, and three cereal plants (wheat, rice and maize) provide 49% of human calorie intake (Solbrig 1992).

However, before redundancy is used to justify deliberate ecosystem simplification, serious questions arise concerning ecosystem stability, reliability, adaptive potential, dependencies, utilitarian option costs, aesthetics and ethics. For example, would low-diversity systems be stable? Would reduced populations have sufficient genetic variation for the evolutionary adaptation necessary in a rapidly-changing environment? How interconnected and interdependent are species or sets of species?

Although the ecological relationship between diversity and stability has been much studied, few generalisations have emerged (Callow 1998, Holdgate 1996, De Leo and Levin 1997). Indeed, even the generality of simpler ideas such as the keystone concept (Paine 1969) which proposes that some species have a large influence on others, is under challenge (Hurlbert 1997). Such uncertainties and debates exemplify ecological ignorance (see below).

A stability model proposed by Ehrlich and Ehrlich (1981) views the global ecosystem as an aeroplane, which is losing rivets as species go extinct. If too many rivets are lost, the plane disintegrates and crashes. While this metaphor may be simplistic, the point is that knowledge is insufficient to predict the consequences of large losses of species or even the risks involved (Chapin *et al.* 1992).

Recent evidence concerning redundancy (Naeem 1998) suggests that ecosystem functional efficiency may be reduced by declining biodiversity although this conclusion is qualified by Holdgate (1996). Both agree, however, that maintaining biodiversity amounts to buying insurance. It also keeps options open concerning future discoveries of useful goods such as pharmaceuticals. And, of course, many people have deep aesthetic, ethical and moral objections to the degradation of nature.

6. *Carrying Capacity*

Carrying capacity is defined as the maximum population size that can be supported indefinitely without degrading resources. The concept is complex concerning humans because the carrying capacity depends on technology, consumption rates and desired environmental quality. It thus cannot be readily operationalised (Cocks 1992) and remains a matter for speculation (Cohen 1995).

However, carrying capacity remains a useful concept for examining limits and patterns of growth. According to Meadows *et al.* (1992), there are four possible scenarios:

- * continuous growth can occur if physical limits are either very far off or are themselves growing exponentially;
- * sigmoidal growth (growth which levels out at or below the carrying capacity) results if signals from physical limits are responded to immediately or the population limits itself without needing signals;
- * the population overshoots the carrying capacity because signals or responses are delayed and then oscillates to conformity with the carrying capacity because limits are unerodable or are able to recover quickly; and
- * overshoot and collapse results if the signals or responses are delayed and limits are irreversibly degraded when exceeded.

Given a) current large declines in biodiversity and some finite non-renewable resources, b) the constraints implied by global-level changes listed above, and c) the societal desire to conserve nature rather than convert every possible hectare to productive purposes, it seems certain that the carrying capacity of Earth is declining. Further, this decline is arguably a result of overshoot in the size of the human population combined with excessive first world per capita impact and inappropriate technologies and organisation. If so, it becomes crucial to achieve the oscillating state of the third scenario and avoid the collapse of the fourth. This requires that signals from science are reasonably accurate and that responses from government and the community are immediate.

7. *Global Nitrogen Cycle*

As a basic building block of proteins, nitrogen is essential to all forms of life and to ecosystem function. The nitrogen cycle is one of several great biogeochemical cycles that are being disrupted by human activities. It includes the fixing by certain bacteria and algae of atmospheric nitrogen into ammonium and nitrate compounds, which become available to plants (as nutrients) and subsequently to animals. Until recently, the natural nitrogen-fixing process has constrained the nutrient supply so that it often limits the production of undisturbed ecosystems.

Now, however, human activities have changed all this. The huge increase in fertiliser use, land clearing and burning fossil fuels has meant that humans contribute

substantially more fixed nitrogen (210 million metric tons per year) than natural processes (140 million metric tons per year) (Vitousek *et al.* 1997). Many terrestrial and aquatic ecosystems are now receiving 10 or 20 times the natural level of fixed nitrogen with serious consequences for ecosystem health, especially in waterways (World Resources Institute 2000). Here, nutrient overload is called eutrophication and causes explosive plant growth (blooms) followed by oxygen depletion, the death of many organisms and serious effects on human amenities and economies.

The extent of degradation can be huge as in the 1,000 km algal bloom in the Darling River in 1991-92 and the enormous 'dead zone' that has developed in the Gulf of Mexico off the mouth of the Mississippi River. As well, the atmosphere is being polluted by increased concentrations of oxides of nitrogen with consequences for acid rain, smog and the greenhouse effect.

8. *Ignorance and Uncertainty*

Ecological science is plagued by much ignorance and uncertainty (Ludwig *et al.* 1993, Dovers and Handmer 1995). Reasons for this include the youth of ecology as a science, the extreme complexity of ecosystems and the unprecedented rates of anthropogenic change in ecosystems (Dovers *et al.* 1996). In consequence, the discipline that should be in the forefront of providing policy and management advice in the environment-sustainability debate has been largely marginalised (Dovers *et al.* 1996, Fairweather 1993). Even at the descriptive level there are large ecological knowledge deficits (SoEAC 1996).

This situation has consequences for sustainability because ecological problems are key issues needing resolution. However, their features include 'complexity, uncertainty, irreversibility, and spatial and temporal scales at odds with those which underpin human systems of governance, law, policy and management.' (Dovers *et al.* 1996). Moreover, as discussed above, the views of biological scientists are frequently at odds with those of the pro-growth corporate and economic lobbies that heavily influence government policy.

Discussion

The above sections summarise the state of the natural environment at global and Australian scales and list some of the underlying ecological issues. By any assessment that values biodiversity and natural values, there is much to be alarmed about. Indeed, there are even threats to basic life-support systems. Of course, it is possible to hold optimistic views by discounting natural values, by emphasising the power of human ingenuity and technology to fix problems, and by disputing scientific claims about the size and consequences of large environmental changes. Certainly, scientific opinion is divided on some questions such as whether the data on the relationship between diversity and productivity are sufficient to inform public policy (Kaiser 2000) or the size and consequences of the enhanced greenhouse effect. However, concerning the big picture of global ecological health, there is great unity in scientific concern (see Introduction).

Whatever other disagreements exist, the following propositions need to be universally accepted. Firstly, ecosystems provide life-support for humans and secondly, ecosystems are being degraded at unsustainable rates. Thirdly, although the underlying causes of degradation are several (i.e., the PLOT factors – see Introduction), population size is relevant because it is a multiplier. This is not to deny the importance of the L, O and T factors, especially consumption (Trainer 1998), but regardless of any mitigating effects of greener technologies, better organisation or reduced consumption, there is an irreducible demand (footprint) that each person places on the Earth for resources and waste disposal. Moreover, every Australian imposes a much larger footprint (8.1 ha/person) than the world average (2.3 ha/person) (Wackernagel and Rees 1996). Reducing Australian per capita consumption will be a great challenge because it is rising sharply, not falling. For example, in Sydney since 1970, consumption of water, energy and food has risen by 25%, 37% and 70%, respectively (SoEAC 1996).

It is also essential to grasp that the natural and human economies operate in fundamentally different ways concerning sustainability. The autotrophs (plants) in natural economies produce complex, energy-rich materials via photosynthesis. The importance of photosynthesis cannot be overstated because it generates complexity and is the ultimate source of all renewable resources. This process is sustainable in natural ecosystems because solar energy is essentially unlimited, materials are recycled and wastes become resources for complementary trophic groups. As well, growth is constrained within material limits.

In sharp contrast, human economies degrade order and complexity, depend heavily on finite fossil fuels for energy, recycle only partially and produce toxic wastes. Moreover, the need for sustained economic growth (termed ‘growthmania’ and ‘an oxymoron’ by Daly, 1991) is universally voiced by politicians and business leaders. These influential people may not understand that material human capital is usually expanded at the expense of natural environmental capital (Daly 1991, Rees 1990) which is being depleted because both human numbers and economies are growing relentlessly. This growth will thus impose environmental penalties and disbenefits for many people (Daly 1991). Unfortunately, these disbenefits may ultimately be the cause of population stabilisation, i.e., misery will cause population growth to cease as suggested by the ‘dismal theorem’ of eminent economist Kenneth Boulding in 1971.

Population growth in non-human species usually ceases if the carrying capacity (maximum sustainable population) is reached. However, the human carrying capacity is very elastic and would be enlarged by lower consumption and better technologies (Daily and Ehrlich 1992). For example, agriculture greatly expanded the carrying capacity compared with hunter-gathering. Optimists conclude that technology will continue to enlarge the carrying capacity sufficient to meet growing needs. However, the optimists need to allow for the large projected growth in demand for resources such as food, clean water and wood (Ayensu *et al.* 1999), the declining capacity of many waterways and productive areas (World Resources Institute 2000), and the huge costs of remedial action (Fisher 2000, Office of the Chief Scientist 1995). To be convincing, they also need to make evidence-based, reasoned arguments relevant to shared societal goals. Moreover, it is notable that the optimists include few, if any, ecological scientists, the people who actually study ecosystems. In fact, these scientists are so alarmed at population growth and the sheer scale of human

intervention in ecosystems as to shed their inherent reluctance to speak out and become increasingly vocal about environmental degradation, its consequences and its causes, including population size.

As well, ecologists understand that estimates of carrying capacity must accommodate the inevitable poor harvests and catastrophes without drawing down irreplaceable natural capital (Flannery 1994). Moreover, carrying capacity is dependent on consumption rates that vary greatly (Cocks 1996, Cohen 1995). Consequently, the alternative concept of optimum population (Cocks 1992, Grant 1992, Betts and Birrell 1994, Pimental *et al*, 1994) is more useful for policy formulation and management since it maximises benefits and societal goals rather than population size *per se*.

Given that humans wish to retain natural values and high quality of life (as in an optimum population) rather than maximising numbers (as in a battery-hen situation), it seems clear that there has been overshoot (see above under point 6) of population size related to carrying capacity. At issue is whether overshoot will be followed by a stabilising oscillation between carrying capacity and population size or a crash of both. The former would enable an optimum population size to occur if environmental impacts could be greatly reduced. The second overshoot model means large-scale ecological collapse characterised by loss of both ecological structure (biodiversity) and function and the consequent drastic fall in the human population. Such ecological collapses have occurred in ancient civilisations (Diamond 1994) and are now evident at regional scales concerning some fisheries, forests, desertification, freshwaters and coral reefs.

In Australia, the population boosters claim that the country is underpopulated because it is a huge empty land that can support 50 - 150 million people (Neales 1998). However, the carrying capacity of a region depends upon its productivity, not its area. Only about 6% of Australia is arable, the soils are mostly shallow and infertile and rainfall is both poor and variable (SoEAC 1996). As well, much of Australia's primary production is exported to pay for desired imports and is thus unavailable to support more Australians. Further, and crucially, the basic viability of Australia's current agricultural and pastoral output has been seriously questioned (Office of the Chief Scientist 1995, White 1997) for several reasons. These include the unsustainability of current high-input agriculture (Daily and Ehrlich 1992, Whitten and Settle 1997), the depletion of soils and groundwater (SoEAC 1996) and the costs of remedial action for degraded lands (Office of the Chief Scientist 1995). In fact, White (1997) believes that Australia will not be able to feed its own population unless it is capped now.

Concerning Australia, it seems clear that the country is ecologically unsustainable as evidenced by the findings of the Office of the Chief Scientist (1995) and the SoEAC (1996). Moreover, scientific opinion considers population size to be an important factor. For example, the Office of the Chief Scientist said in 1992 that 'The greatest threat to the biological diversity of Australia is not direct human damage or malice but the results of the expansion of the human population and the forms of associated socio-economic activities.' The CSIRO asserted that 'Australia lacks the necessary knowledge and understanding to manage effectively its current population at current living standards.' (CSIRO 1994). Further the Australian Academy of Science

recommended in 1995 the rapid stabilisation of population size, a sentiment echoed by the Chair of the SoEAC, Ian Lowe, who said in 1997 ‘There is no prospect – even in principle – of a sustainable pattern of development unless we devise a socially acceptable way of stabilising the human population.’

Given a) public ESD goals espousing sustained human wellbeing and the protection of biodiversity, b) the documented decline in our life-supporting ecosystems and biodiversity, c) the future increased human population size and resource demands and d) the scientific uncertainty concerning ecosystem stability/collapse, it is surely time to re-evaluate our ‘growth-at-all-costs’ policies. Re-evaluation should apply in particular to the factors known to cause ecological degradation i.e., population growth and material economic growth. In setting policy, ecological considerations should have primacy over social and economic aspects (SoEAC 1996) because, without ecological sustainability, these goals cannot be achieved. Moreover, policy and management should have an integrated ecosystem focus (World Resources Institute 2000) that accommodates ecological interconnectedness and survival requirements at appropriate scales in space and time.

Sometime very soon, humans must learn to cooperate to ensure the sustained wellbeing of all. While greener technologies and organisation have important roles to play, truly sustainable solutions will, in the medium term, mean, fewer and/or smaller human ecological footprints. In the short term, ecologically rational behaviour in our political, economic and social systems and by individuals is needed. As Ian Lowe said in 1997, ‘We are not passengers on spaceship Earth, we are the crew. And it’s about time we took our responsibilities seriously.’

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