NEW ZEALAND ECOLOGICAL SOCIETY

AN ECOLOGICAL APPROACH TO NEW ZEALAND'S FUTURE

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AN ECOLOGICAL APPROACH TO NEW ZEALAND'S FUTURE

Compiled by:

R. A. FORDHAM AND J. OGDEN*

Department of Botany and Zoology, Massey University, Palmerston North

for the Council of the New Zealand Ecological Society

*Present address: Australian National University
Canberra, Australia

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CONTENTS

ABSTRACT OF RECOMMENDATIONS

1. That the Government should consider urgently establishing a permanent, interdisciplinary "Centre for Population Research", * funded to undertake research and to advise the Government on the status of the population of New Zealand in relation to local resources and the environment and to the world population and resources. (P. 24)
2. That the Government should increase educational effort to make the public aware of the effects each child has upon the whole community and its resources. (P. 24)
3. That the Government should accelerate its review of existing land-use policies so as to formulate a comprehensive Land and Resource Use Plan. This plan should recognise the need for both natural and managed ecosystems and ensure the protection of valuable productive land from urban growth. (P. 24)
4. That the Government should modify its economic policy so that ecologically desirable recycling and pollution control are economically attractive to the public and to industry. (P. 25)
5. That because the problems of population growth and use of resources are global and cannot be considered solely at a national level, the Government should participate actively in any international discussions aimed at solving these problems. (P. 26)

*See Appendix 2

FOREWORD

In December 1971 the Council of the New Zealand Ecological Society* established a Population Sub-committee to advise it on matters pertaining to the growth of human populations. This arose from the Council's concern about the growing *per capita* use of resources, and the growth rates of world and national populations. The world population grows every month by about six million people and at this rate of increase will double in size to about seven billions by the year 2000. The Council was also concerned about the paucity of research done in New Zealand in ecology, demography, sociology and psychology as related to planning for the future population.

New Zealand is part of, and affected by, the growth of the world's population. In our view the evidence clearly indicates that this country's population should be stabilised. This view does not conflict with that of the Targets Advisory Group (T.A.G.) of the National Development Council[65] or the Monetary and Economic Council[140], but we differ from them by advocating immediate steps toward this goal. The reports of the T.A.G. and of the Monetary and Economic Council followed the recommendation of the Physical Environment Conference 1970[90] for research into the relationship between the population, the economy and the environment, and for international cooperation in solving related problems. These three papers indicate increasing awareness of the Government's responsibility.

We believe that national and international reports on economic planning, migration, population and the like should be augmented by statements relating them to the fundamental ecological principles that ultimately govern human affairs. Our reason is quite simple: only by appreciating the principles of ecosystem functioning can one see the common factor in apparently unrelated issues such as polluted lakes, starvation, clean air, energy shortages and recycling of metals. From the knowledge of the demography of many species of animals and plants and of their environmental relationships, we are convinced that ecologists can comment usefully upon human populations.

We are aware that some complex situations have been simplified and claim no expertise in some of the areas touched upon. An overview of mankind's environmental problems simply compels reference to topics outside the traditional bounds of ecology. Indeed the difficulties we met in preparing this paper are the very ones which underline the advantages of an interdisciplinary approach to study and planning. Such a synthesis can be produced for New Zealand only by creating a new government agency with wide expertise and realistic funding.

* A Society of over 400. members and a member body of the Royal Society of New Zealand.

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B.D. Bell	Scientist, Ecology Division, D.S.I.R.
I.G. Crook	Scientist, Wildlife Service, Department of Internal Affairs
M.M. Davidson	Scientist, N .Z. Forest Service
M.N. Foggo	Tutor, Department of Mathematics and Science, Central Institute of Technology
J .A. Gibb	Director, Ecology Division, D.S.I.R.
C. Hay	Post-graduate student, University of Canterbury
A. Moeed	Scientist, Ecology Division, D.S.I.R.
L.F. Molloy	Scientist, Soil Bureau, D.S.I.R.
M.R. Rudge	Scientist, Ecology Division, D.S.I.R.
D. Scott	Scientist, Grasslands Division, D.S.I.R.
P. Wardle	Scientist, Botany Division, D.S.I.R.
G.R. Williams	Director, Wildlife Service, Department of Internal Affairs

Various other people read draft manuscripts and offered suggestions and criticisms, in particular:

G.S. Fraser	Professor of Sociology, Massey University
J.W.M. Gardner	Lecturer in Farm Management, Massey University
J.W. Kidd	Assistant Director (Social Work), Department of Social Welfare
E. Roberts	Lecturer in Agronomy, Massey University
J.W. Rowe	Professor of Economics, Massey University
A.D. Trlin	Lecturer in Sociology, Massey University
A.B. Ward	Reader in Agricultural Economics, Massey University
E.W. Wilson	Senior Lecturer in Obstetrics and Gynaecology, University of Otago

INTRODUCTION

The relationship between the number of people in a country and their quality of life is not simple. It depends upon Society's preferences, as well as on levels of technology and the availability of resources, not only in the country in question, but also in those countries with which it trades or competes for trade. However, when "standard of living" is measured by the usual material indices, certain conclusions can be drawn. If there is no increase in resources or technological knowledge, then a large increase in population must depress living standards as the same quantity of material is shared among more people. A larger population may result in some "economies of scale", but if the population continues to rise new resources must be found, or existing ones used more efficiently, to maintain the same material standards of living. These relationships may be formally expressed by the simplified equation[100]:

$$\text{Material standard of living} = \frac{\text{Resources x Technological ability}}{\text{Population size}}$$

Expressed like this it is clear that, contrary to popular opinion, the population need not grow to sustain a rise in living standards. If population size and resources remain constant, an increase in standard of living can be achieved by technological advances such as recycling materials or by alteration of the pattern of distribution of national wealth.

Our material standard of living in New Zealand is commonly measured by the real *per capita* Gross National Product (G.N.P.). The National Development Council[62] recently called for a growth rate of 2.7 percent per annum in G.N.P. However, G.N.P. is a deficient indicator of economic progress, let alone national welfare[97, 136], because economic and non-economic assets are interrelated. Included in it as assets (instead of liabilities) are indicators of "ill-fare" rather than welfare, such as the costs of preventing or cleaning up pollution and crime, medical expenses of car crash victims and all transport costs.

Notwithstanding these anomalies many New Zealanders define "standard of living" in terms of material possessions measured by their dollar value. Yet recent petitions to Government on environ mental issues suggest that a growing number of people no longer equate "quality of life" with the material standard of living indices sometimes employed in planning economic development. For this growing minority "quality of life" is equated more with improving human relations, diversity of natural and cultural environments and a real awareness of the world as a complex of ecosystems in which human beings have only recently (in the geological sense) become an integral part. In a nutshell these people recognise new priorities and preferences in the growth of society and have introduced to the wider public the words "environment" and "ecology".

Ecology is not synonymous with "conservation", "pollution" or "population pressure", and environmental problems are not limited to pollution[135]. The ecologist studies the ways in which individual plants and animals adapt to their environment (population processes) and the ways communities and ecosystems function. Hence he is uniquely placed to comment on these matters. The common thread linking words such as "pollution", "conservation" and "population" is the relationship between man, the area around him and the resources available to him.

Problems of the environment and of population are basically ecological ones. Some of man's interactions with his environment contravene well-established ecological requirements for long-term survival, and this gives rise to the concern currently expressed by experienced ecologists throughout the world. Unlike the vagaries of politics and economics, ecological processes follow natural laws with broadly predictable consequences. Prediction of future events from past experience is an essential part of our planning process, yet in one respect we fail to have concern for the long-term future by disregarding some recently discovered ecological information. This may be because we have evolved by natural selection which has only short-term objectives.

This paper first reviews some principles of ecology relating to the functioning of ecosystems, then goes on to summarise principles of the regulation of plant and animal populations in relation to their resources, stressing their relevance to human populations, especially in New Zealand.

THE FUNCTIONING OF ECOSYSTEMS

1. *The "Ecosystem" Concept*

For hundreds of millions of years before man-like creatures appeared, plants and animals inhabited this planet. Their activity profoundly altered the land, oceans and atmosphere. Primaeval photosynthesis provided much of the oxygen on which our survival depends and created the coal and oil deposits that drive industry. Intense biological activity still takes place in the thin envelope of soil, water and atmosphere clothing the planet. This envelope, the biosphere, has various working parts (deserts, grasslands, oceans, forests, etc.) which ecologists recognise as ecosystems[127]. Our survival and cultural advance are attributable directly to the functioning of past ecosystems. If present-day ecosystems, of which man forms part, are to continue to support him and maintain their vital structure, we must avoid abusing them and understand how they function[80, 111].

The term ecosystem includes all populations of living things inhabiting any coherent area of land or volume of soil, air or water. It describes a dynamic, sometimes fragile[19], often resilient set of relationships in which diverse living organisms interact with each other in many ways and continually alter and respond to changes in their environment. The ecosystem concept directs attention to relationships between organisms and their environment, rather than to mere descriptions of communities of species. It stresses function. Ecosystems are not fixed collections of organisms and their habitats. Some plants, micro-organisms and animals are permanently associated with particular habitats but many move freely between adjacent ecosystems (for example, deer moving between forest and grassland). Such organisms are part-time constituents of several ecosystems and are agents of interaction. Likewise, movements of non-biological constituents - air, minerals and water - bring about exchanges between contiguous ecosystems. Man is a constituent of many ecosystems and so affects, and is affected by, the other components of these systems[111].

2. *Energy Flow and the Food Web*

Whatever the ecosystem, be it forest, paddock or ocean, its sole source of energy (sunlight) enters through the photosynthesis of green plants ranging in size and. structure from forest trees to minute phytoplankton. In some ecosystems organic inputs are important, but even these originate from photosynthesis elsewhere. The amount of energy trapped as carbohydrate in this way constitutes the primary production of the ecosystem (Figure 1). Some may be temporarily stored (e.g., as wood) or permanently stored as fossils, but some becomes food for herbivorous animals. These in turn fall prey to carnivores, and small carnivores are eaten by larger ones. Plants, herbivores, carnivores etc. constitute the food (trophic) levels of the ecosystem which, in most natural situations, form complicated interconnecting food webs. In the conversion from one food level to the next about 90 percent of the energy is lost as heat. Thus only a small proportion of the energy present in one food level is available as food for the next. Consequently ecosystems usually contain much more plant than animal material and many more herbivores than carnivores. Yet the herbivores may profoundly modify the vegetation and the carnivores may help to regulate the numbers of herbivores. Clearly any sudden upset at one point in the system is liable to have repercussions elsewhere.

Because food passes from one food level to the next, compounds that are not metabolised or excreted by herbivores can become concentrated in carnivores. This is why fish 'may have concentrations of DDT in their tissues ten times higher than in their phytoplankton food; and birds eating the fish may have concentrations up to a thousand times higher[123], which may become lethal[95]. Where man sits atop the food web he is also affected - witness mercury poisoning in Japan through eating contaminated fish[28].

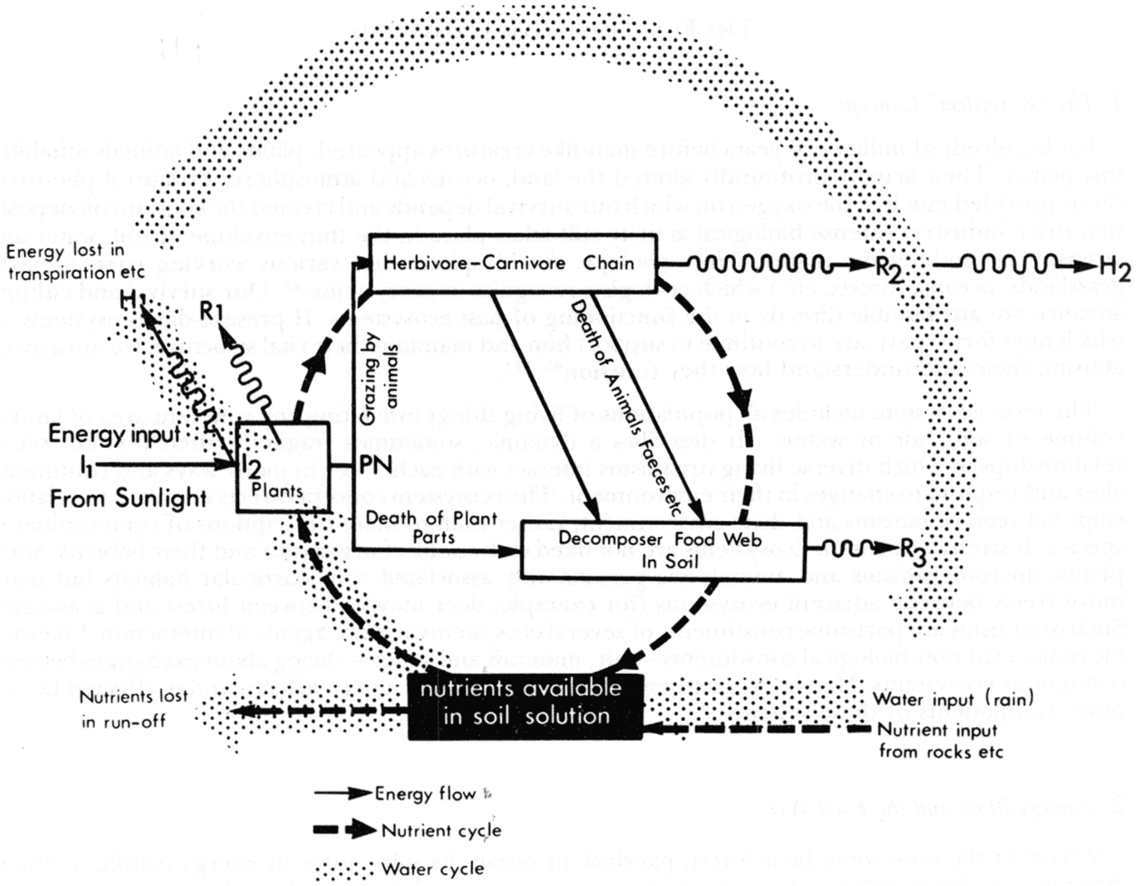

FIGURE 1 Simplified diagram showing the overall relationships between the flow of energy and the cycling of nutrients in a terrestrial ecosystem. Explanation of symbols: I_1, energy enters the ecosystem, and a large proportion of it is lost through reflection, conduction or convection, or in the process of evaporation of water from leaf surfaces (transpiration). The amount of energy lost in this manner is designated H_1, and is subsequently released into the upper atmosphere when the water vapour condenses to form rain (H_2). Transpiration keeps water moving through the vascular systems of the plants, thus allowing the uptake of nutrients from the soil solution by plant roots. I_2 represents energy trapped as carbo-hydrates in the process of photosynthesis and is usually only a small proportion of I_1; some of this energy (I_2) must be used to maintain the plant, and is thus lost in the plant's respiration (R_1), while the remainder constitutes the net production (PN) of the vegetation. This net production is available for plant growth and provides food for the 'animal' component of the ecosystem. The net production may be eaten directly by herbivorous animals or may pass to the decomposing organisms, but ultimately all the energy it contains is released in the process of respiration (R_2, R_3); in a stable ecosystem $I_2 = R_1 + R_2 + R_3$. In the process of decomposition nutrients are released into the soil, where they may be adsorbed onto clay or humus, but where they are potentially available to be taken up again by the plants. Thus the figure shows how ecosystems tend to cycle nutrients, although gains and losses may occur, particularly when the hydrological cycle is altered in some way.

3. *The Significance of Carnivores*

Removing carnivores can lead to excessive numbers of herbivores and consequent damage to man's crops[103] or range lands[46]. Mortality among the herbivores may then increase with population density. The growth of the population stops eventually but only after components of the vegetation have been considerably, perhaps permanently, altered. Removal of carnivores (e.g., by broad-spectrum pesticides) may also upset the competitive balance between the different species of herbivores so that some become more common, others disappear, and the total number of species declines[85].

4. *Productivity, Diversity and Stability*

The productivity of ecosystems (defined as the amount of material produced in a given area in a given time e.g. kilograms/hectare/year) depends on a supply of solar energy and on the ways this is used in the biosphere. Much of the incoming energy goes to evaporate water from leaf surfaces, which helps to power the cycling of water and mineral nutrients through the ecosystem (Figure 1). The relationships between water, air, soil and plants, the flow of energy and the cycling of nutrients, must all be clearly understood if high levels of productivity are to be maintained.

Productivity, diversity and stability are closely linked. As natural ecosystems develop the number of plant and animal species in them usually increases. This increased diversity usually gives mature ecosystems greater stability[80], partly because a reduction of one kind of food in a complex food web can be compensated for by increase of another. On the other hand, young communities are generally simple, lack a large web of consumers and grow vigorously. Hence they are usually highly productive. Man's mono-cultural methods of farming and forestry are of this type. Mono-cultures such as com fields may be highly productive, but they are relatively unstable and are retained only by the continual input of large quantities of energy[99]. This energy includes that of the farmer or forester, that needed to manufacture and drive his machinery and to prepare, distribute and apply fertilisers, herbicides and pesticides.

5. *Nutrient Cycling and the Importance of Micro-organisms*

In a stable ecosystem such as a mature forest organic matter does not continue to accumulate for ever. In any area a certain quantity is achieved which then remains virtually constant: at this stage, gain from photosynthesis balances loss from respiration. In terrestrial ecosystems, microscopic decomposing organisms in the soil (such as invertebrates, bacteria, protozoa and fungi[34]) prevent the accumulation of organic matter. They break it down, utilise the energy it contains and return the components to the soil and atmosphere where once again they are available as nutrients to plants (Figure 2). These nutrient chemicals (nitrogen, phosphorus, potassium, carbon and so on) are effectively indestructible. Theoretically they can be re-used indefinitely by many variations of this cycling process between the organisms and the physical environment.

Nutrient cycles are often referred to as the world's "life-support systems" — a term borrowed from space vehicle technology where similar cyclic systems are very clearly seen as essential for the life of astronauts. Just as life-support systems in a space-capsule depend on energy

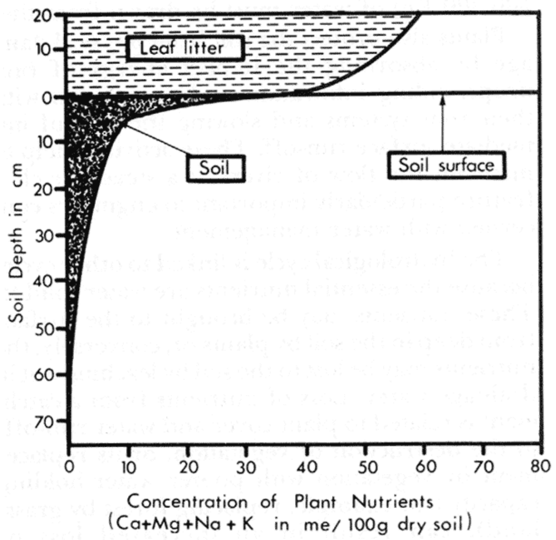

FIGURE 2 Generalised profile of a typical New Zealand forest soil. Note how removal of surface litter and the top few cm of the soil may remove the majority of the plant nutrients. Based on data for 'yellow brown earths' given in N.Z. SOIL BUREAU 1968. Soils of New Zealand, Part 3 (e.g., Judgeford silt loam, Taita clay loam, Tautuku silt loam) and Part 2 (e.g., Fig. 7.3.2). See also CHARLEY. J. L.; COWLING, S. W. (1968) Changes in soil nutrient status resulting from overgrazing and their consequences in plant communities of semi-arid areas. Proceedings of the Ecological Society of Australia 3:28-38.

supplied by solar batteries or by stored fuel, so our planet's nutrient cycles depend on sunlight passing through the' atmosphere, providing energy for the food webs involved in the recycling process. Some cycles, for example those of the gases nitrogen, oxygen and carbon dioxide, and of water (see below), should be considered on a global scale[99].

Changing the soil food web by removing a carnivore, or damaging the vegetative cover, upsets the cyclic processes and eventually leads to changes in the above-ground communities of plants and animals. Man's use of toxic chemicals in the ecosystem[29,111] often disrupts the normal recycling function of the soil organisms so altering soil nutrient cycles and sometimes impairing soil fertility or inducing outbreaks of "pest" species.

Man has also greatly modified the vital biogeochemical cycles by extracting some elements (mining, harvesting, cropping), by putting back others (fertilisation), by changing the hydrological cycle (drainage, irrigation, dams), by burning fossil fuels[16] and by introducing substances which may influence the cycles of other elements. Before initiating such activities their environmental effects should be examined carefully.

6. *The Hydrological Cycle, Nutrient Conservation and Erosion*

Water is continually cycling between the atmosphere and the surface of the earth. Because plants need large quantities of water for growth and photosynthesis they playa major role in this cycle. They take up large quantities of water from the soil and evaporate it, producing a humid atmosphere in the vegetation. In producing five tons (ca. 5,100 Kg) of dry weight of. plant material about 400 tons (ca. 406,300 Kg) of water must be drawn from the soil[89].

Plants also protect the soil from physical damage by absorbing the impact energy of rain drops, aiding infiltration and percolation with their root systems and slowing the rate of immediate surface run-off. These activities help to maintain the flow of rivers at a steady level; a feature particularly important to engineers concerned with water management.

The hydrological cycle is linked to other cycles because the essential nutrients are water soluble. These nutrients may be brought to the surface from deep in the soil by plants or, conversely, the nutrients may be lost to the soil by leaching out in drainage water. Loss of nutrients from a catchment is related to plant cover and water run-off, so the destruction of vegetation, or its replacement by vegetation with poorer water-holding ,capacity (for example, replacing forest by grassland), can result in an increased loss of nutrients[2, 119], (Figures 2 and 3). Moreover, any interference with the plant cover in mountainous areas, such as when forests are browsed by deer, opossums and goats or when sheep and rabbits graze the herb fields, may result in serious erosion of hill country and resultant problems in the lowlands[47]. Healthy communities of plants and animals are effective "biological brakes" on the whole process of erosion.

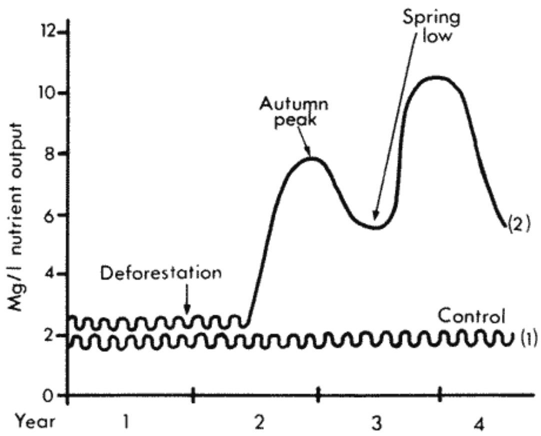

FIGURE 3 Effects of forest removal on output of nutrients from a catchment.
(1) Control catchment in which forest vegetation remained intact.
(2) Experimental catchment from which forest was cleared at the end of the first year. Note that not only does total nutrient loss increase, but also it becomes much more seasonal, being related to total streamflow. Based on data for calcium and other cations in Likens, G.E., Bormann, F.H., Noye, M.,Johnson, D., Fisher, D. W. and Pierce, R.S. (1970). Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook watershed-ecosystem. Ecological Monographs 40:23-47.

MAN'S IMPACT ON THE ECOSYSTEMS OF NEW ZEALAND

Man is manipulating and altering the world's surface, and his ability to deface public or private land and irreparably damage natural ecosystems has increased greatly with the growth of technology and population. Ownership of land carries with it a responsibility to the community. Man has made a heavy impact on the New Zealand landscape and has generated problems embracing all aspects of the human environment including the social, recreational, biological and physical. Some of the problems are out of proportion to our population and are extremely serious, and it is unrealistic for the T.A.G.[65] to state otherwise. Most of our environmental complaints will continue to grow in variety and size with the population, as in other western societies, unless prevention or cure is built into the administrative system. Below are examples of man's impact on New Zealand ecosystems.

1. *Altered Ecosystems*

New Zealand has world famous problems of natural erosion, largely resulting from glacial and volcanic activity. But these have been aggravated, and other sources created, by deforestation, intro duced mammals and. plain bad management[36,49,68,109]. Native vegetation has been removed by logging and conversion to pasture often far beyond what is economically and ecologically sound[24]. The planting of exotic species is one of the major effects that man has had, and continues to have, on New Zealand's natural ecosystems. Often these plants, free from the natural controls which limit their reproduction in their native lands, have spread extensively and become problems.

Thirty one species of introduced mammals now live wild in New Zealand[122] and most have adversely altered native ecosystems. Damage to the vegetation is frequently extensive[35, 51, 68, 116] and costly[53.74]. Obvious expenditure on deer, rabbit and oppossum control is only a small fraction of the .total cost involved. Account must be taken also of the costs of restoring the fertility of eroded land, of building flood control structures and of desilting or replacing reservoirs as they fill with sediment.

2. *Maintenance of Altered Ecosystems*

Once a natural ecosystem has been deliberately altered by man it must be maintained in its altered state by continual effort and extraneous energy. In practice this means that our simple agricultural and land management policies rely largely on the extensive use of herbicides and fertilisers to control plant growth, or to support monocultures, and on pesticides, poisons and shooting for the control of animal populations[92. 125]. The total energy required to support the simple utilitarian ecosystems made by man is considerable[82], and it would be useful to investigate systems of primary production that need relatively low inputs of energy.

a. Poisonous Chemicals

Agricultural (and domestic) production must rise to match population growth and the extent to which increased production depends upon the wide scale use of poisonous chemicals is easily seen. Between 1958 and 1968 the value of insecticides and fungicides made in New Zealand rose from \$1,099,000 to \$1,906,000 while the value of weed killers rose from \$1,539,000 to \$2,998,000[69]. In the same period importations of insecticides rose and those of weed killers fell[71]. Taking imports and local production together, and allowing for price changes and revaluations of the dollar[134], there has been an 11 percent increase in use of biologically toxic chemicals. The increase in use over a ten year period may not appear large, but it is a continuing and cumulative process. Some chemicals are not readily broken down by organisms and so build-up in animals[105]. An example of the long-term effect of such non-biodegradable substances is provided by DDT residues, which continue to accumulate in cows' milk for several years after the use of DDT is abandoned[94].

Man has undoubtedly benefitted from pesticides and much immediate suffering would result if their use was abandoned. But scientists cannot fully assess the long-term effects of pesticide terminal residues in the environment and in human tissues, and concern about these problems has provoked international attention[39]. In the meantime pesticides should be used cautiously and selectively. Concurrently, other ways of improving crop production by biological control of pest or weed species, selective breeding and further application of the knowledge of animal behaviour should be actively pursued. So far very little research into alternative ways of managing land for primary production has been undertaken in New Zealand[132].

b. Fertilisers

Although, as we have seen, minerals cycle naturally, man adds large quantities of certain minerals to his fields and plantations in order to increase crop yields. Between 1958-59 and 1968-69 the value of organic and artificial fertilisers made in New Zealand rose from $19,010,000 to $48,109,000[69] and the import of fertilisers also rose sharply. This represents an 85 percent increase over the period[134]. With many people in the world already hungry or malnourished[5,13,58] intensive or even extensive agriculture without artificial chemicals is out of the question. Indeed any future scheme to reduce the area of land required for food production will probably rely heavily on the use of these chemicals. The environmental significance of fertilisers lies not in the replacement of materials extracted from the soil by growth of crops, or in the addition of elements previously deficient, but in repeated over-application in areas where climate, soil and topography cause rapid run-off which may accelerate eutrophication of fresh waters. This is a waste of both fertiliser and fresh water24.

3. *Exploitation of Marine Resources*

The decline of Antarctic whaling, which New Zealand is geographically and historically linked, serves as a model of over-exploitation through greed and the wilful neglect of ecological advice[18,88]. There are other outstanding local examples of thoughtless over-exploitation of natural marine resources which have long-term biological and economic repercussions. Stocks of dredge oysters have declined over the last 20 years, as has the catch rate, yet the number of boats dredging has increased[20].

Similarly the number of boats actively engaged in rock lobster fishing off the mainland has risen since 1945, especially in recent years, even though catches per fishing permit have fallen since 195621; this resource has been severely over-exploited[117]. A mussel fishery in Auckland collapsed in 1966 from over-use[30] and other prized sea foods (rock oyster, paua, toheroa) have been locally depleted[56]. Population growth, public demand, the rising commercial value of the product and the decline of the fishery are linked in a vicious circle of exploitation - exemplified by the fate of the Chatham Islands rock lobster industry. In managing natural living resources the aim must be to harvest only at a rate sustainable by the species in question. When exploitation occurs in the absence of an ownership system, and with the aim of short-term profit, the resources will inevitably be exhausted.

4. *Pollution*

Despite assurances to the contrary[65] severe pollution problems do exist in New Zealand, both locally and regionally. High levels of atmospheric pollution are sometimes experienced in several cities[14,15,55,93]. Rivers such as the Waikato, Hutt, Heathcote and Waimakariri[9,11,121], lakes such as Rotorua, and estuaries such as Invercargill are polluted by agricultural, industrial or domestic effluents, sometimes leading to excessive weed growth or algal blooms. Regrettably the problem is often widely recognised (for example, Invercargill Estuary) but not speedily remedied despite available technology and increas ing public awareness of the economic costs and health hazards of pollution. For many New Zealanders, drinking water is below standard[90] and the 1970 New Zealand Water Conference has emphasised the importance of improved water quality[78]. Pollution is caused by many different activities and as these expand and diversify with population growth, its amelioration will call for a major contribution from science, technology and industry.

5. *Loss of Ecosystems*

Throughout the country drainage schemes continually reduce swamp areas and other wetland habitats, together with the rich variety of plants and animals dependent on them. Some of these (for example, eel and waterfowl) have economic as well as scientific and aesthetic values. Not only are swamps among the most productive habitats known[118], but they are also frequently repositories of archaeological information stretching back for thousands of years. Furthermore, swamps and marshes serve important hydrological functions; maintaining local water tables, supplying aquifers and reducing run-off velocities in times of flood.

On the Volcanic Plateau seedling *Pinus* derived from large adjacent tracts of exotic forest are spreading rapidly into native alpine moor and grass land. The areas affected by this invasion are so extensive, and money for remedial work so short, that the gradual loss of the unique character of much of this wilderness area seems inevitable.

Loss of forested areas by logging and burning and of estuarine areas and sea shores by reclamation are numerous. Somehow a reconciliation must be reached between the demands of urban and economic growth and the innate qualities of untouched areas. Not the least value of most unaltered areas is a natural beauty and peace.

REGULATION OF POPULATION SIZE

Under favourable conditions all species of plants and animals can increase their numbers in a geometric (exponential) progression, more generally recognised as the law of compound interest. But no species, whether plant, bird, mammal or bacterium can go on increasing like this indefinitely. Populations grow in numbers only to a certain limit called the "carrying capacity"[128] of their habitat, about which they then fluctuate from time to time. It was the observation of these two facts (the potential for increase and the relative stability of natural populations) which led Charles Darwin to deduce that vast mortality of offspring must be the rule in nature, and so to formulate the theory of evolution based on the survival of the best-adapted (fittest) members of those populations.

When the density of a population increases many kinds of interactions between individuals intensify. In plants more seedlings die and the weight of mature individuals drops. In animals competition for food becomes keener, territorial defense more vigorous and imposition of social hierarchies more stringent, leading to lower birth rates and higher death rates. In addition emigration to new areas is stepped up, as in the celebrated case of lemmings. These responses represent *internal population controls* which can act as a brake on further increase long before food supplies are exhausted or the habitat permanently damaged. They are innate patterns of physiology and behaviour resulting from natural selection and, even in animals, are not rational acts. While the ultimate limit to numbers is food, deaths through causes other than starvation also increase as food becomes scarcer. With a limited food supply an animal must spend more time searching for food and may lose condition; it is increasingly exposed to predators and must leave its young unprotected for longer periods. Under-nourishment of both young and old animals makes them more prone to disease and parasites.

The Balance of Numbers in Man

Considerations of animal populations have their lessons for human societies. Latterly, man has used medicines, hygiene and food production in humanitarian efforts to .reduce suffering and death. He rejects mortality as a mechanism for regulating his numbers but has failed to utilise the only realistic alternative - control of reproductive rates. Consequently more young people survive to breeding age and more of their elders survive into old age. Not surprisingly the world population is increasing, at a rate between 1.8 and 2.1 percent per annum (Figure 4). This rate of "compound interest" is not large by commercial standards but the capital involved is now well over 3.7 thousand million people[112]. Two per cent per annum of this is an additional 72 million every year - twenty five times the population of New Zealand. To house these new people according to our standards we would have to build a city the size of Auckland every three and a half days[73]. Finding living space alone is clearly a problem but an even more difficult one is the production and distribution of enough food of the right kinds to prevent hunger, malnutrition and death by starvation[5, 13, 18, 58, 60].

Rapid reproduction alters the relative proportions of the total population in each age group, and these are expressed as a block diagram. Any disproportionate increase in birth rate "can be seen in such a diagram as a bulge which moves upwards through the age structure as the years pass[129]. Clearly such changes have many economic and social consequences, the most obvious being that the welfare of dependents, whether children or old people, rests upon the ability of the working age group to provide essentials. Any situation where the work force is disproportionately small for a long time is undesirable.

In many countries of Africa, South America and Asia, where populations are already near or beyond the carrying capacity of their country[18, 44, 112] and high infant mortality is characteristic, essentials are not being provided. Cultural factors (for instance religious prejudices) may, in some areas, further compound the effects of basic shortages of resources[138].

The student of animal populations, observing such a situation, is concerned at the lack of the usual control mechanisms operating to limit reproduction and numbers as density increases[107]. The same humanitarian activities which ameliorate and prolong life now act to burden it with crowding, hunger

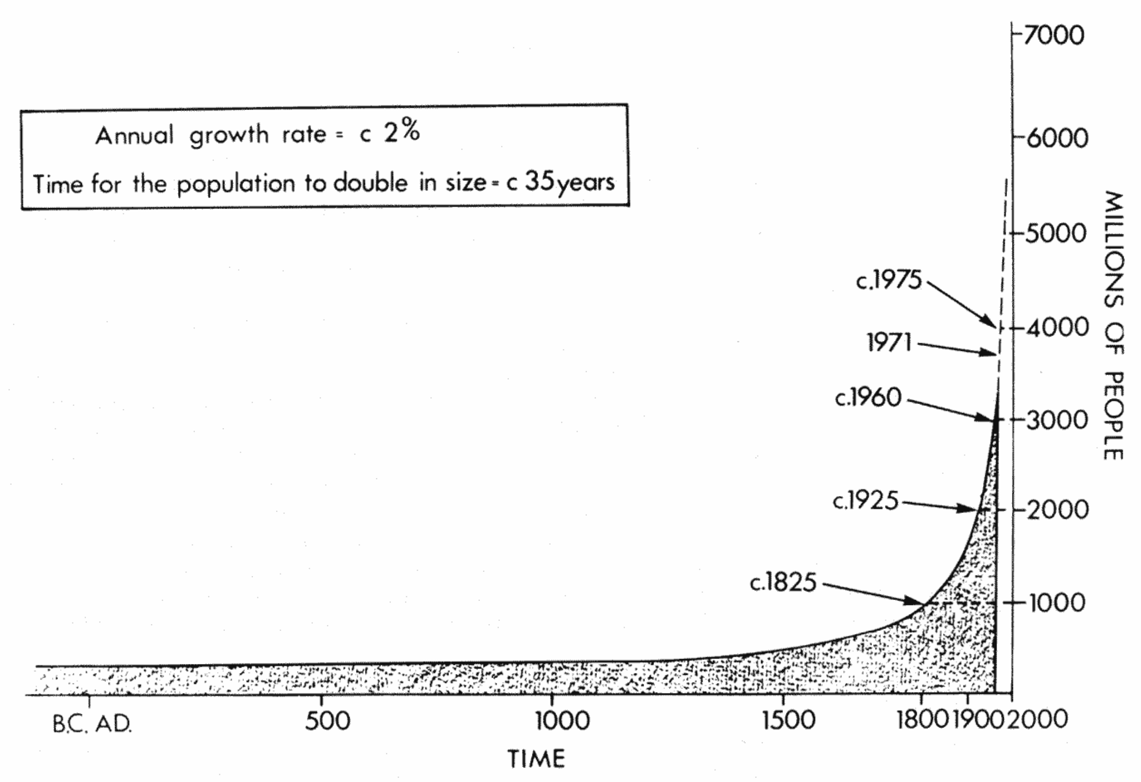

FIGURE 4 Growth of the world population showing the increasing speed with which successive billions (1000 x 106) are added. The estimate of doubling time[18] assumes constant rate of growth. Sources: 44,112

and social disruption. If these conditions are to be eliminated and yet massive emigration or mortality are not to be the brakes on population growth[130] then a limit to fertility is the only course. Improvement of the habitat, more efficient food production, better design of living space are all required as well, but ultimately the only solution is the control of numbers.

POPULATION IN NEW ZEALAND

1. *Population Growth*

The population of New Zealand at present is over 2.96 million. It is increasing at the average rate of 1.7 percent per annum[73], (Figure 5) with some differences between peoples of different races and socio-economic backgrounds[65, 72, 73]. This rate is higher than that of the U.S.A. (1.1 %), U.S.S.R. (1.0%), U.K. (0.5%) and twenty five other European countries which range from decreases of -0.8 percent to increases of 1.2 percent per annum. Each year between 1966 and 1971 over 36,000 people (approximately equal to the population of Wanganui) were added to the nation.

Government statistics indicate that by the year 2000 the New Zealand population will be approaching five millions. If growth rates are maintained at their present level after the turn of the century the population will double every 40 years reaching 10 millions by about 2040, 20 millions by 2080, 40 millions by 2120, and so on. Different predictions can be made by postulating various changes in fertility and migration. One model is the "medium fertility trend", prepared by the Department of Statistics and considered by the T.A.G. to be the most suitable demographic forecast for New Zealand. It assumes that this country will follow similar societies abroad where falling birth rates have been associated with increased urbanisation and changing social attitudes towards family planning and the family unit.

Although this suggestion, that fertility may be undergoing a slow and natural decline in New Zealand, is relevant, in our view it is not a reason for postponing Government planning in the belief that "New Zealand has no real population problem"[65]. Even the "medium fertility trend" graph of the T.A.G. report predicts that by the year 2040 the population will be in excess of seven millions and still rising at an *accelerating rate* (Figure 5).

2. *Urban Growth and Land-use*

It is only realistic to view population growth as the expansion, multiplication and merging of cities as an ever-increasing proportion of people become urban dwellers. These people now represent about 81 percent of the population, compared with about 46 percent in 1900[26, 73] (Table 1). Appreciable growth of the urban proportion of the population prior to about 1911 resulted primarily from reclassification of areas after immigration from other countries. Since 1921, and possibly since 1911, the increase in the urban proportion has largely been due to internal migration from rural to existing urban areas. This type of movement has been conspicuous among Maoris since the late 1930s[26] (Table 1). Just as there is a continuing swing from country to town living, so there is a drift from smaller to larger centres, particularly Auckland[73], and this is not necessarily a good thing[137]. If the prediction is true that 75 percent of mineral production will be in the north and west of the North Island by 1979[42], this trend may be accentuated. The advantages and disadvantages of such a pattern of distribution should receive the close scrutiny of the proposed Centre for Population Research (Appendix 2).

To accommodate expanding towns and cities, land must be converted from some other use, usually agriculture. Between 1949 and 1964 the rate of conversion of farm to urban land was about 1,053 hectares/year, whereas between 1964 and 1984 the planned rate ,will be about 1,579 hectares/year[49].The total area of farm land involved at present is small relative to the amount available, but local expansion can be harmful when high quality soils are lost to agriculture [139]. The significance of urban expansion is this: an area of productive land that is suitable for, say, growing fruit but is committed to urban development is never likely to be re-converted to production of fruit. Nor can such land be "replaced" by an equal area made available elsewhere that is suitable for, say, forestry but not fruit. Dangers of this kind face all expanding towns and cities surrounded by productive land (for example Nelson and Auckland), and they will continue so long as it is more profitable for the farmer to sell land to an urban developer than grow crops. The urgency for detailed land-use planning by local bodies as well as by the Government cannot be over-emphasised[139].

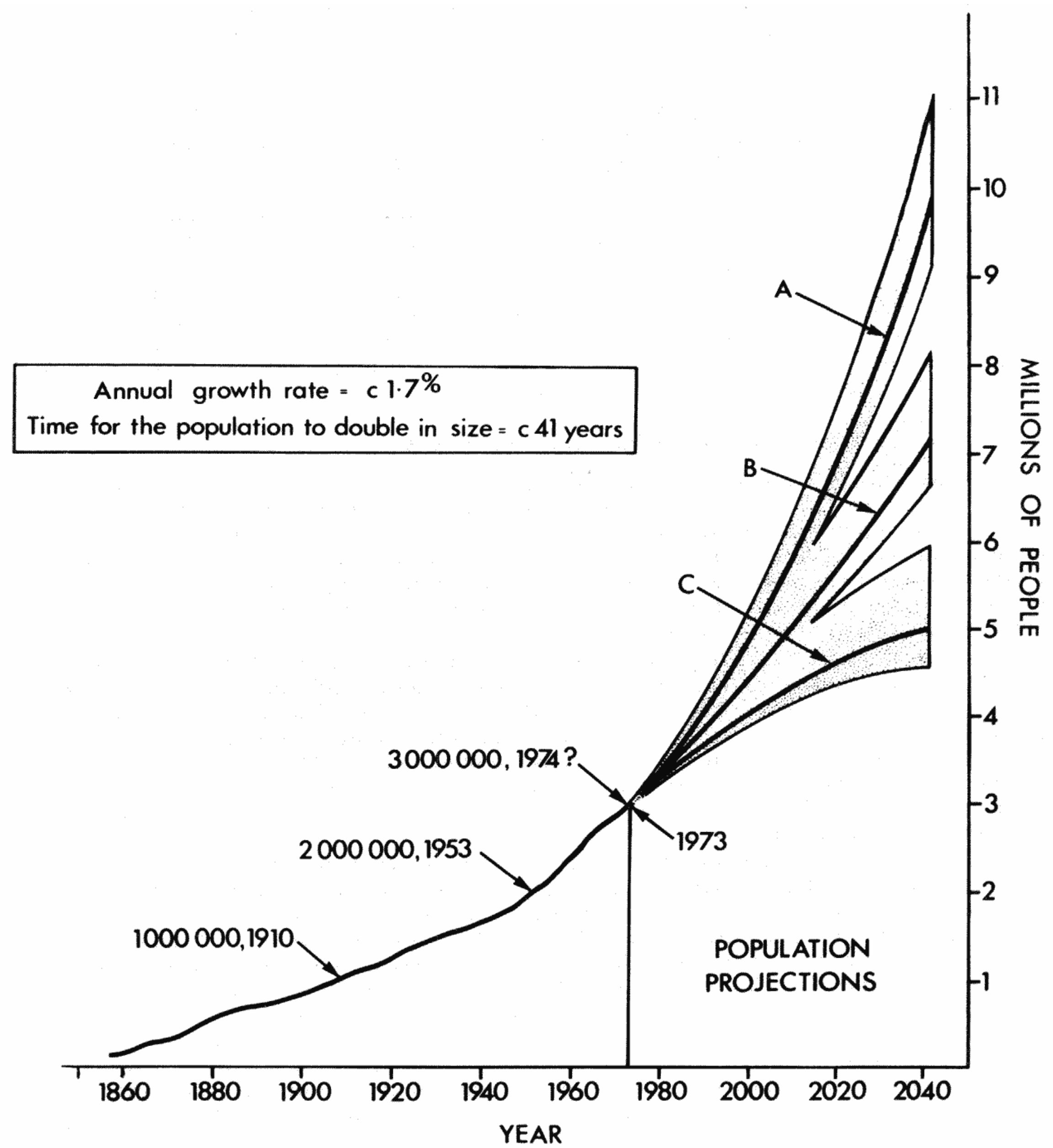

FIGURE 5 Growth of the New Zealand population with projections as in the T.A.G. Report[65]. Lines A (high fertility trend), B (medium fertility trend) and C (low fertility trend) assume 5,000 net annual immigration. The shaded zones above and below each line represent projections when the net annual immigration is assumed to be respectively 15,000 and zero. The estimate of doubling time 18 assumes constant rate of growth. Sources: 65,73.

TABLE 1 *Urban and Rural Components of the New Zealand Population as Given by the Department of Statistics, and the* 1972 *Official Yearbook**.

CENSUS	*URBAN*				*RURAL*			
	Total Population		*Maori Population*		*Total Population*		*Maori Population*	
	No.	%	No.	%	No.	%	No.	%
1926	937.3	66.9	9.8	15.4	464.3	33.1	53.8	84.6
1936	1,050.8	67.0	15.6	19.0	518.2	33.0	66.6	81.0
1945	1,211.4	71.3	24.8	25.1	487.6	28.7	73.9	74.9
1951	1,406.5	72.7	33.5	29.0	527.0	27.3	82.0	71.0
1956	1,600.8	73.8	47.6	34.7	568.8	26.2	89.4	65.3
1961	1,840.2	76.4	76.7	46.0	569.2	23.6	90.2	54.0
1966	2,119.0	79.3	122.9	61.1	553.0	20.7	78.1	38.9
1971	2,328.8	81.5	159.4	70.2	528.6	18.5	67.8	29.8

*Numbers are given in thousands. Rural data exclude shipping.

3. *Social and Other Repercussions of Population and Urban Growth*

The relatively high proportion of births among teenage women[112, 120] and a rising frequency of teenage marriages in New Zealand[70] are features typical of a rapidly expanding population. Such early marriage and reproduction can have social disadvantages, largely because of parental immaturity plus the demographic effect of a cohort of potentially reproductive individuals only 15-20 years later. Reproductive efficiency of teenage women is low compared with older groups (for example because of particular obstetric problems), and in terms of parental and child health reproduction before the age of 20 years is generally considered undesirable[37, 40, 61,120,124].

There are indications too that here, as elsewhere, the proportion of children born that are unplanned and genuinely unwanted is relatively high[22, 23, 45, 101]. As living density and family size increase child care and family relationships tend to deteriorate[67], and there is evidence that the unwanted child is at a special disadvantage[7, 38]. The incidence of infant malnutrition is higher in large families[33], and the health of both mother and children is impaired by too short an interval between consecutive babies[8]. Fulfilment of the emotional and physical heeds of a small child produces a secure and stable adult, but this demands parental care of the highest quality. Such care is forthcoming only when children are recognised as vital members of society, not as adjuncts.

Some problems that are intensified by population growth include the grossly uneven geographic distribution of the population, insufficient housing, problems of adjustment for immigrant Polynesians, the growing use of alcohol[66] and drugs and deficient health and community services in intensive housing areas. Some economic disadvantages[140] and problems such as violent crime[98] are intensified in urban areas which are expanding rapidly. Relatively high *per capita* rates of violent crime in large cities[50. 87, 98], along with other ills such as motor car accidents [76], pollution, increased noise level, other stresses, and tension are suffered by many city dwellers as "trade-off' for increased social or intellectual stimulation and material gain. Excessive population growth (leading to increased density) may become the most significant factor affecting mental ill-health by aggravating the psychological stresses inherent in balancing the need for privacy and the need for communication with other people[48]. Forward planning could minimise many of these ills while retaining the advantages of urban living.

4. *Planning for the Future*

The importance of training environmental planners is becoming recognised in New Zealand, and Lincoln College and Canterbury University have recently established new inter-disciplinary degrees.

There is a growing number of groups and scientific journals which are concerned largely or solely with management of the environment[41, 115]. Prudent resource management will need to be based increasingly upon principles of multiple land-use in order to accommodate the varied, sometimes incompatible, requirements of primary and secondary production, energy production, urban growth, recreation and the environment. The demands for water are an example. Whether land is used for one or several purposes, tomorrow's *per capita* share of some resources, such as recreational facilities[10], simply cannot be as large as it is today.

Whether or not present forecasts are correct in detail our population cannot increase indefinitely. Moreover, every additional person must be cared for in a finite amount/of space and with limited resources. For every family a house or flat must eventually be built, for every 200 children a primary school, for every 37,600 persons a general hospital[31]. If we in New Zealand are to plan our future environment sensibly, then we must begin by planning our numbers. The time is past when decisions about family size could be taken by each couple without regard to the community at large. In the future, would-be parents must be educated to consider the effects of additional children upon the population and its resources.

It is salutary to recall that our children, not ourselves, will inherit the results of our actions and will be members of the vastly bigger and more competitive population of the 21st Century. If these points are recognised then it is time to decide: when will we stop growing? Shall we stop voluntarily or wait until a halt is imposed by forces outside our control? How big a population do we want? How can we adjust our economy to a stable population size? Ecologists believe that these questions must be tackled now while we still have some choice of action.

CONCLUSION

In this paper we have tried to explain how the living world is related to the non-living world and the processes which contribute to the continuity, stability and survival of plant and animal populations. All plants and animals interact with a limited variety of living and non-living things, often in a limited geographical area. But man's habitat is the world, and there is no part of the surface of the earth that he cannot explore, nor any organism or material that he may not manipulate. He therefore has a concomitant responsibility to maintain stable world ecosystems, if only for his own benefit. It should now be clear that man, though considering himself a special case, is still gripped by the same pressures that limit all other species and that he is not infinitely adaptable to increasing population density, pollution and changes in habitat. While technology may improve food production, resource utilisation and pollution control, the greatest contribution man can make to solving the population-resources problem is an active commitment to ecological principles.

Just as populations of animals are linked by nutritive interactions, movement and competition for resources (including space), so human populations interact with each other in a more complicated way. Trade binds human populations firmly together, and the demands of each nation affect all others. For this reason it is false to suppose that the actions of New Zealanders affect neither people living in other countries nor the resources in common use.

The ecological relationships outlined have been established from studies of natural systems, but their application is so general that in the last analysis, man's survival also depends on obeying the immutible ecological laws not to over-populate or over-exploit his habitat. To quote Gibb[25]: "only one thing seems certain: that once populations become over-crowded, they will be knocked back somehow. It is this certainty, born of experience with other animals, that frightens ecologists when they are confronted with a graph of world population trends for *Homo sapiens*. They have seen its shape before."

STATEMENTS AND RECOMMENDATIONS

1. *Introduction*

Depending upon the proportions of material and non-material expenditure in the economy, con tinuous population growth necessitates use of resources at at least a steady rate *per capita* and probably at an increasing rate. In addition, sociological disadvantages resulting from high and rising population density are likely to intensify with growth[10, 50, 83, 110]. Sooner or later growth of population *must* stop, hence restraining measures appear prudent if only to give time for rational thought. This conclusion has been reached by others in New Zealand[3, 24, 75, 114] and elsewhere[43, 52, 57, 59, 60, 96, 108], and the 1970 Physical Environment Conference recommended research into the relationship between the population, the economy and the environment[90]. Initial action taken in some countries is listed in Appendix 1.

There are always certain conflicts between the population, the environment, the economy and the Government which ought not to be ignored. The existence of a present or impending clash between human requirements and the environment is stressed by some (including ecologists) but denied by others. The severity of such a clash is also a matter of debate, as is the required treatment[32, 106]. The T.A.G. has stressed that increased environmental pressures due to population growth will not be serious here, "provided adequate environmental planning and control takes place". This cannot come about unless well financed research programmes are begun immediately.

2. *Statement 1: Population Growth*

The T.A.G.[65] has recognised that "endless cumulative growth of population and production '" is not possible ... ", but while acknowledging that government policies could affect demographic trends it concluded that "New Zealand ... is not yet in a situation where steps need to be taken to halt all net immigration and discourage further natural increase in population". The T.A.G. discussed three variants of zero population growth.

First, immediate adoption of a policy of no population growth. Such a policy would result in an advantageously smaller population, but it would upset the age structure of the population for a generation or more and produce other social and practical disadvantages which weigh against it.

Second, a stabilised population might be achieved eventually if a natural decline in the birth rate led to an equal replacement rate sometime next century. Though selected by the T.A.G., this is effectively a course of "no-action" that is uncertain and therefore undesirable.

A third possible way of achieving a stabilised population is by *gradually* implementing a deliberate policy of family replacement only. This would be a positive step requiring public education, careful guidance by the Government, regular monitoring and the need for a clearly set population goal. Stabilisation of the population would be a planned rather than hoped-for event and could avoid the major ill-effects of too hasty *ad hoc* measures. It would inevitably alter the age structure of the population (as indeed would any significant increase or decrease in the present rate of growth) but it should not lead to a proportion in the older age groups that is undesirably large, providing that suitable economic and social planning has occurred. Any problems associated with the support of a proportion of older people relatively larger than at present would be heavily outweighed by the benefits of stability and small compared with the problems associated with unceasing growth of the population. The argument that New Zealand cannot afford a stabilised population or that this will come about naturally is wrong. On the contrary, ecological experience shows that we cannot afford not to stabilise our population.

The concept of a target population size has many difficulties that have been pinpointed by the T.A.G.[65]. Nevertheless this nettle can and must be grasped sooner or later, and the necessary thought and research should start now[81, 108]. Whether a course of action or inaction is followed, problems will arise, and on balance it will be easier to solve them while the population is still relatively small. Whatever we do now our children will bear the consequences.

RECOMMENDATION 1

That the Government should consider urgently establishing a permanent, interdisciplinary "Centre for Population Research", funded to undertake research and to advise the Government on the status of the population of New Zealand in relation to local resources and the environment and to the world population and resources.*

RECOMMENDATION 2

That the Government should increase educational effort to make the public aware of the effects each new child has upon the whole community and its resources.

3. *Statement II: Land use*

Many of New Zealand's natural forest, tussock grassland and wetland ecosystems have been destroyed or severely modified since the arrival of Man. Areas which are susceptible to soil erosion remain physically (and ecologically) unstable. The Government has adopted a policy of retirement from agricultural production of these critical areas as part of an evolving scheme of Land and Resource Use which embodies the optimum or multiple use of Crown lands. However, there is need for more rapid implementation of this scheme and extension of the work of the Land Use Advisory Council to freehold land. A Land and Resource Use Plan for New Zealand should embody the principle that such resources are finite and must be used wisely for the benefit of the whole community. Our soil, forest, water and mineral resources need to be documented and their potential uses (including, where desirable, reservation from active use) assessed by an impartial planning agency. In ecosystems used for intensive primary production, it will be necessary to devise forms of management which recognise the unity of catchments and which will not grossly alter the capacity of the ecosystem to cycle energy and nutrients. In areas managed less intensively it should often be possible to combine several uses of the land (primary production, water and soil conservation, recreation, visual amenity and so on) in a stable mosaic. At the other end of the scale some representative ecosystems will be so important that they should be preserved from all but minimum interference. However, most remaining natural ecosystems are in mountainous areas; very little is left of the natural lowland ecosystems outside Fiordland and the west coast of the South Island. The bulk of our lowland and hill country supports forms of primary production (17.6 million hectares. or 65.4% of the land[73]) and it will be necessary to employ greater sensitivity in the variety of uses to which this resource is put. These uses will need to be based upon sound ecological principles, as well as a broad understanding of individual needs and of demography.

RECOMMENDATION 3

That the Government should accelerate its review of existing land-use policies so as to formulate a comprehensive Land and Resource Use plan. This plan should recognise the need for both natural and managed ecosystems and ensure the protection of valuable productive land from urban growth.

4. *Statement III: The Economy*

Economic and Population Growth

The New Zealand economy, like that of other countries, has been, and is, following a course of expansion[62, 63, 64]. The rate of economic growth is some function of population growth, since each population increment implies increased investment in new facilities and services. Many economists hold that growth of an economy is necessary and justified. This philosophy is acceptable only if productivity is

*See Appendix 2.

rising and if improvements to the quality of life are measured not only by material standards but also by health, social, cultural and environmental indicators. Notwithstanding views to the contrary[126], rising pollution and degradation of our habitat may result from some types of economic growth.

The common measure of economic progress, G.N.P., comprises several major components (personal consumption, spending by local and central government, investments and so on) the levels of which can be manipulated from time to time. As mentioned in the Introduction some of these components can be regarded justifiably as indicators of "ill-fare" rather than welfare. To assess "quality of life" a new index is required which isolates the wasteful components of G.N .P. and counts them as costs, not benefits.

Although an economy organised towards zero economic growth is feasible[4, 84] it might involve some economic and social disadvantages. But because the population obviously cannot grow indefinitely, the economy must eventually evolve to suit a population of stable size. The economy can still grow even if the population does not[12]. A stable population can maintain economic growth by improved technology and by altering the components of G.N .P. so that individuals still enjoy improvements in personal services and in the quality of life. An economy geared to no population growth would inevitably mean reduced investment in new areas, and adjustments in industry and elsewhere, but these need not be deleterious. For instance, the building trade could be phased gradually and profitably into replacement rather than innovative activities; the packaging industry could usefully operate more within a system in which the materials used are readily biodegradable or can be re-used instead of thrown away. Recently the Monetary and Economic Council considered "that on economic grounds a shift to a stationary population would be advantageous eventually"[140], while in America the Presidential Commission on Population Growth and the American Future stated: "We have looked for, and have not found, any convincing economic argument for continued population growth. The health of our country does not depend on it, nor does the vitality of business nor the welfare of the average person."[12]

Use of Resources

Competitive economic growth fosters a high rate of consumption and exploitation of resources in most countries[133], especially the most affluent ones[79]. .Undesirable results of this in terms of poor resource management, rough handling and pollution of the environment may well out-weigh the advantages claimed for rapid economic growth[64]. New industries that are unacceptable elsewhere because of the kind or amount of pollution produced should not be adopted quickly here.

The demand for all resources will increase greatly by the turn of the century - for example the power required by New Zealanders in 1981 is expected to be double that in 1971. Even if we can meet these immediate demands[31, 65] we must ask: In how many cases can the supply of a resource be doubled and how often? The Monetary and Economic Council[140] advocates more efficient use of resources, but the problem is more than simply one of waste-disposal or extravagance; for example, packaging of some cosmetics is a significant proportion of the purchase price, and the allied problems of advertising to create "needs" and to push sales requires attention in the future.

In summary, economic growth need not have serious ecological disadvantages if the pattern of expenditure comprising the G.N.P. is appropriate. But even if some depleted resources could be substituted by others [1, 126] we cannot indefinitely use all resources at an increasing rate. The basic need is to move away from a purely exploitive economy towards one in which conservation, recycling of non-renewable resources and avoidance of undue pollution are of central importance[27]. The question is not so much whether economic growth is desirable, but rather, as the Monetary and Economic Council[140] points out, what pattern of growth it should be.

RECOMMENDATION 4

That the Government should modify its economic policy so that ecologically desirable recycling and pollution control are economically attractive to the public: and to industry.

5. *Statement IV: International Considerations*

New Zealanders enjoy very high *per capita* rates of use of space, food and energy compared with most other people, and the world trading system enables us to acquire necessities which we lack at home. Hence we form part of a system in which, however it is analysed, the numbers of people are increasing and with them demands for all supporting requirements. The innate reproductive capacity of our present population commits us to a substantially larger population a generation hence. Beyond that time demographic prediction is difficult, but a vague hope that the population might then grow more slowly, or even stabilise, is not enough. Sooner or later a decision must be made to halt population growth the world over, otherwise life supports will ultimately collapse from too-rapid use or from pollution. Such a decision will be reached only after lengthy international discussion of such thorny subjects as the unequal distribution of goods and power between social and political groups, and the effects of any population proposals upon poor as well as affluent peoples[6, 104].

RECOMMENDATION 5

That because the problems of population growth and use of resources are global and cannot be considered solely at a national level, the Government should participate actively in any international discussions aimed at solving these problems.

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Notes

127. The major geographical world ecosystems, for example tropical rain forest, tundra etc. are often called "biomes". They can be further subdivided into smaller ecosystems for purposes of description or study. The ecosystem concept is not tied to any particular area of land, and ecosystem boundaries are always more or less arbitrary.
128. "Carrying capacity" must not be taken to imply the existence of a threshold below which all is well and above which the species is in immediate danger. Carrying capacity varies in space and time according to gradual changes in a variety of parameters associated with population size.
129. The post-war "baby boom" caused a bulge in the age structure with predictable consequences for kindergartens, schools, etc. in later years.
130. Mortality or emigration on the largest scale experienced in modern times still do not provide useful alternatives to lowering the birth rate even if they were acceptable. At the present rate of growth of the world's population all civilian and military deaths in the Second World War (41-49 million. In: Dupuy. R.E.; Dupuy. T.N. 1970. *The encyclopaedia of military history: From 3500BC to the present*. Harper & Row, N.Y.) would be replaced in about eight months. The 10 million refugees that arrived in India from Bangladesh in 1971 represented only a small fraction of the population of Bangladesh, but were still not able to remain in India.
131. Calculations are based on the assumption that the present supply of houses, schools and hospitals is the least number required by the population, and that notwithstanding advances in fields such as preventive medicine each additional population increment would require new buildings in order to retain community services at the same level. At 31 March 1970 the N.Z. population was 2,860,873. There were 76 general public hospitals, and 2,257 State primary and intermediate schools or departments serving 486,435 pupils as at 31 December 1970. New Zealand Yearbook, 1972.
132. The Forest Research Institute, Rotorua, is currently undertaking, research into mixed livestock farming and forestry (see *New Zealand Journal of Agriculture,* (1972), 125:20-24) and similar experiments are being made at the Ministry of Works, Soil Conservation Demonstration Farm in Hawke's Bay.
133. The crux of the spiralling international problem of competitive economic development, and the inevitable results, is nicely demonstrated by the Special Committee of the Canadian Senate. This Committee recently observed that Canada "may in time move closer to zero economic growth, as may the rest of the developed world." Meanwhile Canada needs "to promote at least an equal economic growth, even if (she also has to) expend rather more effort than before on minimising its negative impact on the environment and the quality of life in (her) large urban communities".[102].
134. Figures for annual local production of pesticides etc. and of fertilisers, and annual imports of these commodities refer to statistical years ending in different months[63]." and therefore cannot be directly or readily compared. However for the purpose of measuring crude change in use over a ten year period the values of N .Z. made items and of imported items have been combined. In the period 1958-1968 the Consumer Price Index rose 36 percent (1965 = 1,000), allowing a rough estimate of 30 percent for changes in respect of industrial commodities such as pesticides and fertilisers. The increase in quantum of use over the period 1958-1968 is then obtained by expressing the 1968 value/1.30 as a percentage increase over the 1958 value/1,000.

Value in $000	1958	1968
N.Z. made insecticides, fungicides and weedkillers	2,638	4,904
Imported insecticides and weed killers	2,005	1,776
N .Z. made chemical and organic fertilisers	19,010	48,109
Imported fertilisers	3,678	6,397
Consumer Price Index	809	1,103
	(1965 =1,000) -	

135. Environmental problems (possibly resulting from economic growth) are essentially restricted to those of pollution in: Treasury economic paper No. 2 (1973) *Economic growth: is it worth having?* Government Printer, Australia.
136. The relationship between standard of living and personal welfare is discussed by THRING. M. 1973. The equations of Survival. *New Scientist* 57:482-483.

137. Although animal populations usually concentrate where resources are richest, it is inappropriate for man necessarily to do the same. Animals normally avoid the major deleterious effects of excessive increase in population size and density by means of responses (mentioned in the Section on Regulation of population size) to increasingly unfavourable environmental pressures. In man these responses, which otherwise would ameliorate stresses in the population, are partly or totally suppressed. It is desirable therefore to provide incentives that encourage a more even spread of people, and reduce the sociological disadvantages and pressures of use on land and recreational resources associated with high density areas.

138. Material (resource) and non-material (cultural) factors contributing to the cause of disease and death of infants is discussed by Y ANKAUER. A. 1970. An approach to the cultural base of infant mortality in India. In: *Social Demography*. Editors T.R. Ford and G.F. de Jong. Prentice Hall, New Jersey.

139. Some of the conflicting attitudes towards the use of productive land adjacent to urban areas are summarised by FORREST, J. 1973. Physical and social aspects of urban growth and renewal. In: *Contemporary New Zealand. Essays on the human resource, urban growth and problems of society*. Editors K. W. Thomson and A.D. Trlin. Hicks Smith & Sons Ltd, in association with the Department of Geography, Massey University. Forrest states that cost benefit analysis has not yet been applied in New Zealand for the use of our best soils, accounting for their agricultural potential, the economics of replacing their productive capacity elsewhere, the cost of diverting urban expansion and the effects of increasing residential densities. This sort of problem deserves national as well as local attention. A map illustrating the distributions of New Zealand's towns and cities in relation to good ploughable land is given by Cox, J. W. In: *New Zealand Soil Bureau* 1968. Soils of New Zealand. Part 1 p. 121. New Zealand Soil Bureau Bulletin, 26(1).

140. The significance and interrelationship of population and economic growth is thoughtfully questioned by the NEW ZEALAND MONETARY AND ECONOMIC COUNCIL 1973. *Growth – December* 1973. Report No. 26. Govt Printer, Wellington.

APPENDIX 1

ACTION INITIATED IN OTHER COUNTRIES

In the United Kingdom a Select Committee Report[101] concluded that Government action was needed to avert the intolerable consequences of population growth and made recommendations. As a result of this, the British Government in 1971 appointed a Population Panel to assess the significance of population growth in public affairs and private life, to recommend what further work was required and how it should be conducted[86]. This panel took the view that Britain would be better off with a stationary population than with an expanding one, stressed the need for greatly increased demographic research, and recommended the establishment of a centre for population studies as well as government provision of comprehensive family planning services[91]. A minister with special responsibility for population matters was appointed in December 1973.

In the United States of America the Presidential Commission on Population Growth and the American Future[12] examined the likely effects of different growth rates on the economy, society, government, resources and the environment. The Commission concluded (p.110) that no substantial benefits would result from continued growth of the population, and recommended that the nation should "plan for a stabilised population".

The Singapore Government recently recognised the danger of undue expansion of the population of that country[77] and enacted legislation to restrain further growth. The 1964 Asian Population Conference[17] recognised that rapid population growth in many Asian countries was impeding efforts to attain good standards of living and recommended that countries consider moderating population growth. Recently the World Bank and the U.N. Fund for Population Activities agreed to assist a programme to reduce the population growth rate in Malaysia".

The U.N. Conference on the Human Environment held in Stockholm in 1972 recommended increased research into problems associated with the growing human population and recommended that a World Population Conference be held in 1974 under United Nation auspices[113].

APPENDIX 2

THE PROPOSED CENTRE FOR POPULATION RESEARCH

1. *Organisation*

We envisage that the Centre for Population Research should at least comprise personnel with training in ecology, demography, economics, law, statistics, systems methods, medical, social, natural and physical sciences and administration. It should have access to all relevant information and be responsible directly to the Prime Minister.

2. *Responsibilities*

The Centre for Population Research could fill two significant roles:

1. It could view the New Zealand population as a unit interacting with the populations of other countries and drawing upon the resources common to all. On the basis of demographic, economic, health, environmental and other information it could then provide for the Government a continual synthesis.
2. The Centre could execute research into problems of special significance to planning for the New Zealand of the future. By promoting, and where appropriate, coordinating research in other governmental agencies and universities, the Centre could usefully serve as a national focal point for work related to populations.

Many topics of direct relevance to growth of the population require urgent examination by a body such as the proposed Centre for Population Research. These include:

1. The rationale for gradually stabilising the population, and the introduction of immigration and economic measures appropriate to this action.
2. The long term effects of the continuing drift of the population from rural to urban areas, and from small to large centres.
3. The effects of increasing population size and density on mental health and living standards.
4. The calculation of a target population size.
5. The formulation of a population policy.
6. The synthesis of an index of "standard of living" that takes account of health, social, environmental and aesthetic needs of the individual.
7. The advantages of voluntarily limiting family size, and of planning every pregnancy.
8. The advisability of providing through the Public Hospital Service contraceptive advice, contraceptives and sterilisation for males and females.
9. The gradual removal, according to some test of means, of existing tax concessions or benefits for families and the re-allocation of these funds.