15.964 Strategies for Sustainable Growth, Fall 1973: OK
Background Readings

DRAFT INTRODUCTION

Carroll L. Wilson

Many of our economic and social "articles of faith" are under scrutiny as never before. How much does economic growth help the poor? Will inflation continue to erode our enjoyment of the fruits of economic growth? Are the material goals and purchaseable status symbols of our high comsumption, throw away society really worthwhile? If, some day soon, the petroleum lines to oil-gulping, affluent societies are cut off, will people be forced to acknowledge that quality of life is not directly related to energy construction per capita?

Assuming that exponential growth must cease or lead to ecological disaster, we at M.I.T. decided to investigate environmentally sustainable modes of growth and to conceptualize models for a future steady-state America. As the world's largest consumer of everything, the United States seemed the perfect case for study; U.S. citizens, 6% of the world population, use up 33% of the worlds energy and a sizeable part of the other non-renewable resources. American might serve as a model for other countries, as well as save the global heritage of natural resources, if she could achieve a transition to a steady-state.

We wondered what the system of values, life-style, and form of government in this American would be like. What lessons could be learned from study of the history of earlier societies which had remained stable for long periods of time? Would transition to steady-state be easier in Japan, where an ethic of group action and loyalty take the place of the American spirit of individualism? Could the steady-state evolve, or would revolution be required to effect drastic change?

It had all begun three years ago, in July of 1970, when Professor Jay W. Forrester of M.I.T. created the World Dynamics model of contemporary society.[1] Its most important variables were population, capital investment, natural resource depletion, and pollution. Utilizing computer extrapolations of growth rates from 1900 to 2100, Forrester predicted that resources were depleted, population growth out ran food supply, or pollution became increasingly dangerous. The message of the book was dramatic: there are limits to material growth on a finite globe which must be recognized and lived within if life itself is to be preserved.

One important suggestion of the World Dynamics studies was that, if the life system were to outgrow the carrying capacity of the earth, a sharp decline would take place before the system could be readjusted to a sustainable level. We delay too long before taking remedial action. It may often be many years before a new technology like nuclear power utilization, for example, becomes significant. In the United States, nuclear power furnishes only 1% of our energy after 25 years of effort and the expenditure of billions of dollars. While nuclear fusion is acclaimed as a means to practically limitless energy, scientists are as yet unable to control nuclear fusion in the laboratory. In the absence of acute crises our social and political machinery is operated slowly and inefficiently, and we plan no further into the future than five or ten years.

In World Models, combinations of the possible remedial policies were "tried out" in the hope that one might be found which would lead to the establishment of a steady-state. One set of policies which seemed to achieve such a stabilized world system was the following:

Notes on Sustainable Systems

By

Carroll L. Wilson

23 September 1973

As more people begin to accept the CoR Assessment of the World Problematique and the inevitability of limits to growth on a finite and largely inhabited and utilized planet responsible thought is turning to Sustainable Systems. Thus far there has been very little research or writing on this subject. We can expect rising interest in this subject as greater attention is given to possible answers to the Problematique.

For the purpose of this discussion a Sustainable System is one in dynamic balance on the one hand with the Biosphere and on the other with the Ethosphere. By System I mean a society--really a nation state which is the political, decision-making unit of our times. I regard the pattern of national boundaries and the nationalistic behaviour of nation states from the largest to the smallest as one of the most fixed features of the present world. As such I seek solutions within this pattern. Others believe solutions are possible only by major changes in this pattern. The fixity of the pattern of 135 national sovereign states has been greatly fortified by the rules and structure of the United Nations--a membership organization in which each member has equal rights and privileges--to speak, to hold office, to vote, and to be represented in the many activities and agencies of the United Nations. The obligations of the U.N. members are weighted according to wealth, but the rights and privileges are equal for all.

This system fortifies immensely the motivations of national states not to lose their identity by joining federations with neighbors, and not to alter their boundaries however arbitrarily these were drawn, lest they imperil their national identity and thereby jeopardize their continued recognition and acceptance as nation states with all the rights and privileges that go with such status. Nation states may include within their boundaries many culturally distinct and socially differentiated systems, but there is no indication that fragmentation

into more cohesive and culturally homogenous nation states is going to occur. Remember Biafra.

States do join in loose regional associations with others or in meetings with other states holding similar political views--e.g. the Conference of Non-Aligned States. But these are of an economic kind such as the European Community or a military kind such as NATO or the Warsaw Pact, and in no case does the full national identity of the member state become obscured. Another feature of the international setting within which sustainable national systems must be seen is the impermeability of national borders to migration. In most of the world migration of peoples from one nation to another has ceased. Not since the movement of millions of people after the separation of India and Pakistan 25 years ago has there been mass permanent migration. Millions did flee into India during the recent war which led to the creation of Bangladesh, but such refugees are expected to return to Bangladesh and most of them have done so.

The case of Europe is unique--millions of people from southern Europe have gone to work in France, Switzerland, Germany and Benelux but very few have been accepted as permanent residents. The agony of finding nations to accept a few tens of thousands of educated and skilled Uganda Asians last year reminds us of the inhospitality of nations to immigrants.

The Biosphere is the total physical/biological environment in which the System functions. The Ethosphere is the total web of values, traditions, attitudes, cultural, social, political and governmental which determines the behaviour of the System. If the Biosphere sets quantitative constraints on the System, the Ethosphere comprises the means by which the System develops a mode which allows it to achieve and to maintain a dynamic balance with the Biosphere whose constraints are changing.

With this introduction I will state some of the features of a Systainable System which arise from the constraints of the Biosphere. These include --

1. Population stability at a level which can be sustained in relation to (a) the people-impact on the biosphere and (b) in relation to the availability of goods and services and (c) the decisions within the

Ethosphere which determine the per capita sharing of goods and services.

2. Renewable resources levels which are on a perpetual yield basis.

3. People X Economic Activity levels which do not exceed the environmental regeneration capacities of the Biosphere--land, air, water, wilderness, etc.

4. Non-renewable resource useage which maximizes product lifetime and recovery for reuse.

5. Energy use systems which maximize renewable fuels and fuel efficiency and minimize energy demand.

6. A fixed capital stock in which additions do not exceed depreciation.

It is important to remember that although a sustainable system may be a stagnant system it need not be. In fact, a great variety of activities in a society are compatible with the constraints set by the Biosphere on a Systainable System. Most educational, cultural and many recreational activities can meet the low energy use, low non-renewable resource use, low environmental impact constraints of the Biosphere. Different cultures have great differences in the value structures and traditions which may make easy or difficult a transition to sustainable system state. The obsession with growth--principally economic growth--is very recent in many parts of the world. Sets of values compatible with a sustainable system are within the experience of many living people.

The Ethosphere of each society will determine how and whether there exist within it sufficiently powerful motivations and means of social action to achieve and maintain a sustainable system. Features which in most societies might work toward stability include --

a) Broad income distribution and few rich or poor.

b) Wide access to impartial justice, to health services, and to the opportunity for education.

c) Sufficiently decentralized decision-making to engage a large fraction of the members of the society yet strong enough central management of the system to maintain it in a sustainable mode.

The Ethosphere of societies differ so greatly that generalizations are difficult and hazardous. One of the most durable, sustainable systems is the African tribal village which may include (a) and (b) above but not (c).

If a first focus is on sustainable systems which are nation states what are the relations between such units and the allowable interdependencies. One of the rising sources of frustration in achieving or maintaining an acceptable quality of life in many countries is believed to arise from the growing urban concentrations of people and rising interdependencies within states. Meeting the conditions for sustainable systems may mean reducing such interdependences.

Similarly in the global scene interdependencies have been rising and have been considered an unqualified good. Yet it is probably true that there are explicit limits to the dependency of a system on external relations if it is to achieve and maintain a sustainable mode. Part of the study of this whole field will surely be the scale, nature and degree of dependence of such external relations in terms of the dynamics of sustainable modes for a single society.

In these notes I have identified only a few topics in an immensely complex puzzle. I believe it is important that as we probe ever deeper into these questions we keep an open mind on the issues of interdependence whether within a society trying to achieve and maintain a sustainable mode or in the global scene of many societies.

During a seminar at M.I.T. in 1972-73 we examined some of these questions in relation to the United States as we sought to visualize a sustainable system. Many of the insights reported in these notes come from discussions in the seminar and papers written by the participants. We are encouraged to believe that a book bringing together our papers and those by others which we found most useful would meet a need. Attached to these notes is the Table of Contents of that book with a brief statement identifying each paper. We hope that the book will be published early in 1974.

The seminar is continuing in 1973-74 and one of its activities will be to assist the Committee of the United States Congress which will be holding hearings on Growth and Its Implications.

some suggestions as to people that we might contact for more extended hearings later in the fall. We will do all this fairly soon.

If we can use you, I can assure you that your help will not only be useful, it will be essential if we are to come out of this with the kind of output that I think we can produce and that you have, in fact been demanding that we do.

That is all I have.

Mr. DINGELL. Mr. Mills?

Mr. MILLS. Nothing else.

Mr. DINGELL. Gentlemen, the Chair thanks you for your patience, your attendance, and for your very helpful testimony.

The Chair does reiterate the request made by our counsel, Mr. Potter.

The Chair does advise that we will keep the record open for a reasonable period during which it is the hope and the intention of the Chair that each of you and that other interested citizens should have an opportunity to make submissions and suggestions with regard to the contents of the hearings today and also with regard to the future activities of this committee in this area as may be appropriate.

The Chair does advise that we would very much look to each of you because of your high expertise in this area to give us your counsel as to further activities by this committee in this area.

The Chair is, as you know, much apprehensive of the failure to ignore the problems of growth, the bounds of growth, and so forth.

In the past weeks, the committee staff has prepared a series of questions dealing with a number of growth-oriented issues. Last week, a revised version of this request was mailed to each of today's panelists, and we are asking them to review this and to suggest ways in which these questions may be best explored. Without objection, this material will be included in the record at this point.

[The document follows:]

RELEVANT GROWTH ISSUES

Prophets of catastrophe, their critics and basic governmental issues

Limits to growth;
International issues, including development of third world;
National issues; and
State and local issues, including inner-city problems.

Basic parameters of growth and technical considerations

Population increase;
Economic growth;
Resource scarcity;
Environmental pollution;
Land use; and
Adjustment mechanisms: market system and the "technological fix."

Outlook for Government action

Treatment of growth issues by executive branch; and
Implications of growth for Congress and for the committee.

LIMITS TO GROWTH

What are the constraints to growth on a worldwide scale? What are the costs of continued growth, and what are the costs of constrained growth? What are the short- and long-term implications of present growth trends and of constrained growth?

DISCUSSION

The publication of *Limits to Growth* by the Club of Rome and the publication of "Blueprint for Survival" in Great Britain reopened the debate on the degree to which economic growth and population increase are sustainable given the limitations of finite resource availability and finite capacity of the biosphere to dispense pollution. Both documents point toward catastrophe if growth is not limited soon.

Critics of these antigrowth spokesmen question the assumptions upon which the predictions of doom are based and point to the history of unrealized eschatological predictions as well as to the weakness of the predictive models themselves. Critics point to technological advances and the market system as factors making adjustment to changing resource availabilities less difficult.

The issues raised both by the prophets and their critics are worthy of attention because of their implications for public policy at all levels of government.

ISSUES FOR CONSIDERATION

(1) What is to be included under the rubric "growth"? Economic productivity? population? technological capability? standards of living?

(2) To what extent is growth sensitive to public policy changes?

(3) Assuming that the earth has finite capacities, what happens as the limits of those capacities are approached? Does precipitous decline result—as the authors of "Limits" assume—or will there be smooth, gradual adaptation of social systems? (See discussion of market mechanisms and technologic advance.)

(4) Are the problems described by "Limits" real and pressing, and if so what is the degree of their immediacy?

INTERNATIONAL ISSUES

Economic growth, population growth, and the issues which surround them are of critical importance to both developed and underdeveloped nations. Attitudes toward growth and toward the relative demand for resources among the developed and underdeveloped nations differ considerably. What are the implications of growth patterns around the world for U.S. policy?

DISCUSSION

For years growth, especially economic growth, has been the aim of most nations of the world. Only recently has it been seriously questioned. Developed nations aimed at growth to maintain or raise their already relatively high standards of living, and underdeveloped nations aimed at growth in order to survive. Booming increases in population, especially in the underdeveloped nations of the Third World, continue to reinforce the need for economic growth.

As world resources become more heavily burdened, the differences in demands placed on resources by the different nations will raise the already visible question of equity. Are some nations placing unjustifiably high demands on resources at the expense of others?

ISSUES FOR CONSIDERATION

(1) Do developing nations have any choice other than seeking to increase their rates of growth?

(2) Are developing nations receiving fair prices for their raw materials?

(3) What are the international implications of increasing demands for energy? Is the current U.S. energy problem strictly a national problem?

(4) What are the implications of multinational corporations on worldwide rates of growth as well as on growth rate differentials among the nations?

(5) What international organizations have studied and made recommendations on growth problems? What have their findings and recommendations been, and what are the implications of their work for U.S. policy?

(6) What is the status of international cooperation to deal with pollution problems?

(7) What are the implications of international growth problems for U.S. national defense and security?

National Issues

Is a national growth policy for the United States desirable, and what is involved in the formulation of such a policy? What should be the content of such a policy and how it could be implemented?

DISCUSSION

For a number of years writers from a variety of fields have been calling for the development of a national policy on growth. These calls have been made in several different contexts. Some have been aimed at economic growth, some at urban and some at population growth. Calls for a growth policy have reflected attitudes for and against growth, or they have called for more rational accommodation of growth.

Early on there were calls for growth into the western lands. Later there were calls for policy to increase the rate of national economic growth, to stimulate growth in the depressed regions of the country. During the late sixties there developed calls for a national urban growth policy—calls which eventually resulted in the Urban Growth and New Community Development Act of 1970 (title VII of the 1970 HUD act). More recently there have been calls for national policy to constrain economic growth and population increase in order to conserve scarce natural resources and to protect the environment.

The development of national growth policy has implications at all levels of government and for a variety of interests.

ISSUES FOR CONSIDERATION

(1) What should a national growth policy seek to achieve, how should it be formulated, and who should play key roles in the formulation?

(2) What impact could we expect a national growth policy or the lack of a national growth policy to have? What implementation mechanisms exist?

(3) What are the implications of plausible alternate growth policies for trade deficits, economic stability, full employment, industrial planning, tax policies, population increase and migration, environmental protection and resource planning, urban development patterns?

(4) How are Federal policies affecting growth at present? How can changes in these policies be expected to affect growth in the future?

(5) How will environmental legislation such as air and water bills probably affect growth?

(6) What are appropriate congressional responses to calls for the development of a national growth policy?

State and Local Issues

How are State and local governments and interests related to national growth issues? To what extent should national policy be an aggregation of state and local ("bottom-up") policy—as opposed to a centrally determined ("top-down") policy?

DISCUSSION

Whether growth policy is to be left in the hands of State and local governments or dominated by the Federal Government is a major question. (At least one bill was introduced in the 92d Congress to establish a federal agency charged with national growth policy planning, and national land use policy bills, which have major growth implications, received extensive consideration during the 92d Congress. Several bills have also been introduced during the 93d Congress). The answer to the question will be determined in large measure by intergovernmental structures established both by the Constitution and by practice. Political pressures at the various levels of the federal system will also influence the outcome of the question—even if it happens that the question is left unanswered.

Some efforts are being made now to implement State and local growth policy decisions. Oregon, for example, has shown interest in limiting its population growth and a number of localities around the country have curtailed some forms of new construction in order to limit growth. Some of these local decisions have been the result of conscious growth-limitation policies, and others have been in response to the overburdening of public facilities such as sewage plants. In some

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cases growth limitation policies have been labeled subterfuges to avoid the construction of low-and moderate-income housing in local jurisdictions.

On the other hand, many jurisdictions resist the notion of growth limitations because of business or tax considerations or because of being economically depressed for one reason or another.

ISSUES FOR CONSIDERATION

(1) What is the difference between orderly and disorderly growth, and to what extent is such growth a State or local policy concern?

(2) How does Federal activity influence growth at the State and local levels?

(3) How would growth policy be related to local and State fiscal affairs and to the fiscal disparities among jurisdictions within metropolitan areas?

(4) Can or should a national growth policy address itself to local urban conditions such as central city decline, renewal, housing problems, poverty and the like?

(5) Is governance at the metropolitan level important in the formulation of implementation of growth policy? What kinds of environmental considerations can or ought to be delt with at the metropolitan level? What is the role of State governments in metropolitan area affairs?

(6) How can growth decisions at the State and local level be expected to impact resource use (including land use), and pollution generation? Is there a federal interest which is affected by these state and local decisions?

(7) How do state and local growth decisions influence land, marine, and fresh water wildlife habitats, and to what degree is there a Federal interest in the protection of these habitats? How can federal growth policy influence these state and local decisions?

POPULATION

The growth of population is a key element in any consideration of national growth policy. What are the prospects for population in the United States and on a worldwide basis, and how can we expect population levels and rates of growth to be sensitive to public policy?

DISCUSSION

Rates of population increase differ among and within nations and have varying implications for nations and for subnational groups. The patterns of population change—changing levels, changing rates, changing age distributions, changing mortality rates and birth rates, changing patterns of geographic distribution—all have economic and social implications.

Population growth is effected by a variety of conditions, including the technological, demographic, sociological and the ideological. The degree to which it is sensitive to public policy is not clear.

In order to understand the implications of population growth for public policy decisions, it is important to clarify the relationships among population growth and other growth variables.

ISSUES FOR CONSIDERATION

(1) What are the implications of stabilized population growth for the health of business in the United States?

(2) Through what mechanisms is pollation a function of population?

(3) What is the theory of "demographic transition" and how does it apply to current world and U.S. conditions? What are the implications of demographic transition theory for the predictions contained in Limits and Blueprint?

(4) What are the growth policy implications of the findings and recommendations of the population commissions?

(5) What are the implications of population growth for land use and the pattern of urbanization in the United States?

ECONOMIC GROWTH

Environmentalists and those worried about the rate of resource consumption are calling for restraints on national and world economic growth. To what extent is national and world economic well-being dependent on growth and what are the implications of constrained and unconstrained growth in economic productivity?

DISCUSSION

Economic growth is seen as a key variable in the maintenance of standards of living, quality of life, and the like. It is seen as both a good and a bad variable, depending on the point of view of the evaluator. Since it is seen as a variable that determines our future in many regards, and since it is a widespread belief that economic growth is sensitive to changes in public policy, it is the source of political as well as technical controversy.

ISSUES FOR CONSIDERATION

(1) What is economic growth, how is it measured, and who benefits from it?
(2) What are the costs, both tangible and intangible, of economic growth?
(3) To what extent is national and world economic well-being determined by growth rates?
(4) Is economic growth sensitive to public policy? If so, how?
(5) What are the implications of constrained economic growth for the United States, for other developed countries and for underdeveloped countries? Is continued growth good for everyone? Is constrained growth good for everyone?
(6) To what extent does improved pollution control require the wealth derived from continued economic growth?
(7) To what extent does national security (military capacity) depend on economic growth?
(8) What is the role of agricultural and rural development in economic growth? What are the environmental problems united with such development?

Resource Scarcity

Resource scarcity is a key consideration in predictions of future world and national catastrophe. What is the outlook for resource availability and what are appropriate public policy responses to problems of scarcity?

DISCUSSION

The model builders whose work foretells disaster in the not-too-distant future have been criticized because of their treatment of resource scarcity. Although the finite nature of the earth is generally acknowledged, critics of the prophets assert that although resources will be in increasingly short supply, adjustment mechanisms by which society adapts to changing conditions—the market and technological development—will lead to the availability of additional reserves, to substitution among resources and to reuse of many materials.

In spite of (or, more accurately, because of) the controversy over whether these adaptation mechanisms will be adequate to avoid catastrophe or at least to significantly delay it, the degree to which resource scarcity is a problem now and for future generations requires additional clarification.

ISSUES FOR CONSIDERATION

(1) Among resource experts how much variance exists on the degree to which both energy and nonenergy resource scarcity will lead to national and world crises?
(2) Will changing consumption patterns affect the onset of a resource crisis in any significant way?
(3) How do present governmental programs and policies affect the use and reuse of resources?
(4) What are the pollution effects of using increasingly lower-grade raw materials? What are the energy requirements for drawing upon these lower grade materials? Are we asking for a more severe thermal pollution problem by using such resources?

Environmental Pollution

Pollution can take many forms, and its effects can be both short and long-term. In many, perhaps most, respects, pollution involves the degradation of a commonly-held "good": someone else's environment. To what extent is it reasonable to develop aggregate policies for dealing with "pollution," and how are the costs and benefits of such an approach to be measured?

DISCUSSION

As a phenomenon, pollution has been with us for a very long time. It will be with us into the foreseeable future. The nations which are known as "developed" are beginning to spend considerable sums of money and amounts of time in an effort to cope with the problem; those known variously as "underdeveloped," "less developed," or "never to be developed" have been less so, although there is evidence that concern is rising here as well.

The "Limits to Growth," in its analysis of this variable, concentrated upon the long-term persistent pollutants, such as DDT and radioisotopes. It is also true that short-term pollutants can be highly toxic in their impact, although less globally significant at least on the first systems affected. Where do the real dangers exist, and how do we construct decisionmaking systems for dealing with these?

ISSUES FOR CONSIDERATION

(1) How do we assign priorities for the control of pollutants? By measurable dollar cost? By less measurable "social cost"? By ease of control? Or by source mixture of these?

(2) Who ought to make the decision to control or not control these pollutants?

(3) Who is or ought to be charged with monitoring the flow of pollutants on a global scale? How much budget should be assigned to this? How urgent is this duty.

(4) Has our dependence on this Earth's life support system ever been adequately described? Has the fragility of critical elements of that system been adequately assessed? Where do we find the biological limits to growth?

(5) At what point does a single pollutant—such as heat—become a significant concern?

(6) To what extent can we adjust to increasing levels of pollution? How long will it take and what increased levels of mortality must we accept in consequence?

(7) In what respects is the classical assumption of the "pollution threshold" still realistic?

LAND USE

Economic growth and population growth have strong land use impacts. Public policy influences land use in many direct and indirect ways, and the pattern of land use, in turn, has implications for local, regional, and national economies, for the environment, for the use of resources, and for the welfare of future generations.

DISCUSSION

Many environmental, energy, and economic problems are related to how land is used—to the spatial distribution of economic activity and settlement clusters. To some extent, other social problems have land use dimensions as well. As economic output increases and population expands, the demand for land increases as well; and land use becomes a major element of national policy. This witnessed by the congressional attention given to land use in bills before the 92d Congress. The Senate, for example passed a National Land Use Policy Act, and a Housing and Urban Development Act, with a land use element during 1972. Land use bills were also considered in the House as well.

ISSUES FOR CONSIDERATION

(1) How is land use related to economic growth, to environmental protection and to energy generation, distribution, and consumption?

(2) Do current patterns of urbanization threaten unnecessarily our land, marine, and fresh water wildlife?

(3) How can the competition for land between agricultural and nonagricultural uses be described? Is this an appropriate matter for public policy attention?

(4) How does current or recently proposed Federal policy influence or propose to influence land use? What are the growth implications? What are likely environmental impacts?

(5) What is the appropriate role for each of the various levels of Government in the federal system in land use planning and control? What are the predominant attitudes towards land use planning and control?

(6) What are the principal paradigms of land use and economic development (e.g., growth poles) and what are their policy implications?
(7) What mechanisms exist for implementing land use policy? What is the Federal interest in these mechanisms?

Market Mechanisms for Adjustment to Changing Patterns of Scarcity

How can the mechanisms of the marketplace help society adjust to declining available supplies of resources, stimulate substitution among resources, and encourage the development and application of technologies to problems of resource scarcities and of pollution control?

DISCUSSION

The critics of "Limits" and similar documents have pointed out that one of the major weaknesses of the model is that it does not reflect the existence of adjustment mechanisms which would prevent or at least mitigate or postpone the crisis which is predicted. The market is part of this set of adjustment mechanisms, since the use of scarce resources in production is a function of price, which fluctuates in the marketplace as supply and demand interact. This mechanism will have a number of effects. The first is that as price increases, new reserves of resources can become available. The second is that as price increases, substitution among various resources will occur. The third is that for many products, as price increases, the growth of aggregate demand will be restrained Other effects could be pointed out. These arguments do not allow us to cast aside or to ignore the finite nature of the Earth, but they are considerations that were not included in the formulation of the "Limits" model and they may suggest that the future problem will not be of the catastrophic nature the model builders predict.

ISSUES FOR CONSIDERATION

(1) To what extent can these market mechanisms be relied upon to allocate resources and to buffer future generations from the rapid decline depicted by limits and blueprint?
(2) What are the limitations of the marketplace? What additional incentives and restraints would be required to supplement the price system in order to influence the use and reuse of resources and to influence the generation of pollutants?
(3) How can the marketplace influence research and development efforts aimed at expanding the usability and reusability of resources and at pollution control?
(4) What would be the impact of price determination by cartels on the ability of the market to adjust consumption as physical limits are approached.

Technology as an Adjustment Mechanism

To what extent can we rely on technological advances to ease the problems of scarcity and pollution and to buffer world economic and social systems against rapid decline when growth limits are approached or reached?
What are the implications of technologic differentials among nations?

DISCUSSION

The critics of the movement to limit growth assert that technology is growing expotentially, just as are population and economic production, and that many of the dangers of growth—those associated with resource exhaustion and environmental pollution—will be mitigated by continued technological development. Others assert that this is not the case, that there are "certain kinds of pollution that cannot be avoided, short of the most far-reaching changes in our industrial technology, and one kind (thermal pollution) that cannot be avoided by any known or imagined technology." (Kaysen) Defenders of the limits notion point to the basic finite nature of the earth and to the inevitability of exhaustion in spite of technological advances that allow further exploitation of resources and reuse of resources.

ISSUES FOR CONSIDERATION

(1) What is the state of the art and the foreseeable development of technologies for expanding our ability to draw upon resource reserves?
(2) To what extent can technological methods increase food supplies?

(3) What are the costs of these technologies and how can costs be expected to change over the coming decades?

(4) What are the pollution propensities of these technologies?

(5) What is the state of the art and the foreseeable development of technologies for avoiding or removing pollutants? What are the costs?

(6) How will new technologies affect energy needs and capacities to produce that energy? How can technology affect the polluting outputs of energy production? Is the thermal pollution problem as serious as some would have us believe?

(7) To what extent are new technologies—or existing technologies—applicable to developing countries, and can their need for growth to meet immediate problems be helped by these technologies? Can they bear the costs of these technologies? Can technology help to alter the distribution of wealth and income among nations?

(8) To what extent must there be continued investment in research and development to realize future technological potentials? Do current Research and Development priorities reflect future needs with regard to resource utilization and pollution control?

EXECUTIVE BRANCH TREATMENT OF GROWTH ISSUES

How is the executive branch currently organized to deal with growth issues, and what actions has the administration taken toward the development of a national growth policy?

DISCUSSION

In 1970 the Congress required that a national urban growth policy be developed and that a unit of the President's Domestic Council submit a report on national urban growth to the Congress in every even-numbered year beginning with 1972. The President's 1972 report echoed the widespread conviction that urban growth is a special aspect of more broadly defined growth. Other aspects of growth are properly the subject of energy policy, population policy, land-use policy, materials policy, rural development policy, and the like—just as is urban growth policy. A national growth policy can be seen as a composite of these narrowly defined policies or perhaps as the umbrella under which they are gathered and interrelated.

The executive branch must necessarily play an important role in the development or a national growth policy, if one is to be developed, and it has in fact taken steps to develop an improved understanding of growth policy issues—in spite of the impressions to be gained from the 1972 growth report. The President's domestic adviser John D. Ehrlichman issued a memorandum to a number of executive agencies asking them to respond by July 20, 1972, to an extensive list of questions regarding the formulation of national growth policy.

The nature of Executive efforts toward the formulation of a national growth policy—or toward the decision of whether or not to formulate such a policy—may be of interest to the committee in order to assess the degree to which growth policy may affect the matters over which the committee has jurisdiction.

ISSUES FOR CONSIDERATION

(1) How is the pattern of national growth being affected by the management of existing Federal programs, especially with regard to energy, population, land use, urban and metropolitan development, materials, air and water resources?

(2) How is the executive branch organized to deal with growth issues?

(3) From a substantive point of view, what decisions have been made with regard to national growth policy? How were the decisions related to information provided in response to the Ehrlichman memorandum?

(4) How can the Nation's present growth policy be characterized?

(5) From the administration's point of view, where is growth sensitive to Federal, State, or local public policy?

Mr. DINGELL. The Chair again does reiterate my personal thanks to each of you, the thanks of the committee and the appreciation for your invaluable assistance to us today.

If there is no further business to come before the committee, the committee will stand adjourned until the call of the Chair.

[Whereupon, at 4:05 p.m., the subcommittee adjourned to reconvene subject to the call of the Chair.]

MEMORANDUM

TO: Members of Seminar 15.964

FROM: Carroll L. Wilson

DATE: September 24, 1973

RE: Proposed Strategy Choices and Schedule for Term

September 27	Assignment of reading "classics" of steady-state literature keeping im mind the following questions: why we should discuss the issues of growth and sustainability; how do we define sustainability, goals for sustainability, criteria by which we measure progress towards goals, and policies to undertake to meet goals.
October 4	Professor Wilson's lecture and seminar discussion of the independence/interdependence of nation states and how international politics effect strategies for establishing sustainable growth.
October 11	Discussion of the "classics" and assignment of a paper on your vision of the steady-state in a hypothetical situation--when your grandchild who is 2 years old at present will will be as old as your are now.
October 18	The "grandchild paper" is due. Discussion of everyone's paper.
October 23	Continuation of discussion of the "grandchild papers"
November 1	Discussion of strategies for sustainable society from the holistic, systemic approach.
November 8	Discussion of strategies for sustainable society from the policy-oriented approach.
November 15	Hand in a written statement of a term paper topic and a paragraph explanation.

List of "Classics" obtainable from the COOP *

* Only One Earth by Rene Dubos

* The Closing Circle by Barry Commoner

* Limits to Growth by D. Meadows, et al

* Towards a Steady-State Economy by Herman Daly

* Models of Doom Ed. by H.S.D. Cole, et al

"A Blueprint for Survival" in The Ecologist, Jan. 1972

15.963

STRATEGIES FOR SUSTAINABLE GROWTH

L I T E R A T U R E

Almost no publication deals specifically with the possible strategies for sustainable growth.But various philosophies, ideas and background data of interest for the development of such a strategy may be found in the wealth of recent publications related to the environmental issue. This list has been compiled in order to help in the search for answers of specific problems which may arise during the course. The titles listed should cover most of the existing books and articles of interest to our problems.

A short summary has been included where I have read the book already, so you may judge if its worthwile getting it from the library.

All books available at the Dewey Library are listed with their call-number.

The remark 'coop' means that the book is available at the coop of MIT.

If you need further assistance or references for other books on the environmental issue, you may call Jan-Olaf Willums x 37828 .(54-1418)

A catalogue with the relevant new articles in various journals has been set up by Toni Picardi , Building 48-212 x 31545.

jow Sept 72

1. GENERAL LITERATURE ON THE NEED FOR A NEW APPROACH

BRUBAKER , Sterling — To Live on Earth — Baltimore, John Hopkins 1972

CALDWELL , Lynton — In Defense of Earth — Bloomington, Indiana U Pr. 1972

CARR , Donald — The Breath of Life — New York Norton & Co 1965

Chase Manhattan Bank — Improving the Quality of Life — New York 1972

COMMONER , Barry — Science and Survival — New York Ballantine 1963

COMMONER , Barry — The Closing Circle — New York Knopf 1971 coop

DASMANN , Raymond — The Last Horizon — University of Toronto Pr. 1968

EISLEY , Loren — The Unexpected Universe — New York Harcourt 1964

EWALD , William — Environment and Change:The Next 50 Years — Bloomington Indiana U Pr. 1968

EWALD , William — Environment for Man :The Next 50 Years — Bloomington Indiana U Pr. 1967

FABUN , Don — The Dynamics of Change — Englewood Prentice Hall 1970

HELFRICH , Harold — Agenda for Survival: The Environmental Crisis — New Haven Yale U. Pr. 1970

HENSHAW , Paul — This Side of Yesterday: Extinction or Utopia — New York Wiley 1971

HIGBEE , Edwards — A Question of Priorities — New York Morrow 1970

NICHOLSON , Max — The Environmetal Revolution-A Guide for the New Masters of the earth — London Hodder 1970

PRAT , , Henry — Métamorphose Explosive de l'Humanité
Paris Soc.Enseign.Sup. 1961

REICH ,Charles — The Greening of America
New York Bantam 1970 coop

A book about the present situation in the US and the coming (or existing) revolution against many of the value which Technology has thrust upon us. The question is,can we develop a new Consciousness that places the Individual and Humanistic Values above the machine? Critizied as being too simplistic,misleading and presumptuous. In general synthesis of contemporary ideas.

STEVENS , Mary Otis — World of Variation
New York Braziller 107o

STILL , Henry — Man : The next 30 years
New York Hawthorn 1968

STILL , Henry — Will the Human Race Survive?
New York Hawthorn 1966

WARNER , Aaron — The Environment of Change
- - -

The ECOLOGIST — A BLUEPRINT FOR SURVIVAL
The Ecologist Vol 2 No 1 1972

A very interesting paper, similar to Limits to Growth. From the Introduction :"The principal defect of the industrial way of life with its ethos of expansion is that it is not sustainable.Its termination within the lifetime of someone born today is inevitable-unless it continues to be sustained for a while longer by an entrenched minority at the cost of imposing great suffering on the rest of mankind. We can be certain,however, that sooner or later it will end and that it will do so in one of two ways:either against our will..., or because we wish to create a society which will not impose hardship and cruelty upon our children- in a succession of thoughtful,humane and measured changes." Everyone in our group should try to get a copy of this English approach to the problem of limited growth.

2. GENERAL ENVIRONMENTAL PROBLEMS WITH RELATION TO A NEW GROWTH SYSTEM

JOHNSON	, Cecil	Eco-Crisis	New York	Wiley	197o
JOHNSON	, Huey	No Deposit - No Return : Man and His Envir. A View toward Survival	Reading,Mass	Addison-W.	1970
LOVE	, Glen	Ecological Crisis	New York	Harcourt	1970
MATTEWS	, William	Man's Impact on Climate	Cambridge	MIT Press	1971 coop
MATTEWS	, William	Man's Impact on Terrestrial and Ocean Ecosystems	Cambridge	MIT Press	1971 coop

Both books may serve well as scientific reference material of the various effects of pollution and consumption on the environment.

Mc HALE	, John	The Future of the Future	New York	Braziller	1970
MEADOWS	, Dennis	The Limits To Growth	New York	Universe	1972 coop
ODUM ,	, Howard	Environment, Power and Society	New York	Wileay	1971
HARDIN	, Garrett	Nature and Mans Fate	New York	New Amer.Libr	1959
HARTE	, John	Patient Earth	New York	Holt	1971
PRINGLE	, Laurence	Ecology-Science for Survival	New York	MacMillan	1971
RATTRAY TAYLOR	, Gordon	Le Jugement Dernier	Paris	Calmann	197o
SMITHONIAN ANNUAL II		The Fitness of Man's Environment	Washington	Smithson.Inst	1968

SNYDER , Gary — Earth House Hold — New York — New Direct. — 1957

THORPE , W.H. — Biology and the Nature of Man — London — Oxford U Pr. — 1962

THOMAS , William — Mans Role in Changing the Face of the Earth — Chicago — U.Chicago Pr — 1956

TOKYO METROPOLITAN GOV. — An Urgent Appeal for Reform — Tokyo — Metr. Gov.Pre — 1971

TUNNARD , Christopher — Man-Made America :Chaos or Control? — New Haven — Yale U Press — 1963

WEISBERG , Barry — Beyond Repair — Beacon Press — 1971

3. ECONOMICS

AUDL , D.A.L. — Economic Thinking and Pollution Problems — Toronto — U.Toronto Pr. — 1972

BARDHAM , Pranab — Equilibrium Growth in a Model with Economic Obsolence of Machines. — MIT — HB 31.M 415. no 17

An econometric model investigating a steady state growth equilibrium. The Douglas-Cobb equation is applied to this special caes, where machines embody the technology. The model is very theoretical and only interesting for students of economics- no 'general philosophy'.

BARNETT ,Harold — Scarcity and Growth — Baltimore — John Hopkins P1963

GALBRAIGHT, J.Kenneth — The Affluent Society — Boston — Houghton M — 1969 coop

HOEDL , Erich

A New View on Econ.Aspects of Pollution
in : New Approaches in Air Pollution Research
Willums Ed. Basel Birkhäuser 1973

Traditional economic theory is inadequate for the solution of environmental problems.If env.policy follows economic theory, pollution will be repaired instead of prevented.The shifting from economic theory to political economy allows the integration of economics and technology and thus the cooperation between natural sciences and social science
A short, but still quite theoretical paper

ISEA

Equilibre, Structure et Developpement
Archive de l'ISEA Paris Minard 1970

KNEESE , A.V.

Economics and the Environment
A materials balance approach
John Hopkins 1970
Dewey HC.110.E 5. K 68

KRUTELLA , John

Some Environmental Effects of Economic Development
in : Americas Changing Environment
Revelle Ed.. Boston Beacon Press 1970
Dewey HC 11o.E 5.A 512 1970

Modern Economic research has established that heads of households are motivated by a desire not only to gain satisfaction from consumption but to leave an estate.An estate may be left either as privat goods or as public goods. An aesthetically attractive, scientifically valuable natural endowment of appreciating future value may be an efficient way for the bulk of the populations to leave its heirs an estate of maximum value. This is unlikely to occur if we rely solely on the operation of the privat market...

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Toward Global Equilibrium
Wright-Allen Press 1972

MERA , Koichi

An Equilibrium Model of Regional Growth
The Case of The United States.
Cambridge Harvard RUE Progr. 1970
Dewey HT 390.H 339 no 62

Two main questions are answered in this article of the Harvard program on Regional and Urban Economics:
1) What makes growht rates vary among different regions ?
2) Is it possible to change the growth rate of a regi region by a policy decision at the regional level?
The paper (45 pages) is an applied economic study.

MORISHIMA , Michio

Equilibrium, Stability and Growth
Oxford U.of Oxford Pr. 1964
Dewey HB.71.M 861

Leontief's Input-Output model is applied to equilibrium and dynamic changes.
Chapter 2.2.: Semiglobal Stability of Equilibrium
Chapter 2.3.: Global Stability of Equilibrium
Two interesting approaches, but unfortunately only in purely theoretical equations - no general conclusion is derived from the results.
Chapter 4. : An Alternative System : The promising title deals only with equilibrium prices .

NURSKE , Ragnar

Equilibrium and Growth in the World Economy
Cambridge Harvard U P 1961
Dewey HB.33 N 974

Chapter 1o : Balanced and unbalanced Growth.
Discussion in regard to two nations with various specialization : The dominant idea is still the long range plan of 'maximum growth possible'.
Chapter 11 : Contrasting trends in 19th and 20th century world trade : Discussion of trade as an 'engine to growth'

PATTERSON , Robert

The Art of the Impossible
in : Americas Changing Environment
Revelle Ed. Boston Beacon Press 1970 coop
Dewey HC 110.E 5.A 512

The problem of who has to decide which economic policy for the changing environment is the best, is discussed. Some few interesting remarks on the decision power distribution and the usefulness of polls to establish the 'will of the public' are included, but the article is too superficial and generalized.(14 pages)

TELLER , Azriel

Economic Rationale and Reality in Air Poll.Abatement
in : Americas Changing Environment
Revelle Ed. Boston Beacon Press 1970 coop
Dewey HC 110.E 5.A 512

Short article (14 pages) discussing the best means to establish optimal environmental policies.
' the economic rationale' .
Each project (city etc.) is completely different and needs a different approach.
Not many new ideas for a society of the future with sustainable growth.

TINBERGEN , J. — Toward a Balanced International Growth
H.C.Bos Ed. - - 1969
Dewey HD 82.T 737

WEINER , M. — The Dynamics of Growth
New York Basic Books 1966

WOLLMAN , Nathaniel — The New Economics of Resources
in : Americas Changing Environment
Revelle Ed. Boston Beacon Press 1970 coop
Dewey HC 11o.E 5 a 512

'The most likely effect of a decision to upgrade the physical environment is a change in pattern of goods and service produced, with no change in GNP-at least in the short run.If we are faced with economic rootlessness and lack of purpose as a result of the technological destruction of the psychic importance of work, expenditures on environmental improvement that are economically justified on a long-term basis may be much greater than appear appropriate on the surface.Recreational experiences may have to provide a psychic substitute for work: such need may justify much larger expenditures on the natural environment than anyone today believes reasonable."

4. POLITICS

EDWALD , William — Environment and Policy : the next 50 years
London Indiana Univ.P 1968

KOSTELANTES Richard — Beyond Left and Right
New York Morrow 1968

KNEESE , Allen — Managing the Environment
New York Praeger 1971

SlESSER , Malcom — The Politics of Environment
London George Allen 1972

TUNNARD , Christopher
PUSHKAREV , Boris — Man-Made America : Chaos or Control ?
New Haven Ballantine 1963

OPHULS , William — Leviathan or Oblivion
New Haven Yale Univ. (not publ.)

A widely-acclaimed essay by Garrett Hardin is compared to the thoughts of Thomas Hobbes. Both found that uncontrolled population growth and many other serious environmental problems could be analyzed in terms of "the tragedy of commons": Men seek to maximize their gain. In the absence of control, they are driven by rational calculations of self-interest to overexploit or abuse the commons. Thus freedom in a commons brings ruin to all.Hobbes found that the only solution to the tragedy of the commons was autocratic rule. Ophuls points out that it is time to discredit the Enlightenment myth that all things are possible for man.The commons is not infinite, and men must accept less than they want. Because of the tragedy of the commons,environmental problems cannot be solved by cooperation between individual souvereignstates in a world of scarcity.We shall sooner or later be forced to choose Leviathan (Hobbes' autocratic ruled society) over oblivion.

WILDAVSKY , Nathaniel — Aesthetic Power or the Triumph of the Sensitive Minority over the Vulgar Mass
in : Americas Changing Environment
Ed : Revelle Boston Beacon Press 1970
Dewey HC 110.E 5. A 512 1970

5. INTERNATIONAL RELATIONS

CLAWSON , Marion

Natural Resources and International Development
Essays from the 5th Annual Resources for the Future Forum John Hopkins 1964

COUNCIL on ENVIRONMENTAL QUALITY

International Aspects of Environmental Quality
in : Environmental Quality
US Govnmt. 1972

This chapter is divided into 4 sections :
-review of of internat.activities at present
-internat. problems of ocean pollution
-env.standards and their effects on nat.economies and international trade
-wildlife issues of international interest.

Especially the 4th section may give some insights' in the international problems, especially when discussing the effects of a change of the growth system in an industrialized country on the developing nations.

KLINEBERG , O.

International Exchanges in Education,Science and Culture.
Publication prepared by the international Social Science Council,UNESCO 1966

6. ENVIRONMENTAL QUALITY

HERFINDAHL,Harold

Quality of the Environment
Baltimore John Hopkins 1965

JARRETT , Henry

Environmental Quality in a Growing Economy
Essays for the 6th Resources for the Future Forum
Baltimore John Hopkins 1966

KNEESE , Allen

Environmental Quality Analysis
Baltimore John Hopkins 1972

PERLOFF , Harvey

The Quality of the Urban Environment
Baltimore John Hopkins 1971

7. CONSERVATION

CURRY-LINDHAL, Kai — Conservation for Survival
New York Morrow 1972

JOFFE , Joyce — Conservation - Interdependence in Nature
London Aldus Books 1969

NASH , Roderick — Wilderness and the American Mind
New Haven Yale U Press 1967

STEPHEN , David — Equilibre dans la Nature
Paris Flammarion 1969

ZURHORST , Charles — The Conservation Fraud
New York Cowles 1970

GANNON , Collin — TOward a Strategy for Conservation in a World of Change
Regional Science Research Institute
Philadelphia 1968

8. URBAN ASPECTS

ANDERSEN , Ake — Metropolitan Growth and Unbalanced Ec.Development
in : PLAN: Urban and Regional Research in Sweden 1968
DEWEY HT 169.S8 U 72

Interesting analytical approach to the problems of an unbalances economical development and the growth of big cities. Various POLICIES are suggested. All data reflect the present situation in Sweden .(12p)

ARANGO , Jorge — The Urbanization of The EARTH
Boston Beacon Press 1970

BABUROV , A.
DJUMENTON , G. — The Ideal Communist City (transl.)
New York Braziller 1970

CHARRIER , Jean-Bernard — Ou vont les Villes ?
Paris Colin 1968

MEADOWS , Paul
MIZRUCHI , E. — Urbanism, Urbanization and Change
DEWEY HT 151. M 482

McQUADE , Walter — Cities fit to live in and How we can make them happen.
Urban Environmnet No 1
New York Macmillan 1971

PERLOFF , H.S. — The Quality of the Urban Environment
New Haven John Hopkins 1961
DEWEY HT 169 . U5. Q1

SPILHAUS , Athelstan — The Experimental City
in : Americas Changing Environment
Revelle Ed. Boston Beacon Press 1970 cOop

A short presentation of the University of Minnesota's study project of a new way of life in a city. The only 12 pages long article gives some insight into the problems one has to consider in planning a new kind of city, and may thus be a good introduction to other similar problems. the preceeding article by Gutheim ,'New Cities ?' discusses in more detail existing essays and projects for a new city.

9. POPULATION PROBLEMS

APPLEMAN , Philip — The Silent Explosion. Boston Beacon Press 1965

BEHRMAN , S.J.
CORSA , Leslie — Fertility and Familiy Planning. Ann Arbor U.of Michigan 1969

BORGSTROM , Georg — Too Many. New York Collier ‡969

Commission on the Population Growth and the American Future — Report

The committee believes that :
A gradual stabilization of the population would contribute significantly to the nations ability to solve its problem although such problems will not be solved by population stabilization alone; it would, however. enable the society to shift its focus increasingly from quantity to quality.

EHRLICH , Paul — The Population Bomb. New York Ballantine 1971 coop

FARMER , Richard
LONG , John — World Population - The View Ahead. Indiana University 1968

FRASER , Dean — The People Problem :What you should do about Growing Population and Vanishing Resources. Bloomington Indiana U P 1971

HARDIN , Garrett — Population Evalution and Birth Control. San Franc. FReeman 1969

HAUSER , Philip — The Population Dilemma. Englewood Prentice-Hall 1963

HAZEN , William — Readings in Population and Community Ecology. Philadelphia Saunders 1970

HEER , David — Society and Population. Englewood Prentice Hall 1968

9. APPLEMAN , Philip

LORAINE , John — Sex and the Population Crisis
London Heinemann 1970

MUDD , Stuart — The Population Crisi and the Use of World Resources
Bloomington Indiana U P -

PRINGLE , Laurence — One Earth - Many People : The Challange of Human Population Growth
New York McMillan 1971

RATTRAY TAYLOR, Gordon — The Biological Time Bomb
New York Amer.Libr 1968

SAX , Karl — Standing Room Only
Boston Beacon Press 1955

10. SOCIAL PROBLEMS - SOCIAL ETHIC

ALBERTSON , Peter
BARNETT , Margery — Environment and Society in Transition
The New York Academy of Sci 1970

BERRIEN , F — General and Social Systems
New Brunswick Rutgers 1968

BUCKMINSTER FULLER — Utopia or Oblivion
Bantam Sociology 1969 coop

The chapter 'Geosocial Revolution' deals with various social aspects in the typical "Buckminster-way'

MARGOLIS , Jon — Land of Ecology
in : The Ecological Conscienee coop
Disch Ed. DEWEY HC 110.E5.D611

Margolis investigates the 'modern conservationist': He discusses Wall Streets reaction on 'Stop Growing' and shows how deep the principle of growth is embodies in the American mind. Presentation of the ethic and social problems of 'No Growth".
The introduction to that part of the book , 'ecology and Social Institutions' is also worth reading!

11. LAND - ETHIC

CARSTENSEN, Vernon — The Public Lands
London U.Wisconsin P 1962

CLAWSON , Marion — America's Land and its Use
Baltimore John Hopkins 1972

CROWE , Silvia
MILLER , ZVI — Shaping Tomorrows Landscape.
Amsterdam Djambatan 1964

MOINDROT , C — Villes er Campagnes Britanniques
Paris Colin 1967

NASH , Roderick — Wilderness and the American Mind
New Haven Yale U Press 1967

SAINT MARC, Philippe — Socialisationdde la nature
Paris Stock 1971

SHOMAN , Joseph — Open Land for Urban America
Baltimore John Hopkins 1971

STRONG , Ann-Louise — CRISIS Mentality and the Deteriorating Env.
in : Americas Changing Environment
Revelle Ed. Boston Beacon Press 1970 coop
DEWEY HC 11o.E 5 A 512

Comparison of the rural land ethic to the developers' land ethic and the land ethic of the megapolitan landowner. The megapolitan stands between the two others and should be changed first and most urgently.
An example of different land ethics is presented: The Brandywine Plan.

TANDY , Clifford — Landscape and Human Life
The Impact of Landscape Architecture upon Human Activities.
? 1966

12. PHILOSOPHY

ALBERTSON , Peter
BARNETT , Margery
Environment and Society in Transition
Annals of the New York Academy of Science
Vol 184. New York Ac Science 197o

BUCKMINSTER FULLER
Approaching the Benign of Mankind
London McMillan 1970

BUCKMINSTER FULLER
Technology and the Human Environment
in : The Ecological Conscience
Disch Ed. DEWEY HC 11o.E5.D611 coop

The 'generalized' world problems in a B.F.way : He explains the need for a new look of the worlds:'We can survive only by learning to operate in our universe in a very differenr way' This way is described in some very pittoresque comparisons with the 'bird egg' and 'sailboat vs. bulldozer'. Very nice to read, although sometimes a bit too 'romantic' in its explications and examples, and very few relations to economical problems.

BUCKMINSTER FULLER
UTOPIA or OBLIVION : The prospects for Humanity coop
New York Bantam Books 1969

We do not have a future with scarcity, but one with abundance : Reason :(Thesis) :Mankind has, perhaps for the first time, the prospect of a world of maximum abundance - imminent utopia. Man will be able to solve all the physical problems of his existence because the real wealth of the world is in information and energy. And these are increasing without forseeable limits.

COMMONER , Barry
Science and Survival
New York Ballantine 1963

COMMONER , Barry
The Closing Circle
New York Knopf 1971 coop

COMMONER , Barry — To Survive on the Earth

in : The Ecological Conscience
DISCH Ed. DEWEY HC 110.E5.D611

Following a presentation of the biological factors he discusses some ethical problems and the scientists responsablity for the 'right' solution. More a discussion of how humanity can survive the new power which science has given it. He proposes drasticallchanges in economical structure and social system without giving details.

DUBOS , Rene Jules — The Dreams of Reason : Science and Utopia
New York Columbia U 1961
DEWEY Q 171. d818

DUBOS , Rene Jules — Man Adapting
New Haven Yale U Press 1965

DUBOS , Rene Jules — REASON AWAKE: Science for Man
New York Columbia U P 1970

KAHN / WIENER — The Year 2000
- - 1967

A wide range of possible future scenarios.

PELLERIN , Pierre — Lettres Ouvertes aux Assassins de la Nature
Paris Stock 1972

PRAT , Henri — Metamorphose Explosive de l'Humanite : Comprendre l'Univers ou Perir .
Paris SES,Coll.'Demain"1961

REICH , Charles — The Greening of America
New York Bantam Book 1970 coop

Can we develop a new Consciousness that places the Individual and Humanistic Values above the 'machine' ?

REVELLE , Roger

Americas Changing Environment
Boston Beacon Press 1970 coop
DEWEY HC 110.E 5 A 512

Revelle, editor of the book presents some interesting general thoughts and conclusions in the introduction :
4 areas of action are most important :
- getting rid of poison
- adopting a new land ethic
- recreating urban areas
- balancing population and resources
Quality is inescapably related to quantity . Until we learn more about ourselves, control of population is the high-priority goal.

SHEPARD , Paul
McKINLEY , Daniel

Essays on the Planet as a Home
Boston H.Mifflin 1971

SHEPARD , Paul
McKINLEY , Daniel

The Subversive Science : Essays toward an Ecology of Man
Boston H.Mifflin 1967

SEABORG , Glenn

The Transition to the Steady State Society
in : MOSAIK NSF publication fall 1970

Man can only make the transition to the steady state society when he adapts a completely new philosophy. Where there is no dream ,the people perish.

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Toward Global Equilibrium
Wright ALlen Press 1972

WATTS , Allan

The World is your Body
in : The Ecological Conscience
Disch Ed.
DEWEY HC 110 .E5.D 611

Some interesting approaches to the philosophical questions of understanding a new system. The article may help understand the environmental complexity in a new way and thus enable the reader to develop new ideas for a nwe equil. approach. In general a (too) general artivle. No direct re;ation to our study project.

13. EDUCATION OF MANKIND

BATES , Marston — Man in Nature
Englewood Prentice Hall 1961

BATESON , Gregory — Steps to an Ecology of Mind
New York Ballantine 1972

BUCKMINSTER FULLER — Education for Comprehensivity
in : Approaching the Bening Environment
Littleton Ed. U of Alabama P 1970 coop

BF urges that we need a 'new man':the COMPREHENSIVIST He gives a general view of history and states the lessons to be learned : He explaines his ' ENERGY'-view and his understanding of the univers and'Space Ship Earth' He concludes that a general educated and interested man is still the most important goal for our new society, although BF's reasoning is still more influenced by the nuclear war problem.

HAMANN , Juliana
HUNSAKER , Don — Environmental Education
Santee Jackson 19 -

KLINEBERG , O — International Exchange in Education, Science and Culture
Paris Mouton 1966
Report prepared by the International Social Science Council at UNESCO.

TERRY , Mark — Teaching for Survival
New York Ballantine 1971

THOMAS , William — Man's Role in Changing the Face of the Earth
Published for the Wenner-Gren Foundation for Anthropological Research and the National Science Foundation
Chicago U of Chicago P 1956

14. FORECASTING

Commission on Population Growth and the American Future

Report

Prediction of the US Population Growth."
A gradual stabilization of population would contribute significantly to the Nations ability to solve its problem.

Commission on the Year 2000

Toward the Year 2000
Daedalus Sum 1967

Council on Environmental Quality

Environmental Quality
US Governmnet 1972

Chapter 2 discusses in detail the importance of forecasting, citing both the Club of Rome study and the Commission on Pop.Growth and the American Future study .The difficulties of forecasting environmental trends (secondary effects ,time lags and deceptiveness of short-term projections) and the physical forces influencing future environmental conditions are presented. The 23 page long report ends with the critical role of technology,social and economic factors and the interrelationship of factors determining the future.

GILLIAM , Harold

The Fallacy of Single-Purpose Planning
in : America's Changing Environmnet
Revelle Ed. Boston Beacon Press 1970 coop
DEWEY HC 110 .E5.A512

After a number of examples of insufficient single-purpose planning some promising new plans and organisations are presented. An optimal planning groupi is discussed, which has a limited power due to the adequate legislation, but is efficient in terms of professional personnel.

RESOURCES for the FUTURE Inc.

US Energy Policies - An agenda for research
Baltimore John Hopkins 1968

15. RESOURCES

ALLEE , David

American Agriculture:Its resource issue for the coming years
in : America's changing environment
Revelle Ed. Boston Beacon Press 1970 coop

Allee suggests the displacement of farms and of land. Alternative use of resources. Government has to increase help to farming. In order to make the agriculture a 'competititve' business the timehorizon for planning has to be increased.

BORGSTROM , Georg

The Hungry Planet
London Mc.Millan 1 55

BROWN , Harrison

The Challange of Man's Future
- - 1956

The book deals with availability of resources in relation to population growth and technology.

Council on Environmental Quality

Resource Demand for the US for 1960-2000
US Government Printing

DARBY

DARBY , H.C.

Resources Management in other countries
- - 1961
DEWEY SD 411 r 434

FULLER PROJECTS

Inventory of World Resources.
Human Trends and Needs.
Carbondale South. Illin. U.1965

LANDSBERG , Hans

Natural Resources for the US:PA look ahead to the year 2000.

MUDD , Stuart

The Population Crisis and the use of World Resources.

RESOURCES FOR THE FUTURE

U.S.Energy Policy - an agenda for research.
John Hopkins 1968

16. LAW

ASSOCIATION POUR LE DEVELOPPEMENT DU DROIT MONDIAL — La Defense de l'Homme contre les Pollutions.
Paris Pedone 1970

SAX , Joseph — Defending the Environmnet
New York Knopf 1971
DEWEY HC 11o .E5.S272

Discussion of the legal questions in environmental protection : Many examples, but few, suggestions how a 'new society' could control pollution: In appendix : A model law, rather for todays use; some useful remarks on tomorrows necessary legal approaches.

17. INTERDISCIPLINARY APPROACH

COUNCIL ON ENVIRONMENTAL QUALITY — Environmental Quality Report
US Government 1972

Discussion of various fields where interdisciplinary work is necessary, and where a cooperation between the governmnet and citizen groups seems to be desirable.

KILLIAN , J — Toward a Working Partnership of the Science and Humanities
in : Approaching the Beningn Environment
New York Collier 1972 coop

The burden of responsability for 'todays future' lies on the shoulders of science and humanities : Their cooperation is necessary in order to solve the present problems. The article has few very new ideas and its solutions are more directed toward the 'atomic bomb problem'.

PERIN , Constance — With Man in Mind : An Interdisciplinary Prospectus for Environmental Design
Cambridge MIT Press 1970 coop

SLOBODKIN , L.B. — Aspects of the Future in Ecology
in : The Ecological Conscience
Disch Ed. DEWEY HC 110.E5.D611 coop

Practical problems on the social level are first discussed. The 'ecological Engineering" : Ecology has to develop to a whole science, so research can be improved. The various branches of this new science must get together in order to develop new systems. The existing 'ecoscience' problems are listed : Under 'pure ecology' is also mentioned ;"The Theory of Stability Conditions in Non-linear,Evolving feedback Systems"

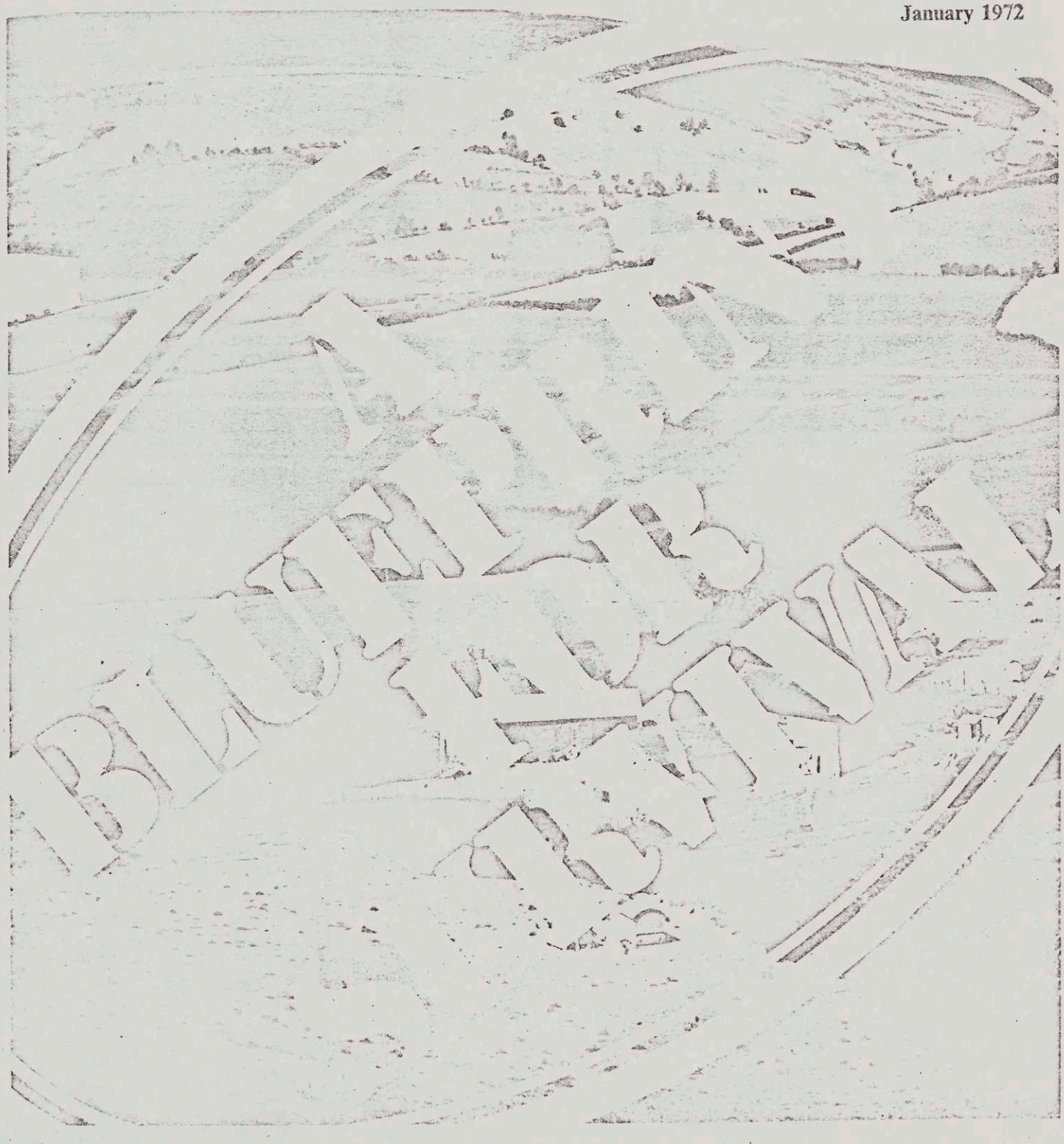
WALKER , E.A. — Engineers and the Nations Future
in : Approaching the Benign Environment
New York Collier 1972 coop

Engineers must recognize more and more the importance of the social sciences and must solve complex social problems with their engineering tools and approaches.

The Price of Power, Electric Utilities and the Environment. Economic Priorities Report Vol. 3 No. 2, May/June 1972 of the Council on Economic Priorities, 456 Greenwich Street, New York, N.Y. 10013

Ecologist

January 1972



A BLUEPRINT FOR SURVIVAL

Statement of Support

The undersigned, without endorsing every detail, fully support the basic principles embodied in the *Blueprint for Survival* which follows (pp 1-22), both in respect of the analysis of the problems we face today, and the solutions proposed.

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The Ecologist

Vol. 2 No. 1 January 1972

A BLUEPRINT FOR SURVIVAL

Preface

This document has been drawn up by a small team of people, all of whom, in different capacities, are professionally involved in the study of global environmental problems.

Four considerations have prompted us to do this:

1. An examination of the relevant information available has impressed upon us the extreme gravity of the global situation today. For, if current trends are allowed to persist, the breakdown of society and the irreversible disruption of the life-support systems on this planet, possibly by the end of the century, certainly within the lifetimes of our children, are inevitable.

2. Governments, and ours is no exception, are either refusing to face the relevant facts, or are briefing their scientists in such a way that their seriousness is played down. Whatever the reasons, no corrective measures of any consequence are being undertaken.

3. This situation has already prompted the formation of the Club of Rome, a group of scientists and industrialists from many countries, which is currently trying to persuade governments, industrial leaders and trade unions throughout the world to face these facts and to take appropriate action while there is yet time. It must now give rise to a national movement to act at a national level, and if need be to assume political status and contest the next general election. It is hoped that such an example will be emulated in other countries, thereby giving rise to an international movement, complementing the invaluable work being done by the Club of Rome.

4. Such a movement cannot hope to succeed unless it has previously formulated a new philosophy of life, whose goals can be achieved without destroying the environment, and a precise and comprehensive programme for bringing about the sort of society in which it can be implemented.

This we have tried to do, and our *Blueprint for Survival* heralds the formation of the MOVEMENT FOR SURVIVAL (see p 23) and, it is hoped, the dawn of a new age in which Man will learn to live with the rest of Nature rather than against it.

THE ECOLOGIST

Edward Goldsmith, Robert Allen, Michael Allaby, John Davoll, Sam Lawrence.

Editor: *E. R. D. Goldsmith*; Deputy Editor: *Robert Allen*; Associate editors: *Michael Allaby, Peter Bunyard, John Davoll, Jimoh Omo Fadaka, Lawrence D. Hills, Brian Johnson, S. G. Lawrence, Jean Liedloff, Charles Maclean, John Papworth, Robert Waller*. Production and design by *The Soil Association*. Administration: *Joyce Robson*. Editorial copy and advertising enquiries should be sent to The Editor, The Ecologist, 73 Kew Green, Richmond, Surrey. Telephone 01-948 0690.

Published by Ecosystems Ltd., registered office 11 Mansfield Street, Portland Place, London W1M 0AH and distributed by the Hachette Group, Continental Publishers and Distributors Ltd., 4 Regent Place, London W1R 6BH; Telephone: 01-734 5259; Telegrams: Aglibrairi London W1; Telex 25114. Subscriptions to: The Ecologist, 73 Kew Green, Richmond, Surrey. Printed by The Garden City Press Ltd., Pixmore Avenue, Letchworth, Hertfordshire, SG6 1JS.

A BLUEPRINT FOR SURVIVAL

Introduction: the need for change

110. The principal defect of the industrial way of life with its ethos of expansion is that it is not sustainable. Its termination within the lifetime of someone born today is inevitable—unless it continues to be sustained for a while longer by an entrenched minority at the cost of imposing great suffering on the rest of mankind. We can be certain, however, that sooner or later it will end (only the precise time and circumstances are in doubt), and that it will do so in one of two ways: either against our will, in a succession of famines, epidemics, social crises and wars; or because we want it to—because we wish to create a society which will not impose hardship and cruelty upon our children—in a succession of thoughtful, humane and measured changes. We believe that a growing number of people are aware of this choice, and are more interested in our proposals for creating a sustainable society than in yet another recitation of the reasons why this should be done. We will therefore consider these reasons only briefly, reserving a fuller analysis for the four appendices which follow the *Blueprint* proper.

111. Radical change is both necessary and inevitable because the present increases in human numbers and *per capita* consumption, by disrupting ecosystems and depleting resources, are undermining the very foundations of survival. At present the world population of 3,600 million is increasing by 2 per cent per year (72 million), but this overall figure conceals crucially important differences between countries. The industrialised countries with one-third of the world population have annual growth rates of between 0.5 and 1.0 per cent; the undeveloped countries on the other hand, with two-thirds of the world population, have annual growth rates of between 2 and 3 per cent, and from 40 to 45 per cent of their populations is under 15. It is commonly overlooked that in countries with an unbalanced age structure of this kind the population will continue to increase for many years even after fertility has fallen to the replacement level. As the Population Council has pointed out: "If replacement is achieved in the developed world by 2000 and in the developing world by 2040, then the world's population will stabilise at nearly 15.5 billion (15,500 million) about a century hence, or well over four times the present size".

112. The *per capita* use of energy and raw materials also shows a sharp division between the developed and the undeveloped parts of the world. Both are increasing their use of these commodities, but consumption in the developed countries is so much higher that, even with their smaller share of the population, their consumption may well represent over 80 per cent of the world total. For the same reason, similar percentage increases are far more significant in the developed countries; to take one example, between 1957 and 1967 *per capita* steel consumption rose by 12 per cent in the US and by 41 per cent in India, but the actual increases (in kg per year) were from 568 to 634 and from 9.2 to 13 respectively. Nor is there any sign that an eventual end to economic growth is envisaged, and indeed industrial economies appear to break down if growth ceases or even slows, however high the absolute level of consumption. Even the US still aims at an annual growth of GNP of 4 per cent or more. Within this overall figure much higher growth rates occur for the use of particular resources, such as oil.

113. The combination of human numbers and *per capita* consumption has a considerable impact on the environment, in terms of both the resources we take from it and the pollutants we impose on it. A distinguished group of scientists, who came together for a "Study of Critical Environmental Problems" (SCEP) under the auspices of the Massachusetts Institute of Technology, state in their report the clear need for a means of measuring this impact, and have coined the term "ecological demand", which they define as "a summation of all man's demands on the environment, such as the extraction of resources and the return of wastes". Gross Domestic Product (GDP), which is population multiplied by material standard of living appears to provide the most convenient measure of ecological demand, and according to the UN *Statistical Yearbook* this is increasing annually by 5 to 6 per cent, or doubling every 13.5 years. If this trend should continue, then in the time taken for world population to double (which is

estimated to be by just after the year 2000), total ecological demand will have increased by a factor of six. SCEP estimate that "such demand-producing activities as agriculture, mining and industry have global annual rates of increase of 3.5 per cent and 7 per cent respectively. An integrated rate of increase is estimated to be between 5 and 6 per cent per year, in comparison with an annual rate of population increase of only 2 per cent".

114. It should go without saying that the world cannot accommodate this continued increase in ecological demand. *Indefinite* growth of whatever type cannot be sustained by *finite* resources. This is the nub of the environmental predicament. It is still less possible to maintain indefinite *exponential* growth —and unfortunately the growth of ecological demand is proceeding exponentially (i.e. it is increasing geometrically, by compound interest).

115. The implications of exponential growth are not generally appreciated and are well worth considering. As Professor Forrester explains it,[1] "... pure exponential growth possesses the characteristic of behaving according to a 'doubling time'. Each fixed time interval shows a doubling of the relevant system variable. Exponential growth is treacherous and misleading. A system variable can continue through many doubling intervals without seeming to reach significant size. But then in one or two more doubling periods, still following the same law of exponential growth, it suddenly seems to become overwhelming".

116. Thus, supposing world petroleum reserves stood at 2,100 billion barrels, and supposing our rate of consumption was increasing by 6.9 per cent per year, then as can be seen from Figure 1, demand will exceed supply by the end of the century. What is significant, however, is not the speed at which such vast reserves can be depleted, but that as late as 1975 there will appear to be reserves fully ample enough to last for considerably longer. Such a situation can easily lull one into a false sense of security and the belief that a given growth rate can be sustained, if not indefinitely, at least for a good deal longer than is actually the case.* The same basic logic applies to the availability of any resource including land, and it is largely because of this particular dynamic of exponential growth that the environmental predicament has come upon us so suddenly, and why its solution requires urgent and radical measures, many of which run counter to values which, in our industrial society we have been taught to regard as fundamental.

117. If we allow the present growth rate to persist, total ecological demand will increase by a factor of 32 over the next 66 years—and there can be no serious person today willing to concede the possibility, or indeed the desirability, of our accommodating the pressures arising from such growth. For this can be done only at the cost of disrupting ecosystems and exhausting resources, which must lead to the failure of food supplies and the collapse of society. It is worth briefly considering each in turn.

Disruption of ecosystems

120. We depend for our survival on the predictability of ecological processes. If they were at all arbitrary, we would not know when to reap or sow, and we would be at the mercy of environmental whim. We could learn nothing about the rest of nature, advance no hypotheses, suggest no "laws". Fortunately, ecological processes *are* predictable, and although theirs is a relatively young discipline, ecologists have been able to formulate a number of important "laws", one of which in particular relates to environmental predictability: namely, that all ecosystems tend towards stability, and further that the more diverse and complex the ecosystem the more stable it is; that is, the more species there are, and the more they interrelate, the more stable is their environment. By stability is meant the ability to return to the original position after any change, instead of being forced into a totally different pattern—and hence predictability.

121. Unfortunately, we behave as if we knew nothing of the environment and had no conception of its predictability, treating it instead with scant and brutal regard as if it were an idiosyncratic and extremely stupid slave. We seem never to have reflected on the fact that a tropical rain forest supports innumerable insect species and yet is never devastated by them; that its rampant luxuriance is not contingent on our overflying it once a month and bombarding it with insecticides, herbicides, fungicides, and what-have-you. And yet we tremble over our wheatfields and cabbage patches with a desperate battery of synthetic chemicals, in an absurd attempt to impede the operation of the immutable "law" we have just mentioned—that all ecosystems tend towards stability, therefore diversity and complexity, therefore a growing number of different plant and animal species until a climax or optimal condition is achieved. If we were clever, we would recognise that successful long-term agriculture demands the achievement of an artificial climax, an imitation of the pre-existing ecosystem, so that the level of unwanted species could be controlled by those that did no harm to the crop-plants.

122. Instead we have put our money on pesticides, which although they have been effective, have been so only to a limited and now diminishing extent: according to SCEP, the 34 per cent increase in world food production from 1951 to 1966 required increased investments in nitrogenous fertilisers of 146 per cent and in pesticides of 300 per cent. At the same time they have created a number of serious problems, notably resistance—some 250 pest species are resistant to one group of pesticides or another, while many others require increased applications to keep their populations within manageable proportions—and the promotion of formerly innocuous species to pest proportions, because the predators that formerly kept them down have been destroyed. The spread of DDT and other organochlorines in the environment has resulted in alarming population declines among woodcock, grebes, various birds of prey and seabirds, and in a number of fish species, principally the sea trout. SCEP comments: "the oceans are an ultimate accumulation site of DDT and its residues. As much as 25 per cent of the DDT compounds produced to date may have been transferred to the sea. The amount in the marine biota is estimated to be in the

* It is perhaps worth bearing in mind that the actual rate of petroleum consumption *is* increasing by 6.9 per cent per year, and according to the optimistic estimate of W. P. Ryman, Deputy Exploration Manager of the Standard Oil Company of New Jersey, world petroleum reserves (including deposits yet to be discovered) are about 2,100 billion barrels.

order of less than 0.1 per cent of total production and has already produced a demonstrable impact upon the marine environment . . . The decline in productivity of marine food fish and the accumulation of levels of DDT in their tissues which are unacceptable to man can only be accelerated by DDT's continued release to the environment . . ."

123. There are half a million man-made chemicals in use today, yet we cannot predict the behaviour or properties of the greater part of them (either singly or in combination) once they are released into the environment. We know, however, that the combined effects of pollution and habitat destruction menace the survival of no less than 280 mammal, 350 bird, and 20,000 plant species. To those who regret these losses but greet them with the comment that the survival of *Homo sapiens* is surely more important than that of an eagle or a primrose, we repeat that *Homo sapiens* himself depends on the continued resilience of those ecological networks of which eagles and primroses are integral parts. We do not need to utterly destroy the ecosphere to bring catastrophe upon ourselves: all we have to do is to carry on as we are, clearing forests, "reclaiming" wetlands, and imposing sufficient quantities of pesticides, radioactive materials, plastics, sewage, and industrial wastes upon our air, water and land systems to make them inhospitable to the species on which their continued stability and integrity depend. Industrial man in the world today is like a bull in a china shop, with the single difference that a bull with half the information about the properties of china as we have about those of ecosystems would probably try and adapt its behaviour to its environment rather than the reverse. By contrast, *Homo sapiens industrialis* is determined that the china shop should adapt to him, and has therefore set himself the goal of reducing it to rubble in the shortest possible time.

Failure of food supplies

130. Increases in food production in the undeveloped world have barely kept abreast of population growth. Such increases as there have been are due not to higher productivity but to the opening up of new land for cultivation. Unfortunately this will not be possible for much longer: all the good land in the world is now being farmed, and according to the FAO[2], at present rates of expansion none of the marginal land that is left will be unfarmed by 1985—indeed some of the land now under cultivation has been so exhausted that it will have to be returned to permanent pasture.

131. For this reason, FAO's programme to feed the world depends on a programme of intensification, at the heart of which are the new high-yield varieties of wheat and rice. These are highly responsive to inorganic fertilisers and quick-maturing, so that up to ten times present yields can be obtained from them. Unfortunately, they are highly vulnerable to disease, and therefore require increased protection by pesticides, and of course they demand massive inputs of fertilisers (up to 27 times present ones). Not only will these disrupt local ecosystems, thereby jeopardising long-term productivity, but they force hard-pressed undeveloped nations to rely on the agro-chemical industries of the developed world.

132. Whatever their virtues and faults, the new genetic hybrids are not intended to solve the world food problem, but only to give us time to devise more permanent and realistic solutions. It is our view, however, that these hybrids are not the best means of doing this, since their use is likely to bring about a reduction in overall diversity, when the clear need is to develop an agriculture diverse enough to have long-term potential. We must beware of those "experts" who appear to advocate the transformation of the ecosphere into nothing more than a food-factory for man. The concept of a world consisting solely of man and a few favoured food plants is so ludicrously impracticable as to be seriously contemplated only by those who find solace in their own wilful ignorance of the real world of biological diversity.

133. We in Britain must bear in mind that we depend on imports for half our food, and that we are unlikely to improve on this situation. The 150,000 acres which are lost from agriculture each year are about 70 per cent more productive than the average for all enclosed land[3], while we are already beginning to experience diminishing returns from the use of inorganic fertilisers. In the period 1964–9, applications of phosphates have gone up by 2 per cent, potash by 7 per cent, and nitrogen by 40 per cent[4], yet yields per acre of wheat, barley, lucerne and temporary grass have levelled off and are beginning to decline, while that of permanent grass has risen only slightly and may be levelling off[5]. As *per capita* food availability declines throughout the rest of the world, and it appears inevitable it will, we will find it progressively more difficult and expensive to meet our food requirements from abroad. The prospect of severe food shortages within the next thirty years is not so much a fantasy as that of the continued abundance promised us by so many of our politicians.

Exhaustion of resources

140. As we have seen, continued exponential growth of consumption of materials and energy is impossible. Present reserves of all but a few metals will be exhausted within 50 years, if consumption rates continue to grow as they are (see Figure 2). Obviously there will be new discoveries and advances in mining technology, but these are likely to provide us with only a limited stay of execution. Synthetics and substitutes are likely to be of little help, since they must be made from materials which themselves are in short supply; while the hoped-for availability of unlimited energy would not be the answer, since the problem is the ratio of useful metal to waste matter (which would have to be disposed of without disrupting ecosystems), not the need for cheap power. Indeed, the availability of unlimited power holds more of a threat than a promise, since energy use is inevitably polluting, and in addition we would ultimately have to face the problem of disposing of an intractable amount of waste heat.

Collapse of society

150. The developed nations consume such disproportionate amounts of protein, raw materials and fuels that unless they considerably reduce their consumption there is no hope of the undeveloped nations markedly improving their standards of living. This vast differential is a cause of much and growing discontent, made worse by our attempts at cultural uniformity on behalf of an expanding market economy. In the end, we are altering people's aspirations without providing the means for them to be satisfied. In the rush to industri-

alise we break up communities, so that the controls which formerly regulated behaviour are destroyed before alternatives can be provided. Urban drift is one result of this process, with a consequent rise in anti-social practices, crime, delinquency, and so on, which are so costly for society in terms both of money and of well-being.

151. At the same time, we are sowing the seeds of massive unemployment by increasing the ratio of capital to labour so that the provision of each job becomes ever more expensive. In a world of fast diminishing resources, we shall quickly come to the point when very great numbers of people will be thrown out of work, when the material compensations of urban life are either no longer available or prohibitively expensive, and consequently when whole sections of society will find good cause to express their considerable discontent in ways likely to be anything but pleasant for their fellows.

152. It is worth bearing in mind that the barriers between us and epidemics are not so strong as is commonly supposed. Not only is it increasingly difficult to control the vectors of disease, but it is more than probable that urban populations are being insidiously weakened by overall pollution levels, even when they are not high enough to be incriminated in any one illness. At the same time international mobility speeds the spread of disease. With this background, and at a time of widespread public demoralisation, the collapse of vital social services such as power and sanitation, could easily provoke a series of epidemics—and we cannot say with confidence that we would be able to cope with them.

153. At times of great distress and social chaos, it is more than probable that governments will fall into the hands of reckless and unscrupulous elements, who will not hesitate to threaten neighbouring governments with attack, if they feel that they can wrest from them a larger share of the world's vanishing resources. Since a growing number of countries (an estimated 36 by 1980) will have nuclear power stations, and therefore sources of plutonium for nuclear warheads, the likelihood of a whole series of local (if not global) nuclear engagements is greatly increased.

Conclusion

160. A fuller discussion of ecosytems and their disruption, of social systems and their disruption, of population and food supply, and of resources and their depletion, can be found in Appendices A, B, C and D, respectively. There will be those who regard these accounts of the consequences of trying to accommodate present growth rates as fanciful. But the imaginative leap from the available scientific information to such predictions is negligible, compared with that required for those alternative predictions, laughably considered "optimistic", of a world of 10,000 to 15,000 million people, all with the same material standard of living as the US, on a concrete replica of this planet, the only moving parts being their machines and possibly themselves. Faced with inevitable change, we have to make decisions, and we must make these decisions *soberly* in the light of the best information, and not as if we were caricatures of the archetypal mad scientist.

161. By now it should be clear that the main problems of the environment do not arise from temporary and accidental malfunctions of existing economic and social systems. On the contrary, they are the warning signs of a profound incompatibility between deeply rooted beliefs in continuous growth and the dawning recognition of the earth as a space ship, limited in its resources and vulnerable to thoughtless mishandling. The nature of our response to these symptoms is crucial. If we refuse to recognise the cause of our trouble the result can only be increasing disillusion and growing strain upon the fragile institutions that maintain external peace and internal social cohesion. If, on the other hand, we can respond to this unprecedented challenge with informed and constructive action the rewards will be as great as the penalties for failure.

162. We are sufficiently aware of "political reality" to appreciate that many of the proposals we will make in the next chapter will be considered impracticable. However, we believe that if a strategy for survival is to have any chance of success, the solutions must be formulated in the light of the problems and not from a timorous and superficial understanding of what may or may not be immediately feasible. If we plan remedial action with our eyes on political rather than ecological reality, then very reasonably, very practicably, and very surely, we will muddle our way to extinction.

163. A measure of political reality is that government has yet to acknowledge the impending crisis. This is to some extent because it has given itself no machinery for looking at energy, resources, food, environmental disruption and social disruption as a whole, as part of a general, global pattern, preferring instead to deal with its many aspects as if they were self-contained analytical units. Lord Rothschild's Central Policy Review Staff in the Cabinet Office, which is the only body in government which might remedy the situation, appears not to think it worthwhile: at the moment at least, they are undertaking "no specific studies on the environment that would require an environmentalist or ecologist". There is a strong element of positive feedback here, in that there can be no appreciation of our predicament unless we view it in totality, and yet government can see no cause to do so unless it can be shown that such a predicament exists.

164. Possibly because government sees the world in fragments and not as a totality; it is difficult to detect in its actions or words any coherent general policy, although both major political parties appear to be mesmerised by two dominating notions: that economic expansion is essential for survival and is the best possible index of progress and well-being; and that unless solutions can be devised that do not threaten this notion, then the problems should not be regarded as existing. Unfortunately, government has an increasingly powerful incentive for continued expansion in the tendency for economic growth to create the need for more economic growth. This it does in six ways:

Firstly, the introduction of technological devices, i.e. the growth of the technosphere, can only occur to the detriment of the ecosphere, which means that it leads to the destruction of natural controls which must then be replaced by further technological ones. It is in this way that pesticides and artificial fertilisers create the need for yet more pesticides and artificial fertilisers.

Secondly, for various reasons, industrial growth, particularly in its earlier

phases, promotes population growth. Even in its later phases, this can still occur at a high rate (0.5 per cent in the UK). Jobs must constantly be created for the additional people—not just any job, but those that are judged acceptable in terms of current values. This basically means that the capital outlay per person employed must be maintained, otherwise the level of "productivity" per man will fall, which is a determinant of both the "viability" of economic enterprise and of the "standard of living".

Thirdly, no government can hope to survive widespread and protracted unemployment, and without changing the basis of our industrial society, the only way government can prevent it is by stimulating economic growth.

Fourthly, business enterprises, whether state-owned or privately owned, tend to become self-perpetuating, which means that they require surpluses for further investment. This favours continued growth.

Fifthly, the success of a government and its ability to obtain support is to a large extent assessed in terms of its ability to increase the "standard of living" as measured by *per capita* gross national product (GNP).

Finally, confidence in the economy, which is basically a function of its ability to grow, must be maintained to ensure a healthy state of the stock market. Were confidence to fall, stock values would crash, drastically reducing the availability of capital for investment and hence further growth, which would lead to further unemployment. This would result in a further fall in stock-market values and hence give rise to a positive-feedback chain-reaction, which under the existing order might well lead to social collapse.

For all these reasons, we can expect our government (whether Conservative or Labour) to encourage further increases in GNP regardless of the consequences, which in any case tame "experts" can be found to play down. It will curb growth only when public opinion demands such a move, in which case it will be politically expedient, and when a method is found for doing so without creating unemployment or excessive pressure on capital. We believe this is possible only within the framework of a fully integrated plan.

165. The emphasis must be on integration. If we develop relatively clean technologies but do not end economic growths then sooner or later we will find ourselves with as great a pollution problem as before but without the means of tackling it. If we stabilise our economies and husband our non-renewable resources without stabilising our populations we will find we are no longer able to feed ourselves. As Forrester[1] and Meadows[6] convincingly make clear, daunting though an integrated programme may be, a piecemeal approach will cause more problems than it solves.

166. Our task is to create a society which is sustainable and which will give the fullest possible satisfaction to its members. Such a society by definition would depend not on expansion but on stability. This does not mean to say that it would be stagnant—indeed it could well afford more variety than does the state of uniformity at present being imposed by the pursuit of technological efficiency. We believe that the stable society, the achievement of which we shall discuss in the next chapter, as well as removing the sword of Damocles which hangs over the heads of future generations, is much more likely than the present one to bring the peace and fulfilment which hitherto have been regarded, sadly, as utopian.

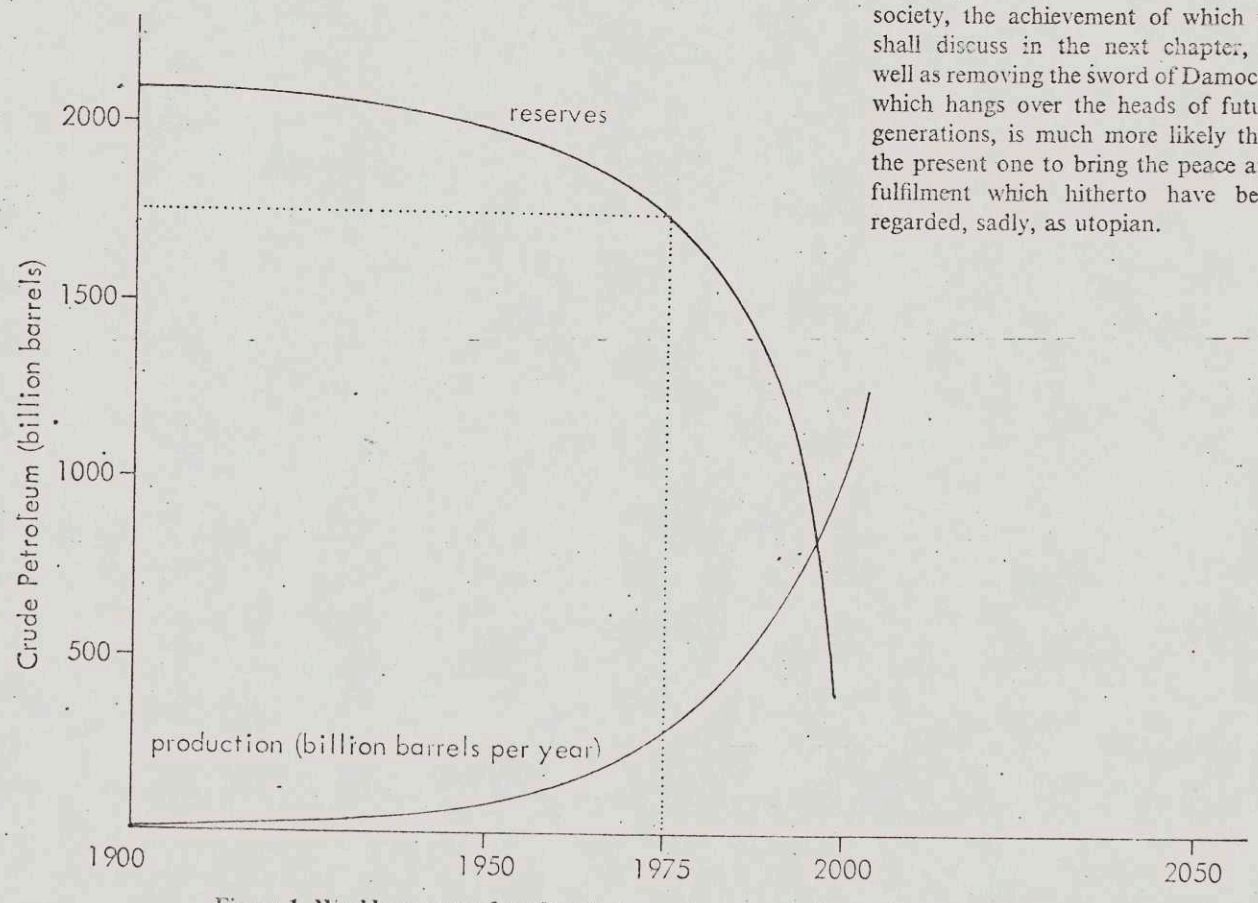

Figure 1. World reserves of crude petroleum at exponential rate of consumption. Note that in 1975, with no more than 15 years left before demand exceeds supply the total global reserve has been depleted by only 12½ per cent.

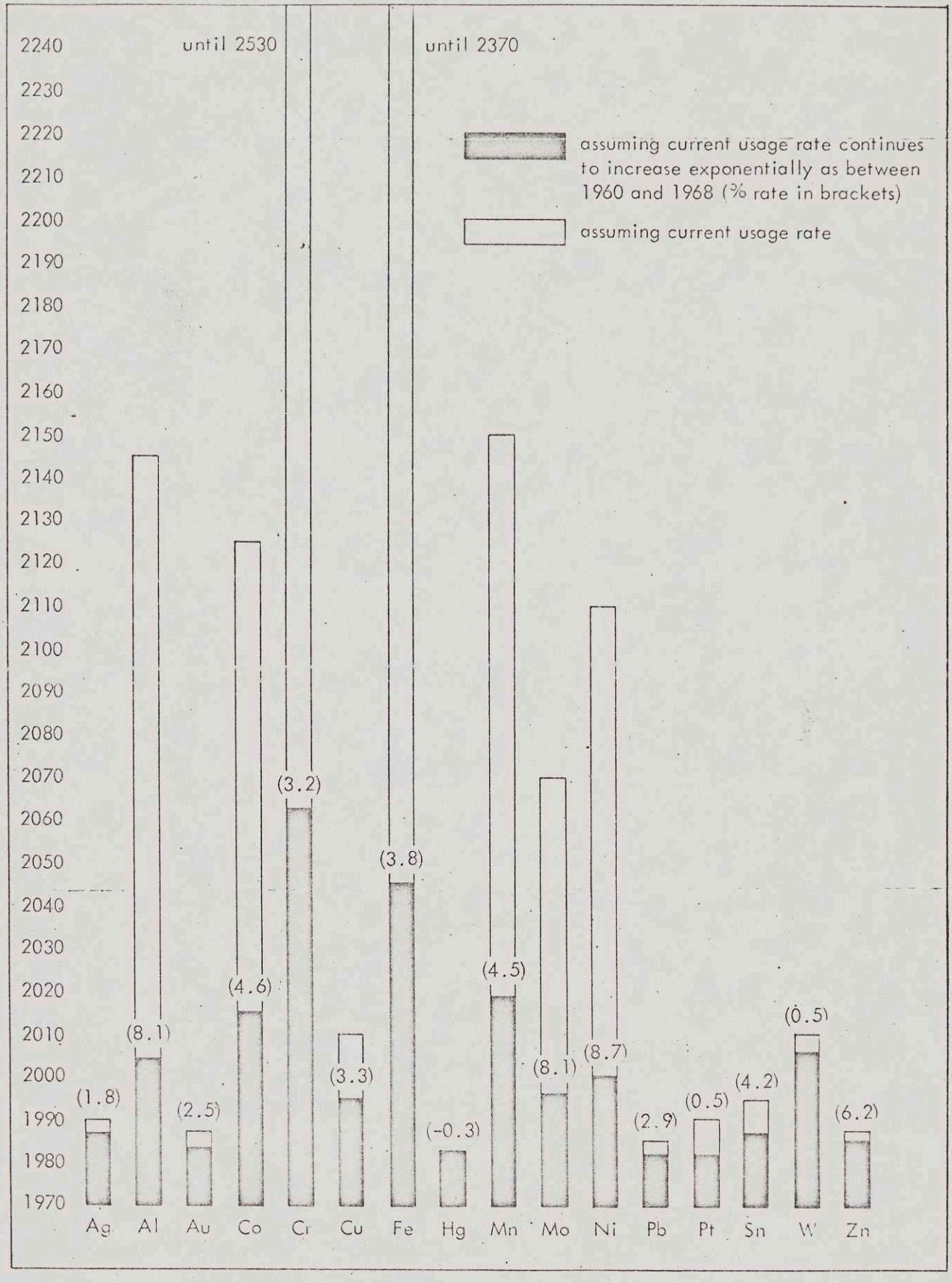

Figure 2. Mineral resources: static and exponential reserves.[7]

(For key, see page 41)

A BLUEPRINT FOR SURVIVAL

Towards the stable society:
Strategy for change

Introduction

210. The principal conditions of a stable society—one that to all intents and purposes can be sustained indefinitely while giving optimum satisfaction to its members — are: (1) minimum disruption of ecological processes; (2) maximum conservation of materials and energy—or an economy of stock rather than flow; (3) a population in which recruitment equals loss; and (4) a social system in which the individual can enjoy, rather than feel restricted by, the first three conditions.

211. The achievement of these four conditions will require controlled and well-orchestrated change on numerous fronts and this change will probably occur through seven operations: (1) a control operation whereby environmental disruption is reduced as much as possible by technical means; (2) a freeze operation, in which present trends are halted; (3) asystemic substitution, by which the most dangerous components of these trends are replaced by technological substitutes, whose effect is less deleterious in the short-term, but over the long-term will be increasingly ineffective; (4) systemic substitution, by which these technological substitutes are replaced by "natural" or self-regulating ones, i.e. those which either replicate or employ without undue disturbance the normal processes of the ecosphere, and are therefore likely to be sustainable over very long periods of time; (5) the invention, promotion and application of alternative technologies which are energy and materials conservative, and which because they are designed for relatively "closed" economic communities are likely to disrupt ecological processes only minimally (e.g. intermediate technology); (6) decentralisation of polity and economy at all levels, and the formation of communities small enough to be reasonably self-regulating and self-supporting; and (7) education for such communities.

212. As we shall see when we examine how our four conditions might be achieved, some changes will involve only a few of these operations, in others a number of the operations will be carried out almost simultaneously, and in others one will start well before another has ended. The usefulness of the operation-concept is simply to clarify the orchestration of change.

213. In putting forward these proposals we are aware that hasty or disordered change is highly disruptive and ultimately self-defeating; but we are also mindful of how the time-scale imposed on any proposal for a remedial course of action has been much-abbreviated by the dynamic of exponential growth (of population, resource depletion and pollution) and by the scarcely perceived scale and intensity of our disruption of the ecological processes on which we and all other life-forms depend. Within these limitations, therefore, we have taken care to devise and synchronise our programme so as to minimise both unemployment and capital outlay. We believe it possible to change from an expansionist society to a stable society without loss of jobs or an increase in real expenditure. Inevitably, however, there will be considerable changes, both of geography and function, in job availability and the requirements for capital inputs—and these may set up immense counter-productive social pressures. Yet given the careful and sensitive conception and implementation of a totally integrated programme these should be minimised, and an open style of government should inspire the trust and co-operation of the general public so essential for the success of this enterprise.

214. One further point should be made before we consider in more detail the various changes required. As each of the many socio-economic components or variables of industrial society are changed or replaced, so various pressure-points will be set up. It is easy to imagine, for example, a situation in which 25 per cent of the socio-economic variables are designed for a stable society and therefore by definition are ill-suited to one of expansion. This situation may create more problems than it solves. When we reach the point at which 50 per cent of the variables are adapted to stability and the other 50 per cent to expansion, the difficulties and tensions are likely to be enormous, but thereafter each change and replacement will assist further change and replacement, and the moulding of a sustainable, satisfying society should be that much easier. It is difficult for the human mind to imagine the temporal sequence of complex change, and no doubt impossible for it to visualise the precise interactions of the various components. While bearing in mind the folly of expecting computers to do our thinking for us, we believe they have an important role to play in demonstrating

the consequences throughout social and ecological systems of a great number of changes over a given period of time.

Minimising the disruption of ecological processes

220. Ecological processes can be disrupted by introducing into them either substances that are foreign to them or the correct ones in the wrong quantities. It follows therefore that the most common method of pollution "control", namely dispersal, is not control at all, but a more or less useful way of playing for time. Refuse disposal by dumping solves the immediate problem of the householder, but as dumping sites are used up it creates progressively less soluble problems for society at large; smokeless fuels are invaluable signs of progress for the citizens of London or Sheffield, but the air pollution from their manufacture brings misery and ill-health to the people near the plants where they are produced; in many cases the dispersal of pollutants through tall chimneys merely alters the proportion of pollution, so that instead of a few receiving much, many receive some; and lastly, in estuarine and coastal waters—crucial areas for fisheries—nutrients from sewage and agricultural run-off in modest quantities probably increase productivity, but in excess are as harmful as organochlorines and heavy metals.

221. Thus dispersal can be only a temporary expedient. Pollution control proper must consist of the recycling of materials, or the introduction of practices which are so akin to natural processes as not to be harmful. The long-term object of these pollution control procedures is to minimise our dependence on technology as a regulator of the ecological cycles on which we depend, and to return as much as possible to the natural mechanisms of the ecosphere, since in all but the short-term they are much more efficient and reliable. In the light of these remarks then, let us consider some contemporary pollution problems and how they might be solved.

222. *Pesticides.* There is no way of controlling the disruption caused by pesticides save by using less, and progress towards this end will probably require three operations: freeze, asystemic substitution, and systemic substitution. The freeze operation consists of the ending of any further commitment to pesticides, particularly the persistent organochlorines. For the developed countries this is a relatively simple procedure, and already the use of Dieldrin, DDT, and so on, is beginning to decline. For the undeveloped countries, however, it would be impossible without an undertaking from the developed ones to subsidise the supply of much more expensive substitutes. In the malaria control programme, for example, the replacement of DDT by malathion or propoxur would raise the cost of spraying operations from US $60 million a year to $184 million and $510 million respectively[1].

223. Once such an undertaking is given, the undeveloped countries could proceed to the second operation. (There is no conceivable reason why the developed ones should not formally do so now.) This consists of the progressive substitution of non-persistent pesticides (organophosphates, carbamates, etc.) for the organochlorines. The third operation, the substitution of natural controls for pesticides in general could follow soon after. Two important points should be borne in mind: (*a*) it is most unlikely that the third stage could ever be complete—we will probably have to rely on the precision use of pesticides for some considerable time as part of a programme of integrated control; and (*b*) the second and third operations would proceed in harness until all countries had fully integrated pest control programmes. The drawback with integrated control (the combination of biological control, mechanical control, crop-species diversity and the precise use of species-specific pesticides) is that as yet we do not know enough about it, so that a full-scale research programme is urgently required. The agro-chemical industries should be encouraged to invest in integrated control programmes though plainly, since the profits cannot be so great as from chemical control, research will need public finance—as will the training of integrated control advisory teams to assist farmers, particularly in the undeveloped countries. Such an investment, however, will appear modest once integrated control is fully operational, in comparison with the vast sums of money currently being spent annually on pesticides. A typical operational procedure for the transfer from chemical to integrated control might be as follows: organochlorines phased out, substitute pesticides phased in; in some cultivations these substitutes would be phased out almost immediately, to be replaced by integrated control; in others the time-table would be somewhat longer, depending on our understanding of the relevant agro-ecological processes and the availability of trained personnel.

224. *Fertilisers.* While on many occasions the use of inorganic fertilisers is valuable, their overuse leads to two intractable problems: the pollution of freshwater systems by run-off, and diminishing returns due to the slow but inevitable impoverishment of the soil (see appendix on food supply). Again the solution will come through three operations: freeze, asystemic substitution, and systemic substitution. The first operation requires there to be no further increment in the application of inorganic fertilisers, and hence the removal of subsidies for them. Again this is relatively easy for the developed countries (although there may be some drop in yield per acre), but next to impossible for the undeveloped countries, which are now being introduced to the new genetic hybrids of rice and wheat. Since the remarkable responsiveness of these hybrids is contingent on massive fertiliser inputs (up to 27 times present ones), the undeveloped world is faced with an unenviable choice: either to keep alive its expanding population over the next ten years at the price of considerable damage to soil structure and long-term fertility; or to improve soil structure so that a good proportion of the population can be fed indefinitely, but in the knowledge that the population will probably be reduced to that proportion by such natural processes as famine and epidemic. In the long-term, of course, the solution lies in population control; but in the intervening period there seems to be no alternative to concentrating on agricultural methods that are sustainable even at the expense of immediate productivity. The consequences of not doing so are likely to be much worse than any failure to take full advantage of the new hybrids. In the meantime, an emergency food-supply must be created by the developed prime-producers (USA, USSR, Canada, Australia, New Zealand) so that as much as possible of any short-fall can be met during this difficult period.

225. The second operation involves the gradual substitution of organic manures for inorganic fertilisers—though occasionally the latter will be used to supplement the former—and the return to such practices as rotation and leys; this would merge into the third operation: the adoption of highly diversified farming practices in place of monocultures. It is necessary to emphasise that this is not simply a return to traditional good husbandry: it is much more a change from flow fertility (whereby nutrients are imported from outside the agro-ecosystem, a proportion being utilised by food-plants, but with a large proportion leaving the agro-ecosystem in the form of run-off, etc.) to cyclic fertility (in which nutrients in the soil are used and then returned to it in as closed a cycle as possible). The great advantage of nutrients in organic form is that the soil appears much better adapted to them. The nitrogen in humus, for example, is only 0.5 per cent inorganic, the rest being in the form of rotting vegetation, decomposing insects and other animals, and animal manure. A high proportion of organic matter is essential for the soil to be easily workable over long periods (thus extending the period in which cultivations are timely), for it to retain water well without becoming saturated, for the retention of nutrients so that they remain available to plants until they are taken up by them (thus reducing wastage), and for the provision of the optimum environment for the micro-organisms so vital for long-term fertility. The rotation of leguminous plants and of grass grazed by animals are the most effective ways of adding organic matter to the soil, while at the same time allowing livestock to select their own food in the open has the double advantage that they are bred with a healthy fat-structure and their wastes enrich the soil instead of polluting waterways or overloading sewage systems. By diversifying farming in these and other ways we are taking advantage of the immense growth of knowledge about agricultural ecology, which plainly will increase with additional research.

226. *Domestic sewage.* The volume of sewage is directly proportional to population numbers and can only be stabilised or reduced by stabilising or reducing the population. However, sewage can and should be disposed of much more efficiently. It is absurd that such valuable nutrients should be allowed to pollute fresh and coastal waters, or that society should be put to the expense of disposing of them in areas where they cannot be effectively utilised. Unfortunately, in developed countries, their disposal as agricultural fertiliser is not generally feasible, largely for two reasons: (*a*) they are contaminated by industrial wastes; (*b*) transportation costs are too high. Both difficulties can be overcome—in the first case by ensuring that there is no (or negligible) admixture of industrial to domestic effluents, which depends on better industrial pollution control (see below); and in the second case by decentralising so that there is an improved mix of rural and urban activities. This will be explored in the section on social systems. In undeveloped countries, the problem of domestic sewage could be overcome by the provision of aid to pay for sewage plants that yield purified water and usable sludge.

227. *Industrial wastes.* Reduction of industrial effluent should proceed by two operations: a control operation, and an alternative (materials and energy conservative) technology operation. We have already suggested that the key to pollution control is not dispersal but recycling, and since recycling is a most important element in resource management it will be discussed in the section on stock economics. The alternative technology operation will be considered in the section on social systems.

Conversion to an economy of stock

230. The transfer from flow to stock economics can be considered under two headings: resource management and social accounting.

231. *Resource management.* It is essential that the throughput of raw materials be minimised both to conserve non-renewable resources and to cut down pollution. Since industry must have an economic incentive to be conservative of materials and energy and to recycle as much as possible, we propose a number of fiscal measures to these ends: (*a*) A raw materials tax. This would be proportionate to the availability of the raw material in question, and would be designed to enable our reserves to last over an arbitrary period of time, the longer the better, on the principle that during this time our dependence on this raw material would be reduced. This tax would penalise resource-intensive industries and favour employment-intensive ones. Like (*b*) below it would also penalise short-lived products.
(*b*) An amortisation tax. This would be proportionate to the estimated life of the product, e.g. it would be 100 per cent for products designed to last no more than a year, and would then be progressively reduced to zero per cent for those designed to last 100+ years. Obviously this would penalise short-lived products, especially disposable ones, thereby reducing resource utilisation and pollution, particularly the solid-waste problem. Plastics, for example, which are so remarkable for their durability, would be used only in products where this quality is valued, and not for single trip purposes. This tax would also encourage craftmanship and employment-intensive industry.

232. The raw materials tax would obviously encourage recycling, and we can see how it might work if we consider such a vital resource as water. The growing conflict between farmers, conservationists and the water boards is evidence enough that demand for water is conflicting with other, no less important, values. At the moment, the water boards have no alternative but to fulfil their statutory obligation to meet demand, and accordingly valley after valley comes under the threat of drowning. Clearly, unless we consider dry land an obstacle to progress, demand must be stabilised, and since demand is a function of population numbers × *per capita* consumption, both must be stabilised, if not reduced (and we have seen that for other reasons they must be reduced). To this end therefore, while a given minimum can be supplied to each person free-of-charge, any amount above that minimum should be made increasingly expensive. As far as industry is concerned, the net effect would be to encourage the installation of closed-circuit systems for water; total demand would be reduced, and there would be less pressure on lowland river systems.

233. Despite the stimulus of a raw materials tax, however, it is likely that there would be a number of serious pollutants which it would be uneconomic to recycle, and still others for which

recycling would be technically impossible. One thinks in particular of the radioactive wastes from nuclear power stations. Furthermore, recycling cannot do everything: there will always be a non-recoverable minimum, which as now will have to be disposed of as safely as possible. This limitation can be made clear if we postulate a 3 per cent growth rate, and the introduction of pollution controls which reduce pollution by 80 per cent throughout—it would then take only 52 years to bring us back where we started from, with the original amount of pollution but with a much greater problem of reducing it any further; if we had a 6 per cent growth rate, we would reach this position in a mere 26 years. It is also worth mentioning that recycling consumes energy and is therefore polluting, so that it is necessary to develop recycling procedures which are energy conservative.

234. The problem of uneconomic recycling can be resolved by the granting of incentives by government. Indeed, in the short-term, the entire recycling industry should be encouraged to expand, even though we know that in the long-term industrial expansion is self-defeating. This brings us to the intractable problem of the disposal of the undisposable, which can only be resolved by the termination of industrial growth and the reduction of energy demand. Again fiscal measures will be supremely important, and we propose one in particular: (*c*) A power tax. This would penalise power-intensive processes and hence those causing considerable pollution. Since machinery requires more power than people, it would at the same time favour the employment intensification of industry, i.e. create jobs. It would also penalise the manufacture of short-lived products. In addition to this tax, there should be financial incentives for the development and installation of total energy systems, a matter to which we shall return in the section on social systems.

235. Finally, industrial pollution can also be reduced by materials substitution. The substitution of synthetic compounds for naturally occurring compounds has created serious environmental damage since in some cases the synthetics can be broken down only with difficulty and in others not at all. The usage rate of these synthetics has increased immensely at the expense of the natural products, as can be seen from the following examples[2]:

(*a*) In the US, *per capita* consumption of synthetic detergents increased by 300 per cent between 1962 and 1968. They have largely replaced soap products, *per capita* consumption of which fell by 71 per cent between 1944 and 1964.

(*b*) Synthetic fibres are rapidly replacing cotton, wool, silk and other natural fibres. In the US, *per capita* consumption of cotton fell by 33 per cent between 1950 and 1968.

(*c*) The production of plastics and synthetic resins in the US, has risen by 300 per cent between 1958 and 1968. They have largely replaced wood and paper products.

All of these processes consume the non-renewable fossil fuels, and their manufacture requires considerable inputs of energy. On the face of it, therefore, a counter-substitution of naturally occurring products would much reduce environmental disruption. However, it is possible that such a change-over, while it would certainly reduce disruption at one end, might dangerously increase it at the other. For example, many more acres would have to be put under cotton, thus increasing demand for pesticides, more land would have to be cleared and put under forest monocultures, and so on. This problem can only be solved by reducing total consumption.

236. *Genetic resources.* Before leaving the subject of resources, it is appropriate that we consider the world's diminishing stock of genetic resources. Genetic diversity is essential for the security of our food supply, since it is the *sine qua non* of plant breeding and introduction. The greater the number of varieties, the greater the opportunities for developing new hybrids with resistance to different types of pests and diseases, and to extremes of climate. It is important that new hybrids be continually developed since resistance to a particular disease is never a permanent quality. The number of plant varieties to be found in nature is infinitely greater than the number we could create artificially. Most of them are to be found in the undeveloped countries either as traditional domesticated plants or as wild plants in habitats relatively unaltered by man. There is a real danger that the former will be replaced by contemporary high-yield varieties, while the latter will disappear when their habitats are destroyed. An FAO conference in 1967 concluded that the plant-gene pool has diminished dangerously, for all over the world centres of diversity, our gene banks as it were, are disappearing, and with them our chance of maintaining productivity in food[3].

237. Such centres—areas of wilderness—are often destroyed because their importance is not understood. Because they seem less productive than fields of waving corn, or because they are not accessible or attractive to tourists, they are considered in need of "improvement" or development, or simply as suitable dumping grounds for the detritus of civilisation. This is particularly true of wetlands—estuaries and marshes—where pollution, dredging, draining and filling are looked on almost with equanimity, certainly with scant regard for what is being lost. Yet the complex of living and decomposing grasses, and of phytoplankton, characteristic of wetlands, supports vast numbers of fish and birds and makes it one of the world's most productive ecosystems. Estuaries are the spawning grounds of very many fish and shellfish and form the base of the food-chain of some 60 per cent of our entire marine harvest. Should they go we can expect a substantial drop in productivity.

238. It is vital to the future well-being of man that wilderness areas and wetlands be conserved at all costs. This cannot be a matter simply of taking seed and storing it, since to be valuable genetic stock must continue to be subject to normal environmental pressures, and besides we have scarcely any idea of what plants we shall find useful in the future. For these reasons we must not only conserve large areas of natural habitat, we must also draw upon the knowledge and experience of the hunter-gatherers and hunter-farmers who gain their livelihood from them.

239. We therefore have recommended to the UN Human Environment Conference that[4]:

(1) Certain wilderness areas of tropical rain forest, tropical scrub forest, and arctic tundra be declared inviolate, these being the least understood and most fragile biomes;

(2) the hunter-gatherers and hunter-farmers within these areas be given title to their lands (i.e. those lands in which

traditionally they have gained their living) and be allowed to live there without pressure of any kind;

(3) severe restrictions be placed on entry to these areas by anyone who does not live there permanently (while allowing the indigenes free movement);

(4) sovereignty over the areas remain with the countries in which they lie; who should also be responsible for the policing of their boundaries;

(5) funds for administration of these areas and payments in lieu of exploitation (to the host country) be collected from UN members in proportion to their GNP;

(6) an international body be appointed as an outcome of the Stockholm Human Environment Conference to supervise an ecological programme of research, the results of which should be freely available to participating countries.

240. *Social accounting.* By the introduction of monetary incentives and disincentives it is possible to put a premium on durability and a penalty on disposability, thereby reducing the throughput of materials and energy so that resources are conserved and pollution reduced. But another important way of reducing pollution and enhancing amenity is by the provision of a more equitable social accounting system, reinforced by anti-disamenity legislation. Social accounting procedures must be used not just to weigh up the merits of alternative development proposals, but also to determine whether or not society actually wants such development. Naturally, present procedures require improvement: for example, in calculating "revealed preference" (the values of individuals and communities as "revealed" to economists by the amount people are willing and/or can afford to pay for or against a given development), imagination, sensitivity and commonsense are required in order to avoid the imposition on poor neighbourhoods or sparsely inhabited countryside of nuclear power stations, reservoirs, motorways, airports, and the like; and in calculating the "social time preference rate" (an indication of society's regard for the future) for a given project, a very low discount should be given, since it is easier to do than undo, and we must assume that unless we botch things completely many more generations will follow us who will not thank us for exhausting resources or blighting the landscape.

241. The social costs of any given development should be paid by those who propose or perpetrate it—"the polluter must pay" is a principle that must guide our costing procedures. Furthermore, accounting decisions should be made in the light of stock economics: in other words, we must judge the health of our economy not by flow or throughput, since this inevitably leads to waste, resource depletion and environmental disruption, but by the distribution, quality and variety of the stock. At the moment, as Kenneth Boulding has pointed out[5], "the success of the economy is measured by the amount of throughput derived in part from reservoirs of raw materials, processed by 'factors of production', and passed on in part as output to the sink of pollution reservoirs. The Gross National Product (GNP) roughly measures this throughput". Yet, both the reservoirs of raw materials and the reservoirs for pollution are limited and finite, so that ultimately the throughput from the one to the other must be detrimental to our well-being, and must therefore not only be minimised but be regarded as a cost rather than a benefit. For this reason Boulding has suggested that GNP be considered a measure of gross national cost, and that we devote ourselves to its minimisation, maximising instead the quality of our stock. "When we have developed the economy of the spaceship earth", he writes, "in which man will persist in equilibrium with his environment, the notion of the GNP will simply disintegrate. We will be less concerned with income-flow concepts and more with capital-stock concepts. Then technological changes that result in the maintenance of the total stock with *less* throughput (less production and consumption) will be a clear gain". We must come to assess our standard of living not by calculating the value of all the air-conditioners we have made and sold, but by the freshness of the air; not by the value of the antibiotics, hormones, feedstuff and broiler-houses, and the cost of disposing of their wastes, all of which put so heavy a price on poultry production today, but by the flavour and nutritional quality of the chickens themselves; and so on. In other words, accepted value must reflect real value, just as accepted cost must reflect real cost.

242. It is evident, however, that in a society such as ours, which to a large extent ignores the long-term consequences of its actions, there is a substantial differential between accepted cost and real cost. An industrial town, for example, whose citizens and factories pollute the air and water systems around it and who feed themselves from a number of increasingly intensive monocultures, not only has no way of measuring the satisfactions or otherwise afforded by its life-style, nor of equitably distributing the costs imposed by one polluter on another, but no way either of assessing ecological costs, some of which will have to be paid by generation 1, others by generations 2, 3, 4, etc., and still others by people elsewhere, with whom in every other respect there might be no contact. Thus its agricultural practices might provide cheap and plentiful food for one generation and stimulate its agro-chemical industries, but may so impoverish the soil and disrupt the agro-ecosystem, that the next generation will have to import more food, or failing this, to resort to still riskier expedients, thereby seriously compromising the food supply of the following generation; or the wastes of one generation might affect the health of the next, or its marine food supply, or so increase the mutation rate that future generations receive an unlooked for genetic burden. The extent to which we are simplifying ecosystems and destroying natural controls so that we are forced to provide technological substitutes is a real cost against society and should be accounted as one. At the moment, however, we merely add up the value of mining operations, factories and so on, and that of cleaning up the mess whenever we attempt to do so, and conclude that we have never been better off.

243. Since the full costs of any action anywhere in the world must be borne by someone, somewhere, sometime, it is important that our accounting system makes provision for this. We accept, however, that ecological processes are so complex, and can spread so far in space and time, that this will be exceptionally difficult. Nonetheless, given the truism that a satisfactory accounting system is one which supports and helps perpetuate the social system from which it derives, we must attempt to devise one which is fitted to a society based on a sober assessment of ecological reality and not on the

anthropocentric pipe-dream that we can do what we will to all species, not excepting, it seems, future generations of our own. It is worth recalling Prof. Commoner's dictum that since economics is the science of the distribution of resources, all of which are derived from the ecosphere, it is foolish to perpetuate an economic system which destroys it. Ideally (and as befits the etymology of the two words), ecology and economics should not be in conflict: ecology should provide the approach, the framework for an understanding of the interrelationships of social and environmental systems; and economics should provide the means of quantifying those interrelationships in the light of such an understanding, so that decisions on alternative courses of action can be made without undue difficulty.

244. One of our long-term goals, therefore, must be to unite economics and ecology. The specific measures we have proposed are, we believe, necessary steps in this direction, albeit crude ones. A raw materials tax, an amortisation tax, a power tax, revised methods of calculating revealed preference, social time preference rate, and so on, with legislative provision for their enforcement, a set of air, water and land quality standards enforceable at law and linked with a grant-incentive programme—these and other measures will have to be introduced at an early stage. Naturally, the full force of such measures could not be allowed to operate immediately: they would have to be carefully graded so as to be effective without causing unacceptable degrees of social disturbance. Plainly the social consequences will be great, and these will be considered in the section on social systems. The key to success is likely to be careful synchronisation, and this too will be considered in a separate section.

Stabilising the population

250. We have seen already that however slight the growth rate, a population cannot grow indefinitely. It follows, therefore, that at some point it must stabilise of its own volition, or else be cut down by some "natural" mechanism —famine, epidemic, war, or whatever. Since no sane society would choose the latter course, it must choose to stabilise. To do this it must have some idea of its optimum size, since again it is unlikely that any sane society would choose to stabilise above (or indeed below) it.

251. The two main variables affected by population numbers, as opposed to *per capita* consumption, are the extent to which the emotional needs and social aspirations of the community can be met (i.e. the complex of satisfactions which has come to be known as the quality of life), and the community's ability to feed itself. In our opinion there is good social and epidemiological evidence that Britain and many other countries in both the developed and undeveloped worlds are overcrowded. However, since this is impossible to prove, and since there is immense variation in individual emotional requirements, it would be unwise in the present state of our knowledge to rely on quality of life judgements when calculating the optimum population. Fortunately, we know much more about feeding ourselves, and assessment of the optimum becomes a realisable task if we base it on the simple ecological concept of the carrying capacity of the land.

252. Carrying capacity is usually defined as the amount of solar energy potentially available to man via food-plants in a given area. This definition must be accompanied by a caveat to the effect that if carrying capacity is considered in terms of energetics alone, a number of essential ecological and nutritional variables are in danger of exclusion. For example, it would be easy to assume that land used for a combination of purposes (mixed farming, woodland, etc.) would be better employed and could support a larger population if it were exclusively given over to the intensive production of food-plants high in calories (e.g. wheat). We know, however, that protein and the other nutrients are no less vital to us than calories, while there is evidence that we are more likely to get the proper nutritional components from meat if it comes to us from free-living animals. This requirement alone demands a certain diversity, both of species and habitat, and we have seen too (in the appendix on ecosystems) that diversity is essential if fertility and stability are to be maintained over the long-term.

253. As we have seen Britain supports a population well in excess of the carrying capacity of the land owing to its ability to import large amounts of food, especially the cheap protein required to feed our poultry and pigs. As world population grows, and with it global agricultural demand, so will it be increasingly difficult for us to find countries with exportable surpluses, surpluses which in any case will become progressively more expensive. Unless we are willing (and able) to perpetuate an even greater inequality of distribution than exists today, Britain must be self-supporting. We have stated already our belief that on the evidence available it is unlikely that there will be any significant increase in yield per acre, so that there is no other course open to us but to reduce our numbers before we stabilise. Since we appear capable of supporting no more than half our present population, the figure we should aim for over the next 150 to 200 years can be no greater than 30 million, and in order to protect it from resource fluctuation probably less.

254. Not every country is in such a difficult position as Britain. A few will be able to stabilise at or relatively near present levels. But taking world population as a whole, and using *per capita per diem* protein intake as the key variable in assessing carrying capacity, we believe the optimum population for the world is unlikely to be above 3,500 million and is probably a good deal less. This figure rests on three assumptions: (*a*) that the average *per capita per diem* requirements of protein is 65 grams[6]; (*b*) that present agricultural production *per capita* can be sustained indefinitely; and (*c*) that there is absolutely equitable distribution, no country enjoying a greater *per capita per diem* protein intake than any other—which compared with today's conditions is absurdly utopian. Utopian though they may be, unless these assumptions are realised, we are faced either with the task of reducing world population still further until it is well below the optimum, or with condoning inequalities grosser and more unjust than those which we in the developed countries foster at present.

255. While they cannot grow indefinitely, populations can remain above the optimum—indeed above the sustainable maximum—for some time. The fact that the global population, including that of Britain, is above both levels, means only that our numbers are

preventing the optimisation of other values. It means that while most people receive the bare minimum of calories necessary for survival, a large proportion are deprived of the nutrients (especially protein) essential for intellectual development. They are alive, but unable to realise their full potential —which is the grossest possible waste of human resources. An optimum population, therefore, may be defined as one that can be sustained indefinitely and at a level at which the other values of its members are optimised—and the fact that we are above this level does not justify despair, but does justify a great sense of urgency in working towards our long-term goal of the optimum. For it is obvious that given the dynamic of population growth, even if all nations today determined to stabilise their populations, numbers would continue to rise for some considerable time. Indeed the Population Council has calculated (Annual Report 1970) that ". . . if the replacement-sized family is realised for the world as a whole by the end of this century—itself an unlikely event—the world's population will then be 60 per cent larger or about 5.8 billion, and due to the resulting age structure it will not stop growing until near the end of the next century, at which time it will be about 8.2 billion (8,200 million) or about 225 per cent the present size. If replacement is achieved in the developed world by 2000 and in the developing world by 2040, then the world's population will stabilise at nearly 15.5 billion (15,500 million) about a century hence, or well over four times the present size". Clearly we must go all out for the "unlikely event" of achieving the replacement-sized family (an average of about two children per couple) *throughout the world by the end of this century*, if our children are not to suffer the catastrophes we seek to avoid.

256. Our task is to end population growth by lowering the rate of recruitment so that it equals the rate of loss. A few countries will then be able to stabilise, to maintain that ratio; most others, however, will have to slowly *reduce* their populations to a level at which it is sensible to stabilise. Stated baldly, the task seems impossible; but if we start now, and the exercise is spread over a sufficiently long period of time, then we believe that it is within our capabilities. The difficulties are enormous, but they are surmountable.

257. First, governments must acknowledge the problem and declare their commitment to ending population growth; this commitment should also include an end to immigration. Secondly, they must set up national population services with a fourfold brief:

(1) to publicise as widely and vigorously as possible the relationship between population, food supply, quality of life, resource depletion, etc., and the great need for couples to have no more than two children. The finest talents in advertising should be recruited for this, and the broad aim should be to inculcate a socially more responsible attitude to child-rearing. For example, the notion (derived largely from the popular women's magazines) that childless couples should be objects of pity rather than esteem should be sharply challenged; and of course there are many similar notions to be disputed.

(2) to provide at local and national levels free contraception advice and information on other services such as abortion and sterilisation;

(3) to provide a comprehensive domiciliary service, and to provide contraceptives free of charge, free sterilisation, and abortion on demand;

(4) to commission, finance, and coordinate research not only on demographic techniques and contraceptive technology, but also on the subtle cultural controls necessary for the harmonious maintenance of stability. We know so little about the dynamics of human populations that we cannot say whether the first three measures would be sufficient. It is self-evident that if couples still wanted families larger than the replacement-size no amount of free contraception would make any difference. However, because we know so little about population control, it would be difficult for us to devise any of the socio-economic restraints which on the face of it are likely to be more effective, but which many people fear might be unduly repressive. For this reason, we would be wise to rely on the first three measures for the next 20 years or so. We then may find they are enough—but if they aren't, we must hope that intensive research during this period will be rewarded with a set of socio-economic restraints that are both *effective* and *humane*. These will then constitute the third stage, and should also provide the tools for the fourth stage—that of persuading the public to have average family sizes of slightly *less* than replacement size, so that total population can be greatly reduced. If we achieve a decline rate of 0.5 per cent per year, the same as Britain's rate of growth today, there should be no imbalance of population structure, as the dependency ratio would be exactly the same as that of contemporary Britain. Only the make-up of dependency would be different: instead of there being more children than old people, it would be the other way round. The time-scale for such an operation is long of course, and this will be suggested in the section on orchestration.

Creating a new social system

260. Possibly the most radical change we propose in the creation of a new social system is decentralisation. We do so not because we are sunk in nostalgia for a mythical little England of fetes, olde worlde pubs, and perpetual conversations over garden fences, but for four much more fundamental reasons:

261. (*a*) While there is good evidence that human societies can happily remain stable for long periods, there is no doubt that the long transitional stage that we and our children must go through will impose a heavy burden on our moral courage and will require great restraint. Legislation and the operations of police forces and the courts will be necessary to reinforce this restraint, but we believe that such external controls can never be so subtle nor so effective as internal controls. It would therefore be sensible to promote the social conditions in which public opinion and full public participation in decision-making become as far as possible the means whereby communities are ordered. The larger a community the less likely this can be: in a heterogeneous, centralised society such as ours, the restraints of the stable society if they were to be effective would appear as so much outside coercion; but in communities small enough for the general will to be worked out and expressed by individuals confident of themselves and their fellows as individuals, "us and them" situations are less likely to occur—people having learned the limits of a stable society would be free to order their own lives

within them as they wished, and would therefore accept the restraints of the stable society as necessary and desirable and not as some arbitrary restriction imposed by a remote and unsympathetic government.

262. (*b*) As agriculture depends more and more on integrated control and becomes more diversified, there will no longer be any scope for prairie-type crop-growing or factory-type livestock-rearing. Small farms run by teams with specialised knowledge of ecology, entomology, botany, etc., will then be the rule, and indeed individual smallholdings could become extremely productive suppliers of eggs, fruit and vegetables to neighbourhoods. Thus a much more diversified urban-rural mix will be not only possible, but because of the need to reduce the transportation costs of returning domestic sewage to the land, desirable. In industry, as with agriculture, it will be important to maintain a vigorous feedback between supply and demand in order to avoid waste, overproduction, or production of goods which the community does not really want, thereby eliminating the needless expense of time, energy and money in attempts to persuade it that it does. If an industry is an integral part of a community, it is much more likely to encourage product innovation because people clearly want qualitative improvements in a given field, rather than because expansion is necessary for that industry's survival or because there is otherwise insufficient work for its research and development section. Today, men, women and children are merely consumer markets, and industries as they centralise become national rather than local and supranational rather than national, so that while entire communities may come to depend on them for the jobs they supply, they are in no sense integral parts of those communities. To a considerable extent the "jobs or beauty" dichotomy has been made possible because of this deficiency. Yet plainly people want jobs *and* beauty, they should not in a just and humane society be forced to choose between the two, and in a decentralised society of small communities where industries are small enough to be responsive to each community's needs, there will be no reason for them to do so.

263. (*c*) The small community is not only the organisational structure in which internal or systemic controls are most likely to operate effectively, but its dynamic is an essential source of stimulation and pleasure for the individual. Indeed it is probable that only in the small community can a man or woman be an individual. In today's large agglomerations he is merely an isolate—and it is significant that the decreasing autonomy of communities and local regions and the increasing centralisation of decision-making and authority in the cumbersome bureaucracies of the state, have been accompanied by the rise of self-conscious individualism, an individualism which feels threatened unless it is harped upon. Perhaps the two are mutually dependent. It is no less significant that this self-conscious individualism tends to be expressed in ways which cut off one individual from another—for example the accumulation of material goods like the motor-car, the television set, and so on, all of which tend to insulate one from another, rather than bring them together. In the small, self-regulating communities observed by anthropologists, there is by contrast no assertion of individualism, and certain individual aspirations may have to be repressed or modified for the benefit of the community—yet no man controls another and each has very great freedom of action, much greater than we have today. At the same time they enjoy the rewards of the small community, of knowing and being known, of an intensity of relationships with a few, rather than urban man's variety of innumerable, superficial relationships. Such rewards should provide ample compensation for the decreasing emphasis on consumption, which will be the inevitable result of the premium on durability which we have suggested should be established so that resources may be conserved and pollution minimised. This premium, while not diminishing our real standard of living, will greatly reduce the turnover of material goods. They will thus be more expensive, although once paid for they should not need replacing except after long periods. Their rapid accumulation will no longer be a realisable, or indeed socially acceptable goal, and alternative satisfactions will have to be sought. We believe a major potential source of these satisfactions to be the rich and variegated interchanges and responsibilities of community life, and that these are possible only when such communities are on a human scale.

264. (*d*) The fourth reason for decentralisation is that to deploy a population in small towns and villages is to reduce to the minimum its impact on the environment. This is because the actual urban superstructure required per inhabitant goes up radically as the size of the town increases beyond a certain point. For example, the *per capita* cost of high rise flats is much greater than that of ordinary houses; and the cost of roads and other transportation routes increases with the number of commuters carried. Similarly, the *per capita* expenditure on other facilities such as those for distributing food and removing wastes is much higher in cities than in small towns and villages. Thus, if everybody lived in villages the need for sewage treatment plants would be somewhat reduced, while in an entirely urban society they are essential, and the cost of treatment is high. Broadly speaking, it is only by decentralisation that we can increase self-sufficiency—and self-sufficiency is vital if we are to minimise the burden of social systems on the ecosystems that support them.

265. Although we believe that the small community should be the basic unit of society and that each community should be as self-sufficient and self-regulating as possible, we would like to stress that we are not proposing that they be inward-looking, self-obsessed or in any way closed to the rest of the world. Basic precepts of ecology, such as the interrelatedness of all things and the far-reaching effects of ecological processes and their disruption, should influence community decision-making, and therefore there must be an efficient and sensitive communications network between all communities. There must be procedures whereby community actions that affect regions can be discussed at regional level and regional actions with extra-regional effects can be discussed at global level. We have no hard and fast views on the size of the proposed communities, but for the moment we suggest neighbourhoods of 500, represented in communities of 5,000, in regions of 500,000, represented nationally, which in turn as today should be represented globally. We emphasise that our goal should be to create *community feeling* and *global awareness*,

rather than that dangerous and sterile compromise which is nationalism.

266. In many of the developed countries where community feeling has been greatly eroded and has given way to heterogeneous congeries of strangers, the task of re-creating communities will be immensely difficult. In many of the undeveloped countries, however, although it will not be easy, because the process of community collapse and flight to the city has begun only recently there is a real chance that it can be halted by such means as the abandonment of large-scale industrial projects for the development of intermediate technologies at village level; and the provision of agro-ecological training teams so that communities can be taught to manage the land together, rather than encourage farmers to turn to expensive and dangerous procedures like the heavy use of pesticides and fertilisers, which tend to reduce the number of people needed on the land.

267. At home, industry will play a leading role in the programme to decentralise our economy and society. The discussion of taxes, antidisamenity legislation, and enforceable targets for air, land and water quality in the section on stock economics might lead some to believe that we are willing to bring about the collapse of industry, widespread unemployment, and the loss of our export markets. It is therefore worth emphasising that we wish strongly to avoid all three, and we do not see that they are necessary or inevitable consequences of our proposals. It is obvious that for as long as we depend on imports for a significant proportion of our food, so we must export. And since we are likely to require food-imports for the next 150 years, we are left with the question of whether it is possible to develop community industries, dedicated to the principles of maximal use/recycling of materials and durability of goods, and at the same time to earn an adequate revenue from exports.

268. We believe that the answer is yes, if the change-over is conducted in two stages. The first stage is to alter the direction of growth so that it becomes more compatible with the aims of a stable society. We have already mentioned that the recycling industry must be encouraged to expand, and it is obvious that willy-nilly it will do so as over the years taxes and quality targets become more stringent. To give a clearer idea of how the direction can be altered we will consider briefly the question of transport.

269. There are more than 12 million cars in Britain today, and according to the Automobile Association this figure will rise to 21 million by 1981. About half the households in Britain own a car today, and presumably the car population is expected to rise in response to a rise in this proportion, though presumably too, more households will own more than one car. At all events we have sufficient experience of traffic congestion in our towns and cities and the rape of countryside and community by ring-roads and motorways to realise that the motor-car is by no means the best way of democratising mobility. Indeed, if every household had a car, we would be faced with the choice of leaving towns and country worth driving to and thereby imposing immobility on the motorist, or of providing him with the vast expanses of concrete which are becoming increasingly necessary to avoid congestion at the expense of the areas they sterilise and blight.

270. No-one can contemplate with equanimity the doubling of roads within this decade necessary to maintain the *status quo*, and we must therefore seek sensible transportation alternatives. It is clear that broadly-speaking the only alternative is public transport—a mix of rapid mass-transit by road and rail. Rail especially should never have been allowed to run down to the extent that it has. The power requirements for transporting freight by road are five to six times greater than by rail and the pollution is correspondingly higher. The energy outlay for the cement and steel required to build a motorway is three to four times greater than that required to build a railway, and the land area necessary for the former is estimated to be four times more than for the latter. Public transport whether by road or rail is much more efficient in terms of *per capita* use of materials and energy than any private alternative. It can also be as flexible, provided it is encouraged at the expense of private transport.

271. This is the key to the provision of a sound transportation system. First the vicious spiral of congestion slowing buses, losing passengers, raising fares, losing more passengers, using more cars, creating more congestion, etc., must be broken. A commitment to build no more roads and to use the capital released to subsidise public transport would be an excellent way of doing this. The men who would normally live by roadbuilding could be diverted to clearing derelict land and restoring railways and canals as part of a general programme of renewal. From there, the progressive imposition of restrictions on private transport and the stimulation of public transport so that it could provide a fast, efficient and flexible alternative would be a matter of course. Within the motor industry, the decline in production of conventional private vehicles would be compensated for by the increased production of alternative mass-transit systems. There would also be a switch of capital and manpower to the redevelopment of railway systems. In the long term, however, decentralisation will bring a diminished demand for mobility itself. As Stephen Boyden has pointed out[7], people use their cars for four main reasons: to go to work, to go to the countryside, to visit friends and relations, and to show off. In the stable society, however, each community will provide its own jobs, there will be countryside around it, most friends and relations will be within it, and there will be much more reliable and satisfying ways of showing off.

272. This brings us to the second stage of the change-over, in which industry turns to the invention, production, and installation of technologies that are materials and energy conservative, that are flexible, non-polluting and durable, employment-intensive and favouring craftsmanship. Progress as we conceive of it today consists in increasing an already arbitrarily high ratio of capital to job availability; but if instead this ratio were to be reduced, then our manpower requirement would go up, while at the same time the pollution which is the inevitable by-product of capital growth would be cut down. The switch in emphasis from quantity to quality will not only stimulate demand for manpower, it will also stabilise it *and* give much greater satisfaction to the men themselves. Instead of men being used as insensate units to produce increasing quantities of components,

they should be trained and given the opportunity to improve the quality of their work. The keynotes of the manufacturing sector should come to be durability and craftsmanship—and such a premium on quality should assure us an export revenue large enough for us to continue buying food from abroad, while providing our manpower with more enjoyable occupations. In the case of industries like the aircraft industry, which would naturally have a greatly reduced role in the stable society, their engineering expertise could be turned to the development of such things as total energy systems—designed to provide the requirements of a decentralised society with the minimum of environmental disruption.

273. Industry can completely fulfil its new role only in close harmony with particular communities, so that the unreal distinction between men as employees and men as neighbours can be abandoned, and jobs then given on the basis that work must be provided by the community for the sake of that community's stability and not because one group wishes to profit from another group's labour or capital as the case may be. As industry decentralises so will the rest of society. The creation of communities will come from the combination of industrial change and a conscious drive to re-structure society.

274. The principal components of this drive are likely to be the redistribution of government and the gradual inculcation of a sense of community and the other values of a stable society. Over a stated period of time, local government should be strengthened and as many functions as possible of central government should be transferred to it. The redistribution of government should proceed on the principle that issues which affect only neighbourhoods should be decided by the neighbourhood alone, those which affect only communities by the community alone, those which affect only regions by the region alone, and so on. As regions, communities and neighbourhoods come increasingly to run their own affairs, so the development of a sense of community will proceed more easily, though we do not pretend that it will be without its problems.

275. Those regions which still have or are close to having a good urban-rural mix will be able to effect a relatively smooth transfer, but highly urbanised areas like London, the Lancashire conurbation, and South Wales will find it much more difficult to re-create communities. Nevertheless, even in London the structural remains of past communities (like the villages of Putney, Highgate, Hackney, Islington, etc.) will provide the physical nuclei of future communities—the means of orienting themselves so that they can cut themselves away from those deserts of commerce and packaged pleasure (of which the most prominent example is the Oxford Street, Regent Street, Piccadilly complex) on which so much of London's life is currently focused.

276. It is self-evident that no amount of legislative, administrative or industrial change will create stable communities if the individuals who are meant to comprise them are not fitted for them. As soon as the best means of inculcating the values of the stable society have been agreed upon, they should be incorporated into our educational systems. Indeed, it may not be until the generation of 40–50 year olds have been educated in these values (so that as far as possible everybody up to the age of 50 understands them) that stable communities will achieve sufficient acceptance for them to be permanently useful.

Orchestration

280. A cardinal assumption of this strategy is that it will not succeed without the most careful synchronisation and integration. We cannot say of a particular section of these proposals that it alone is acceptable, and therefore we will go ahead with it immediately but consider the rest later on! This section, therefore, is devoted to a schematic, annotated outline of how change might be orchestrated. It is necessarily unsophisticated and oversimplified, but we hope it will give some idea of how change in one quarter will aid change in the others.

281. Variables included in schematic outline:

(a) establishment of national population service

(b) introduction of raw materials, amortisation and power taxes; anti-disamenity legislation; air, land and water quality targets; recycling grants; revised social accounting systems

(c) developed countries end commitment to persistent pesticides and subsidise similar move by undeveloped countries

(d) end of subsidies on inorganic fertilisers

(e) grants for use of organics and introduction of diversity

(f) emergency food programme for undeveloped countries

(g) progressive substitution of non-persistent for persistent pesticides

(h) integrated control research programme

(i) integrated control training programme

(j) substitution of integrated control for chemical control

(k) progressive introduction of diversified farming practices

(l) end of road building

(m) clearance of derelict land and beginning of renewal programme

(n) restrictions on private transport and subsidies for public transport

(o) development of rapid mass-transit

(p) research into materials substitution

(q) development of alternative technologies

(r) decentralisation of industry: part one (redirection)

(s) decentralisation of industry: part two (development of community types)

(t) redistribution of government

(u) education research

(v) teacher training

(w) education

(x) experimental community

(y) domestic sewage to land

(z) target date for basic establishment of network of self-sufficient, self-regulating communities.

282. Notes:

(1) should be operating fully by 1980; review in 1995—if replacement-size families improbable by 2000, bring in socio-economic restraints; UK population should begin to slowly decline from 2015–2020 onwards; world population from 2100; little significant feedback expected in UK until about 2030.

(2) progressive; ironing out run to eliminate inconsistencies up to 1980; thereafter revise and tighten every five years; increasingly significant feedback from 1980 onwards, stimulating materials-energy conservation, employment-intensive industry, decen-

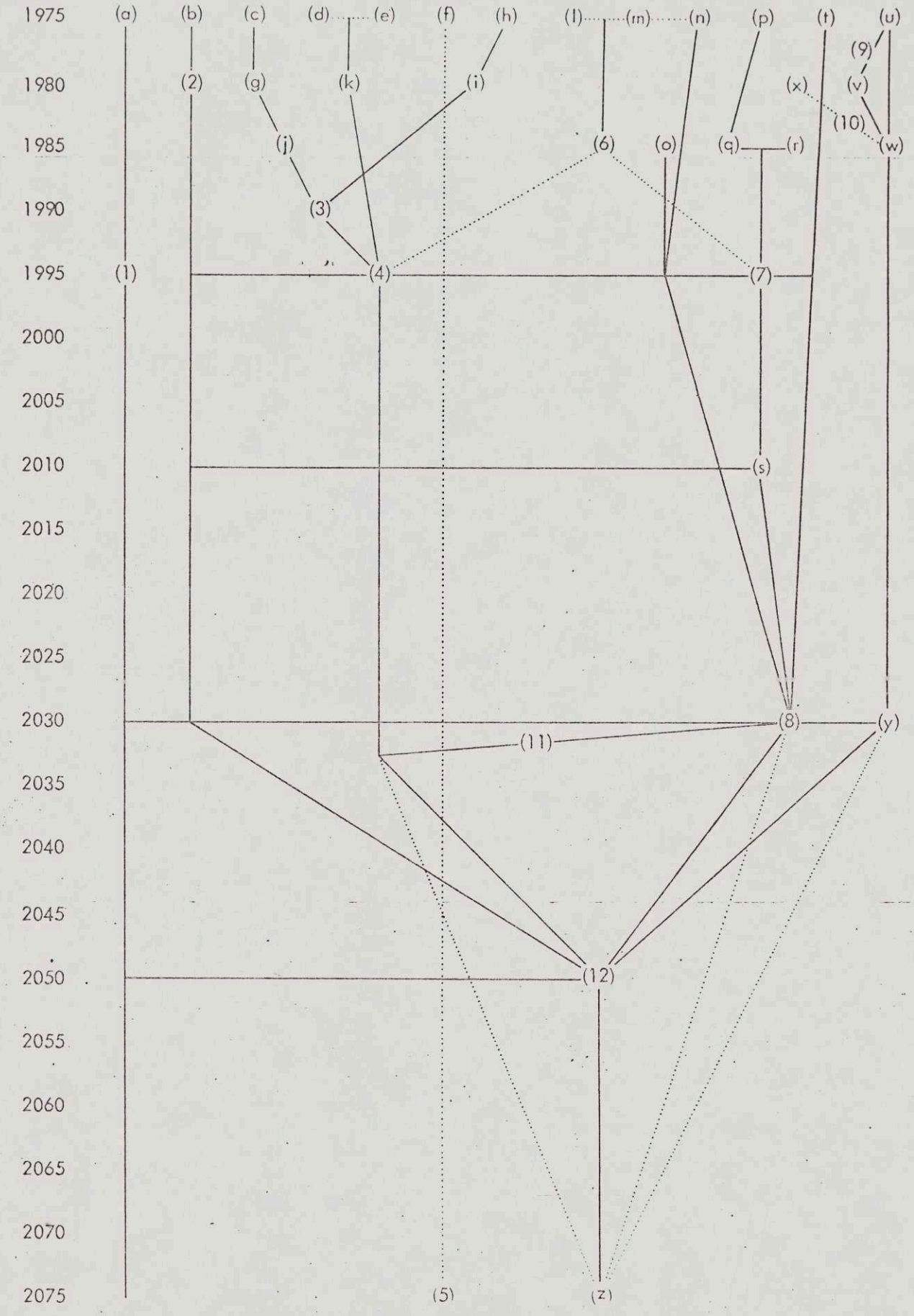

Figure 3 Schematic outline of change.
(See text for key)

tralisation, and progress in direction of (p), (q), (r) and (s).

(3) limited substitution of integrated control can begin quite soon, but large-scale substitution will depend on (h) integrated control research programme; naturally (h), (i) and (j) will run in parallel and are therefore represented as one; (g) will also continue for some time.

(4) diversified farming practices (k) and integrated control (j) will link up and form an agriculture best-suited for small, reasonably self-sufficient communities, so stimulating their development: significant feedback, therefore, will occur from this point.

(5) likely to be necessary at least until 2100.

(6) labour released from road building can go to (m) clearance of derelict land, which should be completed by 1985; thereafter there may be other renewal programmes such as canal restoration, while agriculture will increasingly require more manpower.

(7) development of alternative technologies (q) and redirecting of industry (r) will proceed in harness; progressively significant feedback between (b) and (t).

(8) target date for maximum redistribution of government 2030 to coincide with 45 years operation of (w); see note (9).

(9) five years only allowed for preliminary organisation and research, since it can proceed in harness with teacher training (v) and also with the education programme itself (w).

(10) an experimental community of 500 could be set up to clarify problems; feedback to (u).

(11) as soon as communities are small enough, domestic sewage can be returned to the land; there should be the firm beginnings of a good urban-rural mix by then.

(12) by this time there should be sufficient diversity of agriculture, decentralisation of industry and redistribution of government, together with a large proportion of people whose education is designed for life in the stable society, for the establishment of self-sufficient, self-regulating communities to be well-advanced. At this point taxation, grants, incentives, etc, could be taken over by the communities themselves. A further generation is allowed until target date, however.

A BLUEPRINT FOR SURVIVAL

The Goal

311. There is every reason to suppose that the stable society would provide us with satisfactions that would more than compensate for those which, with the passing of the industrial state, it will become increasingly necessary to forgo.

312. We have seen that man in our present society has been deprived of a satisfactory social environment. A society made up of decentralised, self-sufficient communities, in which people work near their homes, have the responsibility of governing themselves, of running their schools, hospitals, and welfare services, in fact of constituting real communities, should, we feel, be a much happier place.

313. Its members, in these conditions, would be likely to develop an identity of their own, which many of us have lost in the mass society we live in. They would tend, once more, to find an aim in life, develop a set of values, and take pride in their achievements as well as in those of their community.

314. It is the absence of just these things that is rendering our mass society ever less tolerable to us and in particular to our youth, and to which can be attributed the present rise in drug-addiction, alcoholism and delinquency, all of which are symptomatic of a social disease in which a society fails to furnish its members with their basic psychological requirements.

315. More than a hundred years ago, John Stuart Mill realised that industrial society, by its very nature, could not last for long and that the stable society that must replace it would be a far better place. He wrote[1]:

"I cannot . . . regard the stationary state of capital and wealth with the unaffected aversion so generally manifested towards it by political economists of the old school. I am inclined to believe that it would be, on the whole, a very considerable improvement on our present condition. I confess I am not charmed with the ideal of life held out by those who think that the normal state of human beings is that of struggling to get on; that the trampling, crushing, elbowing, and treading on each other's heels which forms the existing type of social life, are the most desirable lot of human kind. . . . The northern and middle states of America are a specimen of this stage of civilisation in very favourable circumstances; and all that these advantages seem to have yet done for them . . . is that the life of the whole of one sex is devoted to dollar hunting, and of the other to breeding dollar-hunters.

"I know not why it should be a matter of congratulation that persons who are already richer than anyone needs to be, should have doubled their means of consumings things which give little or no pleasure except as representative of wealth . . . It is only in the backward countries of the world that increased production is still an important object; in those most advanced, what is economically needed is a better distribution, of which one indispensable means is a stricter restraint on population . . . The density of population necessary to enable mankind to obtain, in the greatest degree, all the advantages both of cooperation and of social intercourse, has, in all the most populous countries, been attained . . . It is not good for a man to be kept perforce at all times in the presence of his species . . . Nor is there much satisfaction in contemplating a world with nothing left to the spontaneous activity of nature . . . If the earth must lose that great portion of its pleasantness which it owes to things that the unlimited increase of wealth and population would extirpate from it, for the mere purpose of enabling it to support a larger population, I sincerely hope, for the sake of posterity, that they will be content to be stationary, long before necessity compels them to it.

"It is scarcely necessary to remark that a stationary condition of capital and population implies no stationary state of human improvement. There would be as much scope as ever for all kinds of mental culture, and moral and social progress; as much room for improving the Art of Living and much more likelihood of it being improved, when minds cease to be engrossed by the art of getting on."

The importance of a varied environment

321. In our industrial society, the only things that tend to get done are those that are particularly conducive to economic growth, those in fact that, in terms of our present accounting system, are judged most efficient!

322. This appears to be almost the sole consideration determining the nature of the crops we sow, the style of our houses, and the shape of our cities. The result, among other things, is the dreariest possible uniformity.

323. In a stable society, on the other hand, there would be nothing to prevent many other considerations from determining what we cultivate or build. Diversity would thus tend to replace uniformity, a trend that would be accentuated by the diverging cultural patterns of our decentralised communities.

324. As Rene Dubos has pointed out[2]:

"In his recent book, *The Myth of the Machine*, Lewis Mumford states that 'If man had originally inhabited a world as blankly uniform as a "high-rise" housing development, as featureless as a parking lot, as destitute of life as an automated factory, it is doubtful that he would have had a sufficiently varied experience to retain images, mould language, or acquire ideas'. To this statement, Mr Mumford would probably be willing to add that, irrespective of genetic constitution, most young people raised in a featureless environment and limited to a narrow range of life experiences will be crippled intellectually and emotionally.

"We must shun uniformity of surroundings as much as absolute conformity of behaviour, and make instead a deliberate effort to create as many diversified environments as possible. This may result in some loss of efficiency, but the more important goal is to provide the many kinds of soil that will permit the germination of the seeds now dormant in man's nature. In so far as possible, the duplication of uniformity must yield to the organisation of diversity. Richness and variety of the physical and social environment constitute crucial aspects of functionalism, whether in the planning of cities, the design of dwellings, or the management of life."

Real Costs

331. We might regard with apprehension a situation in which we shall have to make do without many of the devices such as motor-cars, and various domestic appliances which, to an ever greater extent are shaping our everyday lives.

332. These devices may indeed provide us with much leisure and satisfaction, but few have considered at what cost. For instance, how many of us take into account the dull and tedious work that has to be done to manufacture them, or for that matter to earn the money required for their acquisition? It has been calculated[3] that the energy used by the machines that provide the average American housewife with her high standard of living is the equivalent of that provided by five hundred slaves.

333. In this respect, it is difficult to avoid drawing a comparison between ourselves and the Spartans, who in order to avoid the toil involved in tilling the fields and building and maintaining their homes employed a veritable army of helots. The Spartan's life, as everybody knows, was a misery. From early childhood, boys were made to live in barracks, were fed the most frugal and austere diet and spent most of their adult life in military training so as to be able to keep down a vast subject population, always ready to seize an opportunity to rise up against its masters. It never occurred to them that they would have been far better off without their slaves, fulfilling themselves the far less exacting task of tilling their own fields and building and maintaining their own homes.

334. In fact "economic cost", as we have seen, simply does not correspond to "real cost". Within a stable society this gap must be bridged as much as possible.

335. This means that we should be encouraged to buy things whose production involves the minimum environmental disruption and which will not give rise to all sorts of unexpected costs that would outweigh the benefits that their possession might provide.

Real Value

341. It is also true, as we have seen, that "economic value" as at present calculated does not correspond to real value any more than "economic cost" corresponds to real cost.

342. Our standard of living is calculated in terms of the market prices of the goods that it includes. These do not distinguish between, on the one hand, the gadgets that we do not really need and such essentials as unpolluted water, air and food on which our health must depend. In fact it tends to place greater value on the former, as we usually take the latter for granted.

343. It is in terms of these market prices that the GNP is calculated, and as we have seen, this provides the most misleading indication of our well-being.

Edward Mishan[4] points out that "... An increase in the numbers killed on the roads, an increase in the numbers dying from cancer, coronaries or nervous diseases, provides extra business for physicians and undertakers, and can contribute to raising GNP. A forest destroyed to produce the hundreds of tons of paper necessary for the American Sunday editions is a component of GNP. The spreading of concrete over acres of once beautiful countryside adds to the value of GNP ... and so one could go on."

344. In the same way, many of the machines whose possession is said to increase our standard of living are simply necessary to replace natural benefits of which we have been deprived by demographic and economic growth. We have pointed out how true this is of the ubiquitous motor-car. Also, many labour-saving devices are now necessary because with the disintegration of the extended family there is no one about to do the household chores. The fact that both husband and wife must, in many cases, go out to work to earn the money to buy the machines required to do these chores can serve only to render such devices that much more necessary.

345. In a stable society, everything would be done to reduce the discrepancy between economic value and real value, and if we could repair some of the damage we have done to our physical and social environment, and live a more natural life, there would be less need for the consumer products that we spend so much money on. Instead we could spend it on things that truly enrich and embellish our lives.

346. In manufacturing processes, the accent would be on quality rather than quantity, which means that skill and craftsmanship, which we have for so long systematically discouraged, would once more play a part in our lives. For example, the art of cooking would come back into its own, no longer regarded as a form of drudgery, but correctly valued as an art worthy of occupying our time, energy and imagination. Food would become more varied and interesting and its consumption would become more of a ritual and less a utilitarian function.

The arts would flourish: literature, music, painting, sculpture and architecture would play an ever greater part in our lives, while achievements in these fields would earn both money and prestige.

347. A society devoted to achievements of this sort would be an infinitely more agreeable place than is our present one, geared as it is to the mass produc-

c

tion of shoddy utilitarian consumer goods in ever greater quantities. Surprising as it may seem to one reared on today's economic doctrines, it would also be the one most likely to satisfy our basic biological requirements for food, air and water, and even more surprisingly, provide us with the jobs that in our unstable industrial society are constantly being menaced.

348. Indeed, as we have seen, the principal limitation to the availability of jobs today is the inordinately high capital outlay required to finance each worker. This limitation is withdrawn as soon as we accept that, within the framework of an overall reorganisation of our society, it would be possible for capital outlay to be reduced without reducing our real standard of living.

349. One of the Bishop of Kingston's ten commandments[5] is: "You shall not take the name of the Lord thy God in vain by calling on his name but ignoring his natural law." In other words, there must be a fusion between our religion and the rest of our culture, since there is no valid distinction between the laws of God and Nature, and Man must live by them no less than any other creature. Such a belief must be central to the philosophy of the stable society, and must permeate all our thinking. Indeed it is the only one which is properly scientific, and science must address itself much more vigorously to the problems of co-operating with the rest of Nature, rather than seeking to control it.

350. This does not mean that science must in any way be discouraged. On the contrary, within a stable society, there would be considerable scope for the energies and talents of scientist and technologist.

Basic scientific research, plus a good deal of multidisciplinary synthesis, would be required to understand the complex mechanisms of our ecosphere with which we must learn to co-operate.

351. There would be a great demand for scientists and technologists capable of devising the technological infrastructure of a decentralised society. Indeed, with the application of a new set of criteria for judging the economic viability of technological devices, there must open a whole new field of research and development.

352. The recycling industry which must expand very considerably would offer innumerable opportunities, while in agriculture there would be an even greater demand for ecologists, botanists, entomologists, mycologists etc., who would be called upon to devise ever subtler methods for ensuring the fertility of the soil and for controlling "pest" populations.

353. Thus in many ways, the stable society, with its diversity of physical and social environments, would provide considerable scope for human skill and ingenuity.

354. Indeed, if we are capable of ensuring a relatively smooth transition to it, we can be optimistic about providing our children with a way of life psychologically, intellectually and aesthetically more satisfying than the present one. And we can be confident that it will be sustainable as ours cannot be, so that the legacy of despair we are about to leave them may at the last minute be changed to one of hope.

Acknowledgements

We would like to acknowledge the valuable comments contributed by Gerald Leach, The Rt. Rev. Hugh Montefiore, Brian Johnson and John Papworth.

We are grateful to Potomac Associates, Washington DC, for permission to reproduce a graph from their forthcoming book *The Limits of Growth* by Dennis Meadows; to the MIT Press for permission to use a number of tables and to quote extensively from their book *Man's Impact on the Global Environment, The Study of Critical Environmental Problems (SCEP)*; to Pemberton Books for permission to reproduce a graph from their book *Population and Liberty* by Jack Parsons; to Collier-MacMillan for permission to reproduce two tables from their book *Too Many*, by Georg Borgstrom; to Tom Stacey for permission to quote extensively from his book *Can Britain Survive?*, edited by E. Goldsmith.

Parts of the Introduction and "Towards the Stable Society", notably those sections on stabilising the population and on creating a new social system, have been adapted from *The Fall of Man* by Robert Allen (to be published later this year by Allen Lane, The Penguin Press) by permission of author and publisher.

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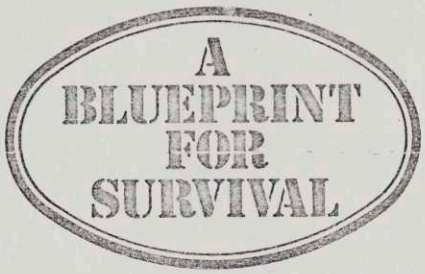
Forthcoming issues of The Ecologist . . .

will discuss in detail—regional environmental problems; particular aspects of ecological and social disruption; and the full implications of this *Blueprint*, the research required to improve it, and the tactics required to further its adoption.



The Movement for Survival (MS)

1. Aim

We need a Movement for Survival, whose aim would be to influence governments, and in particular that of Britain, into taking those measures most likely to lead to the stabilisation and hence the survival of our society.

2. Structure

We envisage it as a coalition of organisations concerned with environmental issues, each of which would remain autonomous but which saw the best way of achieving its aims was within the general framework of the *Blueprint for Survival.*

The organisations have already expressed general support for the *Blueprint:*

The Conservation Society
Friends of the Earth
The Henry Doubleday Research Association
The Soil Association
Survival International

Two representatives of each member organisation would join the Action Committee of the MS, which would elect a chairman and secretary to run the day-to-day business of the Movement.

3. Individual membership

Members of constituent organisations would automatically become members of the MS. Individuals who belonged to none of these bodies could join the MS only through one of these organisations.

Regular news of MS activities would be published in *The Ecologist*, a subscription to which would be available to MS members at the reduced price of £3 p.a. (25 per cent reduction). Representatives of the constituent organisations could become members of *The Ecologist's* editorial board.

4. Further information

Organisations wishing to join the MS and all others seeking further information should write to the Acting Secretary, The Movement for Survival, c/o *The Ecologist*, Kew Green, Richmond, Surrey.

A BLUEPRINT FOR SURVIVAL

APPENDIX A

Ecosystems and their disruption

It is necessary to survey the essential features of the environment in order to understand how it is being affected by man's activities.

We can define the environment as a system which includes all living things and the air, water and soil which is their habitat. This system is often referred to as the ecosphere. To describe it as a system is to accentuate its unity; a system being something made up of interrelated parts in dynamic interaction with each other, and capable for certain purposes, of co-operating in a common behavioural programme.

Such a programme must be regarded as goal-directed, and its goal the maintenance of stability. This appears to be the basic goal of all the self-regulating behavioural processes that make up the ecosphere.

Stability is best defined as a system's ability to maintain its basic features—in other words to survive in the face of environmental change. This means that, in a stable system, change will be minimised and will occur only as is necessary to ensure adaptation to a changing environment. In other words, as stability increases so the frequency of random changes will be correspondingly reduced.

It is easy to see how the ecosphere during the last few thousand million years of evolution has slowly become more stable.

Whereas the deserts, which once covered our planet, reflected the environmental pressures to which they were subjected, the forests that developed to replace them have a capacity to maintain a relatively stable situation in the face of internal and external change. For instance, they ensure an optimum balance between the oxygen and carbon dioxide contents of the air by emitting one and absorbing the other. They provide good conditions for the run-off to rivers to be regulated. They periodically shed their leaves which build up humus, and hence ensure the continued fertility of the soil. They provide a relatively constant ambient temperature to the wild animals that live within their shade, who, as they evolve also develop stabilising mechanisms ensuring the stability of what is sometimes called their "internal environment"; the constant body temperature of warm blooded mammals being an obvious example.

Perhaps the most important feature of the ecosphere is its degree of organisation. It is made up of countless ecosystems, themselves organised into smaller ones, which are further organised into still smaller ones. Each of these is made up of populations of different species in close interaction with each other, some of which are usually organised into communities and families—further organised into cells, molecules and atoms etc.

The opposite of organisation is randomness or, what is often referred to as entropy. In fact it can be said that the ecosphere differs from the surface of the moon and probably from that of all the other planets in our solar system, in that randomness, or entropy, have been progressively reduced and organisation, or negative entropy, have been correspondingly increased. According to the second law of thermodynamics, there is a tendency in all systems towards increasing randomness, or entropy. This must be so, since to move in this direction is to take the line of least resistance and also because whenever energy is converted (and this must occur during all behavioural processes), waste, or random parts must be generated—from oxidation and friction if from nothing else.

The ecosphere has succeeded in counteracting this tendency by virtue of several unique features and because it is an open system from the point of view of energy, being continually bombarded with solar radiation.

This radiation is used by green plants during photosynthesis to organise nutrients in the soil into complex plant tissue, which are then eaten by herbivores, and hence reorganised into still more complex animal tissue.

In such processes waste or random parts must be generated. However, so long as the corresponding reduction in organisation is less than the increase in organisation achieved during the process, then entropy will have been reduced. Such increases will be limited by all sorts of factors including the availability of energy and materials, the environment's capacity to absorb waste and the organisational capacity of the system. Waste must therefore be kept down to a minimum. This can only be done by recycling it so as to ensure that the waste generated by one process serves as the materials for the next. This is essential for another reason:

Whereas the ecosphere is an open system as regards energy, it is a closed one as regards materials, which is another reason why all materials must be recycled, and why the waste products of one process must serve as materials for the next.

Also some of the more highly organised materials required for sophisticated processes have taken hundreds of millions of years to develop in the case of fossil fuels, for instance, and thousands of millions of years in the case of the herbivorous animals required as food by carnivores. It is thus clear that to avoid increasing entropy, they cannot be used up faster than they are produced. Hence the essential cyclic nature of all ecological processes and the absolute necessity for recycling everything.

It is possible to trace just how all the resources, such as carbon, nitrogen, phosphorus, water, etc., made use of in behavioural processes, are recycled. The food cycle is particularly illustrative. Take the case of a marine ecosystem: fish excrete organic waste which is converted by bacteria to inorganic products. These provide nutrients, permitting the growth of algae which are eaten by fish, and the cycle is complete. In this way the wastes are eliminated, the water kept pure, and, at the same time, the materials for the next stage of the process are made available.

One of the most important features of life processes is that they are automatic or self-regulating. Self regulation can only be ensured in one way: data must be detected by the system, transducted into the appropriate informational medium, and organised so as to constitute a model or "template" of its relationship with its environment. Whenever this relationship is modified in such a way that it deviates from the

optimum, the model is correspondingly affected, and it can be used to guide the appropriate course of action, and monitor each new move, until a new position of equilibrium has been reached. This basic cybernetic model explains how all systems, regardless of their level of complexity, adapt to their respective environments. The fact that all the parts of the ecosphere are linked to each other in this way ensures that a general readjustment of the most subtle nature can occur to restore its basic structure after any disturbance.

To suppose that we can ensure the functioning of the ecosphere ourselves with the sole aid of technological devices thereby dispensing with the elaborate set of self-regulating mechanisms that has taken thousands of millions of years to evolve, is an absurd piece of anthropocentric presumption that belongs to the realm of pure fantasy.

It may be possible to replace certain natural controls locally and for a short while without any serious cataclysm occurring, but if we push things too far, if for instance the insecticides we use to replace the self-regulating controls that normally ensure the stability of insect populations were to destroy nitrogen-fixing bacteria or pollinating insects, all the money and all the technology in the world would not suffice to replace them and thereby to prevent life processes from grinding to a halt. Yet this substitution is implicit in the aim of industrial society.

As this aim is progressively realised, and as we become more and more dependent on technological devices, i.e. external controls, so must there be a corresponding increase in the instability of our social system and hence in our vulnerability to change. Imagine, what it will be like when water supplies have been exhausted and we are dependent upon desalination plants for our drinking water, when traditional methods of agriculture have totally given way to ever more ingenious forms of factory farming, and when the natural mechanisms providing us with the air we breathe have been so completely disrupted that vast installations are needed to pump oxygen into the atmosphere and filter out the noxious gasses emitted by our industrial installations.

Clearly under such conditions, the slightest technical hitch or industrial dispute, or shortage of some key resource, might be sufficient to deprive us of such basic necessities of life as water, food and air—and bring life to a halt.

If man wishes to survive, to ensure the proper functioning of the self-regulating mechanisms of the ecosphere must be his most basic endeavour. For this to be possible however the latter's essential structure must be respected. Deviations may be possible but only within acceptable limits.

One way of exceeding these limits is to supply the system with more waste than can be used to provide the materials for other processes. In such conditions the system is said to be "overloaded"; the self-regulating mechanisms can no longer function and the waste simply accumulates. In other words entropy, or randomness, has increased and the surface of the earth resembles that much more that of the moon.

Thus, to return to our marine ecosystem, if the cycle is overloaded with too much sewage, detergents or artificial fertilisers which are nutrients to aquatic plant life, the amount of oxygen required to ensure the decomposition of these substances by the appropriate bacteria may be so high that other organisms will be deprived of an adequate supply.

If this goes on long enough the oxygen level will be reduced to zero. Without oxygen, the bacteria will die and a crucial phase in the cycle will have been interrupted, thereby bringing it rapidly to a halt. As a result, what was once an elaborate ecosystem, supporting countless forms of life in close interaction with each other now becomes a random arrangement of waste matter.

Needless to say the cycle will also come to a halt if, on the contrary, there were a shortage of nutrients. In such conditions the algae could not survive, and the fish population deprived of its sustenance, would rapidly die off.

This illustrates an essential principle of organisation; there must be an optimum value to every variable in terms of which the system is described. When each variable has its correct value, then the system described can be regarded as having its correct structure. This means that there is no value that can be increased or reduced indefinitely without bringing about the system's eventual breakdown.

To cherish the illusion that the population and affluence of human social systems are exceptions to this law, is, as we shall see, to court the gravest possible calamities.

In order to maintain the system's structure, the actions of the self-regulating sub-systems not only seek to establish a stable relationship with another sub-system, but with their environment as a whole. In other words, they do not aim at satisfying a specific requirement, but at achieving a compromise between a whole set of often competing requirements; that which best satisfies the requirements of the environment as a whole.

Technological devices, of course, do precisely the opposite. They are geared to the achievement of specific short-term targets, regardless of environmental consequences. Since many requirements must be satisfied to maintain stability, such devices by their very nature must cause environmental problems, and, as a result, they must inevitably tend towards achieving equilibrium positions which display lower rather than higher stability. This means that the probability that disequilibria will occur and their degrees of seriousness are both likely to increase as must the rate at which new devices will be required as well as the effectiveness required of them.

In other words, the role played by technology must increase by positive feedback and our society must become even more addicted to it.

In these circumstances, unless technological innovation can proceed indefinitely at an exponential rate, then it is only a question of time before a disequilibrium occurs for which there is no technological solution, which must spell the complete breakdown of the system.

Industrial society, when it reaches a certain stage of development, begins to affect its environment in yet another manner; it devises, and becomes correspondingly dependent upon, synthetic products of different sorts to replace ever-scarcer natural products. Thus plastics are developed to replace wood products; detergents to replace soaps made from natural fats, synthetic fibres to replace natural fibres; chemical fertilisers to replace organic manure. At the same time, nuclear energy slowly replaces that previously derived from fossil fuels.

It is probable that our ecosphere does not produce a single molecule for which there is not an enzyme capable of

breaking it down, in order to perpetuate the essential cycle of life, growth, death and decay. This is not so with synthetic products. They cannot normally be broken down in this way—save in some cases by human manipulation, which is only practicable on a small scale and in specific conditions. It is thus no longer a question of overloading a system. Even the slightest amount of these products, when introduced into our ecosphere, constitutes pollution, while since by their very nature they must continue accumulating, to produce them methodically is to ensure the systematic replacement of the ecosphere with extraneous waste matter.

What is worse, many of these substances find their way into life processes with which they can seriously interfere. Thus strontium 90 gets into the bones of growing children and can give rise to bone cancer; Iodine 131 accumulates in the thyroid gland and can give rise to cancer of the thyroid; DDT accumulates in the fatty matter and in the liver and may cause cancer and other liver diseases; plastics and many other pollutants also accumulate in the liver and kidneys, etc.

It is not surprising that as industrialisation proceeds, so there is a very rapid increase in the so-called degenerative diseases. Carcinogenic agents also tend to be mutagens, and their proliferation must mean a gradual reduction in the adaptiveness of our species, a process that clearly cannot go on indefinitely[2].

There is another way in which we are degrading the ecosphere. One of its most important features is its complexity. The greater the number of different plant and animal species that make up an ecosystem, the more likely it is to be stable. This is so because, as Elton points out, in such a system every ecological niche is filled. That is to say, every possible differentiated function for which there is a demand within the system is in fact fulfilled by a species that is specialised in fulfilling it. In this way it is extremely difficult for an ecological invasion to occur, i.e. for a species foreign to the system entering and establishing itself, or, worse still, proliferating and destroying the system's basic structure.

It also means that no species forming part of the system is likely to be able to expand beyond its optimum size. The availability and size of an ecological niche undoubtedly constitutes an effective population control. Thus the diet of a specialised member of a highly differentiated ecosystem will itself be of a specialised nature, which means that if the population of a particular species were to increase, or, alternatively, to decrease, the food supply of the other species would not be affected. The opposite would be the case with species that normally form part of a simple ecosystem.

Thus goats are adapted to live in mountain areas, where ecological complexity is low, and in order to survive they have to be able to eat almost anything. The result is when they are brought down to the plains, they make short shrift of its vegetation, and their proliferation compromises the food supply of many other species.

As industrial man destroys the last wildernesses, as herds of domesticated animals replace inter-related animal species, and vast expanses of crop monoculture supplant complex plant ecosystems, so complexity and hence stability are correspondingly reduced.

Industrial man is also reducing complexity in other ways. For instance, economic pressures force farmers to reduce the number of different strains of crops under cultivation. Only those that present short-term economic advantages tend to survive. This process has been accentuated with the so-called "green revolution". Special high yield strains of rice and wheat that respond particularly well to artificial fertilisers have been developed and introduced on a large scale in many parts of the third world. In these areas many other strains have been abandoned. In this way we are reducing complexity, in some cases irreversibly, and if anything should happen to the surviving strains, essential crops like wheat and rice could well be jeopardised.

We are reducing complexity in still another way. The greater the number of trophic levels (in other words the greater the length of food chains), the more stable is an ecosystem likely to be. Thus the simplest marine ecosystem would consist of phytoplankton, capable of harnessing the sun's energy and micro-organisms capable of decomposing them. By introducing zooplankton into the system, another link has been introduced into the food chain. These, by preying on the phytoplankton, keep down their numbers and weed out the weak and unadaptive. In this way, they exert both quantitative and qualitative controls, and exert an important stabilising influence. If fish are then introduced to feed on the zooplankton, the system becomes correspondingly more stable.

Needless to say, man's activities are everywhere leading to a reduction in the length of food chains. The larger terrestrial predators have been virtually eliminated in industrial countries, and this process is now taking place in the seas. Man, by refusing to tolerate competitors for his food supply, is ultimately jeopardising the stability of this food supply, and hence, its very availability.

Also, as SCEP points out, environmental stress appears to affect predators more radically than herbivores. In aquatic systems the top-level predators, which eat other predators, are the most sensitive of all. This appears to be the case with such disruptive situations as oxygen deficiency, thermal stress, and the introduction of toxic materials such as pesticides and fertilisers.

The effect must be to reduce the number of trophic levels in any ecosystem thereby increasing its instability. SCEP cites several examples:

"Overenrichment by sewage waste and fertiliser runoff of freshwaters, or pollution with industrial wastes, leads to the rapid loss of trout, salmon, pike, and bass. Spraying crops for insect pests has inadvertently killed off many predaceous mites, resulting in outbreaks of herbivorous mites that obviously suffered less. Forest spraying has similarly 'released' populations of scale insects after heavy damage to their wasp enemies."

In addition, SCEP points out that "such fat-soluble pesticides as DDT are concentrated as they pass from one feeding level to the next. In the course of digestion a predator retains rather than eliminates the DDT content of its prey. The more it eats, the more DDT it accumulates. The process results in especially high concentrations of toxins in predaceous terrestrial vertebrates."

Predators also suffer from the destruction of their food supply. Severe damage to the lower levels in the food chain usually leads to the extinction of the predator before that of the species on which it preys.

There is yet another way in which we are reducing complexity. Populations at any given moment will be made up of individuals of every possible age group. We tend to replace such balanced populations with plantations of trees

and other crops which are all of the same age and are particularly vulnerable to diseases affecting them at particular stages in their life cycle. This principle must apply equally well to intensive stock rearing units and especially factory farms. Once more the result is to reduce stability.

Technological devices must also reduce complexity. They constitute external controls exerted by precarious human manipulation. They invariably replace natural controls of a far more complex nature.

Thus, to replace the natural controls which ensure the stability of an insect population by a single chemical pesticide involves a drastic reduction in complexity. The same must be true when we replace the natural mechanisms ensuring soil fertility with nitrogen, phosphorus and potassium which are the main ingredients of artificial fertilisers.

In fact, most human activities are reducing the stability of the ecosphere, which is simply another way of saying that they are determining its systematic degradation.

For several thousand million years, the ecosphere has been developing into an extremely complex organisation of different forms of life in close interaction with each other. In doing this it has been counteracting the basic tendency of all systems towards randomness or entropy. The elaborate mechanisms that have enabled the ecosphere to develop in this manner have been disrupted by man's activities. In his gross presumption, he has sought to replace them with devices causing dereliction and confusion, which rather than seek to satisfy the countless competing requirements of the ecosphere, have been geared to the satisfaction of petty, short-term anthropocentric ends. As a result, the organisational process has been reversed; waste, or random parts, are accumulating faster than organisation is building up. Rather than counteract the inexorable trend towards entropy, industrial man's activities are accelerating it.

If these activities continue to increase exponentially at 6.5 per cent per annum, or double every 13½ years, it cannot take many decades before our planet becomes incapable of supporting complex forms of life.

Pollution

Studies of the effects of pollutants on ecosystems have often yielded contradictory results. Rather than attempt to weigh these up, we have chosen to summarise some of the findings of what is almost certainly the most authoritative study, that undertaken in 1969 by an impressive group of scientists from many different disciplines under the auspices of MIT and referred to as "The Study of Critical Environmental Problems" or SCEP. This study is to be used as background material for the UN Conference on the Human Environment 1972.

SCEP accentuates the necessity for adopting a holistic approach. "The significant aspect of human action is man's total impact on ecological systems, not the particular contributions that arise from specific pollutants. Interaction among pollutants is more often present than absent. Furthermore, the total effect of a large number of minor pollutants may be as great as that of one major pollutant. Thus, the total pollution burden may be impossible to estimate except by direct observation of its overall effect on ecosystems."

The scale of human activity can be estimated by comparing specific man-induced processes with the natural rates of geological and ecological processes. It can be shown that in at least 12 cases man-induced rates are as large or larger than the natural rates (see Table 5).

It is pointed out that with a five per cent natural growth increment in the mining industries, this will apply to many more materials.

". . . these comparisons show that at least some of our actions are large enough to alter the distribution of materials in the biosphere. Whether these changes are problems depends upon the toxicity of the material, its distribution in space and time, and its persistence in ecological terms."

Most of the disruptive processes already described are well advanced, however, and as they occur slowly the most visible effect is a gradual deterioration of ecosystems, "characterised by instability and species loss".

Many lakes and urban centres have severely deteriorated ecosystems. Less severe deteriorations occur more commonly, often as temporary afflictions in ecosystems that otherwise manage to survive intact: . . . This general problem is labelled "attrition" because it lacks discrete steps of change. Stability is lost more and more frequently, noxious organisms become more common, and the aesthetic aspects of waters and countryside become less pleasing. This process has already occurred many times in local areas. If it were to happen gradually on a global scale, it might be much less noticeable, since there would be no surrounding ecosystems against which to measure such slow changes. Each succeeding generation would accept the status quo as "natural".

Energy products

Present and future levels of energy consumption are particularly relevant to estimating our capacity to disrupt ecosystems. The best available calculation appears to be that made by the Battelle Memorial Institute in 1969. In 1968 energy consumption in the US was slightly over 60,000 trillion BTU. It appears to be rising at 3.2 per cent per annum and is expected to be 170,000 trillion BTUs by the year 2000.

Over the last 50 years there has been a decreasing amount of energy used for each unit of GNP. The increased technical efficiency of energy used has tended to more than offset the more intense use of energy. The trend, however, appears to be changing. The present policy is to encourage energy use while the technical efficiency of new electric power plants and other energy conversion devices is no longer increasing and may even decrease over the next decades. If this is so, then it is possible that this and other projections have underrated future energy requirements. On the other hand conservation pressures might lead to a reduced usage and this has not been taken into account.

World wide energy consumption projection made by Joel Darmstadter of Resources for the Future has appeared in a work *Energy and the World Economy* (see Table 1).

What are likely to be the emissions from power production and other forms of energy production?

It is estimated that in 1967 some 13.4 billion metric tons of CO_2 were released from fossil fuel combustion and that emissions in 1980 (using Darmstadter's projection) would be 26 billion metric tons for the world as a whole.

SCEP points out that the trend towards depleting the remaining stands of original forests, such as those in tropical Brazil, Indonesia and the Congo, will further reduce the capacity of the ecosphere to absorb Co_2 and may

release even more Co_2 to the atmosphere. The Co_2 content of the atmosphere is increasing at a rate of 0.2 per cent per year since 1958. One can project, on the basis of these trends, an 18 per cent increase by the year 2000, i.e. from 320 ppmm to 379 ppmm. SCEP considers that this might increase temperature of the earth by 0.5°C. A doubling of Co_2 might increase mean annual surface temperatures by 2°C (see Table 3).

Heat

Thermal waste energy is increasing at a rate of 5.7 per cent per annum, which means that it is likely to increase by a factor of 6 before the end of the century. The total for 1970 was 5.5 10^6 MW which is likely to increase to 9.6 by 1980 and 31.8 10^6 MW by 2000. The effects on global climate are not known.

Emissions of pollutants such as sulphur oxides, nitrogen oxides, hydrocarbons, carbon monoxide and particulate matter, cannot be predicted with any assurance. The theoretical knowledge necessary to make these predictions does not yet exist nor are the relevant facts available.

As far as emissions of radionuclides are concerned the major source will be at the site of fuel reprocessing plants. One estimate is that 99.9 per cent of all such emissions entering the environment are from such sources. Concern is expressed for emissions of "potentially hazardous" radionuclides such as iodine 131, xenon 153, strontium 90, and caesium 137. Possible releases of tritium (hydrogen 3) and krypton 85 are also of concern.

Total emissions would not lead to anything like maximum permissible concentrations (MPC) if dispersal was assured. However, one must take into account the tendency of radionuclides to concentrate in certain organisms and to get into food chains. Concentration factors of 1,000 for caesium in the flesh of bass have been found, of 8,700 in the bones of the blue gills, of 350,000 for radioactivity content in caddis fly larvae, 40,000 for duck egg yolks and 75,000 for adult swallows. Table 7 shows estimated concentration factors for some radionuclides in aquatic organisms.

Phytoplankton also tend to concentrate activation products such as zinc 65, cobalt 67, iron 55 and manganese 54 to an even greater extent than fission products.

When breeder reactors are introduced plutonium emissions will also become a concern.

The management of concentrated and highly radioactive wastes is a serious problem deserving far more study. Table 2 provides an estimate of accumulated wastes for 1970, 1980 and 2000.

Domestic and agricultural wastes

Dredged wastes from urban areas contain sediment, sewage solids, agricultural and industrial wastes. These also tend to be deposited in rivers or coastal waters. The total amount deposited in this way is estimated at between 150 and 220 million metric tons per years, and appears to be increasing at 4 per cent per annum.

World production and consumption of chemical fertilisers (except during periods 1914-18 and 1940-45) have doubled or tripled in each decade. Total world use in 1963-64 exceeded 33 million metric tons, only 10 per cent of which were used in developing countries. Their share, however, is increasing rapidly.

Present annual world production of pesticides is probably about 1 million metric tons. It is likely to go on increasing in view of the increasing world food shortage and because of diminishing returns on their use. Thus to double world food production which as we have seen is likely to be necessary, it will be necessary to increase consumption by no less than six times (see Table 12).

In the industrialised countries there is likely to be a move away from DDT to less persistent but more toxic pesticides such as phorate, dimiton, parathion, etc. These require more frequent sprayings to make up for their reduced persistence. It is unlikely that the developing countries will be able to afford them, so consumption of DDT is likely to continue growing.

SCEP points out the way in which agriculture becomes increasingly dependent on the use of these poisons: "Realisation that the use of pesticides increases the need to continue their use is not new, nor is the awareness that the constant use of pesticides creates new pests. For many of our crops on which pesticide use is heavy, the number of pests requiring control increases through time. In a very real sense, new herbivorous insects find shelter among

Table 1
Darmstadter's Projection of World Energy Consumption in 1980

		Solid		Liquid		Gas		Hydro†		Nuclear†		Overall	
	A*	10^{12} kWh(t)‡	Percentage of World Consumption	10^{12} kWh(t)‡	Percentage of World Consumption	10^{12} kWh(t)‡	Percentage of World Consumption	10^{12} kWh(t)‡	Percentage of World Consumption	10^{12} kWh(t)‡	Percentage of World Consumption	10^{12} kWh(t)‡	Percentage of World Consumption
Developed Countries													
United States	3.5	5.0	17.3	9.4	25.3	8.3	41.9	0.34	18.1	0.98	52.0	24.0	26.8
Canada	5.5	0.3	0.9	1.2	3.2	1.0	4.8	0.22	11.6	0.05	2.8	2.8	3.0
Western Europe	4.0	2.7	9.4	9.2	24.9	2.1	10.3	0.46	24.1	0.63	33.5	15.1	16.8
Communist Eastern Europe	4.6	3.6	12.5	1.5	3.9	0.7	3.5	0.02	1.2	0.04	2.1	5.9	6.6
USSR	6.5	5.7	19.7	5.2	14.0	5.9	29.8	0.29	15.3	0.04	2.1	17.1	19.1
Japan	7.9	0.5	1.9	3.5	9.5	0.1	0.4	0.11	5.7	0.11	5.6	4.3	4.9
Oceania	4.8	0.4	1.3	0.4	1.2	0.1	0.7	0.04	2.1	0.01	0.3	1.0	1.1
Total	4.7	18.2	63.0	30.4	82.0	18.2	91.4	1.48	78.1	1.86	98.4	70.2	78.3
Developing Countries													
Communist Asia	7.6	7.3	25.4	0.7	2.0	—	—§	0.04	2.2	0.01	0.4	8.1	9.1
Other Asia (exc. Japan)	8.5	2.3	3.1	2.4	6.5	0.4	2.2	0.14	7.3	0.02	1.0	5.2	5.8
Africa	6.5	0.9	0.6	0.7	1.9	0.2	0.9	0.06	3.0	—	—	1.8	2.0
Other America	7.4	0.2	7.9	2.8	7.6	1.1	5.5	0.18	9.4	0.00	0.2	4.3	4.8
Total	7.7	10.7	37.0	6.6	18.0	1.7	8.6	0.42	21.9	0.03	1.6	19.4	21.7
World Total	5.2	28.9	100.0	37.0	100.0	19.9	100.0	1.90	100.0	1.89	100.0	89.6	100.0

Source: Estimated by Joel Darmstadter in *Energy and the World Economy* (to be published by The Johns Hopkins Press for Resources for the Future, Inc.).
* Column A contains the projected average annual percentage of growth in energy consumption for 1965–1980.
† Darmstadter follows the UN system of evaluating hydro and nuclear electricity. This means that he used for *both* nuclear and hydropower the system used by the Group *only* for hydropower. Darmstadter's actual figures were in metric tons of coal equivalent and were converted to kWh (both thermal and electrical in this case) at the UN rate of 1,000 kWh per 0.125 m.t.c.e. (for the factor see UN *World Energy Supplies* or the Appendix of any recent UN *Statistical Yearbook*).
‡ Converted from metric tons coal equivalent by using 27.3×10^9 Btu/m.t.c.e. and 0.293×10^{-9} kWh(t)/Btu.
§ Unknown, but believed to be small.

our crops where their predator enemies cannot survive. Fifty years ago most insect pests were exotic species, accidently imported to a country lacking their natural enemies. More recently many of the pests, including especially the mites, leaf-rolling insects, and a variety of aphids and scale insects, have been indigenous. Thus pesticides not only create the demand for future use (addiction), they also create the demand to use more pesticide more often (habituation). Our agricultural system is already heavily locked into this process, and it is now spreading to the developing countries. It is also spreading into forest management. Pesticides are becoming increasingly 'necessary' in more and more places. Before the entire biosphere is 'hooked' on pesticides, an alternative means of coping with pests should be developed."

Of all pesticides, DDT is the most commonly used, and is now present in the fatty tissue of animals in every part of the world. Its effects are well documented. SCEP summarises some of the implications:

"The oceans are an ultimate accumulation site of DDT and its residues. As much as 25 per cent of the DDT compounds produced to date may have been transferred to the sea. The amount in the marine biota is estimated to be in the order of less than 0.1 per cent of total production and has already produced a demonstrable impact upon the marine environment.

"Population of fish-eating birds have experienced reproductive failures and population declines, and with continued accumulation of DDT and its residues in the marine ecosystem additional species will be threatened. The decline in productivity of marine food fish and the accumulation of levels of DDT in their tissues can only be accelerated by DDT's continued release to the environment.

"Certain risks in the utilisation of DDT are especially difficult to quantify, but they require most serious consideration. The rate at which it degrades to harmless products in the marine system is unknown. For some of its degradation products, half-lives are certainly of the order of years, perhaps even of decades. If most of the remaining DDT residues are presently in reservoirs which will in time transfer their contents to the sea, we may expect, quite independent of future manufacturing practices, an increased level of these substances in marine organisms. And if, in fact, these compounds degrade with half-lives of decades, there may be no opportunity to redress the consequences. The more the problems are studied, the more unexpected effects are identified. In view of the findings of the past decade, our prediction of the hazards may be vastly underestimated."

Heavy Metals

Pollution by heavy metals also gives cause for concern. "Some heavy metals are highly toxic to plants and animals including man. They are highly persistent and retain their toxicity for very long periods of time. Some have been used extensively as pesticides and have been dispersed into the environment as pesticides, as uncontrolled industrial wastes and emissions and other means." Much enters natural water systems through sewage discharges and only a portion is removed by normal sewage treatment.

Those heavy metals that are most toxic, persistent and abundant in the environment have been selected by SCEP for special review. These include mercury (Hg), lead (Pb), arsenic (As), cadmium (Cd), chromium (Cr), and nickel (Ni). Most heavy metals are

Tabl 2

Radioactive Wastes as a Function of Expanding US Nuclear Power

	Calendar Year		
	1970	1980	2000
Installed nuclear capacity, MW(e)	11,000	95,000	734,000
Volume high-level liquid waste[a,b]			
Annual production, gal/yr	23,000	510,000	3,400,000
Accumulated volume, gal[c]	45,000	2,400,000	39,000,000
Accumulated fission products, megacuries[b]			
Sr^{90}	15	750	10,800
Kr^{85}	1.2	90	1,160
H^3	0.04	3	36
Total for all fission products	1,200	44,000	860,000
Accumulated fission products, tons	16	388	5,350

Source: Snow, 1967 (reproduced from SCEP).
[a] Based on 100 gallons of high-level acid waste per 10,000 thermal megawatt days (MWd) irradiation.
[b] Assumes 3-yr lag between dates of power generation and waste production.
[c] Assumes wastes all accumulated as liquids.

Table 3

CO_2 Produced by Fossil Fuel Combustion, 1950-1967
(Billions of metric tons) (reproduced from SCEP)

Year	Coal	Lignite	Refined Oil Fuels	Natural Gas	Total
1950	3.7	0.9	1.4	0.4	6.4
1951	3.8	0.9	1.7	0.5	6.9
1952	3.8	0.9	1.8	0.5	7.0
1953	3.8	0.9	1.9	0.5	7.1
1954	3.8	0.9	2.0	0.6	7.3
1955	4.1	1.0	2.2	0.6	7.9
1956	4.4	1.1	2.4	0.7	8.6
1957	4.5	1.3	2.5	0.7	9.0
1958	4.6	1.4	2.6	0.8	9.4
1959	4.8	1.4	2.8	0.9	9.9
1960	5.0	1.4	3.1	1.0	10.5
1961	4.5	1.5	3.3	1.0	10.3
1962	4.6	1.5	3.5	1.1	10.7
1963	4.8	1.6	3.8	1.2	11.4
1964	5.0	1.7	4.2	1.3	12.2
1965	5.0	1.7	4.5	1.5	12.7
1966	5.1	1.7	4.8	1.6	13.2
1967	4.8	1.7	5.2	1.7	13.4
1980 (est)	11.1		10.8	4.0	26.0

biologically accumulated in the bodies of organisms, remain for long periods of time, and function as cumulative poisons. Table 4 indicates world production of these metals between the years 1963 and 1968 and illustrates the rate at which it is increasing.

It may be worth looking more closely at the problem of mercury pollution which is particularly topical.

SCEP quotes Stockinger: "Elemental mercury and most compounds of mercury are protoplasmic poisons and therefore may be lethal to all forms of living matter. In general, the organic mercury compounds are more toxic than mercury vapour or the inorganic compounds. Even small amounts of mercury vapour or many mercury compounds can produce mercury intoxication when inhaled by man. Acute mercury poisoning, which can be fatal or cause permanent damage to the nervous system, has resulted from inhalation of 1,200 to 8,500 micrograms per cubic meter of mercury. The more common chronic poisoning (mercurialism) which also affects the nervous system is an insidious form in which the patient may exhibit no well-defined symptoms for months or sometimes years after exposure".

Mercury is also dangerous when ingested in food. In Japan 111 cases of mercury poisoning occurred (with 44 deaths) a result of eating fish taken from Minamata Bay. Another outbreak occurred at Big Niigata City with 26 cases (and five deaths).

Mercury's toxicity is permanent. In addition when fish, shellfish, birds or mammals containing mercury are eaten by other animals the mercury may be absorbed and accumulated.

Industrial wastes and agricultural pesticides have caused severe mercury contamination in waters in Japan, Sweden and the US. Its use is increasing throughout the world and it "threatens to become critical in the world environment". Moreover, as SCEP points out mercury is but one of approximately 2 dozen metals that are highly toxic to plants and animals.

Table 4

World Production[a] and US Consumption[b] of Toxic Heavy Metals
(Thousands of metric tons) (reproduced from SCEP)

	Hg		Cd		Pb		Cr_2O_3		Ni	
Year	World	US	World	US	World	US	World	US	World	US
1960	——	1.77	——	4.53	——	930	——	1,110	——	98.2
1961	——	1.92	——	4.65	——	932	——	1,090	——	108
1962	——	2.26	——	5.56	——	1,010	——	1,030	——	108
1963	8.28	2.70	11.8	5.19	2,520	1,060	3,920	1,080	340	114
1964	8.81	2.81	12.7	4.31	2,520	1,090	4,150	1,320	372	134
1965	9.24	2.54	11.9	4.75	2,700	1,130	4,810	1,440	425	156
1966	9.51	2.46	13.0	6.60	2,860	1,200	4,390	1,330	414	171
1967	8.36	2.40	12.9	5.28	2,880	1,150	4,300	1,230	441	158
1968	8.81	2.60	14.1	6.05	3,000	1,200	4,730	1,200	480	144[c]

[a] Sources: 1963 data are from the *Minerals Yearbook*, 1967; 1964-1968 data are from the *Minerals Yearbook*, 1968.
[b] Source: *Chemical Economics Handbook*, 1969.
[c] Source: *Minerals Yearbook*, 1968.

Table 5

Man-Induced Rates of Mobilisation of Materials Which Exceed Geological Rates As Estimated in Annual River Discharge to the Oceans
(Thousands of metric tons per year) (reproduced from SCEP)

Element	Geological Rates[a] (In Rivers)	Man-Induced Rates[b] (Mining)
Iron	25,000	319,000
Nitrogen	8,500	9,800 (consumption)
Manganese	440	1,600
Copper	375	4,460
Zinc	370	3,930
Nickel	300	358
Lead	180	2,330
Phosphorus	180	6,500 (consumption)
Molybdenum	13	57
Silver	5	7
Mercury	3	7
Tin	1.5	166
Antimony	1.3	40

Sources:
[a] Bowen, 1966.
[b] United Nations, *Statistical Yearbook*, 1967. Data for mining except where noted.

Oil pollution

We tend to regard oil pollution of the seas as caused principally by accidental spills like that of the Torrey Canyon. Such accidents cause the most evident damage, "but they make up less than 10 per cent of the estimated 2.1 million metric tons of oil that man introduces directly into the world's waters. At least 90 per cent originates in the normal operations of tankers, other ships, refineries, petro-chemical plants, and submarine oil-wells; from disposal of spent lubricants and other industrial and auto-motive oils; and by fall-out of airborne hydrocarbons emitted by vehicles and industry (see Table 6).

The actual amount that goes directly into the seas must be taken as proportionate to production. It is normally estimated at 0.1 per cent of production but if possible fall-out of airborne hydrocarbons on the sea surface is added it may be as much as 0.5 per cent.

This is because estimated emissions of hydrocarbons of petroleum origin to the air is 90 million tons, 40 times that emitted to the seas. Nobody knows how much may finally settle in the seas. SCEP points out that if "10 per cent does, then the total hydrocarbon contamination of the oceans could be almost five times the direct influx from ships and land sources."

The increase in the size of tankers must make things worse. The danger of large-scale accidents will increase with the scale of the tankers. 800,000 ton tankers are projected. "A single spill from one of these would add 20 per cent to the amount of oil entering oceans in a single year" (SCEP). Cleaning up oil spills does more harm than good "even with a non-toxic dispersant, the

dispersed oil is mush more toxic to marine life than is an oil slick on the surface". (SCEP).

The effect of spills in shallow water is particularly damaging. Thus "an accidental release of 240 to 280 tons of No. 2 fuel oil from a wrecked barge off West Falmouth, Massachusetts in 1969 caused an immediate massive kill of organisms of all kinds—lobsters, fish, marine worms and molluses".

The difficulty of estimating biological effects in coastal waters is that "many other pollutants are also present in this zone and it is hard to separate their different effects. Indeed, the effects may not be separable, but instead additive or mutually reinforcing".

One possible effect of oil dispersed over wide ocean areas could arise from the fact that "chlorinated hydrocarbons such as DDT and Dieldrin are highly soluble in oil film. Measurements . . . in Biscayne Bay, Florida showed that the concentration of a single chlorinated hydrocarbon (dieldrin) in the top 1 millimetre of water containing the slick was more than 10,000 times higher than in the underlying water . . . We know that the small larval stages of fishes and both the plant and animal plankton in the food chain tend to spend part of the night hours quite near the surface, and it is highly probable that they will extract, and concentrate still further, the chlorinated hydrocarbons present in the surface layer. This could have seriously detrimental effects on these organisms and their predators."

Implicit throughout this study is the knowledge that these ecologically disruptive trends cannot be allowed to persist indefinitely. SCEP concludes "In general, the expected losses from present impacts do not exceed our capacity to carry the burden; this leads us to the conclusion that an intractable crisis does not now seem to exist. Our growth rate, however, is frightening. The impact of two, four, or eight times the present ecological demand will certainly incur greater losses in the environment. If the process of change were gradual, the present ecological advantage that is reflected in our 5 to 6 per cent annual growth would taper off in the face of decreased environmental services, and growth would be correspondingly slowed. Instead, the risk is very great that we shall overshoot in our environmental demands (as some ecologists claim we have already done), leading to cumulative collapse of our civilisation. It seems obvious that before the end of the century we must accomplish basic changes in our relations with ourselves and with nature. If this is to be done, we must begin now. A change system with a time lag of ten years can be disastrously ineffectual in a growth system that doubles in less than fifteen years."

Table 6

Estimates of Direct Losses into the World's Waters, 1969
(Metric tons per year) (reproduced from SCEP)

	Loss	Percentage of Total Loss
Tankers (normal operations)		
Controlled	30,000	1.4
Uncontrolled	500,000	24.0
Other ships (bilges, etc.)	500,000	24.0
Offshore production (normal operations)	100,000	4.8
Accidental spills		
Ships	100,000	4.8
Nonships	100,000	4.8
Refineries	300,000	14.4
In rivers carrying industrial automobile wastes	450,000	21.6
Total	2,080,000	100.0

Table 7

Estimated Concentration Factors in Aquatic Organisms

Radionuclide	Site	Phyto-plankton	Fila-mentous Algae	Insect Larvae	Fish
Na^{24}	Columbia River	500	500	100	100
Cu^{64}	Columbia River	2,000	500	500	50
Rare earths	Columbia River	1,000	500	200	100
Fe^{59}	Columbia River	200,000	100,000	100,000	10,000
P^{32}	Columbia River	200,000	100,000	100,000	100,000
P^{32}	White Oak Lake	150,000	850,000	100,000	30–70,000
Sr^{90}-Y^{90}	White Oak Lake	75,000	500,000	100,000	20–30,000

Source: Eisenbud, 1963 (reproduced from SCEP).

APPENDIX B

Social Systems and their Disruption

The activities of industrial man are having a very serious effect on society. They can be shown to be leading to its disintegration, and it can also be shown that such pathological manifestations as crime, delinquency, drug addiction, alcoholism, mental diseases, suicide, all of which are increasing exponentially in our major cities, are the symptoms of this disintegration.

Unfortunately, before we can understand why and how this is happening, we must know a little more about human society. Sociology, which should provide us with this information, is failing to do so, mainly because it is studying human society "in vacuo", i.e. without reference to behaviour at other levels of organisation. This is the result of regarding man and the societies he develops as unique, and in some way exempt from the laws governing all the other parts of the ecosphere. If we establish this false dichotomy between man and other animals it is partly because we fail to understand the nature of the evolutionary process. Thus, owing to our tendency towards subjective classification, we recognise that certain events among which a connection can be made within our immediate experience can be regarded as constituting one process, while, on the other hand, we refuse to admit that this can be the case with events whose connecting bond lies outside our experience. Thus we are willing to admit that the development of a foetus into an adult is a single process, and that it is difficult to examine, separately and in isolation,

any of its particular stages apart from the process as a whole. On the other hand, we are less ready to regard evolution in this way.

We still imply that radical frontiers exist between life at different levels of complexity, in spite of the fact that they are part of the same evolutionary process. Yet, it can be demonstrated that no such frontiers obtain. When Kohler synthesised urea, the barrier between the "organic" and the "inorganic" was suddenly shattered, as was that between the "animate" and "inanimate" when the virus was found to manifest certain features associated with life on being confronted with a source of protein, and at other periods to display the normal behaviour pattern of a crystal. Again, it has been demonstrated repeatedly that no barrier exists separating man from other animals. He is more "intelligent" and that is about all that can be said.

If human societies are not unique, their functions cannot be understood apart from that of other natural systems, such as ecosystems and biological organisms, i.e. in the light of a general theory of behaviour.

To understand this, one must first realise that the vast and chaotic human societies in which we are living are by no means normal. If man has been on this planet for a million and a half years, which is possible, it is only in the last 150 years that he has become an industrialist, and that industry has permitted the development of such societies. This represents no more than two days in the life of a man of 50.

For more than one million four hundred and ninety thousand years he earned his living as a hunter-gatherer. During all this time, there is no reason to suppose that the societies he developed were in any way less adapted to their respective environments than are those of non-human animals.

From our knowledge of surviving hunter-gatherer societies, such as the Bushmen of the Kalahari, one can presume that they probably consumed less than a third of the available food resources. They did not clear forests for agricultural land, nor did they hack down trees for building houses, nor were they so short-sighted as to exterminate the wild animals on which they depended for their livelihood.

At the same time they avoided increasing their population over and above that which might lead them to have to alter their life-style in any way.

Even if one considers an area overpopulated, as does Professor Ehrlich[1], "when human numbers are pressing against human values", and not just when they actually starve, then such societies were never overpopulated.

What is more, the survival of such societies was compatible with that of climax ecosystems, to which they contributed by fulfilling within them their various ecological functions. Take the case of the Plains Indians of North America who lived off the vast herds of bison. They did not, on the whole, attack the main herd, which would have been a dangerous undertaking, but rather killed off the stragglers; the old and the weak, thereby exerting quantitative and qualitative controls on these animals.

It is significant that exactly the same is true of the lions living off the buffalo herds in East Africa.

If human societies for 99.75 per cent of their tenancy of this planet, behaved as an integral part of our ecosphere (before the invention of agriculture 10,000 years ago and industry 150 years ago) it is unreasonable to suppose that such behaviour is not subject to its laws.

Nor is there any reason why sociology should be anything but a branch of the natural sciences, that which deals with a particular type of natural system: the human society.

Let us briefly look at human society in this light.

First of all, like all other natural systems, a human society displays organisation. This is probably its most important feature. If one gathers on an island a random collection of people from different societies speaking different languages it would be naive to suggest that these constituted a society. Nevertheless there would be a tendency for organisation, or negative entropy, to build up (or entropy and randomness to be reduced). First of all men would pair off with women and have children. Families would be formed and groups of these families would tend to be associated and grow into small communities. As this occurred so their members would develop more and more things in common. They would learn to speak the same language and dress, eat and build their houses in a similar way. Slowly a common set of values and aspirations would emerge, and these would bind them together in a common purpose and transform them into a true society.

This organisational process is not a linear one. Thus, in its development from the simple to the complex, matter passes through certain critical stages, where the possibilities of a particular type or organisation are exhausted and further advance can only be achieved by the development of a new type.

Thus, an atom can be developed only up to a certain point. This point will vary with different types of atoms, some of which, such as the tungsten atom, are relatively large.

Beyond this critical point, however, development can occur only by the association of several atoms together to form a molecule. As soon as the latter stage is reached, the constituent atoms undergo a considerable change, in that a radical division of labour occurs, in accordance with the law of economy.

To explain their behaviour now requires the introduction of several new principles.

There is no reason to suppose that this notion of levels of organisation does not apply equally well to human social systems. Thus the family, which clearly represents the first level of human organisation, is a universal feature of all human societies, and there is no example of its suppression without the most serious social consequences. The family is held together by bonds which are extendable in the sense that the stimuli required for triggering off the corresponding behavioural responses are not specific as in the case of simpler forms of life.

For example, not only a mother, but a mother-like figure, can trigger off filial responses, or vice versa[2]. It is this feature of the family bonds which permits the development of larger social units. The latter can, of course, be of many kinds. They can be bilateral extended families, or unilateral, or the members of the different families constituting these units need not be related at all, as mere contiguity is sufficient to allow the development of such bonds[3]. Another essential characteristic of the family bonds is that they cannot be extended indefinitely. This is a feature of all bonds, whether they be holding together the nucleus of an atom or the solar system. A point must, therefore, be reached where the bonds cannot be extended any further, and development only becomes possible by the association of a number of such units. At this

point it can be said to have reached a new level of organisation.

Once we pass the level of the village, clan or lineage, we reach a level of social organisation that has not often been achieved by the human species. To harness the family bonds in such a way as to build up a larger unit requires the development of very elaborate forms of organisation. This involves "criss-cross" bonds that permit the establishment of a veritable cobweb of associations of one sort or another, all of which transcend each other in such a way that each individual is linked to each other member of the society in at least one, and preferably more ways.

Thus a tribesman is at once a member of a family, of a maternal and of a paternal kinship group. As neither of these may coincide with the social unit that is the village in which he lives, he is a member of yet another group: the village. He is also likely to be a member of an age grade, of a secret society of some sort, possibly also of a military club and of some other group with a common economic activity. Such a man has a very definite status which Linton[4] defines as "The sum total of all the statuses which he occupies and hence his position with relation to the total society".

The same principle is apparent in the more stable segment of our modern societies. As Linton writes: "... the status of Mr Jones as a member of his community derives from a combination of all the statuses which he holds as a citizen, as an attorney, as a Mason, as a Methodist, as Mrs Jones' husband, and so on." As a result of such criss-cross associations, a man is in contact with a very large number of cross-sections of the society. There is what Ortega y Gasset[5] calls "social elasticity".

All the parts of the society are in contact with each other. Any change in the society will, therefore, effect each individual and the actions of each individual must effect the society as a whole through the agency of all the associations of which he is a member.

Without social elasticity there would be no bonds, no organisation: in fact no real society. Yet social elasticity can only be maintained in special conditions. Thus it is likely that if the society grows too big, the bonds holding it together become of an ever more precarious nature and eventually incapable of holding it together.

The social system is, in fact, overloaded, with more people than it is capable of organising into a society. Its essential structure breaks down, and it ceases to be capable of self-regulation.

As already mentioned, it is a basic feature of all bonds that there is a limit to their extendability. Those holding together a community which are already extensions of the family ones, cannot be extended to hold together more than a certain number of people. Aristotle considered that a city could be made up of no more citizens than could not know each other by sight. The Greek city states which displayed some of the features of self-regulating units, were, in fact, very small. Only three had more than 20,000 citizens (Athens, Corinth and Syracuse). It is significant that a recent study in America has revealed that the crime rate appears to be proportionate to the size of the city. Violent crime appears to be about six times greater *per capita* in cities of 1 million people than in cities of 10,000.

Social elasticity is also seriously affected by mobility. It is impossible to create sound societies when people are being constantly moved from place to place. In such conditions, the towns are not made up of people who have grown up together and among whom bonds have had time to develop, but simply of people who have been thrown together for various random reasons. Bonds cannot be manufactured at will. Nor can that socialisation process that will enable people to fulfil their specific functions within their social system be compressed into a few years of adult life. It is a slow, educative process, the most important part of which must occur in the early years of life—when the generalities of a cultural pattern, i.e. its basic goals and values, are inculcated via the family and the small community.

To understand this principle, it is necessary to see how cultural information is used to determine the adaptive and self-regulatory behaviour of a social system, in fact, how the basic cybernetic model applies to a society.

If a society is capable of self-regulating behaviour, it is that its responses are based on a model of its relationship with its environment, in the light of which they are being continually monitored. Such a model is a society's world-view, or "Weltanschauung", which is compounded of its religion, mythology, traditional law, etc.

As soon as one understands a society's culture, one understands the reason for its behaviour and all its actions that previously appeared random or irrational, now appear quite logical. The following example illustrates this point.

It is well known that some Australian aborigines failed to establish a cause and effect relationship between copulation and conception. Instead, they generally believed that the spirits of children yet unborn, which were apparently referred to as "ngargugalla", inhabited some strange world from which they only emerged when dreamt of by their mothers. Daisy Bates[6] tells us that among the Koolarrabulloo it was the father who had to have such a dream:

> "They believed that below the surface of the ground and at the bottom of the sea, was a country called Jimbin, home of the spirit babies of the unborn, and the young of all the totems. In Jimbin there was never a shadow of trouble or strife or toil or death: only the happy laughter of the little people at play. Sometimes these spirit babies were to be seen by the jalngangooroo, the witch-doctors, in the dancing spray and sunlight of the beaches, under the guardianship of old Koolibal, the mother-turtle, or tumbling and somersaulting in the blue waters with Pajjalburra, the porpoise ...
>
> "... So firm was the belief in the 'ngargalulla' that no man who had not seen it in his sleeping hours would claim the paternity of a child born to him. In one case, that came under my observation, a man who had been absent for nearly five years in Perth proudly acknowledged a child born in his absence, because he had seen the 'ngargalulla', and, in another, though husband and wife had been separated not a day, the man refused absolutely to admit paternity. He had not dreamed the 'ngargalulla'. Should a boy arrive when a girl came in the dream, or should the ngargalulla not have appeared to its rightful father, the mother must find the man who has dreamed it correctly, and he is ever after deemed to be the father of that child."

It is evident that, if we were not aware of this aspect of the world-view or model of the Koolarrabulloo, we would find their attitude towards the acceptance of paternity totally illogical. However, once we were acquainted with

their model, their attitude would appear quite reasonable, and could even be predicted with a fair measure of probability. There is no reason why all seemingly irrational behaviour can be explained on the basis of a cultural model of this sort.

We regard as "rational", behaviour which is based on *our* cultural model of the world and which somewhat presumptuously we regard as the only valid one. However, if we realised that the object of cultural information is to mediate the behaviour that will lead a society to adapt to its particular environment, it then becomes apparent that whether or not this information constituted "scientific" knowledge is irrelevant, and hence our particular scientifically based culture is in no way superior to those developed by the most primitive societies.

Equally important is the fact that a culture also provides a society with a goal-structure and a means of achieving it. The goal of all self-regulating societies appears to be the acquisition of social prestige. It is important to realise that this goal is only possible in a closely knit society, in which there is fundamental agreement as to what are the determinants of prestige. These will vary in each society. In general one can say that these will coincide with the qualities that must be cultivated if the society is to survive. Thus in a society of hunter-gatherers, success in a hunt is likely to be a determinant of prestige; among societies involved in war-like pursuits courage is likely to be particularly prestigious. The prestige achieved will determine one's position in the social hierarchy. This hierarchy is of immense importance in avoiding strife and in ensuring a socially acceptable division of labour among the members of the society. If there is no hierarchy there will be constant bickering and fighting. There will also be no mechanism for ensuring the perpetuation of those qualities required if the society is to survive. Hierarchy is another word for organisation. There are only two ways of dispensing with it: one is to accept chaos and with it asystemic controls such as dictators, the other is to reduce the size of the society. In an extremely small social grouping such as the Kalahari Bushmen and the Pygmies of the Ituri Forest, the requirement for hierarchy is reduced to a minimum, and very stable egalitarian societies are possible. However, as the size of the groupings increases so must the requirement for hierarchy.

Each society has a whole set of beliefs regarding the supernatural forces that can be exploited to enable individuals, associations and society as a whole to achieve their ends.

Many ceremonies and rituals are performed to this end, all of which have the additional effect of tightening social bonds, and hence of further increasing social organisation. At the same time, every society has a set of taboos, basically to prevent supernatural forces from being mobilised to hinder the achievement of the society's goal-structure[7].

There is every reason that the goal that self-regulating societies set themselves is one whose achievement permits the satisfaction of the environment's many competing requirements and is not purely arbitrary as in the case of our society.

This may be illustrated by the way in which the size of the simple society is determined. Thus if the Eskimos live in small family units during the summer months, it is because there is no need for a larger unit, indeed the arctic areas they inhabit would not support one. If the Pygmies of the Congo live in small bands it is because this is the ideal number of people for survival in tropical rain forests, possibly providing the minimum number of hunters required to trap an elephant. If the society is truly self-regulating, however, it should be capable of reducing or increasing complexity to permit adaptation to changing environmental conditions—so long as these occur within certain limits. Thus when faced with the Macedonian menace, it would have been adaptive for the Greek city states to join together to form a league, i.e. to achieve a higher level of organisation. This they never really succeeded in doing, though there were many attempts.

On the other hand, in the absence of environmental challenges requiring action on the part of a larger, more complex social unit, it would be adaptive for complexity to be reduced, for the society to break up, temporarily at least, into its constituent parts. Usually, however, institutional barriers prevent this from occurring. Central governments are jealous of the territories that they control and usually refuse to face reality, once environmental conditions render superfluous and artificial the states that they control.

The important thing is that a self-regulating society must be goal-directed. It moves in a particular direction, and both the goal towards which it is moving, and that behaviour pattern that permits its achievement, are culturally determined.

For the society to keep moving in this direction, it means that all its members must be imbued with the cultural information that will enable them to fulfil their specific functions as specialised members of their social system. It also means that every cultural trait which we often tend to regard as being of little practical significance, and which our missionaries, educators, administrators, etc., are only too pleased to interfere with, has a specific function in the overall social behaviour pattern.

If one were acquainted with the culture of any stable society and were capable of working out the role played by each of the customs and institutions within this culture, i.e. by determining in what way they contributed towards the adaptive behaviour of the society to its particular environment, one could easily imagine what would be the consequences of their suppression by outside interference. Let us take the case of the marital customs of the Comorians, who inhabit a group of islands between Mozambique and Madagascar. The people of the Comores have a complex social organisation, probably based on indigenous customs upon which were superimposed those of their Islamic conquerors. From the former they inherited a matrilineal and matrolocal tradition; from the latter a patrilineal and patrilocal one. Islamic marital law has also been adopted. As a result, there is polygamy and a high frequency of divorce. Indeed, so high is the latter that it is perfectly normal for a woman to have been married five to ten times. From the experience gained in our society, we would tend to associate such a consequent number of "broken homes", with a very high rate of juvenile delinquency, schizophrenia and suicide, i.e. the symptoms of social disorder. However, things do not work out that way.

In Mayotte, one of the islands making up the Comores Archipelago, there have been only two deaths by violence in the last fifty years, and neither were premeditated murders. Crime in general is minimal, as are mental diseases, delinquency, suicide and the other symptoms of social disorder.

The society is thus culturally adapted to marital instability, which ours is not. The reasons are two-fold. First, by virtue of the institution of matrilinearity and matrilocality, a child is partly the responsibility of the mother's clan. Many of the functions of fatherhood are in fact fulfilled by the mother's elder brother, and inheritance, for instance, is primarily through him rather than through the father. Secondly, by custom, the step-father automatically assumes many of the responsibilities of fatherhood, *vis-à-vis* the children that his new wife has had with previous husbands. The step-father, or "baba combo", is, in particular, responsible for the payment of the very large expenses involved in the circumcision ceremony of his stepsons. Also, the father's role is reduced by the fact that the children are brought up in the mother's home. As the father probably has several other wives, he will in any case only be physically present in one particular house on one or two days a week. For all these reasons, divorce does not have the same unsettling effect in the Comores that it does in our society. Now, supposing a missionary or administrator suddenly decided that matrilinearity and matrilocality were vestiges of barbarity not to be found in modern civilised societies, and that they must, therefore, be abolished; unless he abolished at the same time many of the other customs making up this complex culture, the results would be disastrous. Schizophrenia, delinquency, and the other symptoms of social disorder would result, as they do in our society with the break-up of the nuclear family.

What is particularly striking about the self-regulating society is the absence of these forms of deviation. Crime is, in fact, an extremely rare occurrence in spite of the fact that there are no policemen, lawcourts, tribunals, etc. Indeed in such a society, there is no need for external controls of this sort. Systemic controls, i.e. those controls applied by the society as a whole through the medium of public opinion, are sufficient to prevent any deviation from the accepted norm[4].

As Linton writes: "The Eskimos say that if a man is a thief no one will do anything about it, but the people will laugh when his name is mentioned. This does not sound like a severe penalty but it suffices to make theft almost unknown. Ridicule will bring almost any individual to terms, while the most stubborn rebel will bow before ostracism or the threat of expulsion from his group."

Besides in a stable society, all the citizens will have the good of the society at heart. They will feel part of it and will all equally oppose the behaviour on the part of any of its members that is contrary to the established customs and that might compromise the interests of the society as a whole. Solon was once asked which was the best policed city[8]. "The city" he replied "where all the citizens, whether they have suffered injury or not, equally pursue and punish injustice." The same spirit that Solon expressed is apparent in Pericles' celebrated speech over the bodies of the first victims of the Peloponnesian war: "... We are prevented from doing wrong by respect for authority and for the laws, having an especial regard for those which are ordained for the protection of the injured, as well as for those unwritten laws which bring upon the transgressor of them the reprobation of the general sentiment."

We regard government, parliaments, and vast bureaucracies as essential to all societies. However, it is probable that most of the societies ever developed by man dispensed with such external controls. As Lowie writes[9]:

> "... it should be noted that the legislative function in most primitive communities seems strangely curtailed when compared with that exercised in the more complex civilisations. All the exigencies of normal social intercourse are covered by customary law, and the business of such governmental machinery as exists is rather to exact obedience to traditional usage than to create new precedents."

Indeed, in such societies, nothing can be found to correspond to our notion of government. There are no kings, presidents, or even chiefs, no courts of law, prisons or police force. The closest approximation to a political institution is the council of elders that occasionally gathers to discuss important issues. It is for this reason that the Australian aboriginal tribe has often been referred to as a "gerontocracy", or as a government by the old men—a title that can aptly be applied to most simple, ordered societies.

The absence of formal institutions, rather than give rise to the permissiveness that we would expect, is in fact associated with discipline and the strictest possible adherence to the tribal code of ethics. Behaviour which, in a disordered society, could only be exacted at the cost of brutal coercion, is with them ensured by the force of public opinion, the sanction of the elders, and the fear of the ancestral spirits.

In more advanced societies, we find the same principle obtaining in a less extreme form. Thus, in ordered societies where public opinion plays an important role, the need for strong government, and in particular, dictators, is correspondingly reduced.

Conversely, in these disordered societies where public opinion plays but a small part, we find that the absence of the most authoritarian government, linked to an all-pervasive and coercive bureaucracy inevitably leads to lawlessness and mob rule.

By causing the disintegration of a society, by overloading the social system with too many people, or by increasing mobility so as to prevent their proper socialisation, one is reducing the power of public opinion, and thereby the society's capacity for self-regulation. We are introducing asystemic controls in ever greater quantities: more politicians, more bureaucrats, more laws, more tribunals, so one is rendering the systemic controls ever more redundant, and further reducing a society's capacity for self-regulation.

A society used to being run in this manner ceases to be capable of running itself. In many South American republics, the deposition of one dictator will lead merely to the installation of another. Real democracy is not possible since the essential social structure for rendering it possible does not obtain. A mass democracy is, in fact, a contradiction in terms, and as our society becomes ever more massive and ever less organised, i.e. as entropy and randomness increase, so must there be a proportionate increase in the precarious asystemic controls required to maintain a semblance of social order, and a similar reduction in its stability and hence in its capacity to survive.

We can thereby formulate the essential principle that the higher the entropy or randomness of a social system, the greater must be the need for asystemic controls of which the most extreme kind is a dictator.

Such controls are as unsatisfactory in social systems as they are in ecosystems, and for the same reasons. A dictator gears his society to the achievement of what is usually an arbitrary goal regardless of environmental requirements. This can therefore only increase the society's instability.

As we have seen, it creates a need for further dictatorship by destroying natural systemic controls which it renders redundant.

It is also highly vulnerable. One can exterminate a large proportion of the population of a self-regulating society without affecting its organisation or its capacity to govern itself, whereas in a dictatorship, it suffices to kill the dictator for the society to be plunged into chaos and civil war, a point that is particularly well illustrated by the experience of the later Roman Empire.

Dictatorship, in other words, involves a drastic simplification of a society's control mechanisms, and must determine a corresponding reduction in its stability.

Our industrial society is further affecting human society by absorbing non-industrial cultures. Whereas there were previously innumerable cultures geared to totally different ends, so, as they fall within the orbit of industrial "civilisation", they come more and more to resemble each other.

It is significant that in New Guinea, that last great reservoir of primitive cultural wisdom, there are still 700 different cultural patterns, each with its own distinct language. In such circumstances mistakes committed by one such social group are likely to have the minimal effect on the others and the probability that at least one cultural pattern provides the solution to a new environmental problem is maximised.

The absorption of these diverse highly differentiated societies into a common mass-society geared to the achievement of short-term material ends is a loss to humanity that cannot be over-emphasised.

It must seriously reduce the complexity and hence the stability of human social organisations on this planet. It must also lead to the irreparable loss of a vast store of cultural information which is as important to man's survival as is the store of genetic plant variety so seriously compromised by modern agricultural techniques.

Social disruption and its effects

There is increasing evidence that deprivation of a satisfactory family environment will affect children profoundly and colour every aspect of their later life.[10] Such children are often referred to as emotionally disturbed. However bright they may be, they will tend to find it very difficult to fit into their social environment, the reason being that the early and most important stages of socialisation were badly impaired. The earlier family deprivation occurred, the more will this be the case, for as D. O. Hebb[11] shows, the effect of early experience on adult behaviour is universally correlated with age.

Sadly, it is rarely possible for socially deprived and emotionally disturbed children to be satisfactorily socialized. No amount of school education can do much for them.

They are characterised by their inability to accept any social constraints. They are unable to concentrate on their work and are only interested in things which are of apparent immediate advantage to them. Regardless of their intelligence level, they are thus extremely difficult to educate. They are particularly concerned with the present, and the short-term, and are predisposed to all pathological forms of behaviour such as delinquency, drug addiction, alcoholism and schizophrenia.

What is worse, when they grow up, they are unlikely to be capable of fulfilling their normal family functions; their children, consequently also deprived of a normal family environment, will in turn tend to be emotionally unstable.

John Bowlby went so far as to compare a delinquent with a typhoid carrier[12]. He is as much a carrier of disease as the latter—of a disease of the personality which will affect his family and his community for generations, until his descendants are eliminated by natural selection.

Socially deprived, emotionally disturbed youths are a feature of disintegrating societies. In the black ghettoes of New York and other large American cities, they are the rule rather than the exception. There is increasing reason to suppose that the low standard of achievement and the high rate of crime, and various forms of retreatism that characterise such societies are mainly attributable to family deprivation.

If a child is seriously affected by being deprived of a satisfactory family environment, an adult is also adversely affected by being deprived of a satisfactory communal environment.

As we have seen, in a stable society, a cultural pattern provides an individual with a complete goal structure and an environment within which these goals can be satisfied.

In a stable society the principle goal appears to be the acquisition of prestige, to be looked up to by one's family and community.

In our industrial society, prestige is achieved in a variety of ways, including the right education, entering a socially acceptable profession and perhaps most important of all, making money.

Those who have not been subjected to the normal socialisation process and in particular members of different minority ethnic groups, may for various reasons, find these avenues of success barred to them. In such conditions they have no alternative but to develop a substitute set of goals. Cloward and Ohlin[13] interpret the development of a criminal sub-culture in the slums of a big city in these terms. It provides people with a new set of goals which they can achieve. Once crime becomes big business, and requires the same sort of qualities that permit success in the mainstream culture, then a further substitute outlet is required.

It is in these terms that Cloward and Ohlin interpret the "violent gang" subculture which also has its own ethic and goal structure, so different from the mainstream culture. However, those who have not succeeded in shedding the latter's values find themselves incapable of participating in it. They are forced to indulge in one or other form of retreatism—to isolate themselves psychologically from an environment which not only fails to provide them with an essential set of goals but also denies them.

Merton[14] describes a retreatist in the following way: ". . . Defeatism, quietism and resignation are manifested in escape mechanisms which ultimately lead him to 'escape' from the requirements of the society. It is thus an expedient which arises from the continued failure to near the goal by legitimate measures and from an inability to use the illegitimate route because of internalised prohibitions, this process occurring while the supreme value of the success-goal has not yet been renounced. The conflict is resolved by abandoning both precipitating elements, the goals and the means. The

escape is complete, the conflict is eliminated and the individual is asocialised."

In a disintegrating society one would tend to find sub-cultures developing along all these different lines in varying degrees, i.e. there will be an increase in delinquency, violence and all the various forms of retreatism, such as drugs, drink, strange religious cults, etc, and mental disease. Such a society will be characterised by a general feeling of aimlessness, a frantic, almost pathetic search for originality, over-preoccupation with anything capable of providing short-term entertainment, and beneath it all a feeling of hopelessness of the futility of all effort.

Crime

In the United States, according to Mr John Mitchell, Attorney-General, crime in cities of more than 250,000 inhabitants is two and a half times that of the suburbs, which in turn is twice that of rural areas, Crime, needless to say, is on the increase. In the United States it has doubled in the last 10 years. In 1969 there were 2,471 crimes per 100,000 inhabitants. There were 655,000 violent crimes and 4,334,000 crimes against property, 14,590 murders, 36,470 rapes and 306,420 aggravated assaults. This is an increase of 12 per cent over the previous year. In the United Kingdom, crime is increasing at a similar rate. In 1970, according to a *Newsight* investigation, there were 1½ million indictable crimes, 300,000 in London alone, an increase of about 10 per cent over 1969.

Crimes of violence and burglary and battery in particular are increasing at the fastest rate, at more than 15 per cent per annum. There are at present 66 crimes of violence per 100,000 people in the United Kingdom as opposed to 324 per 100,000 in the United States. At the present doubling rate of five years it will take approximately 12 years to achieve the US rate of 324 per 100,000 which is so bad that life in cities has become intolerable and economic activity seriously menaced.

Professor Michael Banton of the Department of Sociology, Bristol University, told the British Association for the Advancement of Science that "increased disorder is part of the price we pay for the adaptation of our social arrangements to an economic system which brings us such great material benefits".

The relationships between crime rate and urbanisation has been established in a recent study in the US (see Table 8) which shows that it is considerably higher *per capita* in cities of more than 250,000 than in small towns with a population of less than 10,000.

Crime is part of the price of affluence, or more precisely, of the social disintegration that affluence gives rise to.

Perhaps the most damning indictment of our industrial society is the behaviour of people when the elaborate mechanisms of the law are for some technical reason put temporarily out of action.

In Montreal, during a 24-hour police strike, shops were pillaged, women raped and houses burgled.

In London, during a power strike, theft increased to such as extent in shops and department stores that many had to close until the light came on again.

Nothing better illustrates what can happen when the self-regulating mechanisms which normally ensure the orderly behaviour of the members of a stable society break down and are replaced by a precarious set of external controls.

Illegitimacy

As the family unit breaks down, it is not surprising to find that illegitimacy, another symptom of social disintegration, increases. Nor is it surprising to find that it is closely linked with other symptoms of social disintegration. According to W. R. Lyster, an Australian statistician, "Crime and illegitimacy rates are simultaneous in their incidence. The illegitimacy rate in England and Wales per 100 of all births has increased since 1955 from 4.7 to 7.8; crime has increased from about 45 per 10,000 to 120 per 10,000; thus, both have more than doubled."

Illegitimacy is costing our government £52 million per year. In industrial slums and other societies that have reached the more advanced stages of disintegration it is not unusual to find that up to 70 per cent of children are illegitimate.

W. A. W. Freeman, President of the Children's Officers Association, has recently reported a startling increase in the number of women who are simply abandoning their children, something which would not occur in a stable society.

Alcoholism

For each specific cultural pattern there must exist an optimum degree of alcohol consumption. It is likely that increases over and above this level will be in direct proportion to the development of disorder within the society itself. The number of offences of drunkenness proved in England and Wales for the year 1967 is greater than the number of offences proved in previous years. The increase as expected occurred in the large cities, the City of London having 476.43 offences for each 10,000 of its population. The Home Office with characteristic ignorance of basic sociological matters writes, "No reason for the increase can be adduced. There was no significant change in the liquor licensing laws."

According to the National Council on Alcoholism, alcoholism is costing the country about £250 million a year, mainly by absenteeism from work.

Table 8

Increase in Crime Rates With Increase in Size: Urban Crime Rates per 100,000 Population 1957

	Size of cities		
	over 250,000	50,000 to 100,000	under 10,000
Criminal homicide	5.5	4.2	2.7
Murder, non-negligent manslaughter	4.4	3.7	1.3
Manslaughter by negligence	23.7	9.3	7.0
Rape	108.0	36.9	16.4
Robbery	130.8	78.5	34.0
Aggravated assault	*At this point the scale changes*		313.3
Burglary, breaking or entering	574.9	474.6	992.1
Larceny-theft	1,256.0	1,442.4	112.9
Auto theft	337.0	226.9	

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About seven workers out of every thousand have drinking problems, and there are about 400,000 alcoholics in the country, a figure which is increasing annually.

Mental Health

Social disintegration is a major cause of mental disease. When an individual deprived of his essential social and physical environment is incapable of building a substitute one, or fails to isolate himself from the one he can no longer tolerate, by means of drugs or alcohol, his behaviour pattern, no longer adaptive to an environment for which it was not designed, tends to break down. One remaining position of defence is to build up his own personal world of fantasy which contains just those environmental constituents of which he has been deprived, and which he most requires.

There is considerable evidence to show that members of a society undergoing acculturation, whose culture is breaking down under the influence of an alien one are particularly prone to mental disease.

As national boundaries break down, small communities are swallowed up by vast urban conglomerations, mobility is increased and people move about the place in search of better pay, so cultural patterns break down.

In the United Kingdom, mental disease is increasing at a phenomenal rate. According to Ministry of Health statistics 169,160 people were admitted to hospitals in England and Wales in 1967 suffering from mental illness, two and a half times as many as in 1951.

There were 600,000 mentally disordered people in England and Wales in 1967, 186,901 of them occupying hospital beds or 46.6 per cent of all hospital beds. Thirty-two million working days every year are lost because of mental illness, representing a cost to the nation of £100 million, and local authorities spent £20,250,000 in mental health, more than six times what was spent in 1957.

Suicide

Durkheim regarded suicide as the ultimate manifestation of anomie. He found that the suicide rate was particularly low in poor rural communities where social structures were intact, and high in disintegrating affluent societies, especially among the working classes and even more so among immigrants, in this case Italians to the cities of Lorraine.

He goes so far as to say that "suicide varies in inverse proportion to the degree of integration of the social groups to which the individual belongs".

In Britain the suicide rate has fallen over the last six years by about 200 a year. Nevertheless, according to the Samaritans, a lay organisation that helps depressed and potentially suicidal people, the number of potential suicides has more than doubled in the last two years.

In 1967 their seven London area branches dealt with 5,999 new cases. In 1969 the same branches dealt with a further 11,641 cases. The Reverend Basil Higginson, an official of this organisation, estimates that cases would go on rising at this rate.

Conclusion

There is every reason to believe that the social ills at present afflicting our society—increasing crime, delinquency, vandalism, alcoholism as well as drug addiction—are closely related and are the symptoms of the breakdown of our cultural pattern which in turn is an aspect of the disintegration of our society. These tendencies can only be accentuated by further demographic and economic growth. It is chimeric to suppose that any of these tendencies can be checked by the application of external controls or by treating them in isolation, i.e. apart from the social disease of which they are but the symptoms.

It is the cause itself, unchecked economic and demographic growth, that must be treated. Until such time as the most radical measures are undertaken for this purpose, these tendencies will be further accentuated—until their cost becomes so high that further growth ceases to be viable.

APPENDIX C

Population and food supply

It is a common assumption that throughout the entire history of mankind, human populations have expanded whenever conditions permitted. Thus it is argued that during the 100,000 generations in which our forebears lived by food-collecting, the difficulties of keeping body and soul together were so great that populations were limited largely by crude food availability. Then with the adoption of agriculture, some 200 to 300 generations ago, the new-found sources of food permitted populations to expand until generally-speaking they were held down only by disease. Finally, modern public health methods, principally greatly improved sanitation and vector control procedures, permitted the phenomenal increases which collectively are known today as the population explosion.

Yet there is now good evidence that many of the human societies living before the agricultural revolution (and a few after) were stable societies in the strict sense of the phrase: i.e. they were regulated not by starvation, disease or war, but by cultural controls which only now we are beginning to understand. Why these controls disappeared we do not know. For the time being, however, we may speculate that they were lost in the cultural changes such societies must have undergone in response to the immense ecological changes brought about by each advance and retreat of glaciation during the Pleistocene Ice Age.

Since in a nutshell the problem of populations and food supply is how to live within one's ecological means without being forced to do so by naked hunger, it is worth bearing in mind that man (like many other animals) is potentially capable of so doing. In the meantime, we are faced with the task of reducing birth rate to compensate for the fall in death rate, because daunting though it undoubtedly is, the alternative of satisfactorily feeding an expanding population is still more so. Nonetheless, so far attempts to reduce birth rates have been largely ineffective on a global scale and even if they were to be successful it is unlikely that they could produce significant reductions in population growth rates within the time scale required to avoid major food shortages.

It is argued that the raising of living standards will, of itself, limit population growth by offering economic incentives that are reduced if the ratio of wage-earners to dependants within the family group is weighted too heavily in favour of dependants. Evidence of this is contradictory, although it is true that families have become smaller in Europe as levels of material prosperity have risen. However, it is not possible that this situation can be repeated throughout the world as a whole. The planet lacks the resources to permit the

industrialisation that would be required and even if these were to be found the levels of pollution generated by such a level of industrial activity would be greater than could be absorbed by the ecosphere. Even then, although the rate of increase would be reduced, populations would continue to grow.

The population of Britain is growing at 0.5 per cent per year, which gives it a doubling time of 138 years. While this is much lower than the world average (1.9 per cent each year) each individual within an industrial society consumes far more resources and contributes far more to environmental pollution than an individual in an agrarian society. Prof Wayne Davis[1] considers that an American has 25 times the impact on the environment as an Indian so that, worked out in terms of "Indian equivalents", the population of the United States is equivalent to that of 5,000 million Indians. Thus the problem of population is more acute in developed than in developing countries.

We must consider whether it is possible for the planet to provide food in sufficient quantities to sustain the populations that are forecast.

Food production may be increased either by extending the area under cultivation or by intensifying production on existing farmlands, or by both. Current FAO programmes concentrate on intensifying production on existing farms.

The extension of agriculture into marginal lands is expensive in terms of investment and produces only limited returns. It is more rational to direct such capital as is available into the improvement of existing farming.

Indeed, the amount of marginal land available for agriculture is severely limited and it has been estimated that if the required increases in food production were to be met from this source alone, the reserves of land would be exhausted within a decade or less[2]. Of a total land area of 32.5 billion acres estimates indicate that only 3 billion are cultivated at the present time[3]. Most of the world's land surface is occupied by the icecaps and permafrost, deserts, forests and urban and industrial areas. Sometimes it is suggested that the remaining tropical forests, in Amazonia in particular, might be cleared to provide agricultural land. It is unlikely that such schemes could be successful, even if the resources were available to carry them out. Experience with clearing primeval forest in Central America has shown that the removal of the climax vegetation triggers an erosion process leading to desert. The process is all but irreversible for organic matter once exposed is quickly mineralised. The unstable lateritic soils of Amazonia are 70 feet thick but they would be likely to erode very quickly if they were unprotected against the equatorial climate, while this itself would certainly be affected by the removal of such a large area of forest. When Kruschev cleared the forests in Kazakhstan for agriculture he left a dust bowl of some 30 million acres, an area equivalent to the entire agricultural land area of the British Isles.

The US President's Science Advisory Committee estimated in 1967 that the total arable and potential arable land in the world amounted to 8 billion acres. While some expansion is possible it is unlikely that the resources of capital and materials can be made available to produce more than minor increases in food production from these sources. There is little marginal land remaining for development in the Soviet Union, China, Asia or Europe and extension of farmlands in the more arid regions of the Middle East and North Africa would require new sources of fresh water for irrigation that are not available at present and will not be within the immediate future. It is possible that the United States might increase its area under cultivation from 300 to 350 million acres[3].

In fact, it is likely that existing agricultural land will be reduced as demands for urban and industrial development with all that that implies in terms of roads, airports, railways, etc., are met. Between 1882 and 1952 the total land area of the world occupied by permanent buildings has increased from 0.87 billion to 1.6 billion hectares[2]. This will be much higher if, by the year 2000, 81 per cent of the population of the developed countries and 43 per cent of the population of developing countries will be living in urban areas (Table 9).

Beyond a certain point, which varies with climate and soil type, the intensification of farming causes soil deterioration and eventually erosion. This is already a problem in many of the developed countries, where very intensive farming systems have been imposed. The extension of monocultural arable farming, the heavy use of artificial

Table 9

Changes in Land Utilisation 1882-1952
(In billion hectares) (reproduced from G. Borgstrom, *Too Many*)

	1882	Percentage	1952	Percentage	Change 1888-1952	Change Percentage
Forest	5.2	45.4	3.3	29.6	−1.9	− 36.8
Desert and wasteland	1.1	9.4	2.6	23.3	−1.5	−140.6
Built-on land	0.87	7.7	1.6	14.6	−0.73	− 85.8
Pastures	1.5	13.4	2.2	19.5	−0.7	− 41.9
Tilled land	0.86	7.6	1.1	9.2	−0.24	− 24.5
	9.53	83.5	10.8	96.2	−1.27	− 12.9
Area not especially utilised	1.81	16.5	0.27	3.8	−1.54	− 79.9
Total	11.34	100	11.07	100	−0.27	− 2.4

Source: R. R. Doane, 1957. *World Balance Sheet* (Harper, New York).

Table 10

Quality Classification of Tilled Land

	1882 Percentage	1952 Percentage
Good	85.0	41.2
Half of original humus lost	9.9	38.5
Marginal soils	5.1	20.3

Source: R. R. Doane, *loc. cit.* (reproduced from G. Borgstrom, *Too Many*).

fertilisers, the use of heavy machinery and, in other areas, overstocking with farm animals, all contribute to deterioration in soil structures, leading to a loss in the efficiency of drainage systems and in the effectiveness with which soluble fertilisers can be used. In this situation irrigation can lead to problems of waterlogging and/or salinity, while the overconsumption of groundwater for irrigation purposes can lead to a lowering of water tables that may compromise the future of farming. In large parts of Texas, for example, the present long drought is exacerbated by low water tables and it is possible that farming in Texas may have to be abandoned altogether.

The deterioration of soil structure has been observed in Britain, where stable soils and a temperate climate provide near-ideal farming conditions. In more severe climates and on poorer soils erosion is likely to appear more quickly and once it begins it could become an accelerating process. As the poorer lands fail the pressure on the better lands will increase, so tending to encourage still further intensification which will damage soils more rapidly than might be anticipated (see Table 10).

Erosion of farmlands in some areas is associated with the spread of deserts. In 1882 the world had a total 1.1 billion hectares of desert and wasteland. In 1952 the area had increased to 2.6 billion hectares[2] (see Table 9).

Given that demand for land must increase with population growth, and that populations are increasing exponentially, and assuming that the *per capita* requirement of land is 0.4 hectares for agricultural purposes and 0.08 hectares for non-agricultural purposes (a low estimate), Meadows[4] has shown that by the year 2000 the land available is likely to have decreased by 250 million hectares, while the demand will have increased by about 2.4 billion hectares, and that somewhere between 1980 and 1990 the demand for land will exceed the supply. Furthermore, if yields per acre were to double, the effect would be to add no more than 30 years to the world's food supply. Similarly a quadrupling of yield, which no serious person would consider possible, would add only 60 years. The net demand for food, then, will double every 30 years and it can be satisfied only by doubling yield every 30 years.

Britain has one of the most intensive farming systems in the world. In the 25 years since the end of World War II very large sums of money have been invested in technological developments aimed at increasing output and reducing the requirement for labour. Nevertheless, when the effect of inflation on farm prices is taken into account, the productivity of British agriculture has increased by only 35 per cent and there is good reason to suppose that in most major products yields have now levelled off and in some they are declining. Short of major technological breakthroughs in plant genetics and, possibly, the introduction of entirely new concepts in farming, none of which is in sight at present, it is extremely unlikely that agricultural production in Britain can achieve further significant increases. It is not possible for agriculture in developing countries to receive the heavy investments that British agriculture has received and so it is unlikely that increases in production can be achieved to match those in Britain. Even if they were, they would be insufficient, even to sustain the present inadequate dietary levels. Although the so-called "Green Revolution" has produced important improvements locally, overall the world food situation shows no sign of improving, and there seems little chance of the FAO's targets for 1985 being met.

In past years local emergencies have been alleviated by the provision of food, principally grains, from world stocks, which have been held mainly in North America. These stocks have been allowed to run down and so even this "cushion" is lost.

There are definite biological reasons for the limits on food production. Plants depend on a complex mixture of inputs, many of which are beyond man's control. Even of the principle requirements—sunlight, water and nutrients—it is only nutrient that man has succeeded in manufacturing and supplying to his crops. Fertiliser use is subject to diminishing returns beyond certain levels of application and these may be much lower in the field than controlled experiment under near-laboratory conditions would suggest. Thus an 11 per cent increase in the agricultural pro

Table 11

World Average Rates of Increase for the Period 1951-1966 for Selected Aspects of Human Activity Related to Food Production

	Percentage[a]
Food	34
Tractors	63
Phosphates	75
Nitrates	146
Pesticides	300

Source: Digested from United Nations, *Statistical Yearbook*, 1967 (reproduced from SCEP).
[a] Rates in constant dollars.

Table 12

Pesticides Needed to Increase Food Production on Acreage now under Cultivation in Asia (except Mainland China and Japan), Africa, and Latin America by the Percentages Indicated

Percentage of Increase in Agricultural Production	Tonnage Needed (metric tons)
—	120,000
10	150,000
20	195,000
30	240,000
40	285,000
50	342,000
60	402,000
70	475,000
80	558,000
90	640,000
100	720,000

Source: President's Science Advisory Committee (PSAC), 1967 (reproduced from SCEP).

duction in the United States between 1949 and 1968 was achieved with a 648 per cent increase in the use of nitrogen fertiliser while Britain's 35 per cent increase required an 800 per cent increase in nitrogen fertiliser consumption. The consumption of pesticides to control the effects of the ecological imbalances created by the farming system has increased also. Between 1950 and 1967 US pesticide consumption increased by 267 per cent and achieved a 5 per cent increase in total crop yields[6].

The use of agrochemicals on a large scale makes a serious contribution to the pollution of the global environment. They are biologically potent, which is why they are used, and when introduced at random into the environment they interfere with living processes. Many pesticides affect the central nervous system of man, they may interfere with hormone secretions and some are known to be carcinogenic or teratogenic. Under certain circumstances some fertilisers can be harmful to health and by forming random associations with amines present in the environment, nitrites can become nitrosamines, which are carcinogenic. There is no way of knowing the extent to which the environmental carcinogen and mutagen loads have been increased because it is impossible to monitor all the possible interactions between pollutant and pollutant and between pollutants and substances present naturally. Pesticides that are persistent accumulate along food chains, so depressing predator populations and, in the long run, tending to encourage increases, rather than decreases, in pest populations. Organochlorine insecticides are particularly harmful to fish. Excess fertilisers enter water systems where they contribute to eutrophication problems. There must be an upper limit to the tolerance of the ecosphere to pollution from agriculture.

The effectiveness of pesticides is further reduced because insects, weeds and micro-organisms acquire resistance to them. Such resistance is based on hereditary characteristics in certain individuals within populations. It is transmitted genetically and so repeated application leads to the build-up of a resistant pest population by a process similar in all ways to natural selection. Throughout the world there are now some 250 species of insect pest that are immune to most insecticides[7].

In common with most organic chemicals, pesticides are derived from petroleum and their continued production is related to the availability of petroleum or of an alternative source of raw materials, although any alternative is likely to be more expensive. All agrochemicals consume power and water in their production and the availability of cheap sources of power and plentiful supplies of water is liking to limit any increase in production.

The intensification of agriculture in many areas of the third world would require much improved systems of transport to convey fertiliser, pesticides, machinery and seeds in and food out. It is doubtful whether the capital is available to develop such transport systems or the fuel to power them.

It is unrealistic to suppose that there will be increases in agricultural production adequate to meet forecast demands for food, and the notion that technological inputs can be made available that would guarantee a doubling of production by 1980 and a further doubling by 2100 is no more than fantasy. Such a thesis can be advanced only by "experts" who fail to take into account basic ecological, physical and biological principles, or who are not in possession of all the relevant information.

The intensification of agriculture cannot prevent famines within the next 15 to 20 years, probably affecting parts of Asia, Africa, the Near East and Latin America. Indeed, by causing further disruption to terrestrial and marine ecosystems it must reduce the capacity of the planet to support life.

Attempts to increase the world's protein availability from fisheries show no sign of solving the problem. The seas are experiencing serious pollution which may be undermining the phytoplankton that form the base of the marine biotic pyramid, and they may be overfished. In 1969, for the first time in a quarter of a century, total fisheries production did not increase, owing to poor catches, and this in spite of heavy capital investment by the developed countries. Fishery vessels are operating in deeper and more remote waters and owing to the high levels of investment in ships and processing plant the developed countries, which are also the major fishing nations, are irrevocably committed to increasing yields by a large factor within a very short space of time. In their efforts to do so there is little reason to suppose that they will not so deplete fish stocks that within a decade or so the contribution of fisheries to world food supplies will reduce rather than increase. If there is a temporary increase, little of this will benefit the developing countries which by and large cannot afford to participate in such a heavily capitalised operation. At present less than 20 per cent of the world's total catch of sea and fresh water fish is consumed within the third world.

APPENDIX D

Non-renewable resources

Introduction

For the purposes of this discussion, non-renewable resources are divided into two types: metals and fuels.

Metals

The 16 major metals we are concerned with are:

Silver (Ag)
Aluminium (bauxite) (Al)
Gold (Au)
Cobalt (Co)
Chromium (Cr)
Copper (Cu)
Iron (Fe)
Mercury (Hg)
Manganese (Mn)
Molybdenum (Mo)
Nickel (Ni)
Lead (Pb)
Platinum (Pt)
Tin (Sn)
Tungsten (W)
Zinc (Zn)

As can be seen from the chart on p.7, at present rates of consumption all known reserves of these metals will be exhausted within 100 years, with the exception of six (aluminium, cobalt, chromium, iron, magnesium and nickel). However, if these rates of consumption continue to increase exponentially at the rate they have done since 1960, then all known reserves will be exhausted within 50 years with the exception of only two (chromium and iron)—and they will last for only another 40 years!

Of course this is by no means the whole picture: there will be new discoveries and improvements in mining technology, and we can turn to recycling, synthetics, and substitutes. It should be obvious, however, that recycling, although a necessary and valuable

expedient in a stable economy, cannot supply a rising demand (it is not a source of metals, merely a means of conserving them); while synthetics and substitutes cannot be imagined into production, but must be made from the raw materials available to us, those most suitable being themselves in short supply. Petroleum, for example, from which many valuable synthetic polymers are derived, will run out within the lifetime of those born today and will probably be increasingly scarce—and correspondingly expensive—from about the year 2000. Improvements in mining technology will be necessary in any case if we are to make use of the lower grades of ore that will be the only ones available to us as reserves are depleted. However, exponential increases in consumption will inevitably lead to a situation in which grades decline much faster than technology is improved and costs will therefore soar. Similarly, as William W. Behrens[1] has shown, the dynamic of exponential growth will considerably reduce the lifetime of new discoveries. For example, even if reserves of iron (which has a relatively long lifetime) are doubled, they will stave off exhaustion for only another 20 years. Thus, given present rates of usuage and the projected growth of those rates, most raw materials will be prohibitively expensive within about 100 years. Political difficulties will arise well before then—as indeed they are beginning to do in the case of oil.

As Preston Cloud[2] has pointed out, the extra iron, lead, zinc and so on, necessary to raise the level of consumption of the 3,400 million non-Americans to that of their fellows in the United States is from 100 to 200 times present annual production—and although this would be exceptionally difficult to achieve, it is paltry compared with the problem of providing an equivalent standard of consumption for the doubling of world population projected for 40 years' time. And yet we in the industrial countries expect our consumption of metals to go on rising and at the same time lure the non-industrial countries with promises that they too can have "wealth" like ours!

Only those acrobats of the imagination who argue that, come what may, technology will find a way, believe that problems such as these can be solved in any way save a diminution of consumption. In particular, they are confident that the abundance of cheap energy they assure themselves will be available in the near future will enable us to extract the metals present in ordinary rock and in seawater. Yet energy is already very cheap (comprising only 4.6 per cent of the world's total industrial production by value)[3], while the real limit on such enterprises is likely to be not energy but the fragility of ecosystems. For example, the ratio of unusable waste to useful metal in granite is at least 2,000 : 1, so that the mining of economic quantities of metals from rock or seawater will very quickly burden us with impossible quantities of waste.

Energy

The bulk of our energy requirements today is met by fossil fuels, which like metals are in short supply. At present rates of consumption, known reserves of natural gas will be exhausted within 35 years, and of petroleum within 70 years. If these rates continue to grow exponentially, as they have done since 1960, then natural gas will be exhausted within 14 years, and petroleum within 20. Coal is likely to last much longer (about 300 years), but the fossil fuels in general are required for so many purposes other than fuel—pesticides, fertilisers, plastics, and so on—that it would be foolish to come to depend on it for energy[4].

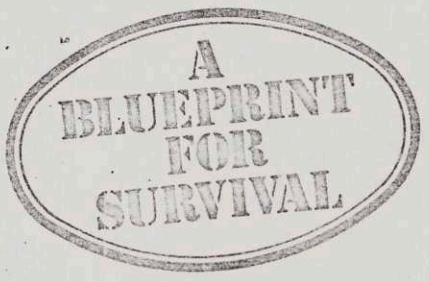
Recognition of this has led to the present emphasis on nuclear fission as a source of energy. However, the only naturally occurring, spontaneously fissionable source of energy is uranium 235, and this is likely to be in extremely short supply by the end of the century[5]. Accordingly, the future of nuclear power rests with the development of complete breeding systems. Breeder reactors use excess neutrons from the fission of uranium 235 to convert non-fissionable uranium 238 and thorium 232 into fissionable plutonium 239 and uranium 233 respectively. Their successful development will mean that man's energy needs will probably be met for the next 1.000 years or so, during which time it is hoped that deuterium-deuterium fusion can be developed—which will provide us with virtually unlimited energy.

Because the successful development of breeder reactors in time to take over from fossil fuels is possible, it may be that fuel availability will not be a limiting factor on growth. This means nothing, however, since shortages of other resources and pollution by radioactive by-products and waste heat will quickly prevent the continued expansion of energy consumption. Since radioactive pollutants have been dealt with in the appendix on ecosystems, we will here consider only waste heat.

Every use of energy always produces waste heat. Power stations "solve" the problem of heat production either by using large amounts of cooling water, or to a lesser extent, air. The disadvantage of the former method is that if the heated water is returned to source it damages the aquatic ecosystem, and if it is evaporated into the atmosphere the source is considerably depleted. The disadvantage of the latter method is that because air temperatures are higher than those of water, the thermodynamic efficiency of the power station is much reduced.

Efficiency is a great problem. In the US, electricity provides 10 per cent of the power actually used by the consumer, but accounts for 26 per cent of gross energy consumption. Earl Cook[6] has calculated that at present rates, by the year 2000 electricity will provide 25 per cent of "consumer-power" and account for between 43 and 53 per cent of gross energy consumption. At that point, half the energy produced will be in the form of useful work and half in the form of waste heat from power stations.

Even if we ignored the waste heat from power stations, that produced by the actual consumption of electricity will quickly call a halt to growth. For example, in the US in 1970, heat from that source amounted to an average of 0.017 watts per square foot, and Claude Summers[7] has calculated that if consumption continues to double at the present rate, within only 99 years, after 10 more doublings, the average will be 17 watts per square foot—compared with the average of 18 or 19 watts the US receives from the sun! Clearly, well before this point energy consumption will be limited by the heat-tolerance of the ecosphere.



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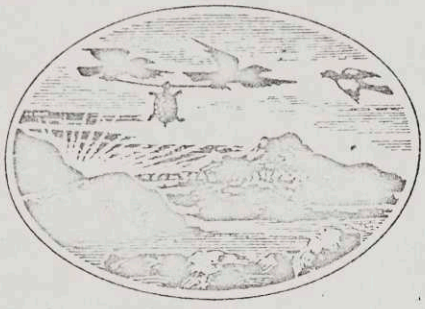

Friends of the Earth Newsletter

Why an FOE Newsletter

Almost from the beginning Friends of the Earth has been keenly aware of the need to communicate regularly with members, now 1,000 strong, in Europe, South Africa, the Channel Islands, and of course throughout Britain. With our present resources it would be quite impracticable to attempt anything as grand as even the simplest newsletter, however rarely we might try to print and distribute it. Our finances would collapse; no campaigns would get fought.

A happy arrangement has now been reached between *The Ecologist*, and Friends of the Earth, whereby a regular monthly new column will appear on this page of the magazine, directed, principally, at FOE membership. Indirectly, it is our hope that FOE membership will be augmented from the ranks of *The Ecologist's* own readership; FOE, after all, is the action group for all practical conservationists.

Inside FOE

FOE operates virtually from inside two filing cabinets at No. 8 King Street, London WC2, Covent Garden—maybe a little closer to the Market than to the Opera. The organisation's working staff consists of a director, a company secretary, two do-it-all-yourself assistants (one of them at the moment writing this article), a one-man legal department, and a dedicated geologist currently examining the National Parks situation—to the joy, no doubt, of RTZ and their friends.

Though I have described FOE's King Street headquarters as minute—two tiny rooms behind a sympathetic book publisher's, with the use of a single telephone extension—we have in recent months become the focusing point for a most extraordinary concentration of energy, generated among an ever-increasing cross-section of the public. In any given day, we handle a hundred letters, endless telephone enquiries, see callers from all parts of the country, and generally cope with the work of a fairly large business organisation. We try never to lose sight of the reason for FOE's existence: the encouragement of the intelligent, economic use of the earth's ever-diminishing natural resources.

To our mind, a sense of urgency, of immediacy must always be maintained, so that the vital get-out-and-do-it approach to life does not give way to sterile theorising. (Theory, of course, is the first requirement. But it must be followed with action.) However, there is in our affairs at the moment an urgent matter to deal with that we could well do without: the need to find new premises by the New Year. Early in 1972 the lease on our building expires, and our benefactors themselves are being forced to move. Where we shall go, we do not know. In the meantime, work goes on, and we are welcoming new Friends at the rate of about 10 a day. Offers of help, both general and specific, continue to come in. One of our greatest needs is for free litho and silk screen printing, and free type setting. We *do* realise that that is almost too much to expect . . .

What next

Immediate problems will not be allowed to cloud long-term objectives. Not surprisingly, a few simple calculations show us that we must stabilise our financial status in order to expand, in order to keep up with the demands of our self-appointed tasks.

Expansion can be achieved in one of two ways. Either FOE London, given the funds and just a little time to organise, will appoint the right person to oversee and co-ordinate each of our selected campaigns from a central control position, or better, autonomous regional FOE offices will be established under the direction of competent full-time secretaries, with all the back-up services of London on call.

Essentially, we want to avoid what Donald Schon has termed the centre-periphery situation, whereby an organisation's forces and resources tend to be drawn to the centre, to "head office", while patently the strength of the group, considered in terms of its day-to-day experience, is derived from experience "in the field". While all current campaigns are national in the sense that we are fighting for legislation by Government, the time will come when we shall take on the polluters, the wastemakers, where their activities may be essentially localised. In that context, FOE London will be involved as one more support-group for the principal, local group.

When will FOE's grass roots begin to spread? When Graham Searle, British FOE director, gets the chance to travel about the country, assess potential and appoint local secretaries. With immediate problems to be overcome in London, this is likely to happen about mid-1972.

How you can help now

Join Friends of the Earth simply by associating yourself with our campaign aims. (Though we hate to ask for donations, donations we do need, as well.) Encourage your friends to become Friends. Invest in a copy of the Consumer's Guide to the Protection of the Environment, by John Holliman: it helps you tackle the practical problems we all face in a world society rapidly spinning out of control.

Ask us for lists of Friends in your area; help us construct a network of activist cells throughout the country. Write to your local council, your M.P. and the Department of the Environment asking them to take immediate steps to curb those who are destroying our environment, and to initiate rational environmental education policies. (They're all political animals: they need you as much as you need them, and pressure is one of the things they understand and respect.) Promote social groups and engineer gatherings to discuss the possibilities of re-cycling centres and transport pools. *Get out and get involved!* If you think your professional capabilities will be useful, tell us what you can do for us: we shall do the same for you.

a call to action . . .

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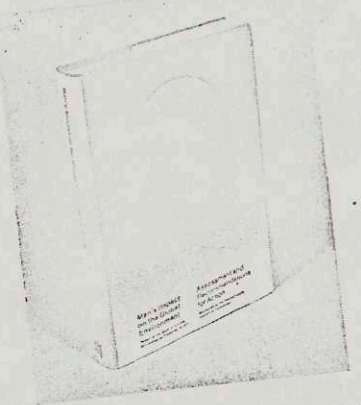

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