3 European/ economic organizations, 1970-1973
American

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MC 0439

BOX 128 FOLDER 3

December 14, 1970

Dr. Erich Jantsch
Gentzgasse 111
A-1180 Vienna, Austria

Dear Erich:

Thank you very much for your letter of November 28 telling me about the meeting at the Institut de la Vie.

I find the whole matter very puzzling. Perhaps you will take the time to write more fully. I would appreciate it.

I had originally been asked to attend the meeting and to be a member of the committee. Because my schedule did not permit going to Paris I declined. They then wrote and asked if I would be a member even if I did not attend meetings. I was told that I could be helpful by answering questions and giving comments by mail. I agreed to this. I certainly have no inclination to intervene nor time to do so. Also, I am entirely unfamiliar with the objectives and purposes of the Institut.

I would appreciate your letting me know how I arrived in the position of controversy which you describe. Since I have taken no positions with respect to the Institut, I find it difficult to understand.

I am so heavily committed at the present time that I probably would not be able to accept an invitation to discuss systems for their proposed meeting. Especially I would not want to do so if there is strong opposition to the idea. We have many fields to cultivate at the present time and do not need to enter those where we are not welcome.

I would appreciate your letting me know who took the two sides of the controversy which you report and what the principal issues might have been. Thank you very much for your letter and for taking additional time to elaborate further.

Sincerely yours,

Jay W. Forrester
Professor of Management

JWF:ie
Air Mail

AIR MAIL

JWF 12/2/70

Erich Jantsch
Gentzgasse 111
A-1180 Vienna (Austria)

Vienna, 28 Nov. 1970

Dear Jay,

I was sorry that you did not come to the Institut de la Vie meeting in Versailles last weekend. It was the more a pity since I think that your presence might have off-weighed other influences on the program of the planned conference. On the one hand, the 7 members present of the international committee had a difficult time to get the 15 or so members of the French Academies and the chairman Jacques Rueff (who is Chancellor of all five Academies) to go along with some more modern and more interdisciplinary thinking. On the other hand, there was some opposition against you, as you might guess.

I tried at the meeting, and I wrote again to Marois about it, to get a discussion of two important aspects of systems theory into the first day : complex feedback systems (you), and hierarchical structures (Mesarovic). One might have along this line also a discussion of game theory since Morgenstern (who came to Versailles) wants to speak about it, and one might have a general view about a possible integrated framework for a general systems theory (Ozbekhan suggested the Australian Emery, or Churchman). Your active participation was strongly opposed at the meeting. However, I repeated my suggestion in a letter to Marois, and if you want to speak on the subject, I will go on supporting that idea. You will also be asked, as a committee member, to give your views yourself. Also Luria and Carroll Wilson.

At the beginning of January, I am going to Berkeley for half a year, as a Visiting Professor both in the Dept. of City and Regional Planning, and the Political Science Dept., and some Centers attached to them.

Cordially yours,
Erich

JOHN A. HARRIS IV
2035 Twinbrook Road
Berwyn, PA 19312

12 February 1990

Jay

Dear USA/COR Board Member:

I was quite perturbed to receive your communication dated 1 February 1990 Volume 1, Number 1, for a number of reasons.

1) PERSONAL

a) I was never consulted as to whether I would like to be honored, or, of at least equal importance, if I would be available or would want to attend the meeting.

b) I gave these grants with the request that as few people as possible should know the amounts.

c) My records show that I gave a little over half a million, not over a million as stated in your communication.

d) I did not suddenly 'in the early 80's shift my giving to help start equally worthy new ventures'. With the possible exception of one year, I never gave over 10% of my total donations to USA/COR, and I had been giving grants long before I helped found USA/COR.

The reason I started cutting back in the early 80's was twofold 1) the departure of Don Lesh and related to this 2) the realization that the Global Tomorrow Coalition and the many other groups which had picked up pieces of the Global Problematique could now do a far more effective job. Thus the need for USA/COR had greatly diminished, and would continue to do so.

2) CLUB OF ROME

I am very much against your group's pretending to associate yourselves with the International Club of Rome, and have unsuccessfully tried to get you to change your name.

For those of you who did not attend the final meeting in November of 1988, Jack and Jeff Fobes and I, plus Don Michael by tape, tried to explain why those U. S. members who belong to the International Club did not want to have a formal U.S. Association continue in existance. I even offered to help finance your

(over)

networking activities, if you would change your name. Others at that meeting also pointed out why they felt there was no need for a continuation of USA/COR. But since those who felt that your association should continue to function took the trouble to come, while those who didn't think that it should continue did not, the meeting's outcome was pretty obvious.

I am enclosing my 28 December 1988 letter which explains this part of the problem to you in more detail.

I would very much appreciate your telling people that I will <u>not</u> be at the March 20-21 meeting in your next communication.

It does look like a very interesting meeting, and I certainly would enjoy seeing many of you again. But, I cannot in good conscience attend while you continue to use the Club of Rome name on your letterhead.

Best <u>personal</u> regards, Sincerely,

Jay

cc: Alex King, Bertrand Schneider, Jack Fobes and other Club members, others.

Just in case you read their material.

JOHN A. HARRIS IV
2035 Twinbrook Road
Berwyn, PA 19312

28 December 1988

Dear current or former USA/Club of Rome member:

As a founder of USA/COR, and either Chair or Treasurer for 12 years (and a member of the International Club) I was hoping that USA/COR would end its active functions with dignity at our good conference this November, proud that we, through our own group and through other associations which we belong to, have brought more holistic thinking and the concepts of the World Problematique to a much wider audience. Unfortunately from the point of view of the U.S. members of the International Club, this did not happen. The following four paragraphs, which were approved as minutes by those international members attending, briefly summarize our opinions and the decisions we reached at a breakfast meeting of all U.S. members in Paris on 10/27/88. Attending were: J. Botkin, H. Cleveland, J. Fobes, myself, M. Mesarovic, and D. Michael.

"There was unanimous agreement that there was no need for any structured organization along the current lines of USA/COR. Some even felt that a structured organization could be counter-productive for the purposes of the International Club.

"That Jack Fobes should continue to be the contact between the International Club and those interested in its activities in the United States.

"That the Newsletter should be further expanded to include more international news. That USA/COR should be dropped from the masthead, and that it should be retitled to include something like "Friends of the Club of Rome".

"That these decisions should be appropriately conveyed to the Club's Executive Committee."

The latter was done both verbally and in writing by various members. I also read the above to those members and nonmembers attending and speaking at the wrap up session on the morning of November 16 after the excellent USA/COR conference, but there was little concern shown by most of those attending about the wishes of the International Members, or the Club itself.

(over)

In a late November letter I again pointed out to Alex King and Bertrand Schneider that some 25% of those 23% responding to our questionaire felt that we should wind down and go out of business, and that 35% preferred to have the organization scaled down. I also stated that of even greater consequence was the fact that after Don Lesh left, it was the most well known members who either reduced their participation, or left the organization. This eventually had a significant effect on our Executive Committee. Much of the EXCOM's time for the last several years has been spent on argueing about the future of the U.S. Association, and/or in power struggles.

I plan to personally subscribe to whatever independent newsletter that Jeff Fobes is able to put together for a greatly expanded audience. However, because of the views of USA/COR held by the U.S. International Club members, I do not plan to renew my membership in USA/COR or attend meetings as long as "Club of Rome" is part of the name of whatever rises from the current Board's efforts.

I have learned a great deal from my official responsibilities and from my friendship with many of you. I know that we all will continue our efforts to improve the world situation as best we can through the many contacts which we have developed over the years.

Respectfully,

Jay

cc: Alex King, Bertrand Schneider

December 11, 1970

Dr. Alexander King
Director General for Scientific Affairs
O.E.C.D.
2, rue Andre-Pascal
Paris XVI, France

Dear Dr. King:

I hope you will be willing to give me some advice and guidance regarding the Institut de la Vie in Paris.

First, let me give you the background. In a letter of 9 October from M. Marois, President du Conseil d'Administration de l'Institut de la Vie, I was asked to be a member of the International Committee of Organization for the next meeting which they are organizing. On October 26 I replied that I was not able to attend their committee meeting on November 21 and that my schedule was too heavily committed to accept their invitation. On 2 November Marois again wrote "I want to renew our request, hoping you will accept to be one of the members of the International Committee for the Conference "Integration Processes in Physics, Biology and Sociology." He indicated that attendance at the meeting would not be necessary and that I could be helpful to them by correspondence. I agreed to serve on that basis in a letter of November 9.

In a letter of 28 November Erich Jantsch wrote to me indicating that I had been the subject of controversy in the committee meeting which had been held. It is not clear what happened but it appears that Jantsch suggested that I should give a paper at the proposed Conference and that there were members of the Committee opposed to the suggestion. It certainly is not my intention to intervene or to become involved in trying to influence their program.

I have now become slightly concerned about the possibility of some conflict of interest or embarrassment to members of the Club of Rome from having allowed my name to be used as a member of their Committee. There may be no problem here but the question comes to mind when I find that Jantsch and Ozbekhan are apparently both members of the group.

This has not created any problem or difficulty to me personally but I would like to have your comments on whether there is any danger of complicating life for others. The easiest thing would be to continue as a member of their Committee and participate only by correspondence. If this does not seem wise it would, of course, be quite possible to resign completely. I would appreciate your comments.

Sincerely yours,

Jay W. Forrester
Professor of Management

JWF:ie
cc - Dr. Aurelio Peccei

Air Mail

file

AIR MAIL

JWF 12/23/70

OCDE

ORGANISATION DE COOPÉRATION
ET DE DÉVELOPPEMENT ÉCONOMIQUES

OECD

ORGANISATION FOR ECONOMIC
CO-OPERATION AND DEVELOPMENT

Téléphone: 524 82-00

Télégrammes: DEVELOPECONOMIE
Télex: 62.160 OCDE PARIS

2, rue André-Pascal, PARIS-XVI[e]

Le Directeur Général des Affaires Scientifiques
The Director General for Scientific Affairs

DAS/D/70.425
AK/jr

18th December, 1970

Dear Jay Forrester

France

Thank you for your letter of 11th December which arrived here today. I do not think the contact with the Institut de la Vie need be in any way embarrassing. I had in fact a talk with M. Marois the other evening and I can assure you that there is no friction between him and the Rome Club unless this has been generated by Erich Jantsch who is a congenital trouble maker in this kind of affair. In the circumstance I think your conclusion to continue as a member of the Committee and participate only by correspondence is probably the wise one. There seems to be no reason of policy or relationship why you should resign unless you want to do so merely through lack of time or interest. The Institut de la Vie is certainly providing useful facilities for discussion and its work is complementary rather than competitive with the Rome Club.

Kind regards,

Yours sincerely,

Alex King

A. King

all good wishes of the season.

Professor Jay Forrester,
Sloan School of Management,
M.I.T.,
50 Memorial Drive,
CAMBRIDGE,
Mass. 02139,
Etats Unis.

copy to Dr Peccei

'THE LIMITS TO GROWTH' IN PERSPECTIVE

A paper submitted at the request of
The Economic Committee of the Parliamentary Assembly of
The Council of Europe

by Aurelio Peccei
and
Manfred Siebker

December 1972

'The Limits to Growth' in Perspective

There are no internal affairs left on our crowded Earth. And mankind's sole salvation lies in everyone making everything his business.

Alexander Solzhenitsyn

We are travelling together, passengers on a tiny space vessel, tributaries of vulnerable resources like water, air and land, all conjointly responsible to guarantee our safety and peace. We cannot escape from annihilation other than by the care, the labor and, I should say, the love which we dedicate to this fragile vessel. We will not be able to succeed as long as one half of the crew lives in wealth and the other in misery, as one half exuberates in self-confidence, whereas the other lives in despair...

Adlai E. Stevenson

The two worlds of man - the biosphere of his inheritance, the technosphere of his creation - are out of balance, indeed potentially in deep conflict. And man is in the middle. This is the hinge of history at which we stand, the door of the future opening on to a crisis more sudden, more global, more inescapable, and more bewildering than any ever encountered by the human species and one which willtake decisive shape within the life span of children who are already born.

Barbara Ward and René Dubos

Our present society is based materially on an enormously successful technology and spiritually on practically nothing.

Growth had become synonymous with hope, and men cannot live without hope... They unconsciously repeated St Augustine's prayer :'Lord, make me good, but not yet!' Let exponential growth continue in my time !

Dennis Gabor

The greatest crime is not described in criminological books: it is geocide, the destruction of life, of the biomass of the Earth.

Henri Ellenberger

The cult of sovereignty has become mankind's major religion. Its god demands human sacrifice.

Arnold J. Toynbee

INTRODUCTION

The present paper has been written at the request of the Economic Committee of the Parliamentary Assembly of the Council of Europe which is preparing a report on 'the limits to growth controversy' and wants a document arguing the case that such limits do exist.

The origin of the controversy the Council of Europe intends to explore is a 200-page book entitled The Limits to Growth, by Donella H. Meadows, Dennis L. Meadows, Jørgen Randers and William W. Behrens III (Universe Books, New York, 1972), brought out in English last March--and in many other languages since--at the conclusion of a research project on world dynamics commissioned by The Club of Rome to be performed by MIT.

We feel that the best way to form a fair judgment on an issue, a thesis or a piece of work is to place it in its proper perspective. This we will do in this case. In doing so, we will take the viewpoint of The Club of Rome--which by the way cannot be identified with the MIT project or any other project it may sponsor and support. This broad approach is at any event required when the purpose is not just reviewing a book, but interpreting an advanced piece of research and its yields, and correlating them to the general body of knowledge. In this instance, this procedure is the more necessary because the research carried out at MIT between July 1970 and the end of 1971 was not intended to be a one-shot operation, a self-contained project that can be examined and assessed focusing only on this book. Whatever the merits or demerits of the first study, it must be viewed as part of a

larger project The Club of Rome has undertaken to develop in the course of a few years on The Predicament of Mankind. Its overall objective is to acquire a deeper understanding of how to face the multiple problems which harass human society at this turn of history--and which are due to growth factors only in part.

Even if the MIT work were considered in isolation--an exercise that would however leave some major aspects of the growth issue itself untouched--it could not be judged by concentrating on this book only, because its theoretical and methodological foundations and their first pragmatic application to world problems are to be found in another book, Jay W. Forrester's World Dynamics (Wright-Allen Press, Cambridge, Mass., 1971). In it Professor Forrester, the originator of the 'systems dynamics' techniques applied earlier to industrial, urban and social 'microsystems', explains how he adapted them, at the request of The Club of Rome, to embrace the global 'macrosystem'.

The picture would be likewise grossly incomplete if the Technical Report compiled by the MIT Work Team were to be neglected. We feel sure that many of the clarifications requested and a great deal of the criticism formulated after reading the limits to growth book will find an adequate response in this Technical Report of upwards of 900 pages. Earlier incomplete editions of it have been circulated. A complete text in mimeograph form has been made available recently by its Authors to all those who are interested in analyzing in detail the characteristics of the model, the data used and their sources, the interrelationships adopted, the computer runs made, or other technical aspects.

Furthermore, a number of ad hoc studies were carried out by the MIT Work Team on specific relevant topics in parallel with the major project. Annex A contains a list of these studies which may be obtained from the Work Team, while a more complete list is included in the book as an Appendix. We would reiterate that they should certainly be taken into account.

We do not feel competent to answer the questions that may remain unresolved even after due consideration is given to all these other documents, and believe that in this complex matter many issues are likely to remain without response anyway, or are points on which opinions will continue to be divergent or contrasting. We would however suggest that, with a view to reducing this area of uncertainty, the Council of Europe at some future date invite Professors Forrester and Meadows to discuss it with some of the people who disagree with them.

For our part, we are pleased about the lively discussion under way on the growth issue generally, and consider the highly emotional reaction to the 'limits' report the best indication that it has touched a nerve centre. At the same time, it is very important to our mind that the debate on this key issue should not descend into polemics and that it should be serious, thorough and in-depth--which unfortunately is not the case with many of the commentaries we have so far seen. Needless to say, finally, the interest shown in it by top political and highly representative bodies, and foremost among them the Council of Europe, is most welcome.

We are deeply indebted to various members of The Club of Rome, and particularly to Dr. Alexander King and the other members of its Executive

Committee whose ideas have been used in this paper. And we share their overall evaluation of the 'limits' report given in their Commentary included in the book:

"How do we, the sponsors of this project, evaluate the report? We cannot speak definitively for all our colleagues in The Club of Rome, for there are differences of interest, emphasis, and judgment among them. But, despite the preliminary nature of the report, the limits of some of its data, and the inherent complexity of the world system it attempts to describe, we are convinced of the importance of its main conclusions. We believe that it contains a message of much deeper significance than a mere comparison of dimensions, a message relevant to all aspects of the present human predicament."

However, this paper represents the views of its authors only, as individuals, and does not engage any other person or any group or organization.

1. The Changed Human Condition

1.1 Man's Ascent and Predicament

For millennia man has struggled upwards from mere subsistence, and throughout this period technical assets, however crude and unsystematic, have helped him to survive in hostile environments. Fire, the wheel, the plough, rudimentary metallurgical skills--these and other findings of great consequences led to a settled agriculture, the establishment of cities and the emergence of a whole series of craft industries. It was not until a great spiritual crisis occurred, however, that one part of mankind, Europe, ceased to be absorbed by the marvels of transcendentalized hierarchies and became fascinated instead by the laws of nature.

The wish to know soon enough became amalgamated with a now unhibited drive to implement the possible. This formidable mixture, which we call technology (so very un-Greek despite its name), was the essence of the industrial revolution, a critical point in man's development. It led to the explosion of activity, ugliness and wealth which became the threshold of the world we now know in the so-called developed countries, reaching its extreme in the United States. Natural science--finally recognized in the esteem of society--paved the way to a whole range of industries, mechanical, chemical and electrical, whose products are commonplace today and form the basis of the present materialist society of consumption and waste which prevails in the 'Westernized' part of the Earth.

At the same time the majority of mankind, living in the remaining

regions, although involved in this whirlwind of change, has only marginally benefited, but mostly suffered, from the dominance of technocratic nations--whose very gifts have often enough turned out to be poisoned.

In our time, advances in scientific research have been spectacular. The immense expenditures allocated to it in all industrialized countries provide a rich and expanding repository of knowledge, from which still further extensive new technological development is certainly emerging, with enormous but dimly perceived consequences for the future of society. We must recognize the outstanding success of science and technology in producing an upsurge of prosperity and economic growth to a level unprecedented on our planet; it has augmented and enriched our food supplies, lengthened our lives, brought health to millions, and provided them with leisure. To past generations, our era seen from this angle could appear as a golden age.

But science and technology, with all their advantages, have also been the main contributors to the complexity of the modern situation, to the extraordinary growth in population we are now experiencing, to pollution and the other unpleasant side effects of industrialization. We have no wish indeed to return to the situation of a few centuries ago when population growth was checked by starvation and disease; but we have not yet learned to control the present. And, lacking a clear view of our desired future, we do not know in precisely what direction to guide the enormous force which scientific and technological progress represents--a force which has the potential of progress or of destruction.

At this point, then, of near attainment in man's struggle upwards from poverty, disease and the enslavement of work, disillusion and doubt have crept in. We begin to perceive that in our technological society each advance makes man more impotent as well as stronger, each new power gained over Nature appears to be a power over man as well. Science and technology have brought us the threat of thermo-nuclear incineration as well as health and prosperity, the nightmare of ruthless manipulation of human genetic material as well as hope for overcoming cancer. Population increase and the drift to the cities have led to new types of poverty and imprisonment in a squalid urbanism, often culturally sterile, noisy and degrading. Electricity and motive power have lessened the burden of physical work but have leaked away satisfaction in such work. The automobile has provided freedom of movement but also led to fetishism for machines as well as cluttering and contamination of the cities. The unwanted aftermath of technology (or rather technolatry) is all too obvious and constitutes a threat, which could become irreversible, to our natural environment; individuals are increasingly alienated from society, and reject authority; crime and delinquency are on the increase; faith is on the decline, not only in religion, which has sustained man for centuries, but also in the political process and the efficacy of social reform. And all these difficulties seem to be growing with affluence.

Therefore, although emphasis is still on the desirability of increasing production and consumtion, in the most prosperous nations there is a rising feeling that quality is draining from life--and the foundation of the whole system is being questioned. At the same time, the situation in the less developed regions of the world is still more

preoccupying. Here the contrasts are even sharper, between the expectations raised by the magic of modern technology and the small share (if any) these populations can glean of a progress which elsewhere seems so glittering. Thus, in the wake of scientific and technological development, intolerable psychological, political, social and economic gaps have appeared, which oppose the 'haves' and the 'have-nots' of the world. Further aggravation of this state of affairs would make political explosions inevitable.

What is in fact wrong is that man has been so intoxicated by his newly acquired capacities that he grossly misuses and abuses them. Lured by the mirage of unending progress and growth, he has forfeited spiritual, ethical and generally non-material values, busily concentrating his best energies on creating a man-made world for his material comfort.

It is remarkable that the strangely intractable and elusive problems with which men everywhere are confronted--from the crisis of institutions to bureaucratization, from uncontrollable urban spread to alienation of youth, from increasing rejection of the value systems of our society to inflation--have three characteristics in common, in spite of their seeming diversity. Firstly, they have worldwide dimensions or impact, and appear at certain levels of development in all countries irrespective of the social and political systems in force. Secondly, they are complex and multivariant with technical, social, economic and political elements. Finally, they interact strongly among themselves in a manner we do not yet fully understand.

It is this intertwined cluster of problems which The Club of Rome

terms the Problematique. The interrelations are so basic and have become so critical that it is no longer possible to isolate any single major issue from the tangle of the problematique and deal with it separately. To attempt this only increases the difficulties in other and often unexpected parts of the mass. For the same reasons, no nation, not even the biggest, can hope to solve its own problems if those threatening the global system remain unresolved. Our customary methods of analysis, our approaches, policies and governmental structures, all fail when faced with such complex situations. We do not even know whether and what unwanted, mediate or indirect, consequences may be provoked by our alleged 'solutions'.

This then is The Predicament of Mankind: we can perceive the individual symptoms of the profound malaise of society, yet we are unable to understand the significance and interrelationship of its myriad components, or diagnose its basic causes, and hence are at a loss to devise appropriate responses.

1.2 Man's New Role

Confronted with this baffling and threatening problematique, society is hard put to to adapt to it, and shows symptoms of a collective syndrome manifesting itself in neurotic if not psychotic behaviour, ranging from impulses of reckless consumption to drug addiction, from unreasonable aggression and violence to the fatalistic depressiveness of those who see inevitable doom. Only recently it is dawning on people here and there that human society is facing a serious crisis in its evolution which may even affect the destiny of

the species, and this generates a newly-won human solidarity which--while still dispersed--tends to overarch our traditional, national, ideological or racial divisions, recognizing the basic oneness of mankind. The tackling of the predicament however needs a powerful rational superstructure.

Man's condition has fundamentally changed in his world; and now he is called to fulfil a new, cybernetic role in it. On the one hand, he has reached such a dominant position in the ecosystem that he is compelled to take upon himself regulative and normative functions heretofore left to the inscrutable designs of Nature or Providence--which requires of him exceptional new qualities of 'ecological wisdom', both words being employed here in their broadest meaning. On the other hand, he has created such an intricate and integrated human system that its regulation and functioning cannot any longer be trusted to automatic mechanisms--man must manage himself his system, developing hitherto unimaginable qualities of 'socio-political wisdom'. Such novel, all-embracing wisdom is far more important than any new technological breakthroughs; for man has made of himself the major agent of change in the world, and what will occur in it in the decades and centuries to come depends on how wisely he uses his immense power. "His role, whether he wants it or not"--says Julian Huxley--"is to be the leader of the evolutionary process on Earth, and his job is to guide and direct it in the general direction of improvement". In a word: man has to realize his responsibility of the truly 'cybernetes', the pilot and helmsman, governor of 'Spaceship Earth'--which at present is drifting along dangerously.

This is the challenge to our generation. The longer we hesitate in recognizing it, the more reduced the options become for us and the next generations. Probably, the first effort has to be of a philosophical and intellectual character. With respect to our environments, we must prepare for self-restraint and self-discipline, and direct our knowledge and technology rather towards protecting Nature and the other forms of life than over-exploiting them, as well as managing the use and conservation of the world's patrimony of soil, water, air and geological deposits. In the social, political and economic order, we must see the collective good take precedence, and individual initiative and profit, even freedom, become subordinate; and substitute for the fatal ideal of national sovereignty and closed-circle interests that of a hierarchy of inter-dependent human groupings or systems, where the requirements of the higher levels come first, and at the top are the requirements of the world system. And, more generally, we must accept the rule that expansion or benefit in some area or field usually requires a counterbalancing reduction or sacrifice elsewhere, now or in the future, and that we had better plan these trade-offs, even when they are painful, than leave them to chance.

Altogether new rational approaches have to be developed if we are to assume the cybernetic role necessary to guide our fortunes in the decades and centuries to come. This forward thinking and planning has to be more than just the sum of singular projections into the future in a number of important fields--such as the economy, security, education, or science policy. To meet the world's reality and problematique on their own terms, our rationale has to match their dimensions with an approach that must be, at the same time:

- Systemic, in order to envision and analyse not individual issues, but the clusters of systems into which human activities and expectations are channelled, their interrelationships with the natural environment, and the maze of problems which derive from their multiple cross impacts.

- Global, or system-wide. Since many key issues have become so large as to exceed national or regional bounds, this means worldwide. Our 'spatial horizon' cannot be narrower than the consequences of our actions.

- Diachronic (the parametric extension of the systemic dimension into time). Our 'temporal horizon' should embrace all moments during the whole period of the possible consequences of our actions.

- And finally, normative, or goal-oriented. Setting long-term global goals, both feasible and acceptable to the entire mankind is the most difficult challenge, but it is the most vital as well at this point in man's evolution.

Without an urgent, intensive acculturation to update and upgrade our value system, this Copernican revolution of hearts and of minds cannot occur. We will be unable to fulfill our inescapable role, and remain prisoners of our prejudices, taboos, and motivations of other ages, our cultural bases, our thinking and behaviour utterly inconsistent with our new condition and power. This vicious circle can but end in disaster--and must be broken before it is too late.

2. The Club of Rome: Purpose and Action

2.1 Origin and Objectives

One has to bear in mind the preceding evocation of man's actual predicament and the vision of his new role to understand the climate that produced The Club of Rome--and consequently the study on the limits to growth. The starting point was some conversations held in 1967 in Paris, which led to the decision to call together in April of the following year at the 'Accademia dei Lincei' in Rome a group of Western European intellectuals and scientists to discuss the world problematique. The meeting was made possible by financial support from the Agnelli Foundation. At the end of the meeting, a few of the participants decided to continue the discussions in a widened circle and named their group The Club of Rome after the place of its initiation.

At present, the Club comprises some eighty members, including scientists, humanists, economists, educators, civil servants and industrialists. Although its total membership is limited to one hundred, it is being selected to include representatives of a wide variety of cultures and value systems; and although none of them is involved in current political decisions, nor has the Club as a whole any ideological, political or national commitments, together they have access to decision makers and possess great stores of information and knowledge to draw upon. These individuals of widely different experience and origin have one conviction in common: that the problems now facing mankind are of such complexity and interrelationship that traditional policies and institutions are no longer able to cope with them.

The Club's objectives, including both research and action, are grouped in a wide-ranging project called, after the situation it wants to meet, The Predicament of Mankind. It is directed at:

= Acquiring and diffusing a real in-depth understanding of the critical state of human affairs and the narrowing and uncertain prospects for the future, and thus creating a climate for action with the more responsive world public opinion and decision makers;

= Recognizing and proposing new policy guidelines and organizational patterns to manage the human lot more intelligently in the future.

Due to the Club's nature and dimensions, its action can be only catalytical. The 'limits' research is its first major manifestation.

2.2 Need for Deeper Understanding and New Communications Tools

After its formation in 1968, The Club of Rome devoted the first two years mainly to establishing contacts with key scientific, industrial and political circles in many parts of the world--from Moscow to Washington, from Tokyo to Ottawa and Rio, and in Europe. Its opinion that the problems of modern society were growing and becoming more intractable, with the risk that the situation in many societies might get out of hand, was widely shared; but generally these high-placed personalities seemed to consider themselves powerless or were unwilling to do anything about it. Many others, engrossed in reaping short-term benefits, had a carpe diem attitude, or just hoped that something would sometime turn up and set everything right again. As a matter of fact, the repeated and pressing exhortations of U Thant,

of the World Council of Churches, the Pope and other moral and spiritual leaders, and even the protests of youth had so far succeeded in but barely denting the Olympian official conviction, or wishful thought, that mankind is on a basically satisfactory course--which just needs an odd correction, here and there.

One clear demonstration of the ineffectiveness of this hortatory method is the pathetic and urgent 'Menton Message' addressed by 2200 environmental scientists from 23 countries to warn their three and a half billion neighbours on planet Earth of the unprecedented common dangers facing mankind. This cry of alarm went practically unheeded. Another example of meagre yields is provided by the United Nations world conferences on matters of great import. Such are the UNCTAD conferences, the third of which was held this year in Santiago, and the Stockholm Conference on Man and His Environment which followed on its heels. Nor are expectations high, either, for the 1974 Conference on Population, which may well become another grand arena for mass rhetoric and power politics, leaving this cardinal issue more obscure and controversial than before.

Clearly, the inertia keeping society on the present course is a formidable force. Other, more powerful and comprehensible tools of communication and conviction than those now used were necessary if world public opinion and policy makers were to be moved --tools which would reflect the inherent complexity of the message The Club of Rome wants to put through, and yet have a strong, lasting impact on people's hearts and minds.

Professor Jay W. Forrester of MIT, participating in the Bern meeting

of the Club in 1970, thought that he could forge one such tool by upgrading his 'systems dynamics' techniques already successfully utilized to simulate and analyze large and complex social problems in the urban, regional and corporate spheres, and make them applicable to nothing less than the entire world system. His proposal was accepted, the Volkswagen Foundation generously made financial provision for the project, and a team of scientists under the leadership of Professor Dennis L. Meadows was constituted.

It is the report of this team, published in March 1972 under the title of The Limits to Growth and the debate it has triggered off, and which reverberates in all parts of the world, that we are trying to put into perspective in this paper.

3. The Research Project at MIT: A First Step

3.1 Its Character and Inherent Limitations

As already mentioned, this first research, undertaken at MIT, is a study of world dynamics, namely the trends and the cross impact of some critical and quantifiable factors which characterize modern society: population growth, food production, industrialization, natural resources depletion, and pollution. It essentially explores the effects of the interaction of the growth modes of these variables, which mutually influence and often reinforce one another. And, even if what it can do is but a first assessment of the combined results of these growth trends, the MIT study conveys in effect, and for the first time, a panoramic view of the world's workings--which could

never have been obtained by making a separate analysis of each of these interlinked elements. It is worth noting in this regard that, as the demonstrative effect of the project was deemed necessary at the earliest date possible, only the factual information, forecasts and computer techniques available were used, without embarking on research in these areas.

When The Club of Rome asked MIT to make this analysis of world dynamics, the aim pursued was essentially to show in a comprehensive and comprehensible way what futures might stem from the present according to current behavioural modes, inherent time constants, perception of problems and 'classical' remedies.

The project was thus expected to be, and substantially is, a description of the present dynamic situation and the outcomes which are inherent in and consequential to it--if mankind's main course is not substantially changed. In other words, the MIT study was not intended to indulge in predictions, to be itself a piece of futurology, an attempt to draw likely scenarios for the world or any part of it at any time in the future.

At the same time, The Club of Rome was aware that the research would probably conclude with a very serious warning that unless a great change of direction does occur, mankind is heading towards a series of grave crises--possibly of unprecedented dimensions, as is everything today with respect to the past, and will be even more so in the future with respect to today. But it was clear from its inception that the MIT projections could and should not try to anticipate how, where and when these crises would happen, or what their sequence and aftermath could be.

Since the MIT research is then explorative, not even predictive, even less can it be prescriptive. The whole of the project is an invitation to think where the present world dynamics may lead us, and it is a means to arouse our awareness, a cry of alarm maybe, but certainly not an instrument for planning or decision-making proper. This nature and scope of the project could not eliminate a certain degree of subjectivity on the part of the Work Team--a subjectivity which, we feel, is no greater than that which characterizes the mental models on which human decisions are currently based. It is true that, confronted as they were day after day with the evidence emerging from the study that continuous, indefinite growth would lead to disaster within a few generations in spite of all imaginable orthodox measures, the MIT Work Team did express opinions as to the necessity to guide the human system away from the present growth stance to a 'situation of equilibrium'. But it would be naive to infer that these preliminary philosophical and general considerations--which the signatories on the whole share--are in themselves normative, namely that they contain precise norms for action.

In spite of the limited scope of the MIT project, many of its supporters or adversaries have tried to read into it much more than it actually is. Let us then repeat that this is a pioneering exploration along a new road in search of vantage points from where a reasonably comprehensive overview of man and his world can be obtained; and that to gain a first foothold on it, it was expressly decided not to invest time and energy to improve the existing modelling techniques or to correct the uneven and often biased body of data available. To position this pilot project correctly in perspective, one can liken it to

the early attempts of those pioneers who at the beginning of this century demonstrated that man could fly. Now this project has tried to demonstrate that man can have a universal view of self and Earth--and according to our judgment it has succeeded. The age of aviation started some sixty years ago. That of global thinking in operative terms is probably starting now.

In the general strategy to approach effectively the world problematique, the MIT undertaking can be considered, functionally, as a commando operation. It was aimed at breaking a stalemate situation and transforming it into one of dynamic debate as a prelude to action. The Club of Rome thought that one could not wait four or five years to have the study refined in every detail or supported from an important body of academic consensus before presenting its rough conclusions to world public opinion. The incredibly wide diffusion of the report--in some twenty languages--and even the bitterness and acrimony of the current debate show that this has been a good short cut. We will examine later on the importance of this initial impact, and how it can be exploited.

3.2 Summary of Basic Assumptions and General Conclusions

The objective of this paper is not to restate the findings of the 'limits' report. For self-explanatory reasons, however, and in order to facilitate the reader in judging seriously the degree to which the antitheses and counter-arguments--reviewed in the next chapter and in Annex B--are relevant or not, a glimpse of the main assumptions adopted in the model and of the general conclusions is given.

As a preliminary remark one should note that essential elements of a physical character only (e. g. food, raw materials, energy, ecology) and social factors (e. g. peace, social stability, education, research, employment) influencing them were considered. The basic and more elusive anthropological aspects of the human predicament were not taken into account, as they call for much more systematic treatment and special studies, which no doubt are going to expand and deepen, and probably also modify, the vistas offered by this first research.

In the various model runs, assumptions of different degrees of severeness were employed. However, since it is frequently said that over-pessimistic hypotheses only were chosen, we want to dispel such misgivings by listing below the most optimistic assumptions used in the study, and then some of the model responses. Here are these assumptions:

Food

= Exploitation of all arable land is considered possible (regardless of soil erosion, city growth, etc.).

= Quadrupling of present productivity is assumed, each doubling in about 30 years.

= Sufficient fresh water is supposed available (though this is one of the biggest bottlenecks already now).

Resources

= Energy: unlimited (^)

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(1) Even if Alvin Weinberg's prospects of using nuclear reactors for all energy needs were feasible from the fuel supply standpoint, the pollution hazards would be frightening: imagine 24, 000 reactors in operation, each six times the biggest size used today, with a replacement ratio of two per day supposing their average life to be 30 years! (UN Conference on the Peaceful Uses of Nuclear Energy, Geneva 1971).

= Non-renewable mineral resources (aggregated): five times the present estimated reserves (corresponding to 500 years at 1970 consumption).

= Use of such resources: input reduced by a factor of 4 per unit of industrial output (from 1975) by reclamation and recycling.

Pollution

= Reduction to less than one-fourth of the present generation rate per unit of economic output (all sources aggregated, including agricultural pollution by fertilizers, pesticides, etc.). (1)

Birth Control

= Perfect in the sense that it prevents the birth of unwanted children (from 1975). (2)

Technology

= Assumptions as to its relative development are not explicitly stated but are implicit. In terms of effect (productivity, disentropic efficiency, etc.) a technological development rate much higher than today's is presupposed at least for a considerable period of time: e. g. permitting the use of fuel and mineral supply of decreasing quality, recycling of non-renewable resources and creation of means for 'perfect' birth control.

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(1) The long-term destruction of the biomass by factors other than pollution proper (urbanization, overfishing, single-cropping, etc.) is not considered, although perhaps more disastrous.

(2) Even if the medico-technical problem were solved in a practicable way, the main hidden question, cultural and motivational, would remain. There is considerable evidence that it is not so much ignorance and lack of access to birth control devices that are responsible for the high birth rate of the poor, as the urge to generate children (for many reasons, and perhaps mostly the absence of alternative modes of personal gratification and affirmation).

By and large, if this set of assumptions is unrealistic, it is because of their over-optimisms. Now, using them, the model shows that serious non-reversible crises (sometimes also called collapses) will nevertheless occur well within the next 100 years, the nature of these crises (food, pollution, resources) depending on the particular set of parameters chosen for the respective model run.

In the model's logic, the only way to avoid or attenuate this disaster-bound behaviour is the concomitance of limitations both in population and in capital growth--provided they are adopted in time. Two illustrative examples are given, both presuming strong remedial action embodied in the following world policies:

= The population has access to 100 percent effective birth control.

= The average desired family size is two children.

= The average industrial output per capita remains unchanged (excess industrial capability being employed for producing consumption goods rather than increasing the industrial capital investment rate above the depreciation rate).

Assuming these policies can be made effective in 1975, the outcome is a situation that seems generally acceptable:

= Population increases for another 70 years up to about 6.5 billion people.

= First a rapid, then a slower increase in food production per capita occurs, up to 150% of the present value by the year 2100.

= Industrial output per capita increases in the same period by one-third (in absolute terms by 130%).

= Depletion of resources is about 40% by 2100.

On the hypothesis instead that these policies are not implemented until the year 2000, the situation is bound to deteriorate possibly beyond repair. In fact:

= Population increases to about 8. 5 billion in 2040.

= Food production per capita doubles within 50 or 60 years, but decreases markedly from 2050 onwards down to little more than the present value.

= Industrial output per capita increases more rapidly, up to 240% in 2040, but precipitates afterwards to three-fourths of the present value.

= Depletion of resources reaches almost 80% by 2100.

In this second case, an equilibrium state is no longer attainable in the world, and food and resource shortages would be inevitable and crippling. Presented in today's terms, if the shortage first reached were that of food production, the population of the non-industrialized countries would suffer most and be drastically reduced; while if exhaustion of non-renewable resources occurred first, the industrial countries would be most affected. Whatever fraction of the human population remained at the end of the process, it would have very little left with which to build a new society in any form we can now envisage.

Before reviewing the criticisms, we want to underline again that these are not predictions or forecasts, but indications of outcomes reasonably to be expected if the present world dynamics are not changed by the only agent which can do it--we ourselves. This is expressed in the general conclusions of the report as follows:

"1. If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next hundred years. The most probable result will be a fairly sudden and uncontrollable decline in both population and industrial capacity.

2. It is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future. The state of global equilibrium could be designed so that the basic material needs of each person on Earth are satisfied and each person has an equal opportunity to realize his individual potential.

3. If the world's people decide to strive for this second outcome rather than the first, the sooner they begin working to attain it, the greater will be their chances of success."

3.3 Review and Assessment of Criticisms

The wave of criticism raised by the study has many facets of varying nature. As usual, some of the objections are to the point, others off-centre, some referring to things actually said, others referring to imaginary theses falsely attributed. The confusion is often great--e.g. that between diachronic analysis and prophecy. (Incidentally: calling somebody Cassandra is rather double-edged: Cassandra proved to be right!)

The bulk of the criticism is based on one or more of the following ways of reasoning:

= The assumptions are wrong (that is: too pessimistic).

= The model is imperfect.

= The presumed remedial policies are unrealistic or the alternatives to present society are unacceptable.

= More important problems are not dealt with.

A short discussion of each of these categories is given below, while in Annex B some of them are examined in the form of point and counterpoint. We shall deal here mainly with the objective and constructive criticism--which The Club of Rome sincerely welcomes--rather than the emotional sort, although it is most instructive to see how in many cases they overlap.

As already indicated, a thorough analysis of the criticism can be made only by a confrontation between their proponents and the MIT Work Team.

3.3.1 Criticism of the Assumptions

In the field of <u>demography</u> and the interpretation of population phenomena opinions are generally divided. Recurrent criticisms are based on hope for a fast demographic transition in poor countries, or on under-estimation of the time lag between birth control and population stabilization, or neglect the age structure as a factor, or treat population growth in industrialized countries as a minor matter. These arguments do not hold against proven knowledge.

The attempts to prove that the assumptions on <u>food</u> availability

are too pessimistic are unconvincing as well. 'Green revolution' advocates, and even Nobel laureate Norman Borlaug, seem sceptical about the material feasibility of the future production quantities assumed by MIT, even disregarding social and ecological costs. Harvesting more food from the sea and having recourse to synthetic food may help to defer a crisis somewhat, but are to be ruled out as permanent solutions of the problem.

Non-renewable resources are a much more complex subject, on which some serious and constructive critical remarks have been made. In fact, some of the data used in the study have a rather low confidence level, while others seem too conservative in view of the possible use of low-grade though high-cost base materials or of new sources, such as seabed extraction. More research on resource availability is needed before definite statements can be made on the effective life of critical materials and their possible substitution. There is however good reason to believe that the basic overall conclusions of the study will not be fundamentally changed, also because the very nature of the predicament lies in the fact that its problems are too strongly entangled for success on any isolated item to change the total picture.

As to substitution, it involves other resources (an important consideration if substitution is generalized), or may be based on technically feasible but uneconomic extraction processes (e.g. seawater or rock extraction), or else may require enormous additional energy consumption or forbidding invest-

ments syphoning money away from other needs, and finally is likely to be another source of pollution. Along with recycling (assumed in the study to reduce resources demand by a factor of 4), which at any rate faces similar problems, it requires also a change in social behaviour, with legal and fiscal implications.

The optimal assumption of limitless energy is perhaps one of the weaker points of the study, especially in view of the probability of an energy crisis within the next twenty years owing to scarcity of petroleum and natural gas, while the phasing-in of fast breeder reactors and massive utilisation of thermal, in particular high-temperature reactors, is still terribly uncertain. The need to push ahead with R&D and planning or simply to know more in the field of high energy liquids from coal and lignite, the utilization of tar sands, or other energy sources is urgent since the provision of sufficient energy is quite a critical point in relation to the adoption of stop-gap or even basic technological solutions to increase the time to manoeuvre towards a more stable and secure society.

Another relatively weak point of the model assumptions (and of the respective model structure) concerns pollution; the aggregation is by all means extreme, and the hypotheses on death rate values as a function of pollution are rather arbitrary. The report though makes it clear that its consideration of the pollution aspects is fractional in that it concentrates exclusively on the accumulation of products which are non-biodegradable or decompose very slowly (e. g. DDT and mercury)--a point on which ecologists are

very alarmed, excessively so, it is to be hoped. This whole matter is again one for long-term research before one can speak conclusively one way or the other. Time only can prove the pessimists or optimists right.

Some critics of rather general argumentation, emphasize the success the city of London achieved in air pollution abatement--an atypical case of pollution very ably and decisively handled--forgetting at the same time that the situation in Los Angeles, Tokyo and Milan has by no means improved. The most worrying pollution anyway is not that of air but of water (lakes, rivers, ground-water and finally the ocean), climbing from there into the food chain. A final caveat: not dealt with in the study (although mentioned) but perhaps even more disastrous than pollution proper, is the increasing destruction and retrogradation of the Earth's biomass, the equilibrium of which is already severely compromised, as mentioned before, by the unabated, extraordinary expansion of the presence and activity of one single species--that of man.

Technology as the ultimate answer to all prayers is a leitmotiv to be found in the criticisms of the most diverse kinds. In many parts of this paper we decry the fervid and naive reliance on technology as a cure-all. A general statement is perhaps befitting at this point. We find it in an interesting document (^) which says that this kind of belief rests, if on anything rational, on the premise "that the steady technical progress of the past century or two can be sustained indefinitely into the future, and that science and technology are flexible with respect to goals, i. e. that they will be as effective in dealing with pollution or materials shortage

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(^) 'Technical Change--Social Change?' by the Science Policy Research Unit at Sussex University in the Field of Forecasting, September 1972.

as they have been in developing communications technology or in raising productivity in oil refineries or making nuclear weapons. Now, technical progress has been won at steadily increasing cost and specifically the returns to R&D investment have been steadily diminishing for the past century. Economists are unanimously agreed that the rate of increase in R&D expenditure in the past 50 years has been far greater than that of the GNP or of any of the indicators of technical progress in the economy. Even if technological solutions to these problems can be found, national and international social systems may simply not be able to accommodate the necessary rate of change". One should add moreover that the net useful output of new industrial techniques will become relatively smaller and smaller as more and more effort and ingeniousness have to be devoted to remedying harmful side effects of primary techniques.

3.3.2 Criticism of the Model

The pilot nature of the model is not always acknowledged, nor is the fact that its high degree of aggregation justifies imperfections which may be overcome only in later model generations. The absence of adjustment mechanisms in the model is often noted instead with the observation that especially in the functioning of the economy these--and particularly price--play an essential role.

It is true: only a few adjustment mechanisms (like the birth rate as a function of per capita income) were introduced into the model. But, for one thing, in the real world social mechanisms do adjust insufficiently, and at any rate with too long time lags with respect to modern growth and change rates, e. g. in technology,

industrialization and urbanization; or they do correct just one part of the system, possibly disrupting other parts. In fact, no adjustment mechanism so far has prevented the formation of untenable situations in world nutrition, or city transport, or the cancerous growth of metropolitan areas filled with misery, or the extreme disparity of wealth among and within countries. However, we do recognize that price as a regulatory factor has not been given enough importance in the model, even if it is no longer a valid regulator in many fields, often being itself the resultant of many other factors perturbing the genuine demand/supply relationship.

3.3.3 Criticism of the Presumed Policies and their Outcome

In order to stabilize the MIT world model for the period until 2100 and possibly beyond, the simulation of several simultaneous remedial policies was necessary, concerning mainly birth control measures and limitation of the average industrial output per capita. Some critics rightly deduce that the implementation of such policies would require a drastic change in the structure, motivational pattern and way of life of present societies--an event which is considered 'subversive' by some, unrealistic by others. Let us briefly review the main criticisms.

To start with, there is the usual misinterpretation that the limits message purports that economic growth should be stopped everywhere, now--which is nonsense. This posture is alien to both

the MIT report and very definitely The Club of Rome, as the Commentary of its Executive Committee included in the book and some of our observations herein explicitly underline.

Once this point is clear, the question is asked whether millions of people in the rich countries would be willing to accept a cut in their living standard. The answer to this very reasonable question probably is that, in the past, many nations have given up their high standard of life (and much more than that) when under threat of war or natural calamities; and that, today, polarizing attention to material standards alone appears to many tantamount to diminishing the quality of life. One may infer that a better knowledge of the alternatives confronting our societies may pave the way to acceptance of different value systems apart from the merely material. Propensity to change is greater when the need for change is understood. It is not surprising that countries of both high industrial and population density have been more moved by the report than emptier areas of the world, and that studies on social change are particularly advanced, e. g., in Japan.

Another objection concerns the possibility, or rather impossibility, to conceive of substantial economic growth taking place in the poor countries in a context of economic stagnation in the industrialized world. Admittedly, this is hardly imaginable, as would also be a cut in the standard of living in an industrialized country which would not cause severe hardship to the disadvantaged citizens of that country. However, this is not the recipe suggested. The hard fact to be faced, the study says, is that--if some growth limits are proven, or even if it is not disproved that they

do exist--mankind has to keep within such limits. And one may add that--if this demands that the value system and structure of society be changed--we had better use our imagination, all our political will, all our energies to make that change while still in time. If we are not able to do so, one does not see how this world--underdeveloped and developed--can go on.

A corollary criticism is that growth is an essential attribute of and condition for capitalism. But this affirmation is now disputed, even by no less a person than Jan Tinbergen, and it seems to equate capitalism with good--which is open to question. Similarly, the doubt is expressed whether the liberties of individuals and business could be preserved in the context of a no-growth world. This is again a double-edged question: optimum individual freedom for all can be but freedom limited by social responsibility--a limitation negative only in appearance.

In the same order of ideas, there is the contention that, since economic equalty is unattainable in this world, growth is its best substitute; thus stopping growth would imply perpetuating the existing inequalities in world income distribution. Whatever truth there is in this reasoning, it looks like a Machiavellian expedient actually to freeze the relative condition of the poor, who possess a lesser capacity to grow. We substantially question the premise, believing that there cannot be any long-term, structural substitute for reasonable economic equality (or at least equal chances) in the modern world. And we would recall a line by Christian Morgenstern, that "nothing can be that shouldn't be" (^).

(^) ".....dass nicht sein kann, was nicht sein darf".

We know that we have not touched upon all the major areas of criticism; but the discourse on this matter would be endless, and the hard fact remains that to accept a change of policies and even more of condition, people need to be convinced that the danger point is here; or at least want to know what advantages they can reap in the trade-off. For the time being, one may conclude with the thought that the future way of life, seen with the eyes of people conditioned by our rich, consumer societies, may look perhaps morally rewarding but a little bit austere; while seen with the eyes of the rest of mankind, it may look unbelievably plentiful. But in any event, the present way of life, seen in retrospect with the eyes of a future generation, will look incredibly disorderly and harebrained.

3.3.4 Criticism that 'More Important Problems' Exist

Of all the different critics advancing this argument, Carl Kaysen (^) has put it in the most articulate manner:

"How much does 'crying wolf' help to direct social energies towards improving our responses to these problems? To be effective, the cry must be well directed: the wolves must be imminent and they must indeed be wolves. On this score we can give only a moderate grade to ' limits', or more properly, to its sponsors in The Club of Rome. The problems they call us to attend are real and pressing. But none are of the degree of immediacy that can rightly command the urgency they feel. Indeed, at least two problems of worldwide

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(^) 'The Computer that Printed Out W. O. L. F. ', Foreign Affairs, July 1972, p. 660-668.

consequences outside the scope of this work seem to be more urgent than any it deals with: the creation of an international order stable enough to remove the threat of nuclear war, and the diminution of the staggering inequalities in the international distribution of wealth. A good sentry does not cry up tomorrow's wolves and ignore today's tigers".

This is a remarkable piece of elegant journalism. In our opinion, it is inspired by another deep-rooted tendency--that of focusing on symptoms and consequences (inequalities, worldwar threat) instead of referring to the underlying causes (inter alia, the impact of overwhelming growth on traditionally organized society). Moreover, as has already been explained, it is the very nature of the predicament that its problems are so critically intertwined that it is not possible to deal with any single major issue separately and in isolation. The habitual kind of linear, sequential thinking ('disarmament first' or 'economic growth first') is basically wrong,and cannotlead us out of the present colossal impasse. Just imagine waiting for the world to be de-nuclearized before attacking the problems of poverty, or vice versa. Nothing has such priority as to relegate the problematique as a whole to second place. All the issues have to be dealt with, or at least understood, in a coherent, systemic way.

Let us close this argument by a quotation from Forrester which is fitting to the point:

"Men with Maddox message are essentially saying: remove the economic restraints, allow growth to continue, and maintain the past trends until economic and social pressures sufficiently

threaten society that the latter alone stop growth. We see these social pressures increasing already. I believe we can clearly trace back to growth and to the changes that accompany technology such social disorientations as drug addiction, rising crime rate, aircraft hijackings, genocide, and the increasing threat of a third world war. A third world war is apt to involve conflict over space, natural resources, pollution dissipation rights, and political freedom. All of these pressures are intensified by rising population and by rising industrialization". (^)

4. The Growth Issue and Beyond

4.1 The Debate Under Way

The bitter and often utterly injustified criticism of the study has shown that a sore spot of society has been touched. On the other hand, after the first shock, an increasing wave of interest and assent from all strata of society confirms that the nature of man is not as stereotyped as some claim. But the most hope-inspiring fact and something indeed amazing is the serious and profound debate of the problematique which has gripped personalities of the highest responsibility in politics, business and science in many countries--which would not have happened had the report not concretized an intuitive disquiet. The debate has just started but it is gaining ground. Within only some eight months after the appearance of the report, an important change of attitudes can already

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(^) 'The Fledgling Cheermonger' by Jay W. Forrester, submitted for the January 1973 issue of the Cambridge Review, University of Cambridge.

be perceived. Incidentally, second-line people still show hostile intransigence when corresponding first-line people have already changed their attitude or have taken a balanced stand--a situation whis is paradoxical only at a superficial glance.

The panoramic overview permitted by the MIT study has changed the average outlook more than anything before. Even ordinary citizens feel that for the first time they have been given the possibility of seeing for themselves the continuously interlocking, tremendous world problems that threaten all peoples and nations regardless of the degree of their development or political regime.

While it is too early to take stock of the situation, it can be stated already now that the higher the responsibility, the greater the attention devoted to the universal problematique invoked. This is confirmed by some of the highlights of the growth debate given in Annex C, and the following sample reactions which cannot be attributed to specific persons:

= Our nations are caught in a vicious circle in which today's difficulties are to a large extent the result of past complacency, improvidence and neglect. But current problems and crises are so absorbing that most of our energies are engaged in facing them. Unable to plan sufficiently ahead to meet tomorrow's greater problems, we are all condemned to be prisoners of the past. This vicious circle gets steadily worse, and must be broken. The time has come to find how.

= The irony of modern society, so amazingly advanced in many aspects, is that it is not organized to tackle the very fundamental

questions where practically everything for everybody is at stake. People want to be effectively informed and to discuss with those politically responsible such crucial issues as the deterioration of the global environment for human life, the danger of over-crowding the planet beyond its carrying capacity, the overkill spiral in armaments, the Third World's growing lags in socio-economic and human development, and their possible worldwide effects.

= We begin to perceive that something fundamental has to be changed in the present way of conducting human affairs, in a world that has become unbelievably small and vulnerable, and are ready to accept that many of these changes cannot be brought about within the enclaves of separate, quarrelling nations.

= For the first time an instrument has been demonstrated which is to some extent in keeping with the complexity of our world and its problematique. Never again will it be possible to regard population, monetary matters, industrial growth and many other problems as autonomous areas of policy determination.

= The need for a new approach to science and technology has been shown to be an area which can no longer be regarded as autonomous in terms of policy. Unless research and development are initiated in a prospective sense, in awareness of social and economic trends and of problem growth, the dichotomy between human needs and technological development will get completely out of hand.

= The fallacy has been shown of the theory that the overall goals of a social system are best approached by working separately towards each sub-goal. On the contrary, in our present condition every effort to enhance one sub-goal reduces the chances of meeting other sub-goals. The problem is to determine the optimum compromise, not only at national but also at global level.

= In cost-benefit relationships among nations there has always been the tendency to realize the benefits in one place and have the cost paid in another. Now it has become evident that the benefits of economic expansion can be increased in exchange for a cost to be paid in the future. This is a dangerous trend. As a matter of fact, we are beginning to pay the price for advantages that mankind (or rather a small portion of it) enjoyed in the past. What will happen to our children if we continue along this path?

= One of the key findings is that a system which tries to accommodate rapid rates of material growth to a slowly changing institutional structure is fundamentally unstable and will undergo profound fluctuations. While no one can say with certainty what the ultimate cause or the precise timing of a major world crisis will be, there certainly will be one. This is true whatever the details of the model we may choose to study the modern world.

= If the book on the limits to growth is read carefully and with an open mind, it becomes clear that, despite the terms of the title, it is not growth as such which is at fault but the present kind of

growth and our methods of measuring growth.

It is sure that the debate presents the danger of polarizing extreme positions, that of apocalypticians and that of incurable optimists--both critical of, and rejected by, The Club of Rome. On the other hand, the debate under way, however confused, is the strongest catalyzer of a new awareness of the trends and interactions going on by our own impetus in this planet in which many more generations have the right to live.

4.2 New Guideposts Emerging

We have pointed out that the MIT project, the first in The Club of Rome's series on The Predicament of Mankind, was conceived as a commando operation, and that its tactical success was expected to trigger off strategic consequences. This purpose has been fulfilled. Apart from its intrinsic merits, the 'limits' study has in fact the merit of having opened up a new dialogue. The debate we have just reviewed is due to the widespread commotion, the new consciousness and the movement of opinion it has created. Considerations which go far beyond the mismatch which exists and grows between an ever-expanding and demanding humankind and the finite nature of our planet are now being made. Unmistakably our Earth-bound species has to watch its own growth on it--unless it wants to trust its future to the exploitation of the cosmos and the 'greening' of the universe. But the growth issue should not monopolize our attention.

Other parts of the mass of problems confronting world society are

as deadly important, and as urgent. To embrace all of them a substantially higher plateau of vision and comprehension must be reached, a quantum leap made in our overall theoretical and positive thinking. This escalation will require time and probably a concerted, joint effort by the entire world community. But already now public opinion has been awakened, and will help to find new responses to the unprecedented challenges it begins to perceive. One can see people of different condition and conviction trying to detect what reliable points of reference and guidance will finally emerge from the present confusion and turmoil. We submit that, even pending deeper research and meditation, some of these points are already within sight as they are so clearly inherent in the unprecedented realities of our epoch.

One such emerging guidelines is that global strategies and covenants for the use, allocation and management of critical non-renewable resources of the planet have become indispensable. The day is not far away when the world community must seriously set about conceiving and organizing these strategies. This may be done at the initiative of a group of particularly interested countries--e. g. the major user nations and those which by geographical chance control these resources--or preferably by a more widely-based international body. Among the critical resources that sooner or later, and for one reason or another, will have to be considered, are probably natural gas and petroleum, copper, mercury, lead, uranium, platinum, some 'exotic' metals, and gold. But, once this principle has been adopted, it may well be discovered that other rare or strategic materials had better be added to the list soon, and that similar criteria of global management are becoming inevitable also

with respect to climate, outer space, the oceans, possibly energy in a general sense--and in the end fertile soil as well.

A second firm norm one is forced to accept at this stage is that of the collective responsibility of mankind for the good management of the Earth's biosphere--not only limited to the species which directly serve human needs. There is already a growing awareness that the human creature must acquire greater ecological sensitivity and wisdom if it is going to fare better, or even survive biologically, among the other living forms. Other swift steps must however be made in this direction to avoid further irreparable damage. Though from an anthropocentric viewpoint the other animal and plant life manifestations are of a lower hierarchy, it is the interplay of all their myriad cycles and systems which provides the polyform, integrated texture of life that some hundred thousand years ago created homo sapiens and still now is at the basis of his very existence. His folly is becoming clearly apparent when he exterminates species after species or disrupts and degrades their ways of life for ephemeral reasons of greed, comfort or expediency--which is precisely what we all are doing at an increasingly massive scale.

These two basic norms call for the definition of a new set of disciplines, together forming the earthkeeping sciences. In writing this paper, it is our hope that Europe, which perhaps needs them to be recognized more than any other region of the world, will take a lead in devising adequate approaches for their systematic elaboration and diffusion.

Another and partly consequential guidepost which, though in the face of much opposition, is gaining recognition is that the human species

cannot go on growing, exponentially or otherwise, beyond certain limits in this finite planet. We have discussed this. Even the die-hard optimists, who argue that human presence and activity can still find ample space and opportunity to expand without worrying too much for the time being, cannot of course claim that such growth can be indefinite. Some limits must exist somewhere. The perception that this is a hard fact is getting stronger. And it is increasingly being realized that it is now urgent to discover what these limits actually are, e. g., for a certain region to enjoy certain standards of life, including quality of life, over time, considering its own resources and capacities, and its relationship with and possible encroachment on other regions faced by similar alternatives. The sooner these assessments are made, the better our collective chances will be for the future.

Let us be permitted to note in this context the unfair posture of those critics who, contesting that mankind is approaching boundary conditions in its occupancy and exploitation of the Earth, denounce their opponents for the sin of advocating a chimeric, but stagnant and decaying 'zero society'; or 'zero demographic or economic growth', and 'zero effluence or pollution' now. In our view such 'zero goals' would again--though in reverse--be an expression of a conception of life which regards human fulfilment and destiny in purely or mainly quantitative terms. Unfortunately, the 'myth of growth' still prevails. But the crude, outdated, purblind addiction it engenders is so unfit for the new world shaping up that it must and will disappear--the sooner the better--although we are not so naive as to believe that the transition will not be turbolent and painful, or that it can be engineered now.

Needless to say, on the other hand, just because society is at present so committed to growth nobody in his senses can dream of successfully launching 'zero growth now' policies. What is needed, now or in the very near future, is instead a proper understanding of where in broad terms the present growth syndrome may lead society, so that it can liberate itself from its spell and be free, for its further ascent, to seek values, motivations and goals consistent with the changing reality of this period of metamorphic transition. We want furthermore to state that it is particularly up to us living in advanced industrial countries--at the forefront both of knowledge and affluence--to feel it a moral obligation to get rid of the material wealth obsession we inherited from times of scarcity which are no longer with us. In saying this we are again thinking of Europe and the role it may have in the embattled and doubt-torn modern society. It behoves perhaps Europe to take the initiative, to find ways to humanize growth, to make it selective, oriented, governable, introducing such qualitative changes as may permit the attainment of different, more complete degrees of wellbeing.

These are just the first guideposts looming up in a sequence of milestones on the path to a new phase of evolution of the human system. To become a responsible and mature society, that has to be in harmony with its habitat, well-balanced with respect to the natural systems which support and condition it. The expanded and thriving community of man foreseeable for the coming decades cannot ever expect to flourish, or even be secure on its planet, if it remains in a grave or permanent state of disequilibrium with its environment. Nobody can yet define what such a condition of equilibrium or 'stable state' should be, although we can imagine

that it could perhaps be not dissimilar to the dynamic, ever-changing and ever-adapting ecological equilibrium of living things. Man, who in his arrogance conceived of himself as a godlike supreme master of the Earth, will have now to seek the way of his terrestrial salvation by seeing himself instead--as he indeed always was--as part and parcel of Nature, and be at peace with it. The fuller this recognition and the better this ecological balance, the higher our quality of life and the greater our individual and collective options for the future will be.

Finally and logically, in the stride of these conceptual developments, though less clearly as yet, another basic norm will have to guide our positive thinking. External equilibrium between society and Nature, however indispensable, cannot be attained, or if attained would soon be disrupted, if society itself is in a state of internal disequilibrium. In point of fact, technological society needs social justice and peace more than any society of the past. In an age of exalted human power and extreme alternatives, social justice and peace not only conserve their primary and lasting ethical value, but turn out to be a matter of great political consequence, ecological concern, and existential significance. Further increases of population, economy and technology will but accentuate this interdependence. And whatever our relative growth restraint and environmental balance, whatever sort of good management of our lot on Earth we can provide, human society will be constantly in danger unless and until the present intolerable disparities between rich and poor, between educated and illiterate, between those who have all the chances life can afford and those who haven't any are eradicated, or at least fundamentally reduced.

Considering the growth issue in this light will help us to appraise it more intelligently and place it in the context of the world problematique. It will then be clear that, even if the offerings of science and technology were boundless, they could not, alone, underpin mankind's growth, make it fully rewarding or acceptable. Certainly society cannot be de-technologized; on the contrary, techno-scientific progress will continue, and may become even swifter. But the very developments that can be imagined--for good or for evil--in the information-communication technologies, in computer technology, in harnessing new energy sources, in controlling and using the climate and outer space for human needs, in human engineering and genetic moulding, and in so many other fields, compel us to match and control them by equally advanced political, social and generally cultural developments. A society that wields more power than reason will remain a barbaric society.

To avoid this degenerative involution, our main effort must be in the direction of social inventions and innovations. For one thing, new institutions are needed--most of them of global jurisdiction, such as those for managing critical resources, as already mentioned. But throughout history the inertia of the institutional setup, whatever this might have been, has always weighed heavily in the evolution of the human system in the face of changing situations. Nowadays, with rapid and radical change everywhere, this drag may have disastrous consequences. If imaginative solutions in our institutions and instrumentalities are not devised quickly, disastrous breakdowns and revolutions have to be expected.

The major obstacle to innovation in this field--and one that hardens

the entire world problematique across the board--is represented by nothing less than the nation-state, outdated but sovereign, unadaptive but strongly entrenched. It is, then, the concept, nature and myth of this basic unit of human organization which needs to be transformed, complemented, diluted in accordance with new world realities (^).

4.3 Further Research

The reality and validity of the pillars of new wisdom just mentioned must be thoroughly questioned and assessed. Their merit for the moment, however, is to evidence how radically different from the traditional wisdom, which in various ways has guided civilization till now, the new wisdom must be that can offer mankind a sporting chance to override challenges and threats that for the first time are of global proportions. Various alternative courses are open, but the danger of miscalculation is enormous. And moreover, the pressure and complexity of new situations building up may push certain human groups to risk shortcut solutions by the logic of force, which may climax in a truly catastrophic Battle for the Earth-- in which humanity and everything else may be lost.

We have already mentioned that the first response should be a joint endeavour to gain a true, comprehensive understanding of the changed human condition and the choice of options open to the community of man. This calls for a blend of research, reflection, insight and

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(^) We would like to suggest, as reading matter for meditation on this general subject, a working document of 'Le Groupe des Dix' prepared "with a view to answering The Club of Rome" (Paris, November 1972).

creative imagination. For its part, The Club of Rome has promoted a series of 'second generation' studies in Europe, Japan, Latin America and the United States. Some of these will be disaggregations from the initial world model, others will go deeply into parts of the system, such as the population-food-agricultural interfaces or materials availability on a global scale; others will attempt to evolve different methodologies for investigation on the world system; yet others will analyze in depth the problematique. In this paper, we will limit ourselves to touching upon two of these new projects which, although still dealing mainly with the material aspects only of our collective life, are a step beyond the first growth appraisal made at MIT.

The first of the two projects, tentatively called Strategy for Survival,(^) is based on a model that recognizes the specific characteristics, standards and dynamics of the various regions in the world, and hence breaks down the total system into interdependent regional subsystems which increasingly interact among themselves. Although the world problem situation is generally viewed by these regional systems as one of crisis, each of them is conscientiously engaged in seeking solutions exclusively or mainly to its own problems only. This response to challenge is simulated by the model, which attempts to represent explicitly the goal-seeking and adaptive nature of the human system, whose efficiency however is hampered by its fragmentation and by time-delays in problem recognition and the organization of remedial action.

We expect that this project will lead us to rediscover the old, sobering truth that, due to human shortcomings, society's limits to growth are

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(^) Since some progress reports have already been prepared, their authors, Professors Mihajlo D. Mesarovic and Eduard C. Pestel, are prepared to make them available.

in fact narrower than the world's physical dimensions; and also to realize how inextricably all nations and peoples have become bound together, none of them any longer being able to escape a fairly common destiny. Solidarity must supersede rivalry.

The second project, called Problems of Population Doubling (^) attempts to explore critically whether and how, or rather under what conditions, it will be possible to lodge, nourish and provide with the other necessities of a decent life the swollen ranks of humankind--which according to current estimates will double its size in a little more than thirty years. The problems and dilemmas created by this doubling of the world population in such a short time, aggravated as they are by ill distribution and rapid urbanization, are simply frightening. Just take the Herculean task of preparing the necessary infrastructures--from houses, schools and hospitals to industries, harbours and roads, and the new lands to reclaim. To perform it, our generation has to do, by itself, a construction job equalling in size all that mankind has built since man ceased to roam about in the wilderness and started to create his first settlements. And the attendant job of rationally using the scarce land available for this and the other human needs will pose planners in most countries well-nigh insoluble problems.

But, of course, the question is not only one of growth--how to multiply the production of infrastructures, food and goods in an orderly manner. Other questions will weigh heavily on our capacity and imagination. Besides providing twice as many citizens on the planet with adequate

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(^) Further indications can be given by the project director, Professor Hans Linnemann, or advisor, Professor Jan Tinbergen.

housing, nourishment and products, will it be possible to guarantee them reasonable sanitary facilities, health services and access to education? Can these production levels be attained in view of ecological dangers and resource exhaustion? Can this effort be organized with the general participation of all the world's inhabitants, without leaving aside, as is now the case, hundreds of millions of 'marginal' men? Can all this be done without impairing the possibility of satisfying further human needs, should the world population continue to grow later on? What new institutions, instrumentalities and approaches will be needed to mount this global undertaking? To be sure, the study will not try to answer all these questions, even in a preliminary way, but they will be kept ever in the forefront while it is being carried out, and consideration will be given as well to the fundamental difference as to the needs and solutions which are most appropriate for the have and have-not parts of the world.

To this effect, the total system will again be broken down into its different, though interlinked, regional components, and the productive activities will be studied with various sets of criteria--according to whether or not they permit recycling or substitution of materials, and what degrees of technological sophistication they require. We anticipate that this study will show that the present industrial and productive establishment of the world, and its structures and modes of operation, are grossly inadequate to respond to the tremendously stepped-up demands of a doubling society. They will therefore have to be progressively reorganized, rationalized and relocated on worldwide bases according to long-term, overall designs--quite a revolutionary idea, to which however we had better start adapting right now if we want to coexist on Earth as decent human beings.

A Word of Conclusion

To conclude, our true understanding of man and his world in the technological age has so far made just a few faltering steps. The authors of this paper believe that the MIT research, its shortcomings notwithstanding, cannot but be considered decidedly meaningful, and hope that subsequent Club of Rome studies will equally be so. They also feel they must underline that the world establishment, and more particularly its main power centres, have failed to recognize the real nature and magnitude of the new challenges confronting mankind, and that even in the questions of growth of our immediate interest they have shown a marked unwillingness to face the whole picture, preferring to take refuge in the analysis of details or peripheral aspects. It was left to a little book to raise the issue.

Now this question and many others of general import are before us. If we, both government and citizens, persist in shutting our eyes to what is new in them, indulging instead in wishful thinking, the old Chinese curse--"may change strike you"--will indeed strike us. On the contrary, it we are alert and try to understand what changes are under way and what they mean, and prepare to meet them adequately, then we can soar above our difficulties--showing yet again that man's finest hour is in adversity.

Annex A

Working Papers Available from System Dynamics Group
Massachusetts Institute of Technology

Behrens, W. W., "The Dynamics of Natural Resource Utilization", 10 pp. (1971). The dynamics of natural resource utilization and the effects of substitution and technology on that usage.

Forrester, Jay W., "Counterintuitive Behavior of Social Systems", Technology Review - Reprint, 16 pp. (1971). An introduction to the nature of social system behavior and the techniques developed at M. I. T. Illustrations drawn from the World Dynamics Model.

Forrester, Jay W., "Counterintuitive Behavior of Social Systems", Hearings Before the Ad Hoc Subcommittee on Banking and Currency, U.S. House of Representatives, Part 3, Reprinted from U.S. Government Printing Office, 65 pp. (1971). Similar to the Technology Review Article, but including transcripts of discussion, and three appended papers:

Forrester, Jay W., "Systems Analysis as a Tool for Urban Planning"

Forrester, Jay, W., "Toward a National Urban Consensus"

Christopher, Michael, "A New Approach to Economic Analysis", from Finance magazine.

Harbordt, Steffen C., "Linking Socio-Political Factors to the World Model," 42 pp. (1971). An analysis of the Changes in the world model needed to include socio-political factors.

Meadows, Dennis L., "Preliminary Draft, Phase One, Dynamics of Global Equilibrium" (Ottawa Presentation), 104 pp. (1971). A description of the World Project including summaries of all the related substudies undertaken.

Meadows, Dennis L., "Testimony Before Senate Subcommittee on Air and Water Pollution in Support of Senate Bill 1113 - The National Environmental Laboratory Act of 1971," 20 pp. (1971). A statement stressing the importance of long-term problems in our national priorities.

Meadows, Donnella H., "Dynamics of Population Growth in the Traditional Agricultural Village," 24 pp. A study of the forces that determine population trends in a typical agricultural village community. This paper is an extract from the proposal of a project still underway.

Meadows, Donnella H., "Testimony Before the Education Committee of the Massachusetts Great and General Court on Behalf of the House Bill 3787," 17 pp. A statement supporting environmental education in Massachusetts.

Milling, P., "A simple Analysis of Labor Displacement and Absorption in a Two-Sector Economy," 15 pp.(1971). An analytical model of potential impacts of labor productivity increases in a predominantly agricultural economy.

Naill, R.F., "The Discovery Life Cycle of a Finite Resource - A Case Study of U.S. Natural Gas," 50 pp. (1971). A study of the forces controlling supply of a finite resource and the effect of policies such as regulation on that supply.

Randers, J., "The Carrying Capacity of our Global Environment - A Look at the Ethical Alternatives," 22 pp. (1971). A look at growth in a finite world and the importance of long-term equilibrium. Paper delivered at World Council of Churches, Nemi (Italy), June, 1971.

Randers, J., "The Dynamics of Solid Waste Generation," 79 pp. (1971). Understanding the nature of the solid waste problem and its possible solutions, including recycling effects.

Randers, J., and Meadows, Dennis L., "System Simulation to Test Environmental Policy: A Sample Study of DDT Movement in the Environment," 50 pp. (1971). An examination of the effectiveness of Environmental policies such as control of DDT.

Annex B

Some Criticisms: Point and Counterpoint

1. The Assumption of the Model

Demography

Criticism	Answer
Birth rates have been falling in almost all countries (Maddox)	Death rates have been falling even more, in particular in the 'developing' countries.
In the Western world a certain adjustment of birth rates to death rates is found ('demographic transition'); the 'developing countries' will follow as they become wealthier (Maddox)	Available evidence shows that lowering infant mortality increases the population growth rate in the short term, with beneficial effects through lowering the fertility rate following only after several decades. There is doubt as to an increase in wealth in the underdeveloped world as fast as the increase used to be in the now industrialized countries. Moreover, decline in birth rates historically has followed industrialization only after a substantial time lag.
Demographic transition in underdeveloped countries may be achieved independently of increase in wealth by special birth control measures	There is no evidence to sustain such a thesis, considerable for the contrary. But if there were and if family size dropped precipitously in underdeveloped countries so that by around the year 2000 reproduction would reach replacement level (and no competent demographer thinks there is the remotest possibility of this occurring), the size of the population of a typical such country would be 2.5 times its present size when it eventually stopped growing. This is

Although the population is rising at an exponential rate, it has not as yet reached the globe's carrying capacity and there are mechanisms in the system which are not included in the model (as they were not operative during 1900-1970 and thus not observable by Forrester-Meadows) which will cause the population to approach the carrying capacity asymptotically from below. (World Bank)

caused by the age structure: more than 40% of the population is under 15 years of age.

It is rather risky to rely on the hope that "there are mechanisms" when there has been no evidence of them during the last 70 years. But more important: the 'carrying capacity' of the planet is not known; it is at any rate not a fixed value but decreases with depletion of non-renewable resources and with increase of the consumption rate per capita; moreover, it varies with cultural and behavioral factors. So if, as we all hope, the long-term carrying capacity of our planet has not yet been trespassed upon, reduction in population numbers and in average consumption would prolong the journey of mankind on this spaceship. Doesn't one use the brakes <u>before</u> hitting the obstacle, in particular when billions of other (if future) human beings are concerned?

Food

Criticism	Answer
There is a food surplus in many regions of the world.	Yes. But about two thirds of mankind is underfed, mainly affected by protein deficiency (UN Food and Agriculture Organization).
Since the late nineteenth century we have multiplied the amount of irrigated land by four to five times, and will see another doubling before the end of the century.	True (perhaps). But despite these enormous accomplishments, the amount of land man has turned into deserts by overgrazing and over-pressure is (perhaps) about five times greater than the amount we have irrigated. In India one quarter of the entire acreage has such heavy erosion that the topsoil will be gone before the end of the century.
The 'green revolution' is expected to produce a fairly rapid improvement in production of cereals.	"The drive for higher yields cannot continue for very much longer because of ultimate shortages of water and fertilizers. But there is a reasonable chance of managing it for the rest of the century. However, that is only under one assumption: that we move to strict population control now, in the 1970's. We have to, because we are already on the verge of the unmanageable". (Norman Borlaug, awarded Nobel Prize for his merits in the 'green revolution'). Besides this, the 'green revolution' necessitates an efficiency and intensity of agricultural effort beyond the possibility of a peasant economy and thus gives rise to social difficulties, flow to the cities, etc. And the ecological consequences have not yet been fathomed.

What about food from the sea?

"The claims have been very exaggerated. The oceans look vast, but we forget they contain large desert areas. We can perhaps double the world's catches, and possibly treble them. It is questionable whether we can double the catches without gross over-fishing. But the most basic point about using the oceans to feed the hungry is what we do with these fish catches today. Approximately half of them go into the feeding troughs of Europe and North America for animal production, primarily broiler, chickens, eggs, white meat and milk." (Borlaug). Furthermore, life itself in the oceans is in danger, and the situation is certain to become worse before it can be improved and uphold the hopes of harvesting large quantities of food from the hydrosphere.

What about synthetic food?

This is a possible, but not yet feasible way to ease the situation. It takes probably decades to develop and implement;and the use of non-renewable resources (fossil fuels?) as well as energy must be taken into account.

"We must stop thinking that there are easy solutions to these fearfully complex issues. People go around saying we have a solution in food from the seas, in synthetic food, in land reform, in irrigation. It is not like that. Let us be realistic about this; we are not going to remove all hunger. All we can do, if we are sensible, is reduce it below a danger point. As it is now, it is moving rapidly to a very grave universal crisis". (Borgstrom).

Resources

Criticism	Answer
The estimate confidence level of the US Bureau of Mines data (main information source of MIT) is relatively low: 80% of the estimates have a confidence level of less than 65%.	True. Better data are difficult to find. Therefore the values used have been arbitrarily chosen five times the presently known resource date (500-year supply of all resources, at 1970 usage rates).
Even 5 times increase of the reserves over the next 100 years seems unduly conservative in the light of recent finds and underwater sources (World Bank)	This may be true for iron ore, aluminium, manganese, cobalt and other minerals. For copper the source cited by the critics gives estimates of twice the exploitable resources at 200% cost increase for 'conventional' origin and a 25% reserve increase by sea-bed extraction. Nickel seabed resources would permit a production corresponding to 3 times the present Western hemisphere value. As to aluminium, a 200% increase in price would make it possible to use clay which is virtually inexhaustible; however, this would entail the use of large quantities of electrical energy which may or may not be easy.
Lowering the demand growth rate from 4% to 1.5% would correspond to a lengthening of the "life" of the resources by a factor of 5. (World Bank)	Lowering of resources input into industry (for equal output) by a factor of 4 has been assumed in several of the model runs.
We do not know the true extent of the resources that exist in, and can ultimately be recovered from, the earth, nor will it be known in the next two years or ten years (World Bank)	Right. That is why the study had to work with assumptions, in order not to wait for another 10 years. More studies on resources are, of course, needed.
To argue that no amount of research or technological breakthroughs will	To argue that research or technological breakthroughs will extend the lifetime of

extend the lifetime of resources indefinitely. . . . is mere intellectual fantasy.

resources indefinitely is mere intellectual fantasy. Technical progress could, however, in a number of cases extend the effective life of a number of critical materials considerably. The whole point of the report is to pinpoint the difficulties, in order that such research should begin now on a number of critical issues because the development process is very lengthy (upwards of 15 years) and the real question is: Have we time?

Energy can be much more economically used. There is scope for smaller cars with weaker engines, public rather than private transport, increasing efficiency in burning fuels and in generating and distributing electricity, and improved design of aircraft engines and bodies (World Bank)

The study assumes unlimited availability of energy. But one must agree that there is scope for great economies in the use of energy and in the improvement of efficiency in energy production. Again it is a matter of beginning to look at these things seriously. The assumption of the study that energy is limitless is perhaps one of the weaker points of the report, especially in view of the probability of an energy crisis over the next twenty years owing to scarcity of petroleum and natural gas. The phasing-in of fast breeder reactors and massive utilization of thermal, in particular high temperature reactors, is still terribly uncertain. The provision of sufficient energy is a quite critical point in relation to the use of technology to increase the time for manoeuvre.

It is not a question of expecting natural resources to accommodate forever our current patterns of growth, production and consumption; clearly, they will not. But we are <u>confident</u> that natural resources will last long enough to allow us time to make deliberate adjustments in our manner of using natural resources in such a way that resource needs can be met indefinitely (World Bank)

Such problems have, unfortunately, up to now really been a matter of <u>confidence</u> not of enlightened judgement. Studies are therefore needed on the question of when adjustments are needed, how far-reaching they have to be, of what potential type, and what potential side effects they might be. It has been one of the objectives of the report to attract new attention to the necessity of adjustments and in particular to the time element involved.

Resources are properly measured in economic, not physical, terms; new mineral resources can be created by investment in exploration and discovery.

This is the traditional economist's argument that economic forces create R & D and innovation. True, they do so, but often too late; moreover, no miracles should be believed in. "Our traditional reliance on research and programs to increase our resource base will be of little avail, nor long lasting" (Russel Train, Chairman of the US Council on Environmental Quality). Finally, the assumption of resources corresponding to 500 year supply, at 1970 usage rates, already takes considerable investment in exploration and discovery into account.

The weakness of the computer is characterized by the famous GIGO principle: garbage in, garbage out.

A computer memory filled with garbage is easily cleared, not so, unfortunately, the brains of people. Some may even never have learned anything of importance and still rate happily along: nothing in, garbage out (NIGO principle).

Pollution

Criticism	Answer
If we were to continue to rely upon fossil fuel for energy production, severe environmental problems would arise (mostly, of a local or regional character), and pollution control would be costly. Eventually, the accumulation of atmospheric CO_2 might prove intolerable, and the further use of fossil fuels would have to be foregone altogether. If, instead, we were to alter the energy production process to rely mainly on nuclear power, we would encounter very large problems of plutonium management, radioactive waste disposal, and reactor safety. Construction of hydroelectric dams also causes severe environmental hazards. In these respects, there is merit in the argument that rapid growth can endanger clean environment unless appropriate long-run safeguards are adopted. By the same token, however, over a time span of decades, fusion power, solar power and the use of hydrogen-oxygen fuel as replacement to the internal combustion engine could drastically alter the pollution problems associated with energy production (World Bank)	The very feasibility of fusion power is not yet proven, eventual economics utterly unknown. Some pollution and waste problems caused by fusion neutrons, uranium blankets and certainly from tritium would show up even with this technique. Fusion would be on the market well after the year 2000, if ever. Solar energy cost is presently estimated (by its promoters) at ten times the 'conventional' value. There are space and storage problems as well as narrow climate limitations. At any rate solar energy cannot probably become of global energetical importance before the end of the century. As again it may be the time factor which could become decisive, an example for substitution delays in the energy field may be interesting: nuclear fission reactors were invented in 1939, proven feasible in 1942, first power use in 1953, commercial in 1966; now, 33 years after their invention, nuclear reactors produce about 3% of electricity, 0.7% of primary energy; it is hoped to produce about half of the electricity by nuclear means by 1990, but not more than 15% of primary energy (50 years after the experimental demonstration of feasibility and with some hundred billion dollars spent on R & D, partly military). Hydrogen may indeed be a good alternative for car engines and many other applications. Production with nuclear energy is possible, although today utterly uneconomic; production efficiency would be about 25% using electrolysis, about 40% using hypothetical processes under development as compared to about 90%

for production of refined products from fossil raw materials. At any rate fossil fuel substitution by hydrogen would constitute a considerable increase in nuclear energy use as a primary source, with corresponding environmental problems of reactors, nuclear fuel cycle and waste storage.

The model assumes that there is a limit to the amount of pollution the world can absorb in a year and that this limit is four times the pollution now produced annually. There is absolutely no scientific evidence to support such a conclusion. Progressive pollution levels may destroy present concepts of living during the next 100 years, but the model builders marshall little scientific evidence to prove it will destroy life itself (World Bank)

At the present status of knowledge the assumption used could not be more than an 'educated guess'. The report makes clear that its consideration of the pollution aspects is fractional in that it concentrates exclusively on the accumulation of products which are non-biodegradable or decompose very slowly (e. g. DDT and mercury). Possibly the ecologists are just alarmists, although their fear of an overall deterioration of living conditions can point to quite a few tragic examples that have already occurred. We just do not know enough, and it is very necessary to undertake long-term research on these matters immediately so as to have some real facts as a basis for action and a means for rationalizing hysterical anxiety.

Technology

Criticism	Answer
A sufficiently large and exponential increase in technology will solve all food, resources and pollution problems.	The answer is complex. Basic arguments against this thesis are already given in many of the above points. In general, it may be said that the 'optimistic' critique of modern variants of 'Malthusian' arguments rests on the belief that the steady technical progress of the past century or two can be extrapolated into the future, and be directed towards new goals with equal efficiency, staving off potential catastrophies. However, this optimistic assumption may itself be vulnerable because of systematically diminishing returns to investment in science, technology and education, as indicated in the paper. Moreover, the net useful output of new industrial techniques will become relatively smaller with the need to devote an increasing part of the effort to remedying the unwanted consequences of primary techniques (pollution, degrading of nature, congestion of cities, fertilizer and pesticide effects, etc.). With the limitations to the possibilities of technology, what is needed is not the haphazard, extemporary, if not military-oriented advances we experience now, but a set of science policies globally coordinated to attack the bottlenecks and weak points endangering our overall situation. But this rational use of our expanding knowledge is still a far cry. Technology's creations still obey private or sectoral interests, not the general one.

2. Imperfections of the Model

Criticism	Answer
The model has a very high level of aggregation. Averages of very dissimilar variables have been taken, a procedure which can give extremely misleading results. Also the number of feedback loops is rather low. (World Bank)	It was acknowledged from the very beginning that the first study is of a 'pilot' nature and that there would be inherent difficulties in interpreting the results in terms of real circumstances in different countries or different subassemblies of aggregated parameters. As to the fear of misleading results, detailed studies under way will show whether the way in which the 'averaging' and aggregation has been done really affects the general conclusions. The feedback loop system will assuredly be perfected in later model generations. Critics and criticised alike should endeavour to 'de-bug' the tool.
At least a 'two-world' model is needed in order to distinguish between the 'developed' and the 'undeveloped' parts of the world.	This belongs to the 'second round' studies now under way as indicated in the paper. Lumping together so many different countries in one camp or the other would however be equally misleading. Further disaggregations must be made as soon as reliable statistics and other data are available.
A major flaw in the analysis lies in the total absence of adjustment mechanisms of any kind in the model. That is not how real social mechanisms work. Especially in the working of the economy, adjustment mechanisms play a crucial role. The most important of these is price (World Bank).	Some adjustment mechanisms (like birth rate as a function of GNP) have been introduced, but rather few. As indicated in the paper, real social mechanisms do adjust rather insufficiently, at any rate with a very long time lag which has turned out to be too long with respect to modern growth and change rates in research, technology, industrialization and urbanization, for in-

stance. No adjustment mechanism has prevented the untenable situation in world nutrition, in private transportation, in the cancerous growth of metropolitan areas filled with misery, in the extreme disparity of wealth among countries and within countries. And price is no longer a valid regulator in many fields; it is often established by factors overruling the demand/supply relationship.

In the case of industrial capital, the rate is defined as output less consumption, agricultural investment and services investments -- in a sort of residual theory of investment which is not in accordance with any modern theories of investment. Moreover, the average lifetime of capital should not be constant but rather a function of level of development and the rate of growth (World Bank).

For a given output, considering investment in agriculture and services of vital importance, the freedom of choice was between consumption and industrial investment. In the model runs which assume no drastic change of policy and behaviour, the present propensity to invest industrially and average lifetime of industrial capital stock have been considered. In some other runs, supposing different policies, the rates of investment and the stock lifetime have been modified to suit a more equilibrated behaviour of society (e. g. longer equipment and product lifetime). It is important to note that pollution abatement investments have to be made besides industry, in the other categories as well: services (e. g. traffic, pollution), agriculture (e. g. fertilizer pollution), and consumption (e. g. household pollution from heating, detergents, etc.). However, more sophisticated investment and capital lifetime hypotheses will have no doubt to be applied in future investigations.

A fairly serious objection can be made about the question of reversibility... Since virtually all of the relations of human behaviour with respect to income level have only been observed on the way up, the model is seriously in error to assume symmetric behaviour... Data shows that as income rises the birth rate falls, and this is incorporated directly in the Forrester

This is another field in which ameliorations are certainly worthwhile. A partial approach to this problem has already been realized in the original model using mechanisms of 'third order' delays.

As to the example of birth rate as a function of income there is considerable evidence that factors such as instruction and habits are less important than the degree in which al-

model and indirectly in the Meadows one. One would expect, however, that on the way down with income the birth rate would not go back up the curve, but rather would remain at very low levels perhaps going up only when income reached low levels or when enough time had passed so that the high income habits of low fertility had been forgotten (World Bank).

ternative modes of personal gratification exist which in modern societies are usually linked to income. The problem is thus not so much one of reversibility but of determining and qualifying psychologically relevant factors, which are insufficiently known as well as their influence on industrial and social behaviour.

A model is sensitive to changes, such as the inclusion of small exponential rate in the discovery of natural resources and pollution abatement techniques, rather than using linear or step functions.

This is true. Such inclusions (with the same 'time integrated content' as the linear or step functions, for a certain period of time) may in fact change model behaviour from 'collapse' into a milder crisis. It should be investigated which of the two modes corresponds more to reality.

The level of detail in the different sub-systems of the model is uneven.

Future disaggregation of the initial model and the replacement of major variables by distribution functions will show the relevance of this imperfection. This and other criticisms should be addressed to be body of information presently available on the problematique and attendant phenomena, rather than to the model of the MIT exercise.

The world is finite, thus it is impossible to expect the population of the world to be able to grow exponentially without stopping, or without something eventually preventing exponentiality. This is an obvious point. Malthus told us this in 1798; he did not need the MIT computer.

True (but arrogant). Comment: That Malthus did not need the MIT computer is irrelevant. He did not have it at his disposal. Wouldn't he have liked to know more about the dynamics of the 'world system' and, about the relative importance and the interaction of various parameters?

3. Presumed Remedial Policies

Criticism	Answer
One is not talking about something within the scope of human experience that millions of people will willingly accept a cut in their living standards.	Many countries have in the past considerably reduced their standard of life (and much more than that) when under threat of war or natural calamities. But even independently of exceptional periods: restricting attention to material standards of living alone appears to many already as diminishing the quality of life. Social aspects were deliberately excluded from the first study; and their consideration would in fact make the picture at once darker, but at the same time pave the way for acceptance of different value systems away from the merely material. It is not surprising that countries of both high industrial and population density have been more moved by the report than emptier areas of the world. Future studies, including some already begun in Japan, are concentrating on the social issues since it is fully appreciated that the attitude of individuals in societies will inevitably greatly influence demand for or rejection of the type of policy solutions suggested by the report.
It is difficult or even impossible to conceive of continued substantial economic growth in the poor countries in general taking place in a context of economic stagnation in the industrialized world.	Withing the present framework, it is impossible. We have to use our imagination, all our political will, all our energies to change that framework. If we are not able to change the framework one doesn't see how this world--underdeveloped and developed--can go on.
A cut in the standard of living, even in an industrialized country, will mean severe hardship for the disadvantaged members of society.	Correct for a truly capitalist society. May one then ask whether a society with material profit as its main motivation can find a place in a homeostatic world, anyway? This does by no

	means imply that communist countries, as they exist today, could easily change direction versus an 'equilibrium society'.
Growth has been an essential attribute of capitalism since its conception in the late Middle Age, and it is questionable whether the liberties of individuals and business could be preserved in the context of a no-growth world. (Leonard Silk)	It is. In the past, individual freedom has proved to be a good slogan to implement and maintain slavery and exploitation, giving every possibility to the strong, the reckless, and the privileged, leaving the handicapped, the morally inhibited and the underprivileged open not only to arbitrariness but even to contempt. What of today? Equal freedom for all should be our goal. But optimum individual freedom for all cannot be but freedom limited by social responsibility, a limitation negative only in appearance.
'Profit' is the essential motivational force of man.	It gave rise to the Divina Commedia, the Ninth Symphony, the Monna Lisa, and polioserum. It really did! Only the kind of profit in these cases has been essentially non-material satisfaction, the respective incentives being cultural, spiritual or social. The whole concept of 'profit' must be revised, and its different kinds placed in a different order in the scale of social values.
If growth is "a substitute for economic equality", then stopping growth implies freezing the existing world distribution of income (Wallich)	If growth is a substitute for economic equality, why not substitute the substitute by the real thing? The carrot swinging before the nose of man may prove to be more perturbing than Damocles' sword.
'Limits' predicts hell in 50 years. Hell is already present on Earth in places such as Calcutta.	No comment.

Note: This point and counterpoint analysis is largely unprofessional. The authors apologize if they have misinterpreted some of the critical observations listed here, or omitted more relevant ones or given irrelevant answers. Their purpose was not one of rebuttal. They wanted inter alia to show that controversy on details may be endless and sterile, and even offuscate the vision of the

drama and the stage in which man's fortunes are played out. And they hope that many of the critics will turn their talents to the constructive task of exploring what we all -- the protagonists -- should do to play our part right.

Annex C

SOME HIGHLIGHTS OF THE GROWTH DEBATE

9 February 1972

Letter from Mr. Sicco Mansholt (at that time European Commissioner) to the Chairman of the Commission of the European Communities, making explicit reference "to the study performed by the Systems Dynamics Group of MIT". He declared that faced with such a problematique "the cause would be lost if Europe refused to take the initiative", as according to him "the United States do not have the necessary political force to guide the world towards a solution". He asks for birth control also in highly developed countries. As to economic aspects, he questions the possibility of implementing the necessary measures and maintaining the present structure of society; he excludes, however, state socialism as a possible solution. His main point is to demand that we do not "orient any more our economic system towards.... a maximization of the Gross National Product (GNP) but to replace the latter instead by the 'Gross National Utility' (GNU)". To this end he proposes a European General Economic Plan and a five-year plan for the development of a 'clean and recycling' (CR) production system. He suggests that the Commission implement a system of CR production certificates and corresponding fiscal and tax measures, promote the durability of consumption goods, create a European distribution system for raw materials, and orient research towards a 'utility' rather than a 'growth' goal.

This letter raises considerable controversy which reaches its culminating point in April 1972 on the occasion of the French referendum on the enlargement of the European Community, right-wing Gaullists and the French Communist Party being the most hostile to Mr Mansholt's theses.

(M. Debré: "The members of the Commission are not politically responsible"; G. Marchais: "A Europe of misery and economic repression"). Other political tendencies show in general careful, sometimes even warm approval of Mansholt's principles, the main reservations being those concerning his proposals for concrete action.

April 1972

Conference of the Commission of the European Communities in Venice on the theme 'Industry and Society', with Chairman Mansholt's theses in the centre of interest. Contrary to Mr. Mansholt, European Commissioners Barre and Spinelli prefer the line of the 'technological fix' in a traditional economy.

May 1972

The 'Rencontres Internationales' organized in Paris at the initiative of Valéry Giscard d'Estaing with the Club of Rome themes as the centre of the discussion, and the participation among others of Swedish Prime Minister Palme, President Senghor of Senegal, Chairman Mansholt and Vice-Chairman Barre of the Commission of the European Communities, Roger Garaudy, Professor Herman Kahn, John Kenneth Galbraith and Bertrand de Jouvenel). The need for a new kind of growth, a 'humanized growth', is generally endorsed.

May 1972

UNCTAD Conference in Santiago de Chile with questions of growth limitations, necessity of a global approach and equilibrium between developing and developed countries, on the agenda.

June 1972

UN Conference on the Human Environment in Stockholm. The third point of the Final Declaration reflects many of the ideas which led to the 'limits' research:

"Man has constantly to sum up experience and go on discovering, inventing, creating and advancing. In our time, man's capability to transform his surroundings, if used wisely, can bring to all peoples the benefits of development and the opportunity to enhance the quality of life. Wrongly or heedlessly applied, the same power can do incalculable harm to human beings and the human environment. We see around us growing evidence of man-made harm in many regions of the earth: dangerous levels of pollution in water, air, earth and living beings; major and undesirable disturbances to the ecological balance of the biosphere; destruction and depletion of irreplaceable resources; and gross deficiences harmful to the physical, mental and social health of man, in the man-made environment, particularly in the living and working environment".

July 1972

UNESCO meeting of experts on science policy selected by Governments of the European Member States, in Budapest. The Committee of Experts, recognizing that "the pattern of world needs and resources is such that national long-term planning can no longer be conceived of solely in terms of increased material prosperity, if only because this framework gives insufficient weighting to conditions which will critically affect the future quality of man's life", recommends, as a matter of urgency "to stimulate the study of socio-economic development phenomena in an expanded framework, linking these

phenomena with the study of all natural processes and equilibria relevant to man's existence and the quality of that existence".

July 1972

UNESCO-sponsored Symposium in Holland on 'Young Scientists and Contemporary Society', organized by the World Federation of Scientific Workers, marks a real rupture with the spirit of the 'old generation'. The fragmentary character of today's sciences, the absence of an opening towards world problems and the 'elitist' character of scientific institutions are criticized. The notion of 'soft technology' is created: labour-intensive, mentally satisfying, ecology-preserving techniques. The MIT study is somewhat criticized for not having dealt with the waste of armaments and for placing too much emphasis on resource limitations rather than stating that the real root of most ills is a crisis of civilization: a single deep-lying problem with many diverse symptoms. This coincides with the Club of Rome thinking.

July 1972

Resolution of the European Parliament in Strasburg on Environmental Protection, endorsing several of the theses of Chairman Mansholt based on 'limits'.

July 1972

At the 22 Meeting of Nobel Prize Winners at Lindau, the German Chancellor, Willy Brandt, states with reference to the MIT study and other investigations: "Above all one has to be ready --as long as there is yet time -- to renounce certain pleasures of civilization, to abandon traditional legal positions and even to get rid of a whole herd of sacred cows".

Mid-1972

US Department of Commerce commissions a special study in response to 'limits'. At that time Mr. Elliot Richardson, Secretary of the US Department of Health, Education and Welfare, had already declared: " 'The Limits to Growth' must be taken seriously even if only half of its assertions prove true".

September 1972

Critical report on 'limits' prepared by a task group of the World Bank. Its main critical arguments are dealt with in this paper. World Bank President Robert S. McNamara, declared in 1971, in a different context: "The marginal men, the wretched strugglers for survival on the fringes of farm and city, may already number more than half a billion. By 1981, they will surpass a billion; by 1990, 2 billion. Can we imagine any human order surviving with so gross a mass of misery piling up at its base?".

October 1972

Russell Train, Chairman of the US Council on Environmental Quality, explicitly endorses The Club of Rome approach as a guideline for the future.

"A question to which we must address ourselves is the limits of the carrying capacity of the earth itself. . . . . I suggest that . . . . . we inquire into the ability of our institutions to cope with change, to get food and fiber products to where people are, and to protect us from some of our own breakthroughs when , for example, a green revolution proves vulnerable to insects, or enhanced agricultural productivity causes farmers to inundate the cities in search of work . . . . . We must ask whether

the market allocates long-term needs in an effective manner of whether prices only rise when a resource is close to depletion. Instead of dismissing these matters with an ideological reflex, we must apply careful analysis, for it is by no means clear that the marketplace and technology will solve all of our problems in an even-handed manner . . . . . Another issue we face is how to develop technology in such a way as to make use of its benefits while at the same time anticipating potentially harmful side effects and taking those actions which reduce the risk of developing technology. The problem is particularly severe in that the side effects are often second or third order, their anticipation difficult, and the development of adequate safeguards complex.

All of these questions suggest that we must improve our ability to understand the future. This means not only better projections of future trends, but a more profound understanding of the interrelationship among a wide variety of factors such as population, food, industrial growth, resources and pollution. . . . . Indeed, we must act as 'one World'.

October 1972

Press Conference by Giovanni Agnelli, Chairman of Fiat, at the Turin Motor Show:

". . . . Many of the conclusions of the MIT I find particularly stimulating even if reality is perhaps much more complex than the model introduced into the computer. At any rate, I hope that there will develop around them not only controversies but also studies and concrete projects to create tools for the control of the possibly negative effects of the most advanced technologies without thereby sacrifying the forces of economic and social development, which

is still needed by such a great part of the world in order to eliminate its oldest ills: hunger, ignorance and endemic diseases".

October 1972

The first 'Information Week' organized by the Japanese Government to launch the plan to transform Japanese society into a 'knowledge-information society'. This and many other attitudes in Japan with respect to the future are to a large extent inspired by The Club of Rome thinking.

November 1972

The Second Symposium on economic and legal questions of environmental protection (University of St. Gallen, Switzerland) deals with the problem of the direction and ends of economic growth, with 'limits' as the hub of the discussion. Well-renowned national economists like Prof. Francesco Kneschaurek, who were thought to take the stand of traditional growthism, pleads for qualitative rather than quantitative growth and qualifies the ecological controversy as being "too often emotionally overcharged, ideologically biased and filled with clichés stemming partly from political opportunism, partly from simple hypocrisy". Even more critical towards the conventional concept of economic growth are Prof. Emil Küng and Prof. Josuah Werner.

November 1972

Quality of life and a new kind of growth, as opposed to the goals of a society of consumption ('growth fetishism') and to artificially stimulated material aims, are points to be found in the election program of the German Social Democratic Party.

November-December 1972

During the elections in the Netherlands, 'limits' and even 'zero growth' theses are among the major issues.

January-February 1973

US Congressional Hearings scheduled for three to four weeks in the House of Representatives on 'Growth and the American Future'.

February 1973

Meeting of the Ontario Research Foundation in Toronto, Canada, on aspects of the Predicament of Mankind.

March 1973

The American Association for Higher Education has selected as its principal theme for its annual convention the implications of 'The Limits to Growth' for planning in American Universities.

AND SO ON.....

SLOAN SCHOOL OF MANAGEMENT
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

INTER-OFFICE CORRESPONDENCE

FOLLOW-UP	
FILE	

TO Carroll L. Wilson DATE Dec. 20, 1972

FROM Jay W. Forrester

SUBJECT

I have read the letter by Arnold Packer of the Committee for Economic Development and the proposal for a study of problems and potentials of economic growth.

Like so much of the present discussion on the Limits to Growth issue, this paper seems to focus disproportionately on the physical and material aspects of the question. It seems to me that the much bigger and more important issue is the way in which the technological and the material aspects of growth affect the intangible components of quality of life.

It seems to me that growth is producing crowding, administrative complexity, the sense of personal frustration, the feeling confidence of individuals in their government, rising crime rates, growing unemployment, expanding government, and rising international stress.

Unless the study addresses itself to these issues it will be looking at only half of the situation and will very likely draw the wrong conclusions.

JWF/dg
Dictated, not read.

ORIGINATOR REMOVES THE DUPLICATE (YELLOW COPY). SENDING THE ORIGINAL AND TRIPLICATE TO CORRESPONDENT WHO RETURNS THE ORIGINAL WITH COMMENT AND RETAINS THE PINK TRIPLICATE COPY.

COMMITTEE FOR ECONOMIC DEVELOPMENT, 1000 Connecticut Avenue, N. W., Washington, D. C. 20036 • 202 296-5860

fromCLW

✓CED 12/15/72

October 20, 1972

Professor Carroll L. Wilson
Sloan School of Management
Room 26-169
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Dear Professor Wilson:

As you know from our September 15 conference on the subject, the Program Committee of CED will consider a project on what has provisionally been titled "Problems and Potentials of Economic Growth" at their meeting on November 14, 1972. The only formal description that the Committee will receive will be a page or two that will be given to them on that date. Enclosed is a preliminary draft of what will be submitted.

Packer

I would appreciate any comments you might have on it.

Very truly yours,

Arnold H. Packer

Encl.

Proposal for a Study of

PROBLEMS AND POTENTIALS OF ECONOMIC GROWTH

The Program Committee decided at its May meeting to consider further the questions raised by the Club of Rome study "Limits to Growth." Since that time we have met with some of the foremost experts in the field and have attempted to define the problem in such a way that a focused and relevant policy statement could be developed.

It is proposed that the policy statement place equal emphasis on two themes and the trade-off between them. One will be the problems that may be caused by a growth policy that ignores the limits on energy, raw materials, usable land, and the capacity of the biosphere to accept waste products. The other theme will be the opportunities for improving the quality-of-life that can be provided by benign growth.

The fundamental challenge made by those who advocate cessation of growth is that neither government nor business is capable or competent to guide growth in a tolerable direction and that safety can only be found by essentially calling a halt to progress. If the challenge cannot be answered the body politic may conclude that it is correct. On the other hand, a policy statement that pointed the way towards avoiding the problems and enhancing the opportunities would be of considerable value.

The Subcommittee might begin by identifying those situations in which current trends will lead to severe long-term consequences, where the problem or institutional setting leads to a lengthy period between the

onset of a problem and its solution, and where self-correcting mechanisms are either absent or too weak and thus intervention is necessary. The study would also identify situations in which self-correcting mechanisms are adequate and existing or planned intervention should be diminished. The approach would be to separate decisions that can be safely postponed from those where neglect will lead to serious and irreversible consequences.

The Subcommittee might conclude by making recommendations on the set of decisions whose effects are long-lived and which will determine the direction of growth. The procedure would be accomplished for five interdependent subjects: energy, materials use, the environment, transportation, and land use. Population growth would be considered as it affects these five subjects but not as a focus for policy recommendations.

The Subcommittee would want to consider a long time period, certainly to 1990 and perhaps out to the year 2000. Though it might prefer to concentrate its policy recommendation on U.S. policy it would consider the international interdependencies and the unique situation of the U.S. in the world community. In this regard, the Subcommittee might collaborate with foreign counterpart organizations. The statement might recommend ways in which external social costs can be internalized and become part of production costs and how this may be accomplished so that individual firms, industries, and nations are treated equally. They might also deal with the difficult problem of bringing the future costs of potential shortages into current prices and how uncertainty about results can be dealt with so that safe economic growth can proceed.

TIMS

MANAGEMENT SCIENCE

APPLICATION

Volume 19, Number 10
June 1973

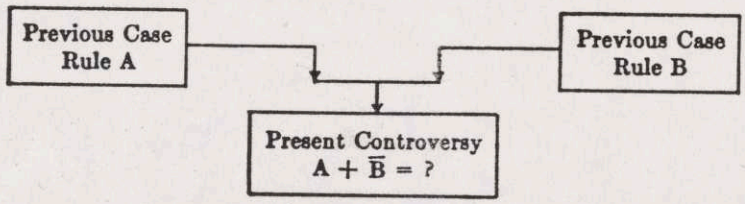
prise" of most questionable advantage, and indeed something to be shunned at all costs. One of the maxims of successful as opposed to spectacular trial procedure is that one never asks a question unless one knows the answer.)

A second requirement is that the parties opposing each other must bring in the facts ("evidence") upon which their arguments rest. This "evidence" must then be made available for hostile scrutiny by the opposing parties. Lastly, and this is indeed the pièce de résistance of the adversary process, is the requirement that the conclusions drawn must be based upon the evidence and, to a lesser extent, the arguments raised therein. This requirement that the conclusions be based upon the overt arguments and facts is indeed one characteristic that distinguishes the legal adversary process from the *ad hominem* approach and covert shennanigans that have plagued other scholarly controversies. (Compare e.g. the subterranean warfare waged against the Chicago school in the economics area and the current guerilla tactics being waged against the Meadows-Forrester ([7] and [12a]) global simulations. In both instances, professional jealousy coupled with the not-invented-here syndrome led to deliberate vituperation and obfuscation in lieu of scholarly inquiry. The legal adversary process could quickly demonstrate whether the proponents and opponents were more interested in advancing knowledge than in eradicating heresy.)

To put it another way, the legal process is a formal method of translating social goals into viable realities under visible concerned scrutiny.

Perhaps if one examines the legal process as a "system" then can one ascertain how this "system" will aid in implementing management science solutions. And here we mean a societal system in the cybernetic sense: "a system of communication . . . that has dynamics in which circular processes of a feedback nature play an important part."[6] More importantly, if one understands this particular system, then one may evaluate the inputs so that the black box outputs resemble the rational choices desired.[7]

Thus, one must realize that this system has as one of its major inputs, the notion of *stare decisis*, the rule that past precedents help determine the outcome of contemporary disputes, as in the following diagram:



However it is also fair to assert that a notion of entropy is equally useful; that is if one assumes that courts (and legislatures) have wide discretion (unbounded energy) at an early stage, then they have less and less freedom (their discretion becomes bounded) as the legal process evolves.[8] In the Weiner sense, as the particular field becomes better and better organized [understood] then the range of possible solutions becomes more and more limited [possibly but not necessarily optimal].[9]

[6] N. Wiener, *Cybernetics*, 2nd ed., Cambridge: M.I.T. Press (1967) 212 pp. at 24.

[7] Ref [18] is a particularly apt exposition of the use of cybernetic techniques to comphrehend the legal process. The discussion above is derived thereform.

[8] Consider the Federal Income Tax vis-à-vis its simplicity in 1913, versus its complexity *after* the Tax Reform Act of 1969.

[9] Wiener, op cit, at 11: "The notion of the amount of information attachs itself to . . . *entropy*. Just as the amount of information in a system is a measure of its degree of disorganization." See

tute of Management Science and a member of the American Mathematical Society and the Society for Industrial and Applied Mathematics. He is a fellow of the Econometric Society, the Operations Research Society of America, the American Association for the Advancement of Science and the Institute of Mathematical Statistics.

The author of *Linear Programming and Extension* (1963) and over 100 technical papers, Dr. Dantzig is associate editor, or on the editorial boards of *The Journal of Combinatorial Theory, The Journal of Linear Algebra and Its Applications, The Journal of Computers and Biomedical Research, The Journal of Computer and System Sciences, Discrete Mathematics, Networks, and Mathematical Programming Society.*

Dr. Dantzig has served as a consultant on mathematical methods to Esso Research and Engineering, Standard Oil of California and Boeing Scientific Laboratories. He is a member of the board of governors of Technicon University, Israel; Phi Kappa Phi; Sigma Chi; and Pi Mu Epsilon. He is listed in *Who's Who in America*, and was awarded the War Department's Exceptional Meritorious Service Medal in 1944. He was elected to the National Academy of Sciences in 1971.

Michael A. Duggan (*"The Law and the Legal Process"*) is a Professor of Business Law and Computer Sciences at the University of Texas at Austin, as well as a member of the Atomic Energy Safety and Licensing Board Panel. He holds a B.S. in Mathematics from Holy Cross College, a J.D. from Boston College Law School, and a M.P.L. from Georgetown University Graduate Law School.

Dr. Duggan is the author of four books, definitive continuing bibliographies, over 70 articles and monographs, more than 110 book and article reviews, and over 200 case précis. In addition to his writings, Dr. Duggan has consulted with over 15 firms and government agencies within the last 5 years, and has "chaired" more than 30 workshop panels and symposia. He has testified before Congressional committees, as well as appearing as an expert witness in legal and regulatory proceedings. Dr. Duggan is a member of the Association for Computing Machinery, the American Bar Association, the American Marketing Association, and is a Commander in the Active Naval Reserve, Research Analysis Division D-1. He is Editor-in-Chief of *Computing Reviews*. He formerly was a Trial Attorney with the Antitrust Division of the U.S. Department of Justice, and was an Assistant Professor of Economics at the Whittemore School, University of New Hampshire.

Neil Jacoby ("Organization for Environmental Management—National and Transnational") is a professor in the Graduate School of Management of UCLA, of which he was the founding dean, combining the careers of scholar, administrator, and corporate director. Born in Canada, he holds a B.A. and an LL.D. degree from the University of Saskatchewan. In 1938 he received the Ph.D. degree in Economics from the University of Chicago, where he later became Professor of Finance and Vice-President. For the past twenty-five years he has been at UCLA. He served on President Eisenhower's Council of Economic Advisers, was U.S. Representative in the Economic and Social Council of the United Nations, headed official missions to India, Laos, and Taiwan, and has been a member of the Pay Board. Jacoby was president of the American Finance Association in 1949 and was on the Executive Committee of the American Economic Association in 1963–66. He has been an organizer or director of several corporations, including one of the largest multinational firms. Author or coauthor of more than fifteen books, including *United States Monetary Policy, United States Aid to Taiwan* and *European Economics—East and West*, Jacoby is an Associate of the Center for the Study of Democratic Institutions at Santa Barbara and a frequent contributor to *The Center Magazine*. His book *Corporate Power and Social Responsibility* will be published by The Free Press in April 1973.

Allen V. Kneese ("Management Science, Economics and Environmental Science") received a Ph.D. in Economics from Indiana University. Dr. Kneese has taught Economics at the University of New Mexico, at Stanford University and at the University of California, Berkeley, and has served as a research economist and Director of the Water Resources Program and is presently Director of the Quality of the Environment Program for Resources for the Future, Inc. Dr. Kneese has authored and co-authored 8 books and been a contributing author to more than 20 publications. His articles have appeared in *International Organization, The Swedish Journal of Economics, American Economic Review, The Forensic Quarterly* and the *Annals of the New York Academy of Sciences* among others. Consultant to the World Health Organization, the National Academy of Sciences, the U.S. Department of the Interior, the Tennessee Valley Authority among many other organizations and institutions, Dr. Kneese still finds time to be an active member of the American Economic Association, the American Association for the Advancement of Science, and the National Academy of Sciences-National Research Council.

Kenneth O. Kortanek ("Revenue Sharing, Regionalized Economic Activity and Social Goals") is a Professor of Urban and Industrial Administration and Operations Research at Carnegie-Mellon University. He received a Ph.D. in Engineering Science from Northwestern University and is interested in numerical optimization and pollution abatement, Semi-infinite programming and moment prob-

Panel Warns of Resources Crisis

By STAN BENJAMIN

WASHINGTON (AP)—Reporting under government contract, a scientific panel yesterday urged that the United States begin limiting its population and is consumption of resources.

It said that the nation, already heavily dependent on foreign raw materials, must shift its industrial base to materials domestically plentiful, or face a disastrous minerals crisis within decades.

The panel needled its employer, the National Commission on Materials Policy, accusing it of ignoring the demand factor in the nation's growing supply-demand crisis in energy and raw materials.

It noted that the commission's interim report last April "nowhere alludes to review, analysis, or restraint of demand."

But the panel, drawn from the National Research

(Continued on Page Eight)

Council of the National Academy of Science, said "it is clear that the difficulties imposed by growing U.S. and world populations prevade all other resource issues . . ."

It added that "there can be no effective national or international materials policy" that evades the relationship between population, per-capita demand and environmental impact.

Thus, in milder terms, the U.S. scientific panel aligned itself with the general thrust of the "Club of Rome" report and British scientists' "Blueprint for Survival," both published last January.

The Club of Rome, a group of international scientists and economists, predicted the collapse of modern industrial society-perhaps within a century, unless population growth and material consumption are stableized within the next few decades.

The U. S. National Commission on Materials Policy was appointed in 1971 with the mission of recommending a national materials policy to the President and Congress by June 30, 1973.

The commission issued an interim report identifying at least 36 issues in the area of materials supply problems, but it noted the list might be incomplete, and it contracted with the National Research Council for another study of issues.

THAT STUDY, now published, said "there was but small support in the panel for the view that market forces alone will solve the forseeable problems."

It said appropriate governmental incentives and controls should be applied to increase production to meet the needs of unavoidable population growth, but at the same time convert the economy in the long run to a no-growth stability.

The report said the United States is already heavily dependent, and is becoming ever more dependent, on foreign sources for its raw materials, adding that this "would provide increasing opportunity for international conflict."

Attempts to increase domestic production of minerals, it said, would mean producing "ever-larger quantities of metals obtained from ever-leaner deposits" at the cost of "ever-larger investments of energy" and "growing potential for damage to all aspects of our environment . . .

"Conservational measures are needed, not only to stretch our resources but to restore, protect, and perpetuate a livable human habitat.

"THE NUMBERS of humans occupying that habitat, moreover, must be limited to numbers it can comfortably sustain and their individual consumptions of materials must be kept within supportable limits."

The report said the nation must gradually convert its economy to reliance on resources of which it has plenty.

"We believe that planned adjustment of technology to available domestic resources is essential," it said. "The alternative is progressive deterioration in the mineral position of the United States, with all that that implies.

"One can foresee, within decades, failing such an an adjustment, the erosion of United States mining, smelting, refining and mineral-based manufacturing industries, growing economic colonialism, international trade, and a tarnished global frictions, a steadily deteriorating balance of trade, and a tarnished global image of the nation."

HERALD TRAVELER and BOSTON RECORD AMERICAN,

THURSDAY, OCT. 5, 1972

Metals: The Warning Signals Are Up

by Edmund Faltermayer

From the time that men in ancient Mesopotamia learned to smelt copper, metal has been synonymous with civilization. The very words bronze and iron denote human epochs. Today an incredibly vast array of objects—from electric appliances to skyscrapers to transportation systems—would be unthinkable without metal, and industry's appetite for it is insatiable. The U.S. has used more metal in the last thirty years than the whole human race had used until then, and demand keeps right on increasing. Yet many essential metals are found in the earth's crust in only limited quantities. One U.S. mining executive puts today's odds against finding a commercially exploitable metallic ore body at 10,000 to 1. Nor is there any way to synthesize metals, short of achieving sustained superhigh temperatures on a scale found only on exploding stars.

To be sure, a variety of nonmetallic substances are also vital to the world economy. Demand for a few of them, notably helium gas, fluorine, and potash, could begin to outrun supply in the generations just ahead. But the supply of most nonmetallic materials, including such basic items as sand, clay, gravel, stone, glass, and cement, can be considered limitless. Another basic material, wood, is renewable and can be made more plentiful through more advanced forestry (see "Timber, the Renewable Resource," on page 113). The world also has a lot of underused land despite the high population densities of some countries. Aside from the energy resources needed to make barren acreage productive and to drive the whole industrial process, therefore, the chief limit to growth is the availability of metal.

Has the U.S. been "creamed"?

A growing chorus of experts and study groups has been saying that this limit is closer than we think. The recent M.I.T. study sponsored by the Club of Rome, *The Limits to Growth*, warns that the world's known reserves of zinc can support the present pattern of growth for only eighteen more years, that copper and lead reserves will be exhausted in twenty-one years, bauxite for making aluminum in thirty-one years, and nickel in fifty-three years. New discoveries might postpone the day of reckoning, the M.I.T. study conceded. But, it added, even a fivefold increase in the reserves of all five metals would be eaten up by compound growth within a century.

There is certainly abundant physical evidence that the U.S., at least, may already have creamed off its *best* metallic resources. The easily accessible, high-grade iron ore of the Mesabi Range is mostly gone. Before World War I, copper companies hesitated to mine ore containing less than 2 percent metal; today they would be overjoyed to find new deposits half that rich. The U.S. Bureau of Mines warned in a massive 1970 study that "the rate of new discoveries and development of reserves is declining for a wide range of minerals."

As a consequence, American industry has been turning increasingly to foreign sources. A net exporter of raw materials until World War II, the U.S. has been an importer ever since, and the trade gap is widening. In 1970 the U.S. metal industry met less than 60 percent of its primary demand with domestic ores. The growing use of foreign ore places the U.S. in competition for the available supply with the rest of the world, where demand for metal has been soaring. With Japan's metal-hungry economy setting the pace, consumption of key minerals outside the U.S. rose 158 percent between 1950 and the late 1960's, compared to a 38 percent increase in this country.

Reserves versus resources

From all this, one might easily conclude that America's great industries are increasingly at the mercy of foreign lands, including some unfriendly ones, and that growing imports are merely a transitional phase to the time when all the world will enter an era of metal famine. Fortunately, the picture is not nearly so bleak.

For one thing, the concept of *reserves*—meaning discovered bodies of ore that can be profitably mined at current prices with existing methods—refers only to a part of the mineral *resources* in the earth's crust. It excludes both undiscovered deposits and known ore bodies of an inferior grade that might someday become exploitable with further improvements in mining and beneficiation techniques or with an increase in prices. With no new discoveries whatever, in fact, reserves of some metals would rise geometrically if prices increased by, say, 50 percent, because low-grade deposits might then be worth mining.

For a variety of reasons, including the high cost of exploration and property taxes, mining companies have little reason at present to hunt for or reveal reserves that exceed their requirements for more than about two decades ahead. Reserves, says a government geologist, "are just a working inventory."

Research associate: Beth Bogie

THE ENERGY COST OF SOME EVERYDAY MATERIALS

		FROM ORE	FROM RECYCLED MATERIAL
Amount of energy, measured in pounds of coal, needed to make one pound of...	Steel	1.11 lb.	.22 lb.
	Aluminum	6.09	.17-.26
	Copper	1.98	.11
	Glass	.36	.36
	Cement	.33	—

Some basic industrial materials are virtually limitless in the earth's crust. But the energy to create them isn't limitless, and indeed may become more precious in the years to come. The energy "costs" shown here for both new and recycled ingot steel, aluminum, and copper are from a study by the Oak Ridge National Laboratory. Bruce Hannon, of the University of Illinois Center for Advanced Computation, supplied comparable figures for glass and cement. Regardless of the fuel actually used, the energy required to produce the materials has been converted to its coal equivalent to facilitate comparison; i.e., it is measured in terms of the coal that would be needed to produce a given amount of the heat or electricity used in the mining, beneficiation, and smelting process.

Aluminum is a special case, however, because half the energy used to make virgin aluminum is hydroelectric power. Accordingly, the coal-equivalency figure for aluminum is lower than it would be if all the electricity were made from fossil fuel, which would involve a considerable loss of energy in the form of waste heat. In that case, another Oak Ridge calculation shows, it would take the equivalent of 8.32 pounds of coal to produce a pound of new aluminum. In some uses—e.g., for containers—a pound of aluminum can do the work of two or more pounds of steel.

Figures on reserves permit inferences to be drawn about the total resources that will eventually place a ceiling on growth, but they understate the metal available to mankind.

The growing importation of foreign ore, moreover, does not mean that this country will be dependent on overseas sources from now on. The U.S. still has large deposits of many of the metals that it now imports; in a future emergency it could work these deposits just as it did during World War II and the Korean conflict. Industry has turned to foreign ores because they are cheaper or of a higher grade than domestic ones, or because they can be transported inexpensively by sea.

Nevertheless, metal consumption cannot go on doubling and redoubling indefinitely into the future. At some point the availability even of abundant metals, such as steel and aluminum, may be limited by lack of the energy needed to mine, concentrate, and smelt their ores. (See "The Energy 'Joyride' Is Over," FORTUNE, September.) For less abundant metals such as copper, lead, and zinc, the sheer finiteness of the supply could begin to place a limit on global consumption in another hundred years or so, regardless of the availability of energy.

Several developments could alter the future supply of metal, however. The growing concern for the environment might constrict the supply. But the available supply might be increased by the development of advanced techniques for locating ore, and by stepped-up recycling of the billions of tons of metal already extant in the advanced countries.

Before these possibilities are examined, let's look briefly at what's currently known about the prospective supply of twenty important metals.

Iron, the raw material for steelmaking and the work-horse metal of the industrial age, constitutes nearly 6 percent of the earth's crust. Iron ores suitable for making steel at the prevailing price of 9 cents a pound, of course, are found only in specific deposits. But the number of known deposits has expanded rapidly. Since 1952, when the presidential commission headed by C.B.S. Chairman William S. Paley looked at natural resources, world reserves of iron ore have increased threefold.

As in the case of so many metals, a big new factor is Australia, which formerly banned the export of iron ore in the belief that its deposits were very limited. Reserves containing ten billion tons of iron have been identified in Australia, New Zealand, and nearby New Caledonia, and Australia's potential iron resources are characterized by the U.S. Bureau of Mines as "vast."

Though its easily accessible high-grade ore is almost gone, the U.S. has a fair amount of magnetic taconite, and domestic mines have been able to hang on to two-thirds of the American ore market through pelletizing techniques that produce blast-furnace feed that is superior to natural high-grade ores. With a 50 percent rise in the price of ore, the amount of available taconite could be expanded greatly. Meanwhile, a technique has been developed for using a type of nonmagnetic taconite that until recently defied concentration techniques. Cleveland-Cliffs Iron Co. will beneficiate the nonmagnetic ore from a big mine in Michigan through a new flotation process.

Aluminum is even more abundant than iron, making up about 8 percent of the earth's crust; it is literally right under our feet. However, the bauxite ore from which the metal is most economically processed is found in only a limited number of places, many of them in the tropics, so the U.S. has long been heavily dependent upon imports. World reserves of bauxite have increased greatly over the last two decades. Current Australian reserves alone—including a bauxite outcrop 300 miles long—are equal to the known total of the globe in 1950.

The U.S. has ample clays and other minerals that could substitute for bauxite if foreign supplies were ever cut off. But it would cost more to produce the metal, and entail an increase in the large energy input already required to make a pound of aluminum (see the chart above). Recently the Aluminum Co. of America purchased 8,000 acres of land in Wyoming to get a deposit of an aluminum-bearing mineral, anorthosite, that is larger than all the world's bauxite reserves combined.

A bit of reverse Malthusianism

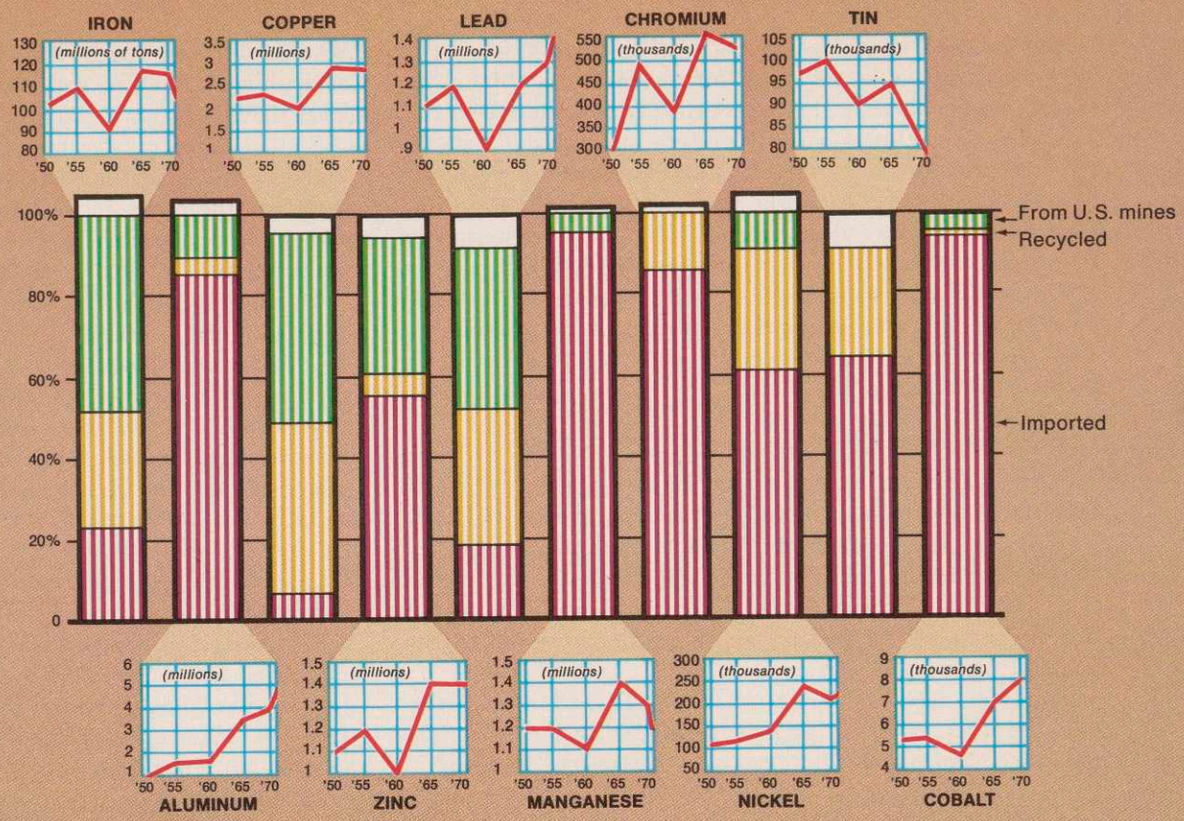
Conceivably, the world could be *paved* with iron and aluminum if economics, energy, and environment imposed no constraints. Few other metals are present in anything approaching such abundance.

Copper, for example, constitutes only about one part in twenty thousand of the earth's crust. Yet despite the inroads of aluminum and plastics in recent years, demand for copper keeps rising, and it ranks third in industrial importance. It

WHERE WE GET TEN OF OUR IMPORTANT METALS

The U.S. is heavily dependent on imports for some metals, including aluminum, manganese, chromium, and cobalt. But domestic ores and recycled material supply the bulk of our needs for others, such as copper, lead, and iron.

The figures in the bar charts are for 1971 except those for chromium and cobalt; 1970 data were used for those metals. All data are from the U.S. Bureau of Mines. Where the bar charts exceed 100 percent—as is the case, for example, with iron and nickel—it indicates that we produced or imported more than was needed, and the excess was added to the national stockpile. In the case of some other metals, such as lead and tin, the stockpile was drawn down. The pattern of recycling varies greatly. Most lead is "old" scrap discarded by consumers, chiefly from used auto batteries. More than half the recycled copper, however, is "new" scrap collected from mills and fabricators.



is indispensable in electric motors—motors with aluminum-wound armatures would be extremely bulky—in indoor wiring, for strong and corrosion-resistant tubing, and in making brass and bronze.

Until now, discoveries of new copper deposits have kept well ahead of demand. While some uncertainty clouds the future accessibility of high-grade copper ores in Chile, Zambia, and Zaïre (formerly the Belgian Congo), scores of low-grade deposits in porphyry rock are being developed in British Columbia, Iran, Panama, Bougainville in the Solomon Islands, and elsewhere. The U.S., which relies almost entirely on low-grade ores, is the world's largest producer of copper, with nearly one-fourth of world reserves. Yet the average grade of U.S. ore keeps declining, and ores containing as little as 0.4 percent copper are now being mined in the Southwest.

That trend may not be as ominous as it sounds. The late American geologist Samuel G. Lasky, a sort of Malthus-in-reverse, said that each arithmetic reduction in the grade of porphyry copper ore mined would open up vast marginal reserves, so that the amount of available metal would actually increase geometrically. That would mean that the steady decrease in the grade of ore presages more copper, not less. Another optimistic theory holds that the Western Hemisphere's entire mountain chain from Alaska through the Andes is sprinkled with copper deposits waiting to be found and worked.

Nevertheless, the Bureau of Mines believes that before the end of this century world demand for copper will exceed "by substantial margins" the supply available at the current price. If this rather gloomy prediction is borne out, the price will have to go up and more substitution of other metals for copper will occur. Men in the copper business, however, think it most unlikely that the world will run out of the metal even in a hundred years. We may use it more selectively, they say, but it will be available.

Lead is less abundant in the earth's crust than copper, but in recent years deposits of the metal have turned up in such places as Ireland and New Brunswick, Canada, as well as Missouri. Missouri's new lead belt, the so-called Viburnum Trend discovered in the mid-1950's by St. Joe Minerals Corp. and now worked by several companies, has reserves of up to 25 million tons of the metal. That looks like an adequate supply for a long time to come, especially when it is borne in mind that a lot of lead is recycled.

Zinc is a somewhat different story. More than a fourth of it goes for the galvanizing of steel, a "dissipative" use that does not easily lend itself to recycling. Over-all, less than 6 percent of the country's zinc comes from old scrap. U.S. reserves increased with new discoveries during the 1950's and 1960's, but some mines that serve obsolete smelters, incapable of meeting new antipollution standards, have shut down. Despite Texas Gulf Sulphur's big discovery at Timmins, Ontario, in 1964, world reserves seem inadequate to meet demand over the next three decades. The Bureau of Mines says that barring big new discoveries, higher prices, or more recycling, other materials will increasingly have to take the place of zinc. Metal experts are sure that more zinc will be found, and note that it is

somewhat more abundant in the earth's crust than copper.

Nickel supplies seem ample for at least a century, even though worldwide usage has been growing at a relatively rapid 7 percent a year. International Nickel's underground deposits of high-grade ore in Ontario's Sudbury district are still the world's largest, but the opening up of low-grade nickel-bearing laterite ores in New Caledonia, the Philippines, Indonesia, and the Dominican Republic has greatly increased nickel reserves. U.S. reserves at current prices amount to a mere 200,000 tons, or about one year's consumption in this country. However, if the price were to rise 50 percent, domestic reserves would increase twenty-five-fold.

Scavengers and toughenners

Four other essential metals used in large quantities (more than 100,000 tons a year) in the U.S. are magnesium, titanium, manganese, and chromium. While **magnesium** ranks just behind aluminum and iron in its abundance in the earth's crust, this country extracts its entire supply from seawater. One cubic mile of the ocean contains more of the metal than has been used up to now.

Titanium, used as a metal alloy as well as for paint pigment, is also a relatively abundant element, though the rutile ore favored by industry is found only in scattered locations. A lower grade of titanium-bearing ore called ilmenite, on the other hand, is virtually limitless in the U.S. and elsewhere. The chief limitation on consumption could turn out to be the supply of energy; titanium production requires about twice as much energy per ton as aluminum.

The U.S. has sizable resources of low-grade **manganese,** but industry has long chosen to import the metal. Close to irreplaceable in steelmaking, manganese acts as a "scavenger"; it combines with and removes the sulphur that contaminates iron. Most U.S. manganese comes from Brazil and Gabon, though the biggest reserves are in South Africa and the Soviet Union. The supply looks adequate for at least a century.

Chromium is essential for making corrosion-resistant and stainless steels. Indeed, it is possible to make stainless without nickel, but not without chromium. Despite chromium's critical importance, U.S. mines have not supplied a ton of it since 1961; our low-grade ores cannot compete with imports. Fortunately, world reserves are large. Even the Club of Rome study sees nothing to worry about for at least ninety-five years. But these reserves are of varying grades, and this fact is currently causing the U.S. some embarrassment. The biggest reserves of "metallurgical-grade" ore are in Rhodesia, and Congress has defied United Nations sanctions by authorizing continued importation of the ore. A lower "chemical-grade" ore, used in pigments and the chemical industry, is found in many foreign lands, but industry shuns it for making stainless steel because of the high costs involved in utilizing it. If new technology lowered these costs, the whole picture would change.

Besides chromium, industry depends on a whole family of other specialty metals that give desired properties to steel. Four important steel "vitamins," all used in modest but growing amounts, are molybdenum, vanadium, cobalt, and columbium. World reserves of **molybdenum,** which imparts strength and corrosion resistance, are considered adequate through at least the end of this century. Half of these reserves are in the U.S., which exports the metal. In contrast, the U.S. has few high-grade deposits of **vanadium,** which among other things increases the strength of structural steel. But vanadium is actually more abundant in the earth's crust than copper, and if necessary the U.S. could rely on low-grade domestic supplies.

This may never be the case with **cobalt,** a rare metal seldom found in this country. Cobalt is essential for electromagnets, and it is also used in heat-resistant turbine blades as well as in paints and ceramics; the world's biggest source is Zaïre, where the metal is a byproduct of copper mining. If no new sources are developed, cobalt could become scarce before the end of this century. But chances are good that the new laterite nickel mines, where cobalt is also present, will be able to make up any deficiency.

Columbium, also called niobium, is used in turbine blades and rocket nozzles as well as other heat-resistant applications. If the electric-utility industry ever switches to the compact cryogenic generating plants and underground transmission systems now being developed, demand for the metal could soar. The U.S. imports all its columbium—Brazil is the largest source—but a doubling of price could make this country self-sufficient because low-grade deposits do exist here. World reserves are adequate well beyond the year 2000.

What platinum does for air pollution

Unless there are some pleasant surprises, the world may become pinched for six other metals during the next hundred years. According to the Bureau of Mines, worldwide **gold** reserves will be adequate to the end of the century only if total demand is at the low end of its range of forecasts. World **platinum** reserves, at first glance, seem more than sufficient to meet prospective demand for that period. But this prognosis excludes two developments that could greatly expand usage. One is the development of economically competitive fuel cells for making electricity, and the other is the use of platinum to reduce air pollution in automobile exhausts. Ford Motor Co. already has signed up with South Africa for a large amount of platinum to assure a supply if it is needed for emission-control systems. For the same reason, Chrysler Corp. has been in discussions with South Africa and the Soviet Union.

The situation in **silver** looks more worrisome. World reserves may prove "seriously deficient" during the next three decades, the Bureau of Mines warns. Aside from its uses in silverware, jewelry, and coinage, silver is increasingly used by the electronics industry and in photography. At the moment there is no satisfactory substitute for silver in photographic film and papers; this use accounts for a fourth of U.S. silver consumption. Some of the photographic silver is recycled in developing laboratories, but more than half is dissipated to photo albums and wallets across the land. Domestic mines supply only a fourth of U.S. needs.

At the moment, the market is glutted with **mercury.** Since the mid-1960's, the price of a seventy-six-pound flask in New

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Metals: Warning Signals *continued*

York has fallen from $725 to as low as $150. One reason is that the chlorine-making industry, whose use of mercury in its production process has accounted for a fourth of U.S. consumption, has been switching away from it because of the controversy over water pollution and the poisoning of marine life.

But the fact remains that mercury is one of the rarest of the commonly used base metals, and it is irreplaceable in many uses. No other metal combines its high specific gravity, its electrical conductivity, and its ability to flow at ordinary temperatures. Sometime around the turn of the century, world demand might very well get ahead of supply. Mercury, says M.I.T. geologist Patrick Hurley, "is really scarce and there is no way to expand reserves of this metal. When it's gone it's gone."

Tin may also become troublesome. Present world reserves, mainly in Thailand, Malaysia, Indonesia, and Bolivia, could turn out to be inadequate before the year 2000. Substitution could stretch the supply, of course. Over a third of the metal is used in making tin-plated steel, mainly for cans, and the U.S. can industry has begun marketing a tin-free container for beverages. But there is no satisfactory substitute for tin in making solder, and tin is essential in making bronze and pewter. Hardly any has been found in the U.S.

World reserves of **tungsten,** another vital metal, have increased over the past two decades, but only modestly. Used in steel armor plate since World War I, tungsten is also the most heat-resistant of all metals. Only 10 percent of tungsten is used for light-bulb filaments in the U.S. By far the major use is for the cutting edges of machine tools and drill bits. Titanium carbide might substitute for tungsten in the event of future scarcity. But in some tools, at least, there would be a loss of machining speed and, as a result, lower productivity. Recently, about half of this country's tungsten has come from domestic sources, but U.S. reserves are not large. World reserves, three-quarters of which are in mainland China, also seem far too low to meet anticipated global demand, and the U.S. Government foresees a possible "tight supply situation" as early as the mid-1980's.

What do you do with all that rock?

The world's exploitable metal resources may eventually turn out to be far larger than any current figures on reserves suggest. This is an especially strong possibility for metals to which the Lasky theory—i.e., greater abundance as lower-grade ores are tapped—may apply. These include lead, zinc, nickel, columbium, and titanium as well as copper. But there are ominous possibilities of environmental devastation in moving more and more rock to produce a given amount of metal. David B. Brooks, a mineral economist in Canada's Department of Energy, Mines and Resources, considers the potential pollution of air and water and the general disturbance of the landscape "frightening."

Unless environmental damage is minimized, therefore, public opinion may bar the way to a lot of metal. Even with today's grades of ore, such as the 0.7 percent copper ore mined in the American Southwest, the environmental impact can be enormous. The most conspicuous effect is the creation of a huge man-made canyon that keeps getting wider and deeper as the years go by. The volume of rock blasted and moved is staggering. In an older mine, it is not uncommon to remove more than two and a half tons of overburden for each ton of ore. All together, the mine may move more than 500 pounds of rock in order to wind up with one pound of copper.

Much of the waste material winds up in huge overburden dumps around the fringes of these man-made canyons. About 99 percent of the rest winds up as tailings after the metal-bearing particles are removed in the concentration process that precedes smelting. The water used in this process can pollute streams. The tailing dumps themselves can be huge eyesores, and wind can blow their powdery material about. Nor does the potential damage stop there. Like nickel, zinc, lead, and some other metals, copper occurs as a sulphide

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compound, and this means that large amounts of sulphur oxides can be emitted into the air by smelters.

The important news, however, is that much of this environmental damage can be mitigated at an acceptable cost. A visit to Kennecott Copper Corp.'s Bingham Canyon mine in Utah, biggest in North America, and to its nearby concentrators, smelter, and refinery, illustrates some of the possibilities. Many environmentalists would be surprised to find the pit itself far from ugly. Its concentric tiers, with electric ore trains moving to and fro, suggest a mammoth version of an ancient Greek amphitheatre carved into a hillside. The overburden dumps are ugly, but could someday be regraded and planted. The pit itself could possibly become a recreational lake.

At the concentrators fifteen miles away, Kennecott takes considerable care with tailings. These are carried in slurry form to a 5,300-acre pond that is sprayed, when dust threatens to blow, by aircraft carrying a polymer or other chemicals that coat the powdery material. In an experimental program, the Bureau of Mines has been making bricks from the tailings, and the Utah highway department plans to take some of the material for fill. No eyesore, the tailings pond looks like a drained extension of nearby Great Salt Lake.

The real environmental challenge is posed by the copper smelter. Kennecott says that it already removes 60 percent of the sulphur dioxide. But it claims not to know at this time how it can modify its smelter, at a bearable cost, to achieve the further reduction that the federal Environmental Protection Agency has proposed. The copper industry has warned that it may cost $600 million to comply with EPA criteria, which it calls excessively strict. If all else fails, says President Frank R. Milliken, Kennecott might have to ship its copper concentrates to smelters outside the U.S. Some copper companies are shifting to new processes, such as "flash-smelting," and experimenting with processes in which the metal is chemically leached from the ore. The change-over to new technologies, assuming they work, will not be cheap.

Someday, leaching might eliminate both the mine and the smelter, and thereby remove most of the objections of environmentalists. Copper men envision so-called *in situ* extraction in which the metal-bearing rock would never leave the ground. Instead, treated water would be pumped in, and the metal would be pumped out in a chemical solution from which it could be separated electrolytically. Some industry spokesmen caution, however, that large-scale mining *in situ* is a long way off.

Stepping up the ore hunt

Today's geologists have an armamentarium of techniques and ore-sensing devices unknown a generation ago. Many of the devices, of course, are refinements of the airborne magnetometers, gravity meters, and spectroscopic equipment that have been in use for some time. One of the most important innovations is induced polarization, a method of passing an electrical current through the ground to detect sulphides of various metals. Where previous methods detected only sulphides in high concentrations, induced polarization has helped geologists locate lower concentrations, including the new copper deposits in British Columbia.

Despite all the improved techniques, there is some evidence that metallic ores are becoming harder to find, at least in this country. Ian MacGregor, chairman of American Metal Climax, says there are three times as many people looking for metal in the western U.S. as there were in 1955. He adds, however, that the estimated value of all the minerals discovered has been running only about 50 percent greater than in the late 1950's.

In many parts of the world, however, the new theory of continental drift may make some metals easier to find in the years to come. During the last decade geology has been revolutionized by the notion, increasingly borne out by evidence, that the earth's crust is composed of large plates slowly moving about. These plates collide to produce

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mountains like the Himalayas or slide under one another to form the deep ocean trenches that occur around the rim of the Pacific and elsewhere.

The whole theory is too new to be credited with any specific ore discoveries. But Philip W. Guild of the U.S. Geological Survey, who has studied the relationship of metallic deposits to continental drift, sees great significance in the fact that the copper deposits found off Southeast Asia in recent years happen to be near so-called "consuming" areas, where thin oceanic plates are slowly sliding beneath the plates on which Indonesia, the Philippines, and other island chains rest. Nobody knows exactly how these copper deposits were formed. One possibility, Guild believes, is that as the lower plate plunged deep beneath the upper one, part of it melted. The heated rock, being lighter in weight, rose through the upper plate carrying metallic compounds with it. While porphyry copper seems to fit most neatly into the new theory, other studies show that the continental-drift theory may also help in finding other metals, including tin and tungsten.

Billions worth of mud

A different kind of payoff is possible in "accreting" zones such as the Red Sea, where continental plates are slowly moving apart. There, new material has been extruded from below to fill the gap between plates, creating sediments rich in iron, zinc, copper, lead, silver, and gold. Studies of the feasibility of dredging these sediments are being carried out by West Germany's Preussag A.G. Not counting iron, the metals under the Red Sea may be worth $2.5 billion.

Continental drift may also account for the deposit of manganese nodules on the deep floors of the oceans over millions of years. Commercial mining of these deposits, which has aroused a lot of excitement for a decade, may become a reality before long. At two U.S. companies, Tenneco and Kennecott, officials say they expect to be selling metal made from the nodules by the end of the decade. The interest lies not so much in the manganese that is the most prominent metal in the potato-sized nodules, but in the nickel and copper that are also present, along with cobalt and up to thirty other metals.

"Contrary to much of the romantic reporting of the past," says John E. Flipse, president of the Tenneco subsidiary that has been studying the nodules for a decade, "the deep ocean floor is not uniformly coated with untold riches." But it does possess, Flipse says, "specific deposits of high-quality ores in realistic concentrations." The Tenneco subsidiary, Deepsea Ventures, has developed a method of collecting the nodules from depths as great as 20,000 feet, as well as a process for separating the various metals. Both Tenneco and Kennecott expect to mine beneath the Pacific Ocean off the West Coast.

The biggest problem may be international law rather than technology or economics; there is no clear-cut international or domestic body of law to protect a particular company's claim in international waters. The United Nations has scheduled a conference next year to take up the problem. The companies say they may go ahead with their deep-sea mining plans if the U.N. fails to come up with a satisfactory solution—provided the U.S. Congress will enact some sort of interim protection for them. Some metal companies are pointedly staying out of deep-ocean mining until they see firmer financial evidence that it can compete with land mining.

Incentives for using scrap metal

There is another metal "mine" all around us, of course: the myriad used objects that we dump somewhere instead of recycling. The Scandinavian countries, Britain, West Germany, and Japan all melt down a larger portion of their old metal than the U.S. does. For all the attention it receives, the ecology movement has done little to improve our performance. All the aluminum beer and soft-drink cans brought into voluntary recycling centers, for example, represent about a tenth of current production.

Economic incentives, rather than ecological zeal, are probably the way to

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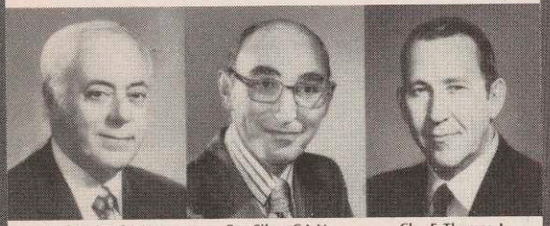

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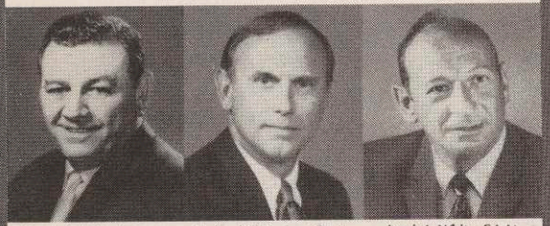

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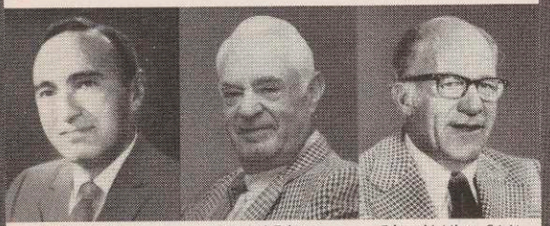

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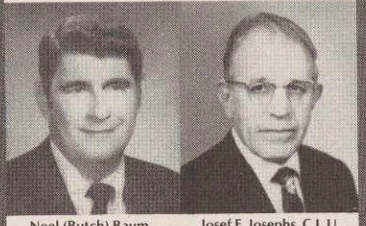

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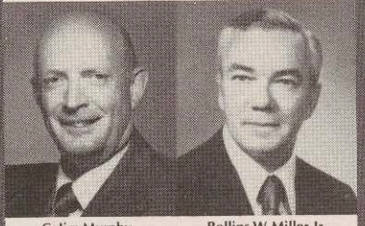

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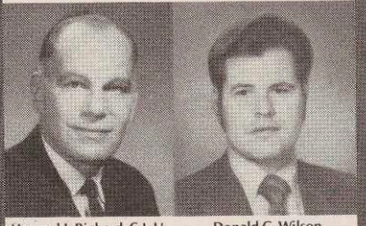

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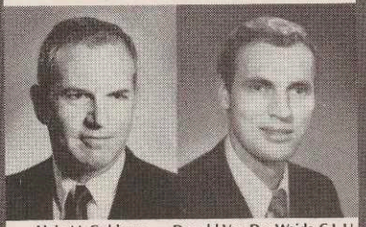

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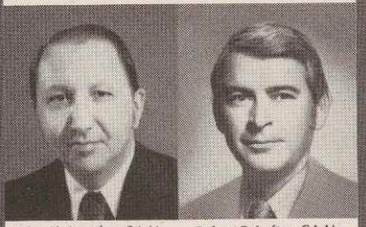

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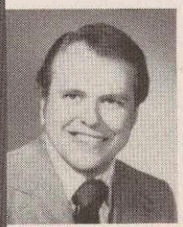

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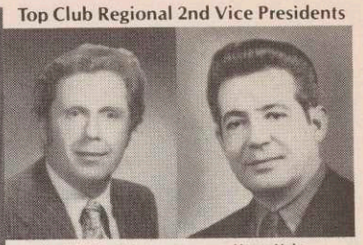

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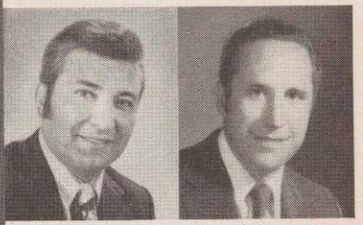

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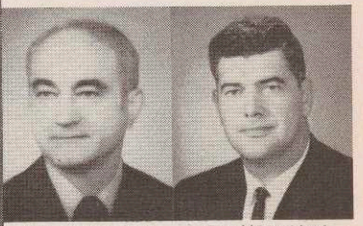

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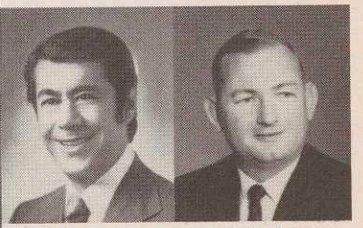

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Metals: Warning Signals *continued*

get more used metal back into the system. For such items as beverage containers, a mandatory deposit system would bring back a lot more cans, or, alternatively, induce the public to use returnable bottles that need only to be cleaned and refilled. But the biggest hope may lie in revising the unfair freight rates and tax laws that put recycled metal at a disadvantage in competing with virgin metal made from ore. For example, virgin metal benefits from depletion allowances of 15 or 22 percent given to the mining industry. M.J. Mighdoll, executive vice president of the National Association of Secondary Materials Industries, which represents scrap processors and users, does not advocate repeal of these allowances. Instead, he has proposed an equivalent tax credit for scrap processors, which would be passed on to customers in the form of lower prices. "If economic impediments were changed," says Mighdoll, "it could turn things around."

Some authorities believe a big increase in recycling is merely a question of time. The Club of Rome study contains an "alternative" computer model under which world industry would become sustainable for the long-range future provided certain criteria were met. These include a curb on pollution, stabilization of population, and recycling programs that would reduce by three-quarters the virgin resources needed per unit of industrial output. No country today comes near meeting the recycling criterion. But Carl Rampacek, who heads research on recycling processes in the Bureau of Mines, believes it "quite likely" that the U.S. would be able to recycle three-quarters of its metal in another ten or fifteen years if necessary. One of the biggest metal mines, he notes, is municipal waste.

But long before cities get around to installing mechanized systems for recovering metal from trash, a better job could be done on such easily recyclable objects as automobiles. Shredders that chew up old cars and magnetically separate out steel scraps have proliferated around the U.S. since the mid-1960's.

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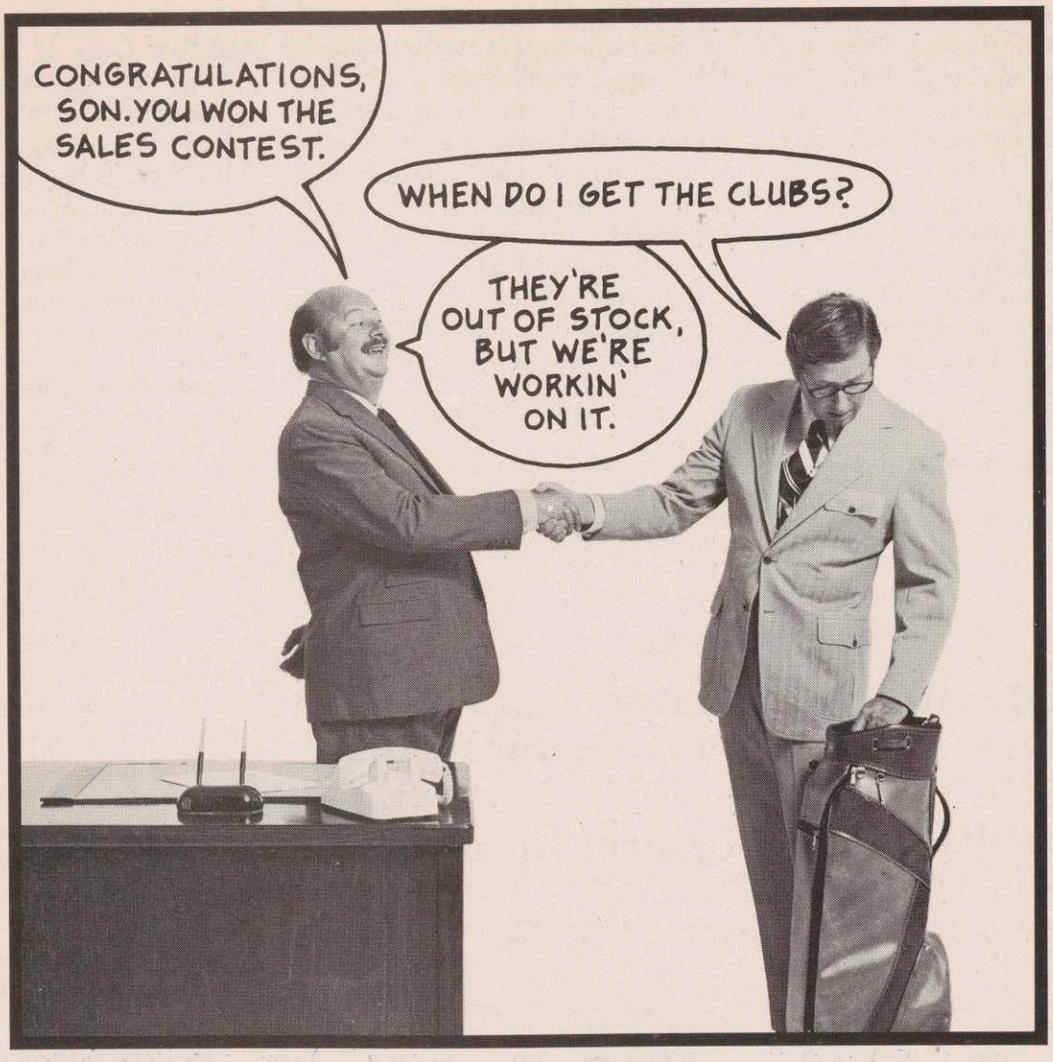

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Now scrap processors are showing interest in a low-cost system, under development by the Bureau of Mines, for mechanically separating other metals from the nonferrous material rejected by the shredders.

It seems almost utopian to talk of an entire world economy organized to recycle at least three-fourths of its metal. To some geologists who worry about impending shortages of metallic ore, it also sounds visionary to talk of achieving high living standards in underdeveloped countries that now use relatively little metal. Even with a lot of recycling, says Preston Cloud of the University of California at Santa Barbara, it would take a huge "standing stock" of metal in circulation to bring the entire world up to, say, a Western European living standard.

According to Cloud's calculations, the world population of seven billion foreseen by around the year 2000 would need a pool of 60 billion tons of steel, or 140 times as much as the entire globe now produces in a year. Cloud sees no great difficulty in finding enough iron in the ground to create that pool, but he finds the prospects dimmer with copper, lead, zinc, and tin. For these, he says, the "standing stock" would have to be far larger than total world reserves at the present time—fifteen times as large in the case of tin.

"Running without a governor"

But there are more optimistic voices, too. Vincent E. McKelvey, director of the U.S. Geological Survey, believes that mankind can meet its mineral needs for "millennia" to come. McKelvey concedes that an eventual cutback in industrial production might prove necessary if mankind fails to develop an abundant new source of energy. But he also believes there are vast mineral deposits that remain undiscovered, as well as huge quantities of "paramarginal" and submarginal" resources that could also be tapped if necessary.

The optimists' strongest argument, of course, is that enough metal has always turned up until now, at prices that usually have risen no faster than prices in general. "We have never run out of any mineral, though some have become a little scarcer," says James Boyd, executive director of the National Commission on Materials Policy. Established by a 1970 act of Congress, the commission is studying the nation's entire materials needs in the years ahead, and next June will produce recommendations on how the country can meet them.

For the rest of this century, it is fairly clear, the world will somehow get most of the metals it needs. But this is scant comfort to those who take a longer view. Even if energy imposes no constraint, worldwide metal consumption cannot go on increasing for very many centuries at its present rate. Joseph Fisher, president of Resources for the Future, Inc., a nonprofit research organization based in Washington, refuses to count himself among the alarmists. But, he adds, "there's a feeling, which I share, that the thing may be running without a governor." END