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OBSERVATIONS ON ECOLOGY AND NATIONAL SECURITY

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Prepared for:

DEFENSE ADVANCE RESEARCH PROJECTS AGENCY
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ABSTRACT

Indications of an impending systemic ecological crisis--such as world population growth, mounting demands on finite mineral resources, and pollution of the biosphere--have led to increased concern with the ecological determinants of international economic affairs. This report reveals that there is a serious mismatch between the scope and complexity of these issues and U.S. practice to perform ~~an ad hoc~~ planning response options in connection with crisis situations. The study concludes that national security policy research must address ecological issues to provide proper consideration of the impact of ecological factors on security planning and policy development. The formulation of courses of action including technological measures is discussed.

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The views and conclusions contained in this report are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Defense Advanced Research Projects Agency of the U.S. Government

CONTRACTUAL TASKS

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FOREWORD

This report relating to an issue area in international economics and national security is one in the series of national security policy research support papers specified in Phase I, B, Task 2 of ARPA Project 2625. The cutoff date for information for inclusion in the drafts of this study was 15 September 1973. The draft report was submitted to ARPA at that time.

The author is John Ford, Senior Policy Analyst, Strategic Studies Center.

Richard B. Foster
Director
Strategic Studies
Center

CONTENTS

ABSTRACT.	ii
FOREWORD.	iii
LIST OF FIGURES	v
A. PROBLEM.	1
B. SUMMARY AND RECOMMENDATIONS.	1
C. BACKGROUND	5
D. ECOLOGICAL PRESSURES FOR INTERNATIONAL ECONOMIC CHANGE	17
1. Introduction.	17
2. Energy.	18
3. Resources	24
4. Population.	39
5. Organizational Issues	52
E. NATIONAL SECURITY IMPLICATIONS OF ECOLOGICAL PRESSURES	60
1. Introduction.	60
2. Implications for U.S. Defense Planning.	62
3. Implications for U.S. Global Interests and Interactions With LDCs.	65
4. Implications of U.S./USSR Asymmetries in Dealing With Ecological Pressures	66
REFERENCES.	71

List of Figures

1.	Time Perspective	25
2.	Mineral Reserve Lifetimes.	29
3.	Distribution of Recoverable Mineral Resources.	31
4.	Distribution of Recoverable Mineral Resources.	32
5.	Distribution of Recoverable Mineral Resources.	33
6.	Distribution of Mineral Resource Producers and Consumers . . .	35
7.	The Shifts in U.S. Resource Imports.	36
8.	Per-Capita Consumption of New Materials (1970)	36
9.	World Population Growth.	45
10.	Projected Population of Developed and Underdeveloped Nations in the Year 2050	45
11.	World Population Growth.	47
12.	World Population Growth in Developed and Underdeveloped Regions, 1910-2050	48
13.	Structure of the Complex Relationships of the Science of Science	69

ECOLOGY AND NATIONAL SECURITY

A. Problem

- To identify ecologically determined pressures for change in international economic relations and their impacts on patterns of trade, monetary stability and economic growth rates;
- To identify those aspects of national security policies affected by ecology-influenced international economic policies and trends; and
- To make preliminary analyses of ecology as a new conceptual means for increasing the effectiveness of international economic policies in the promotion of national security policies.

B. Summary and Recommendations

The discipline of ecology began to emerge a century ago when Ernst Haeckel coined the term from the Greek words oikonos (house) and logos (knowledge) to denote the study of the structure and function of nature. Of more recent vintage is the promulgation of a theory in some quarters that the basic problems confronting twentieth-century man are of an ecological origin. But the thinking and behavior of society-in-the-large remained essentially uninfluenced by ecological principles until "the era of interdependence" came crashing through the world's consciousness with the OPEC oil embargo of 1973.

Since that time there has been a pronounced increase in the world's concern with the ecological determinants of international economic affairs and hence of the national security of states and of mankind's habitat in general. Some facets of this concern are obvious: world population growth, the unequal distribution and rapid depletion of energy and mineral resources, and pollution disturbances of ecosystemic balances. Others are less obvious: the inexorableness of certain national processes,

and the importance and rigidity of world views in matters ecological. The political and security implications of the former derive from the intentional practice of what is tantamount to political ecology for securing political and economic objectives. The latter facets, with ultimately far more significant implications for national security, operate as determinants of action.

This study identified several ecological determinants which exert major pressures upon international economic relations, patterns of trade, monetary stability and economic growth. It projects that they will become far more compelling in the future of our increasingly complex world as dependence grows upon the finite stocks of energy, mineral and other resources situate in foreign locales with their burgeoning, developing and aspiring populations.

The international economic policies and trends consequent from ecological pressures could ultimately affect adversely the whole spectrum of national security policies ranging from those concerned with the operational capabilities of current and planned force structures to those involving the technico-economic infrastructure of society itself. The probability that this contingency will materialize will increase if we continue to ignore or to slight the "ecological imperative" in deliberations of the counsels of defense.

This task also revealed ecology to be an excellent perspective from which to view the promotion of comprehensive, global national security policies by means of international economic policies. Preliminary analyses using that perspective suggest that there is a serious mismatch between the complexity and global dimensions of ecosystemic issues when they are compared with the processes and structures involved in the formulation and implementation of economic and national security policies. This mismatch must be lessened if we are not to be overcome by ecosystemic crises and their consequences.

This study leads us to conclude, therefore, that if the foregoing contingency is to be avoided, bureaucratic inertia must be overcome and new approaches evolved by national security policy research organs for (1) recognizing impending ecosystemic crises, (2) performing "ad hoc" planning response options to accomplish policy objectives, and (3) formulating and implementing ecologically sound, global, economic strategies supportive of national security policies.

The following list of propositions prompted by the ecological perspective deserves attention when political, institutional responses in our increasingly complex world to future crises of ecological origin are under consideration:

- World resources that make up our biosphere, i.e., the thin mantle of sunlight, air, water, soil and minerals that sustain human, plant, and animal life, are finite; yet they are exposed to mounting, seemingly unlimited demands by a steadily growing number of consumers. If the increase of the demands continues at present rates, the end of some resources, such as fossil fuels and minerals, can be predicted in a not too distant future.
- Attrition of resources through normal or excessive use is being further accelerated through pollution. This occurs through the infusion of extraneous, often toxic, bodies into the biosphere, which change the complexion, corrupt the quality, and reduce the utility of nonrenewable as well as renewable resources on which life depends.
- The biosphere forms a single balanced global system of interdependent and interacting elements. Hence significant changes in the quality or quantity of any of these elements are bound to upset the total balance.
- Human relations with nature are still largely in a state of anarchy. In the absence of international agreements, resources remain subject to national sovereignty; in the absence of national legislation, they remain under the control of those claiming ownership or physical access. The result is that resources essential to all or to many may be monopolized, manipulated, and even abused by a few. On the other hand, resources such as the oceans or the airspace above them, which are under the sovereignty or control of none, may be tampered with by all.

- Attrition and pollution are substantially the results of direct and arbitrary interference by man with the environment in an effort to satisfy his ever-increasing needs. Management of the crisis becomes, therefore, a matter of social strategy, and ultimately of political control.

The foregoing propositions run counter to the ethos of expansion and to its technology, which tends to stress the earth's carrying capacity and thereby to perturb its equilibrium-seeking processes. Large parts of the world's ecosystem have probably already undergone or are in danger of undergoing irreversible changes.

Ecologically speaking, the central question for defense research planners is: How can mankind approach a kind of dynamic equilibrium with its global environment so as to avert destructive imbalances? Ultimately responses to this question may involve the entire globe, the distant future, and perhaps metaphysics as well as science and technology.

More science and more technology may not be enough to get us out of the present ecologic crises. We may have to find philosophies and, perhaps, a new religion or rethink our old ones to avert the possibility of a complete and apocalyptic end of civilization. Defense research planners should see to it that decisions in this matter are based on a better understanding of man's relationship to the world of nature and to the functions of technology.

Facilitation of the search for the needed understanding is the objective of this report's major recommendation. At the present time we have no system in our vast stable of available or planned sophisticated and complex devices with the capability to perform "ad hoc" planning response options to accomplish stated U.S. objectives in an increasingly complex and interdependent world with its almost infinite number and variety of potential ecosystemic crisis situations. Consequently, our command and control system dealing with ecosystemic crises and their international economic and national security consequences is crippled for the

foreseeable future because of our failure to provide such a capability. This failure is due in large measure to the mismatch between defense concepts and organizations evolved in response to past challenges to security and the spectre of those qualitatively new and imminent threats of the type to which U Thant alluded five years ago:

This is the first time in its history that mankind faces not merely a threat, but an actual worldwide crisis involving all living creatures, all vegetable life, the entire system in which we live, and all nations large or small, advanced or developing. It is a crisis which concerns literally everyone, and involves, directly or indirectly, almost everything. It underlines, as no other phenomenon can, the fact that ours is the first global civilization and that, as such, it can make global mistakes which can wreck not just one nation or society, but the very earth itself.*

This study leads us to conclude that, if the foregoing contingency is to be avoided, national security policy research must be expanded with utmost dispatch to prepare conceptually and organizationally for threats in many guises to the stability of mankind's ecosystem, that complex system of interdependencies whose skeins bind species to species in the web of life and which comprise the dynamic bonds which relate the animate and inanimate realms so inextricably in the process of life.

C. Background

Pollution, resource shortages, crowding--separately or in concert--have plagued different localities at different periods since time immemorial. It seems that the individual items in the litany of mankind's environmental problems which were traditionally the province of international economics are now being related to the common thematic issue of ecology and, thence, to one another in an unprecedentedly complex

* For serially numbered source references, see the Appendix.

interactive pattern of global dimensions. As the old problems are raised from economic problems to the status of "ecological issues" they take on a qualitatively different character. In this process the ecological perspective transforms man's notions about himself, his fellow human beings, the other creatures of the world--about the whole planetary stage upon which the cosmic play is being enacted.

Because it is such a potentially potent transformational influence, ecology per se should be treated as a meta-issue. Subtle but epochal implications of the ecological perspective for both international economics and national security would be missed were the "issues" to be explored only in the usual analytically reductionist manner. By first exploring ecology as a synthesizing perspective, the subsequent literature review relevant to a few selected "issues" should assume an integrated cast more conducive to the perception not only of systemic implications but also of alternative organizational and functional strategies as well.

This is as it should be. Ecology started as a rather metaphysical concept. It then moved to the woods, so to speak as its empirical content increased, and now--laden with systems science, computer technology, and the survival-centered concerns of an anxious humankind--it is returning once again to a realm more philosophical than experimental.

The distinguished scientist, Ernst Haeckel (1834-1919), coined "ecology" in 1874 from the Greek words oikonos (house) and logos (knowledge) to denote the study of the structure and function of nature.² Along with Friedrich Nietzsche (1844-1900), Haeckel led the evolutionary naturalism school of thought in Germany. Haeckel devoted his life to defending Darwin's theory of biological evolution and to studying the philosophical implications of cosmic evolution on the nature of man and his proper place in the universe. He held that the "Law of Substance," as a result of the eternal persistence of matter and force, called for a naturalistic interpretation grounded in what scientists today call the First and Second Law of Thermodynamics:

- The Law of the Conservation of Matter
- The Law of the Conservation of Energy

For Haeckel, the two cosmic laws were fundamentally one. Their unity was expressed as the "law of persistence of matter and force." He referred to it as the fundamental cosmic "Law of Substance" which supported universal unity, continuity, and causality. By the nineteenth century the evolutionary perspective had many proponents: Besides Nietzsche and Haeckel there was Lamarck, Spencer, Wallace, Fiske, Bergson, Sellars, Smuts and Morgan. What they shared was an awareness of the general trend in evolution from the simpler to the more complex.³ This evolutionary theory* and naturalistic interpretations thereof influenced Marx, Engels, and Lenin and a current generation of Soviet philosopher-scientists. Pierre Teilhard De Chardin, also, was of this genre but differed on the naturalistic interpretation of evolutionary processes.

The philosophical implications of evolutionary theory find expression in the Soviet Union of today in theories about social evolution as a consequence of the negentropic effect of social development purposefully guided via the application of, for example, the science of cybernetics. The evolutionary-theoretical framework for ecology is rarely discussed in U.S. ecology texts except at the most elementary level. Among the writer's acquaintances are several ecologists predilected by training to view such a framework with suspicion. However, since about 1955, there has been some evidence of a reversal of this historical tendency. A spin-off from classical ecology is taking place of a growing group of evolutionary ecologists along with the so-called systems analysts.

The philosophical origins of ecology are important because of their relevancy to contemporary strategic issues. According to one widely

* The theory of biological evolution had been anticipated in pre-Socratic thought by Anaximander, Heraclitus, and Empedocles. But Aristotelian biology, holding to the fixity of species, prevented the development of an evolutionary perspective. This anti-evolutionary orientation dominated scientific thought until the Renaissance.

discussed perception of the Soviets' strategic dream, they are aspiring to "the design and implementation of a system of social organization that will be the optimal variant in the process of social system evolution."⁴ The evolutionary ecology notions of Haeckel now laced with cybernetics and its allied sciences find expression in the "theory of development that provides the theoretical infrastructure for that aspiration."⁵

Following its early preoccupation with the philosophy of evolutionary naturalism, ecology entered a period of historical development similar to that of many other branches of science. During the late 1800s and early 1900s it became primarily a descriptive field. Ecologists sought patterns in the appearance and structure of organisms from different environments; these patterns--often named after their discoverers--became the biogeographic "rules" of ecology. These ecologists developed techniques for quantitatively describing the structure and taxonomic composition of communities of organisms. They erected comprehensive and increasingly detailed systems for the naming and classification of these communities. Armed with these tools they resolved patterns of geographical variation in community structure and composition into discrete, named units: life zones, associations and biomes. They recognized patterns of temporal change in community characteristics and resolved these patterns into seres, seral stages, and various types of climaxes. Throughout the field they built an elaborate and imposing terminology. At the height of this phase they earned for ecology the reputation of being a field that elaborated on the obvious, that engaged in "superdescription," and that was so preoccupied with terminology that a spade was called a "geotome."

Modern ecology has evolved into the study primarily of ecological systems' function and of the reciprocal interrelationships between the structure and composition of systems and their patterns of function. This transition, prompted by the need for solutions of major problems of environmental quality and productivity, has led to several new fields of specialization relevant to the strategic calculus of the future such as

population ecology, community ecology, and ecosystem ecology.*

The currently favored ecosystem approach was forced, according to Cox,⁶ by the environmental crisis. With its increased problem orientation, aspects of ecological study have been drawn together that were formerly distinguished as "theoretical" and "applied" because protection of the world environment requires an understanding of the principles governing function of ecological systems at all levels of organization. In this sense, the "theoretical" and "applied" aspects of ecology are identical.

Attempts at computer modeling of ecosystems have not been very successful. Only a few models have been developed to a point where they provide any useful predictive power of actual ecosystem function. One was developed for nutrient budgets of moist tropical forests in Panama in connection with studies in preparation for the possible construction of a sea-level canal by nuclear excavation.^{7,8} Perhaps the ecosystem models with the greatest utility are those which study ecological communities not in terms of artificial classifications and structures, but via the cycling of energy and materials in what are called food webs and trophic levels.**

For any biological system to persist, there has to be a basic trophic level which traps solar energy and synthesizes food. This function is universally performed by green plants, and this first level is called the producer level. There are two more or less clear series of trophic levels, one (the herbivore chain) dealing with live plant materials as a base and containing plants, herbivores (which eat green plants), predators

* An ecosystem may be defined as an environmental unity consisting of various biotic and abiotic components which are related through interchanges of chemical nutrients and energy. Or, stated more simply, it consists of the community of organisms together with its physical habitat.

** Food webs are the pathways along which energy and nutrients move, and trophic levels are transfer stations along the way at which nutrients are first broken down and used or reassembled into new tissue.

(which eat other animals, mainly herbivores), and parasites; the other using mainly dead materials as a base (the detritus or decomposer food chain).

In addition to extensive research on the flow of energy and materials relative to the food web and trophic levels, the related issues of populations, succession of communities, community interactions, the interrelated phenomena of complexity and stability and the ubiquitous influence of man all in the ecosystemic context have been extensively reported.⁹⁻²⁴

From these studies certain important features of ecological systems can be summarized as follows:

- First, limits are ubiquitous. Not only are there limits to resources, there are limits to the rate at which the environment can receive wastes and return them to the system in usable form, and to its capacity for storing them in innocuous form.
- Second, ecosystems are made up of interacting and interdependent components, and ecosystems are open and linked to each other. As a result, events at one place in the environment are bound to have repercussions in other places and at other times. Because of the interconnectedness and complexity of the environment, some of the consequences are bound to be unpredictable.
- Third, actions which are massive enough, drastic enough, or simply of the right sort will cause environmental changes which are irreversible. This is partly because the genetic material of extinct species cannot be reconstituted. Furthermore, some changes are ecologically irreversible. If a complex climax community is removed, together with important physical characteristics of its environment, it may not be able to redevelop because the conditions are no longer appropriate for a reenactment of the successional stages.
- Fourth, simple communities tend to be unstable and almost without exception man's activities result in simplification. Further, when man's simple ecosystems develop instability, the actions taken (for example, pest control) tend to be inherently destabilizing in the long run. In particular, in artificial simple systems the instability is enhanced because the organisms do not have a shared evolutionary past.

It is easy to see how the injection into strategic economic and security thinking of considerations of features such as these could have disturbing even if salutary effects, as noted by John McHale:

. . . the return to evolutionary thinking and its expression in the ecological attitude . . . may, paradoxically, be as disruptive of traditional American attitudes and values as physical actions have been in the environment. Though seemingly innocuous in its theoretical origins, ecology generates a radical view of human society, which may prove to be more "positively" revolutionary, in its widest implications than any of the socio-political ideologies which have previously challenged our traditional economic and institutional arrangements.²⁵

But such a conceptual and value shift--from the local study of plants, wildlife, and their surroundings to one which suggests responsibility for the viable maintenance of the planet as life space--is in accord with the kinds of changes in human consciousness and conceptuality that already are underway. So, whatever metadiscipline an "applied ecology" might evolve into, it must also move toward a preventive and regulatory concern with the optimal viability of the planetary ecology to which many commentators have addressed attention. The danger here may lie in the possibility that the need for major reforms is obscured by the attention directed at minor reform. Nevertheless, the broad response to the concerns of ecologists gives some reason to hope that the major reforms necessary, if human civilization is to survive, may take place in time and in sufficient scope. A reorganization of human activity equivalent in scale to that caused by the industrial revolution is what is called for, according to A. Nicholson. "We must initiate an 'environmental revolution' . . ."²⁶

Contemporary efforts to rekindle the philosophical spark with which ecology began are based upon certain assumptions as to the adaptability of human character and the flexibility of social and cultural institutions before the simultaneous convergence of ecological problems becomes overwhelming. From the evidence at hand, such assumptions are unwarranted. One reason is that the scientific world-view permeating, especially,

contemporary Western societies militates against the formulation of a sufficiently comprehensive notion of the "situation" to which adaptation would be responsive. The recent experience of Dennis Meadows et al. with disciplinarians picking apart The Limits to Growth while ignoring its perception of a metachallenge to mankind is illustrative of this proposition.²⁷

Rene Dubos shares this rampant skepticism concerning the ability of science to deal with problems of our society or to develop much further man's understanding of himself and the cosmos:

. . . . the scientific community tends to be primarily interested in problems of its own making rather than in the problems--material and emotional--that preoccupy the rest of mankind. From this point of view, there is merit in trying to imagine the future status of society because this may help in anticipating entire new classes of problems.²⁸

He goes on to project the future status of society on the basis of ecological principles and to forecast that, within a very few decades, we will witness a consequent reorientation of the scientific and technologic enterprise.* Dubos' skepticism is reflected in a 1972 presentation by a most prestigious group of scholars entitled A Blueprint for Survival. This group after examining the relevant information available were impressed also by "the extreme of the global situation today. For if current trends are allowed to persist," they said, "the breakdown of society and the irreversible disruption of the life-support systems on this planet, possibly by the end of the century, certainly within the lifetimes of our children, are inevitable." They went on to add that the international implementation of their Blueprint for Survival, for reversing current trends, "cannot hope to succeed unless it has previously formulated a new philosophy of life"29

* Dubos was anticipated in some ways by America's first ecologist. It was the philosophy dominant in the United States of his day to which George P. Marsh addressed his criticism in Man and Nature; or Physical Geography as Modified by Human Action (1864).

It would be most presumptuous even to attempt to develop a new philosophy in this study. At the same time we would be remiss should we fail to point out how ecological insights might contribute to the elaboration of a new paradigm. The intimate linkage in the biosphere of air, sunlight, the soil, plants, and living and dead organisms was discussed earlier. For survival, organisms must meet certain minima in the available environment. Man's survival in the ecosystem depends on the very narrow internal limits and equally narrow external limits governing his capabilities for maintaining a flow of energy and information across the boundaries between the living organism and its external environment. When these limits are exceeded or when the energy and information flows are otherwise curtailed, disintegration and decay follow inevitably in accordance with the Second Law of Thermodynamics. As physicists express this law in nontechnical terms, "In nature there is a constant tendency for order to turn into disorder." Within this theoretical framework, "entropy" is a measure of the degree of disorder. This reference to a physical law is not a digression. According to the Report of the National Goals Research Staff, it might well be the keystone of that evolving ecological philosophy prerequisite for holistic environmental policies.³⁰ Development of an understanding of entropy and living systems relationships was pioneered by Erwin Schrodinger,³¹ L. Brillouin,³² Richard Raymond,³³ Mortimer Ostow,³⁴ and Heinz von Foerster.³⁵ From the work of these and others, even an ethical principle for an ecologically wise society, "The Thermodynamic Imperative," was referenced by John Ford.³⁶

Man as a biological organism can counteract the tendency of nature to disorganize and can grow and develop. "What an organism feeds upon is negative entropy," Schrodinger has explained. "Or, to put it less paradoxically, the essential thing is freeing itself from all the entropy it cannot help producing while alive. When the organism can no longer counteract the forces of disorganization and disorder because its limits are unmet or exceeded due to internal or external reasons, death, the static stability of an organism, ensues."³⁷

The above discussion of internal metabolism is extendable, according to a sizable group of observers, to what one might call the external metabolism of organisms' surround as in, for example, a city, nation or even the planet. Georgescu-Roegen addresses this notion in a most informative while somewhat depressing study.³⁸ Impetus to an acceleration of research along such lines could result from the recent criticism leveled at the economics profession by Oskar Morgenstern. In a recent article he holds that economics today is in crisis because it lacks the concepts, methods and philosophy that would enable it to come to grips with social and political reality. In his broad attack, he tried to tell economists that their real subject matter is human beings, in conflict and cooperation with each other. He wants economists to look freshly at the economy as a living and changing organism, not as a clockwork orange whose movements are pre-determined.* National security policy research would be supported to advantage if the international economics inputs to such research were enriched by such a fresh look and by release from the hubris of science past.

At both the quantum and cosmic levels of the physical universe there loom questions that grow in complexity and whose answers become ever more elusive. "We have sought for firm ground and found none," Max Born wrote of the quantum universe. "The deeper we penetrate, the more restless becomes the universe, and the vaguer and cloudier There is no fixed place in the universe; all is rushing about and vibrating in a wild dance."³⁹ Born is echoed at the astronomical level by Wheeler, who describes the geometry of space at small distances as fluctuating between one configuration and another like a carpet of foam "made up of millions of tiny bubbles . . . continually bursting and new ones being formed."⁴⁰

And this "restless universe" and "millions of tiny bubbles" of space must be comprehended by a human organ that itself may be incomprehensible

* For an elaboration of this viewpoint, see Oskar Morgenstern, "Thirteen Critical Points in Contemporary Economic Theory: An Interpretation," Journal of Economic Literature, pp. 1163-1189 (December 1972).

for, as Sherrington described the waking brain, "It is as if the Milky Way entered upon some cosmic dance. Swiftly the head-mass becomes an enchanted loom where millions of flashing shuttles weave a dissolving pattern, always a meaningful pattern though never an abiding one."⁴¹

Perhaps Shakespeare was prescient when he wrote:

"In Nature's infinite book of secrecy
A little can I read."

And the "book" has not been opened too much by the computer, Big Science, systems analysis or travel to the moon! Our collective intelligence continues to be limited by, among other things, what are called epistemological problems. Science is based intrinsically upon a number of a priori assumptions whose acceptance is dependent on faith. Among these assumptions is the concept that nature is orderly, that through the exercise of reason this order can be discovered and employed to harness nature in the service of man even though man is a part of nature, and that what happens to nature rebounds in turn upon man. The concept of reason has, in fact, an antirational ring because dealing only with facts, not beliefs, science eschewed an integrative philosophy that united disparate phenomena. The enthronement of "facts" was self-serving, for "facts" were the only reality that science could manipulate after it had excised philosophy, morality, ethics, and all considerations of quality from its ken of observation. "Facts" were selected for scientific scrutiny only if they were amenable to observation and measurement, if they could be placed within an orderly structure.

In this scheme, knowledge became, as Norbert Wiener has wisely observed, the interpretation for man's convenience of a system that had not been designed for man's convenience. In short, science selected as "facts" those phenomena that accorded with the intuitive faith in natural order and were reducible to what Whitehead has termed the tenets of scientific materialism. In a reversal of Platonic dualism, science termed phenomena real and ideas and qualities unreal. Because of its narrow

selection of "facts," the scheme was successful because just those areas were selected which were amenable to, and appeared to require, investigation.

Unfortunately, very few pages in nature's vast book are so amenable. The "laws of nature" may be not so much properties of nature as properties of the men who describe and classify phenomena. After all, nature does not have coordinates, and many of our basic concepts are man-imposed--inspired by man's conceit and the psychological craving for order. "The truths of mathematics and the mathematical formulations of the principles of science," Eric Temple Bell observes, "are of purely human convenience."⁴²

The selection of constants and variables in the real world is becoming more arbitrary as the outlying point, the unconforming phenomenon, the unpredictable atom and human, and a disordered universe rebuff the scientists' efforts to snare them in his idealized and artificial Procrustean framework of quantification and order. And these limitations of the scientific method have become much more evident in recent years than they ever were before. Less and less is found to be datum and more and more is found to be inference, although the greater part of the inference is unconscious. Being unconscious, however, Bertrand Russell warns, does not grant validity to the inferences. There remains a "doubt as to the validity of induction," which "remains an unsolved problem of logic."⁴³

Upon hearing that the first atomic bomb had exploded successfully, Einstein is reported to have said, "Now everything is changed except the view men have of what their world is like." The major thrust of this discussion up to this juncture has been to underline the fact that the popularly discussed ecological "issues" are at best some of the pieces of the ecological jigsaw for which there is no model of nature to guide the fitting of those pieces.

As the ecologists return to the realm of philosophy from whence their field emerged with the probing of Haeckel, to wrestle with these

ponderous issues, they may regret having left the woods. But consider them we must if the global, systemic economic and international security implications of the ecological world-view are to be felt and respected even if not understood.

D. Ecological Pressures for International Economic Change

1. Introduction

The many sources surveyed as part of this study proceed in general from an attitude of obeisance toward the macro-issue of ecology to the more mundane micro-analytic analyses of particular "issues" from disciplinary viewpoints. Thus it would appear as if our world-view and its reification in the organization of societal structures is a prism for separating the "dynamics of nature" into its component spectral parts. It is inevitable, therefore, that in this report on that literature the account, too, will have to be somewhat compartmented. However, an attempt was made to process the voluminous potpourri of literature in such a way that the ecological macro-issue is retained in the discussion of isolated issues. Accordingly the issues singled out are those which are ineluctably cojoined not only with ecosystem dynamics but with the international economic facets of national security in the penultimate sense of the latter: energy, resources, and population.

There are many other discrete issues that are often discussed as separate problems. Food, the source of biological energy, is the subject of a rapidly growing literature with heavy emphasis on the international dimension of that issue.⁴⁴⁻⁵⁵ Water and land are two other related issues discussed in what is oftentimes rather narrowly defined disciplinary literature.⁵⁶⁻⁶⁸ Time and other constraints prohibit a review in depth of that literature in this vue d'ensemble.

2. Energy

The development and implementation of an ecologically sound outlook for viewing the tumult of energy-centered activity on the world-stage are essential to any strategy for managing international economic change. The traditional topics addressed in the literature do not suffice for this purpose; trade and prices, reserves and technology, exploration and investment are anachronistic in important ways when contrasted to the concepts of entropy, survival . . . evolution. Because the efficacy of our national behavior will be conditioned fundamentally by how we perceive the flow of events, the development of an appropriate world-view is of vital strategic importance in the new era of energy-centered warfare to which Armstrong recently alluded.⁶⁹ Without it, domestic military and diplomatic policymakers and their counterparts in the private sector will suffer a nightmare as the flow of energy and resources gets more constrained by whatever agency or natural event.

Current events more than academic studies underline this need. The series of crises in the Middle East, the gyrations of OPEC and their impacts on the economic and security interests of the United States change day-by-day any tendentious selection of news items would suggest that the energy-centered, tumultuous drama being enacted on the world stage contrasts sharply with those projected beforehand by well-informed and intentioned maintainers of energy account books operating with an unrealistically ordered world-view. This is one reason why no effort will be made here to penetrate the maze of numbers surrounding the ecological issue of energy in the musings of "expert" reporters.

There is a second and somewhat more emotional reason for this reluctance to concentrate on numbers in the context of international economic and security affairs: The numbers and conclusions offered in many projections of future supply and demand curves seem to be skewed along interest lines, or, at least, they seem to be biased in support of one or another set of scientific or philosophical assumptions.

Illustrative of this is the contrast between Man and His Environment, a study sponsored and endorsed by the members of the British-North America Committee, and the aforementioned A Blueprint for Survival. The former, the work of an economist, was signed by corporation and industrial executives for the most part, and maintains that

. . . the assertion of a coming 'ecological' crisis is as crude and unsophisticated in its economic analysis as the crudest form of Malthusianism, in neglecting the fact that manifest scarcities will give rise to price changes which, in turn, will promote substitutions in favor of cheap as opposed to expensive materials, products and forms of consumption, and the exploration of new technologies for transforming the environment into useful goods and services.⁷⁰

In contrast, A Blueprint, signed by 30 renowned scientists from physical or biological disciplines and by one economist, states:

The principal defect of the industrial way of life with its ethos of expansion is that it is not sustainable. Its termination within the lifetime of someone born today is inevitable--unless it continues to be sustained for a while longer by an entrenched minority at the cost of imposing great suffering on the rest of mankind. We can be certain, however, that sooner or later it will end (only the precise time and circumstances are in doubt), and that it will do so in one of two ways: either against our will, in a succession of famines, epidemics, social crises and wars; or, because we want it to . . . in a succession of thoughtful, humane and measured changes.⁷¹

The dilemma presented above is confounding policymakers not only in government but in private industry as well. An executive of one of our largest electrical power companies, a confessed "Cornucopian" as to the long-term abundance of fuels and the prospects for technological innovations in the energy domain, fears, nevertheless, that psychosocial and political factors militate against its resolution. Cost, he says, no longer has the importance attached to it by economic analysts. In

searching for assured fuel sources, the question he asks is not "how much" but "can you deliver it?" As for technological innovations, he is experiencing prohibitive difficulties with concerned people in siting new plants regardless of the technology involved so that the money allocated for capital construction to meet anticipated demand cannot be spent. And, of course, not the least of his difficulties come from the politically conscious members of his state's utility regulation commission. Understandably, he is turned off by unidimensional econometric analyses as well as by those done by the "saviors of the condor." He is hoping instead for a strategic assessment methodology to service his felt need in the decision process for a comprehensive portrayal of the "metasituation" in which contemporary America finds itself. That his search has been unsuccessful to date, he attributes to the inertia of mind-sets in the energy domain reflective of the past that are anachronistic with turbulently changing reality.⁷²

We are inclined to share his evaluation and to look for insight to neither this nor that limb of the energy dilemma but to a new "mind-set" or paradigm as the basis for a constructive, evolutionary synthesis. That is what is needed if the profusion of energy-related data bases now available are to be used effectively in designing international economic policies more conducive to promotion of national security policies.*

In the meantime the many projections now available have tended to go awry of late under the pressure of a panoply of unanticipated, seemingly discrete, quantitative changes which collectively produce

* The National Science Foundation inventory of the research projects underway in each major energy category: As of late 1970, 3,500 such projects were recorded; approximately half were related to energy conversion; as to the source of energy, 25 percent were in the nuclear and 25 percent were in the fossil fuel categories. Another 25 percent dealt with environmental problems. See: An Inventory of Energy Research, Booz, Allen and Hamilton, Inc., Washington, D.C. (15 October 1971).

qualitative systemic changes. Corporate decisionmakers--let alone government executives--are getting more befuddled by such "discontinuities." It could be that we need new forecasting techniques appropriate to the unprecedentedly complex and interactive processes involved in the energy picture. But if one looks at the energy scene ecologically one wonders if we are indeed measuring the really important things. We are inclined to measure what is important to us as a people, as Eli Goldston avers:

. . . . What we measure provides an insight into what kind of a person--or a firm--or a nation--we are.⁷³

If we measure the wrong things it could be that the kind of people we are could get us into trouble in terms of ecosystem functioning.

Perhaps we should be more concerned with the measure of entropy rather than of GNP. What was written earlier may be underlined by a brief elaboration of that concept. Entropy is an index of the relative amount of "bound" energy (energy which can no longer be used for the same purpose) in an isolated structure or, more precisely, of how evenly the energy is distributed in such a structure. In other words, "high" entropy means a structure in which most or all energy is bound, and "low" entropy a structure in which the opposite is true.

The fact that heat always flows by itself from the hotter to the colder, never in reverse, came to be generalized by the Entropy Law, which is the Second Law of Thermodynamics: the entropy of the universe (or of an isolated structure) increases constantly and irrevocably. That is, there is a "continuous" and "irrevocable" qualitative degradation in the universe of free into bound energy, a continuous turning of "order" into "disorder."

This is not a detached academic excursion; the material basis of life is an entropic process. As Erwin Schrodinger crystallized this idea, any life-bearing structure maintains itself in a quasi-steady state

by sucking low entropy from the environment and transforming it into high entropy. A living being or a social system can evade the entropic degradation of its own structure but it cannot prevent the increase of the entropy of the whole system, consisting of its structure and its environment. Entropy is, therefore, the major pressure for change in international economic and security affairs.

In the case of the human species, especially, the entropy of a system is caused to increase faster than it otherwise would. The economic struggle is only about low entropy; the nature of the economic process viewed as a whole is purely entropic. Thus some economists, starting with Alfred Marshall and now Georgescu-Roegen and most recently Morgenstern, have intimated that biology, not mechanics, is the true Mecca of the economists.* In their constructs the economic process is a continuation of the biological one in the sense that humans, like any other living creatures, use only their "endosomatic" instruments with which individuals are endowed at birth. In the economic process, they use also "exosomatic" instruments (generators, smelters, knives, etc.) which they produce themselves. In that way, through the Entropy Law, cultural tradition enters into the economic process.

The dissipation of energy, as that law proclaims, goes on automatically everywhere. This is precisely why the entropy reversal as seen in every line of production bears the indelible hallmark of purposive activity. And the way this activity is planned and performed certainly depends upon the cultural matrix of the society in question. There is no other way to account for the intriguing differences between some developed nations endowed with a poor environment, on the one hand, and some undeveloped ones surrounded by an abundance of natural riches. The exosomatic evolution works its way through the cultural tradition, not only

* In the USSR, East Germany, and elsewhere this would be extended to the social sciences in general, according to a personal communication from Gotthard Gunther to this writer.

through technological knowledge. It is that tradition that also guides what we measure in our energy supply and demand projections. The ecological dimension raises the issue of the viability of that tradition in the light of the entropy law.⁷⁴

From an ecological viewpoint it is notable that the large-scale use of energy by man's exosomatic devices in industry has taken place during a very brief period compared with the totality of past human history. Another notable fact in the advent of nuclear energy.

The limiting factors in the future growth in the rate of energy consumption in the long run may no longer be the scarcity of energy resources, but rather the principles of ecology. The production of power and its associated industrial activities are quite as much components of the world's ecological complex as are the population of plant and animal species.

Our industrial activities based on energy consumption have been characterized by large exponential rates of growth only during the last two centuries, and the present rate of growth of nuclear power capacity, with a doubling period of but two years, represents the most spectacular industrial growth phenomenon in the entire history of technology. However, it is no less true of powerplants and automobiles than of biological populations that the earth itself cannot sustain or tolerate any physical growth for more than a few tens of doublings. According to Hubbert, the resources of the entire earth would not be adequate to support even a bacterial population were it, beginning with one bacterium, to be doubled as many as 100 times. Therefore, any particular physical activity must either cease its growth and, as in the case of water power, level off and stabilize at some maximum or intermediate level that can be sustained, or else it must reach some culmination and then decline eventually to extinction.

Because of the impossibility of sustaining such rates of industrial growth as those which have prevailed during the last century and a half, it is inevitable that before very much longer such growth may cease and some kind of stability be achieved. As is indicated in Figure 1, the future period of stability could be characterized either by a continuation of a technological culture with a high level of energy consumption or by a cultural decline to a primitive low-energy level of existence.

Regardless of which of these courses may actually be followed, it is clear that the episode of exponential industrial growth can only be a transitory epoch of about three centuries' duration in the totality of human history.

It represents but a brief transitional period between two very much longer periods, each with rates of change so slow that it may be regarded as essentially a period of nongrowth. Although the forthcoming period poses no insuperable physical or biological difficulties, it can hardly fail to face a profound revision of those aspects of our current social and economic thinking which stem from the assumption that the growth rates which have characterized this temporary period can somehow be sustained indefinitely.⁷⁵

3. Resources

A review of the literature dealing with the complex issue of material resources reveals that there are two basic schools of thought: One school takes a long view and doubts that technology can be relied upon to extend the supply of available resources quickly enough to keep pace with population growth; the other infers from historical premises that science and technology can provide the bases for new discoveries and substitutes and thereby keep a little bit, at least, ahead of the "Malthusian Trap." But, as pointed out by Landsberg, not even the most ardent adherents of the second school argue that without reduction and ultimate leveling off of the rate of population growth, the Malthusian proposition can be dismissed.⁷⁶

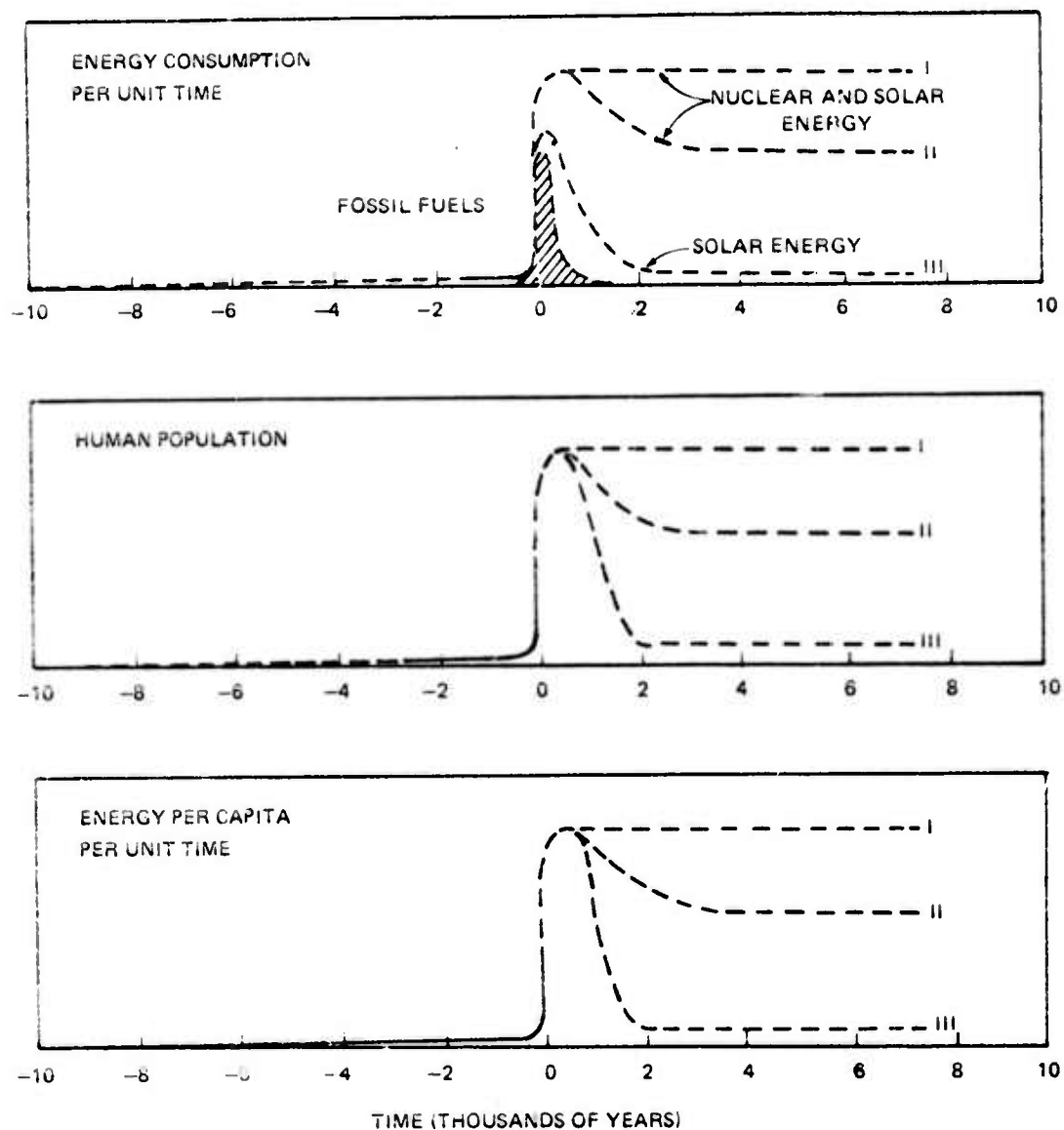


Figure 1 TIME PERSPECTIVE*

Current Human Affairs in a Time Perspective
of Ten Millennia Before and After the Present.

* M. K. Hubbert, Energy Resources. NAS-NRC Publication 1000-D, 1962, Figure 61.

Harrison Brown et al.⁷⁷ subscribe to the latter view, believing that man will find the means for processing poorer and poorer sources as the supply of richer resources dwindles. They also foresee new substances serving as substitutes for traditional materials and others with new properties. They posit a final stage in which machine civilization could be fed entirely by the processing of "average" rock, plus air, seawater, and sunlight, utilizing our ultimate energy resources which will be available in sufficient abundance to power an industrialized world for millions of years.

The latter situation is akin to what Scott⁷⁸ calls the next or "third stage" in the development of the extractive industries, i.e., the controlled stage in which man masters nature and controls his environment and uses the cheapest technological process in an abundant resource to get a desired material.

In contrast to the "Cornucopians" are those with more Malthusian outlooks. Lovering, for example, holds that mineral resources are limited, that they will be exhausted, that we are living in an era of temporary and isolated affluence, and that when mankind is forced to rely on common rock and scrap for metals, it will be difficult to have a standard of living equal to the current standard. In criticizing the assumptions from which the technological optimists derive their evaluations, he comes down heaviest on the one which says that technological progress is automatic--self-reproducing--in modern economies and that technology will continue to make increasing amounts of raw materials available at lower cost per unit.⁷⁹

There are also subschools within schools. For example, there are those who believe that man can continue his technological advances but who question whether he will continue it. One of these is John O'Leary, Director of the Bureau of Mines. In a recent subcommittee, he stated that we are not running out of resources, but we are running out of the technology to exploit them.⁸⁰ There is also the possibility that we are also running out of interested and bright young people for such technological pursuits.

The ecological perspective would suggest that the resources from which our industrial society has been created, the nonrenewable or wasting resources, share certain peculiarities that transcend economics and limit technology and even diplomacy. These resources occur in local concentrations that may exceed their crustal abundances by thousands of times, and particular resources tend to be clustered within geochemical or metallogenic provinces from which others are excluded. That is to say, some parts of the earth are rich in mineral raw materials and others are poor.

No part of the earth is self-sufficient in all critical metals. North America is relatively rich in molybdenum and poor in tin, tungsten, and manganese, for instance, whereas Asia is comparatively rich in tin, tungsten, and manganese and apparently less well supplied with molybdenum. The great bulk of the world's gold appears to be in South Africa, which has relatively little silver but a good supply of platinum. Cuba and New Caledonia have well over half the world's total known reserves of nickel. The main known reserves of cobalt are in the Congo Republic, Cuba, New Caledonia, and parts of Asia. Most of the world's mercury is in Spain, Italy, and parts of the Sino-Soviet bloc. Industrial diamonds are still supplied mainly by the Congo.

Both the "Cornucopians" and the "Jeremiahs" make their projections on the basis of a common data base relative to the apparent lifetimes of estimated recoverable reserves of certain critical mineral resources. When they move from that data base to forecasts of what the future holds, they do so on the basis of what are essentially philosophical assumptions about the physical world, social dynamics, nature and so on. Before going into this source of pressure on international economics and security, let's have a brief look at the base data.

Figure 2 purports to show the lifetimes for different groups of metals and mineral fuels at current minable grades and rates of consumption. No allowance is made for increase of populations or for increased rates of consumption, which tend to increase in the United

States at twice the rate of population growth. Nor is allowance made for additions to reserves that will result from discovery of submarine deposits, use of submarginal grades, or imports--which may reduce but will not eliminate the impact of growth factors.* The open bars represent lifetimes of world reserves for a stable population of roughly 3.5×10^9 at current rates of use. The heavy bars represent similar data for a U.S. population of about 200 million. Actual availability of some such commodities to the United States will, of course, be extended by imports from abroad, just as that of others will be reduced by population growth, increased per capita, and perhaps by political changes. The dashed vertical line represents the year 2042. This is chosen as a reference line because it marks that point in the future which is just as distant from the present as the invention of the airplane and the discovery of radioactivity are in the past.

This assessment is shared by the National Commission on Materials Policy:

. . . in the case of a majority of our basic materials, the gap between our requirements and the remaining easily accessible world supplies is widening . . . our reliance on foreign supplies is steadily increasing . . . Since World War II, with minor exceptions, we have imported far more minerals than we have exported. This annual deficit has increased steadily during the last 20 years until in 1970 our imports of all minerals were valued at about \$9 billion while exports were about \$5 billion, net deficit of about \$4 billion. If trends of the past 20 years continue to the year 2000, this deficit could grow to over \$60 billion a year . . . In 1970 we imported all of our primary requirements for chromite, columbian, mica, rutile, tantalum, and tin; more than 90 percent of our aluminum, antimony, cobalt, manganese, and platinum; more than half of

* Data are updated from the U.S. Bureau of Mines compendia Mineral Facts and Problems and its Mineral Yearbooks as summarized by P. Flawn in Mineral Resources, Chicago: Rand McNally (1966).

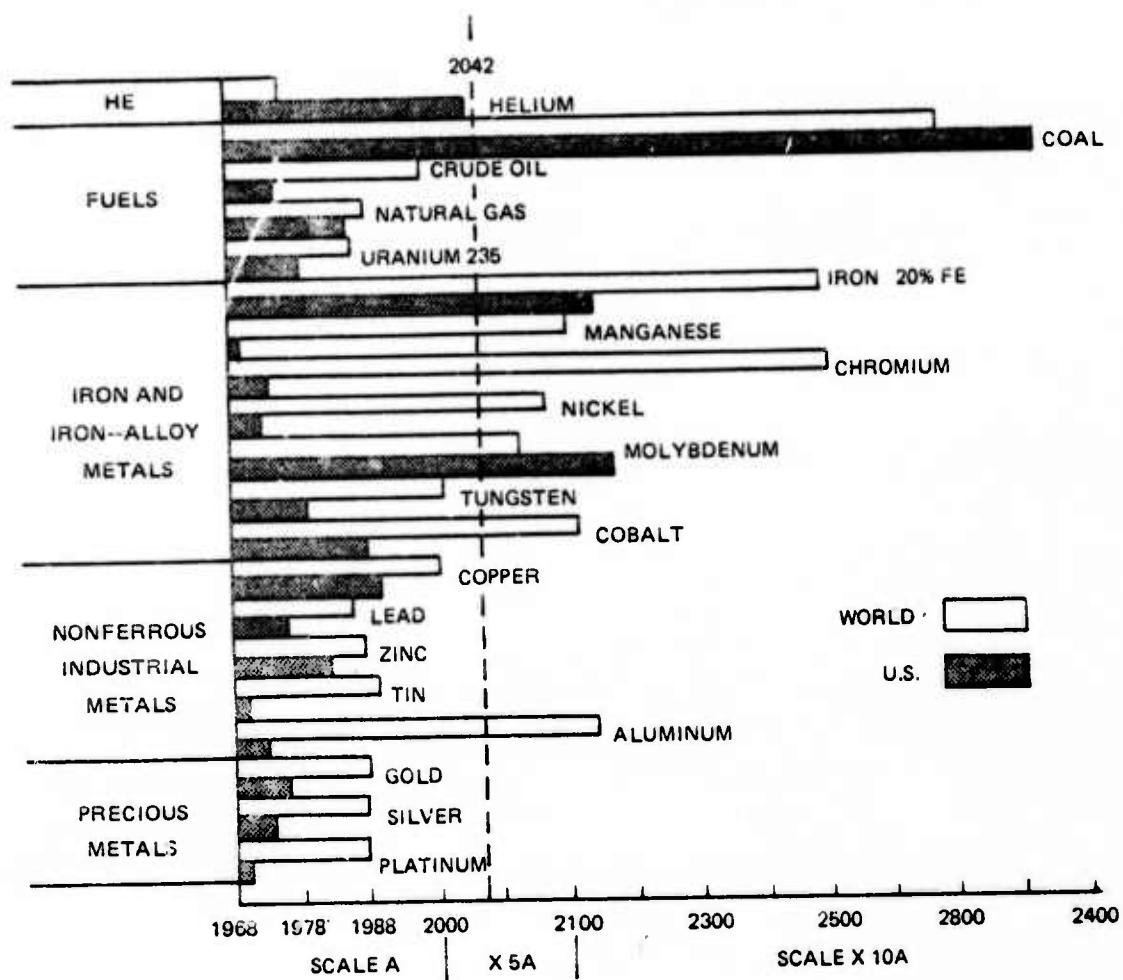


Figure 2 MINERAL RESERVE LIFETIMES*

* P. Cloud, "Mineral Resources in Fact and Fancy," in Environment: Resources, Pollution and Society, W.W. Murdoch (ed.). (Stamford, Conn.: Sinauer Associates, 1971) p. 73.

our asbestos, beryl, cadmium, fluorspar, nickel and zinc; and more than a third of our iron ore, lead and mercury.

The Commission concludes that:

. . . as the Nation's needs continue to grow and as per capita consumption of materials in other countries increases at an even faster rate than ours, it becomes increasingly difficult for the United States to fill its ever-growing deficit by imports, even at increasing prices.⁸¹

This conclusion is based in part on the Commission's projections of the demand and supply of the United States for 18 key resources. Of course, such projections are not to be taken as inevitable. Time will modify them; new reserves will be found; lower-grade reserves will become minable for economic or technological reasons; substitutes will be discovered or synthesized; and some critical materials can be conserved by waste control and recycling. The critical questions from the national security standpoint are: (1) How do we reduce these generalities to specifics? (2) Can we do so fast enough to sustain current rates of consumption? (3) Ought we sustain such rates? Can we increase and sustain production of industrial materials at a rate sufficient to meet the rising expectations of a world population of 3 1/2 billion, growing with a doubling time of about 30 to 35 years, and for how long? (4) If the answer to the last question is NO, the national security policy analyst had better start waxing creative!

A more parochial way of viewing the situation is to compare the position of the United States or North America with other parts of the world. Figures 3, 4 and 5 show such a comparison for 16 commodities with our favorite measuring stick, the USSR plus China. Figure 3 shows the more cheerful side of the coin. The United States is a bit ahead in petroleum, lignite, and phosphate, and neither we nor Asia have much chromium--known reserves are practically all in South Africa and Rhodesia.

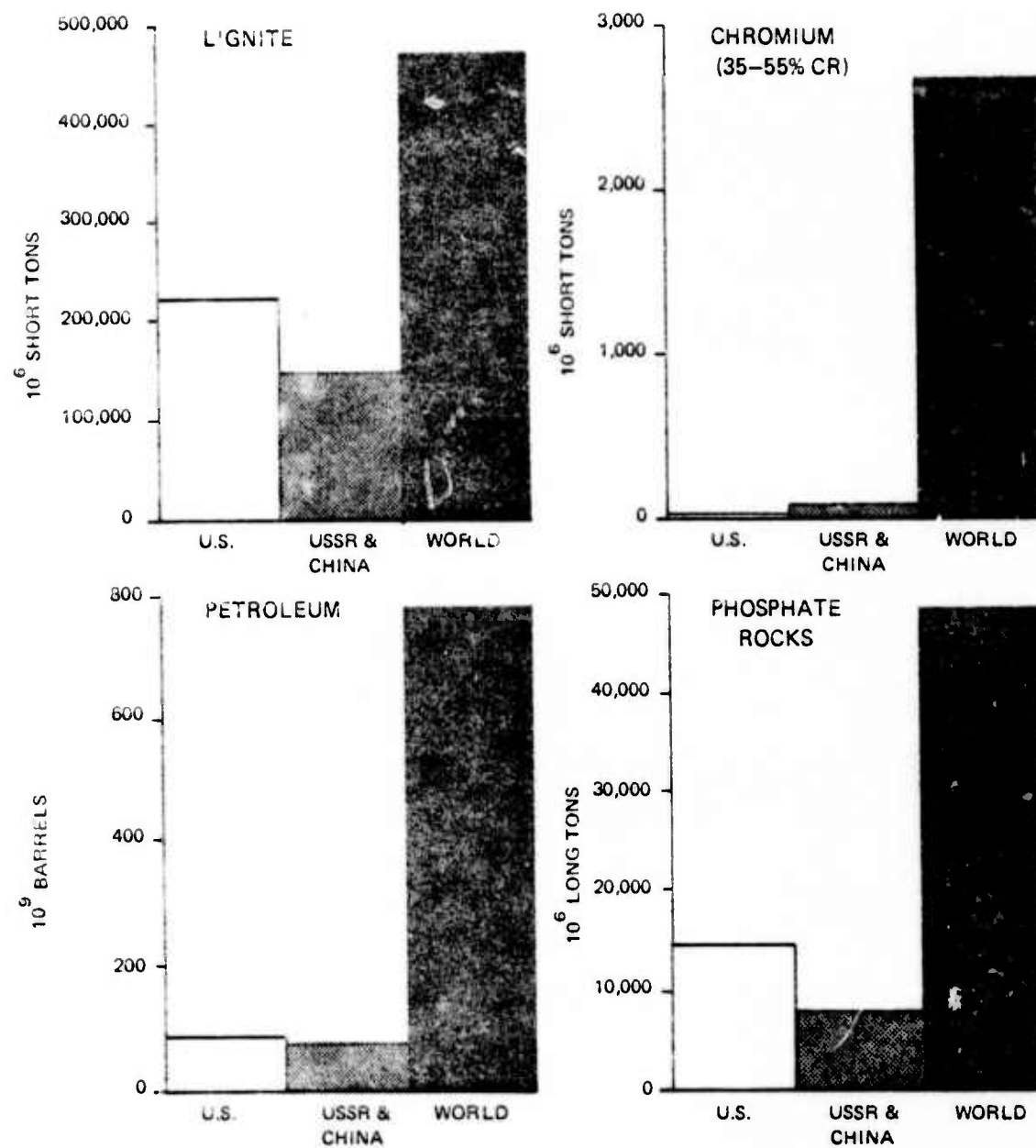


Figure 3 DISTRIBUTION OF RECOVERABLE MINERAL RESOURCES*

* P. Cloud, *op. cit.*, p. 74.

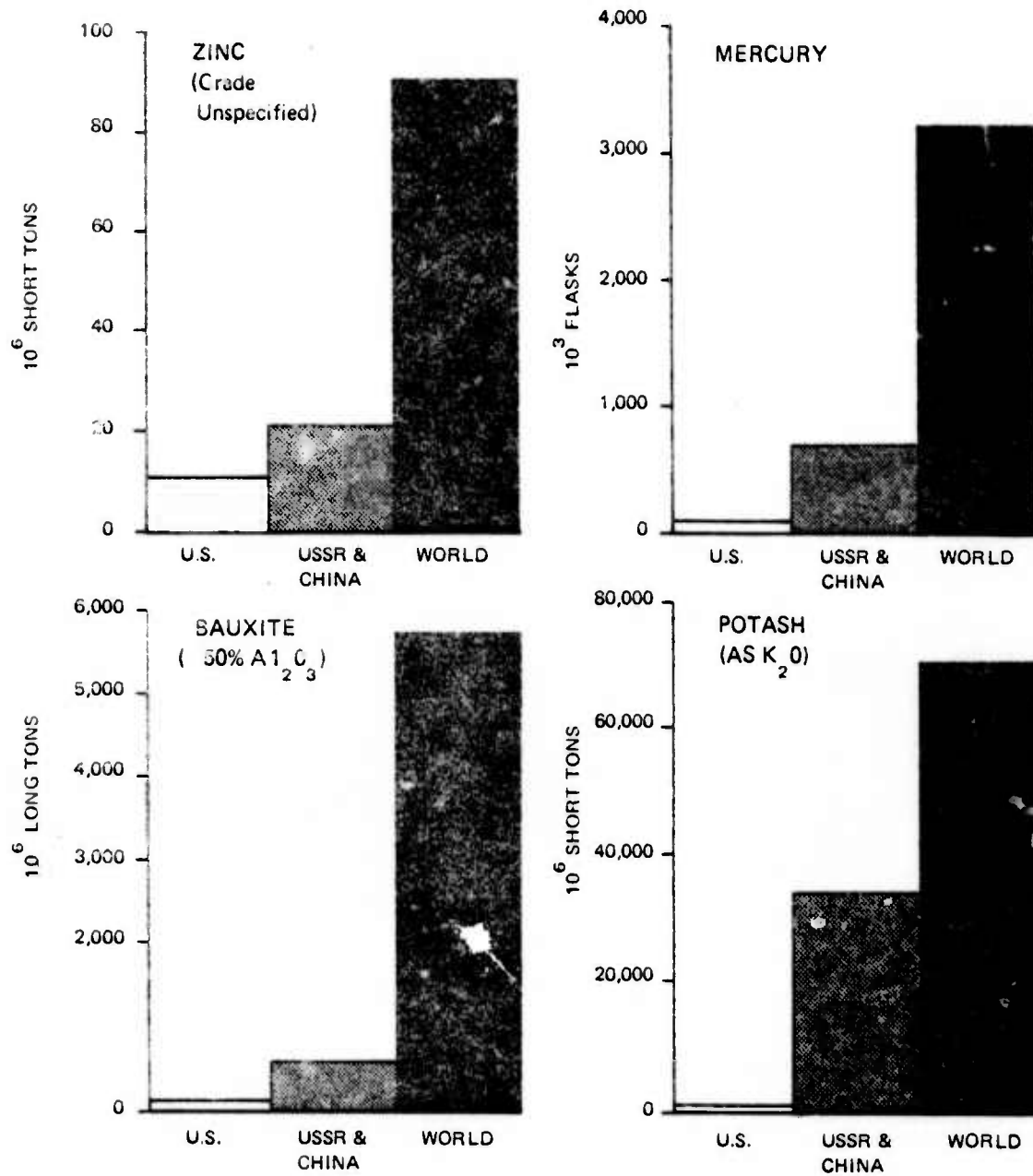


Figure 4 DISTRIBUTION OF RECOVERABLE MINERAL RESOURCES*

* Ibid., p. 75.

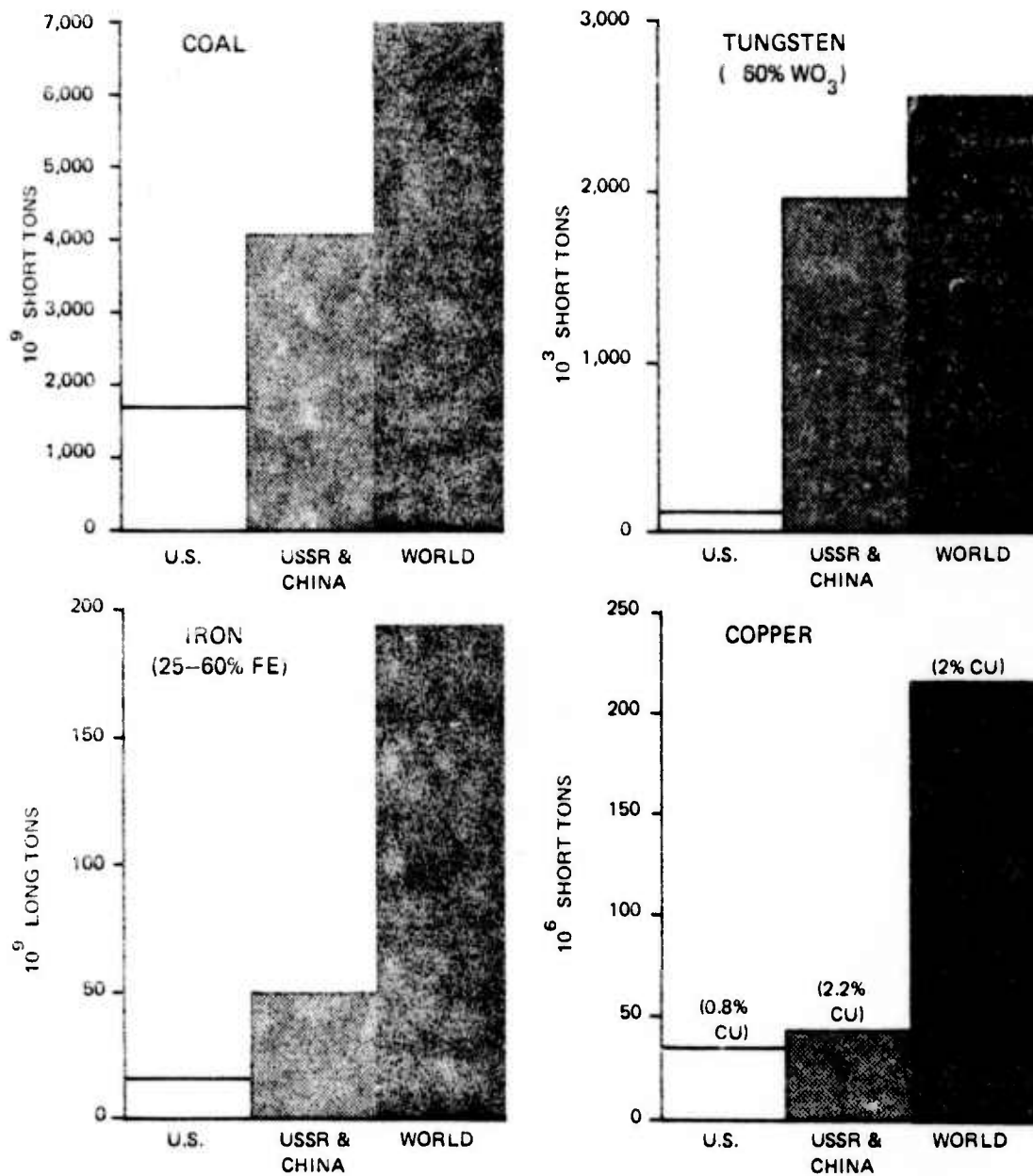


Figure 5 DISTRIBUTION OF RECOVERABLE MINERAL RESOURCES*

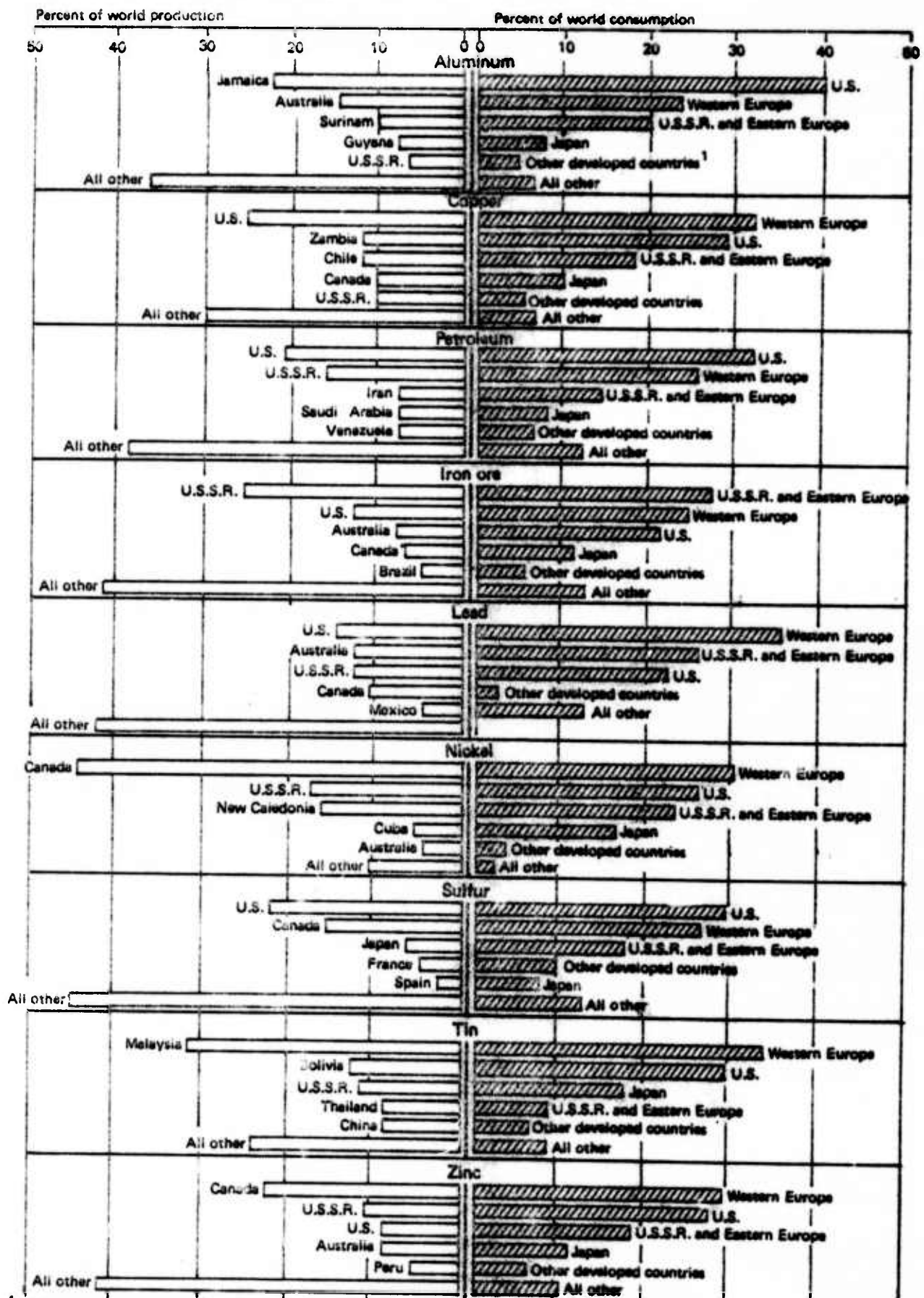
* Ibid., p. 76.

Figure 4, however, shows the USSR plus China to have a big lead in zinc, mercury, potash, and bauxite. And Figure 5 shows similar leads in tungsten, copper, iron and coal.

Again there are brighter aspects to the generally unfavorable picture. Ample local low-grade sources of alumina other than bauxite are available with metallurgical advances and at a price. The U.S. coal supply is not in danger of immediate shortage. Potassium can be extracted from sea water. And much of the world's iron is in friendly hands, including those of our good neighbor, Canada, and our more distant friend, Australia.

No completely safe source is visible, however, for mercury, tungsten, and chromium. Lead, tin, zinc, and the precious metals appear to be in short supply throughout the world. And petroleum and natural gas will be exhausted or nearly so within the lifetimes of many of those alive today unless we decide to conserve them for petrochemicals and plastics. Even the extraction of liquid fuels from oil shales and "tar sands," or by hydrogenation of coal, will not meet energy requirements over the long term. If they were called upon to supply all the liquid fuels and other products now produced by the fractionation of petroleum, for instance, the suggested lifetime for coal, the reserves of which are probably the most accurately known of all mineral products, would be drastically reduced below that indicated in Figure 5--and such a shift will be needed to a yet unknown degree before the end of the century.

Figure 6 gives a finer breakdown of the sources of vital resources and of the countries which consume them. Figure 7 shows the upward shifting trend toward resource imports by the United States, and the per capita rate at which they are being consumed is shown in Figure 8. These prospects should be viewed with some alarm in strategic policy circles concerned with sources of pressure upon international economic patterns. They will be so viewed if visualized from an ecogeological approach to the problem.



¹ Other developed countries include Canada, Australia, New Zealand, Israel, South Africa. Data: National Commission on Materials Policy; Interior Dept.; American Metal Market; Engineering & Mining Journal; American Petroleum Institute. Based on data from 1966 to 1970.

Figure 6 DISTRIBUTION OF MINERAL RESOURCE PRODUCERS AND CONSUMERS*

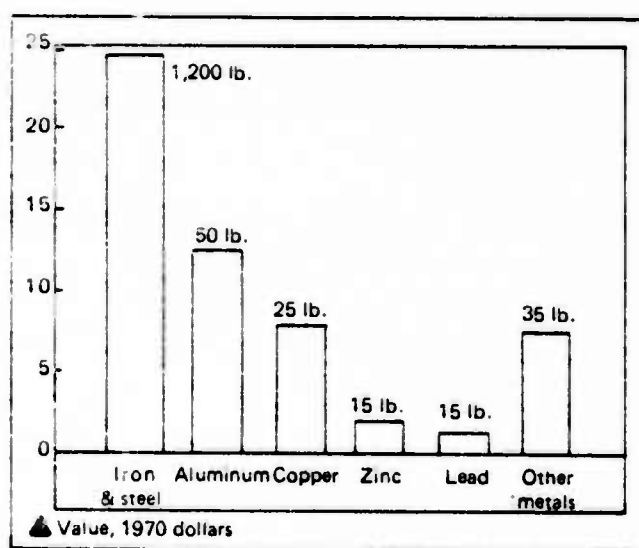
*Special Report, "The Scramble for Resources," *Business Week*, June 30, 1973, p. 57.

Material	Imports as percentage of U.S. consumption		Percentage change
	1950	1970	
Zinc	37%	60%	+23%
Manganese	77	94	+17
Titanium	32	47	+15
Aluminum ¹	71	86	+15
Petroleum	8	22	+14
Iron ore	6	14	+ 6
Platinum	91	98	+ 7
Cobalt	92	96	+ 4
Natural gas	0	3	+ 3
Chromium	100	100	—
Columbium	100	100	—
Tin	100	100	—
Timber	11	8	- 3
Nickel	99	91	- 8
Lead	59	40	-19
Copper	35	8	-27
Tungsten	80	40	-40
Mercury	92	38	-54

¹ Includes bauxite and alumina

Data: National Commission on Materials Policy

Figure 7 THE SHIFTS IN U.S. RESOURCE IMPORTS*



Data: National Commission on Materials Policy

Figure 8 PER-CAPITA CONSUMPTION OF NEW MATERIALS (1970)*

* *Ibid.*, p. 63.

* *Ibid.*, p. 58.

The realities of mineral distribution, in a nutshell, are that it is neither inconsiderable nor limitless, and that we just don't know yet, in the detail required for considered weighting of comprehensive long-range alternatives, where or how the critical lithophilic elements are concentrated. Stratigraphically controlled substances such as the fossil fuels, and, to a degree, iron and alumina, we can comprehend and estimate within reasonable limits. Reserves, grades, locations, and recoverability of many critical metals, on the other hand, are affected by a much larger number of variables. We, in North America, began to develop our rich natural endowment of mineral resources at an accelerated pace before the rest of the world. Thus it stands to reason that, to the extent we are unable to meet needs by imports, we will feel the pinch sooner than countries like the USSR with a larger component of virgin mineral lands.

In some instances, nuclear energy or other technological fixes may buy time to seek better solutions or will even solve a problem permanently. But, sooner or later, man must come to terms with his environment and its limitations. The sooner the better. The year 2042, by which time even current rates of consumption will have exhausted presently known recoverable reserves of perhaps half the world's now useful metals, is only as far from the present as the invention of the airplane and the discovery of radioactivity. In the absence of real population control or catastrophe, there could be 15 billion people on earth by then! Much that is difficult to anticipate can happen in the meanwhile, to be sure, and to center faith in a profit-motivated technology and refuse to look beyond a brief "foreseeable future" is a choice widely made. Against this we must weigh the consequences of error or thoughtless inaction and the prospects of identifying constructive alternatives for deliberate courses of long-term action or inaction, that will affect favorably the long-range future. It is well to remember that to do nothing is equally to make a choice.

The Cornucopian-Malthusian debate as to the prospects of the United States and of mankind in general centers, as was pointed out above,

not on disagreement as to current data but rather on the differing world-views of the forecasters. In this scenario, the Cornucopians perhaps are technological optimists, and the Malthusians are of an ecological bent. Both share somewhat a "futures" orientation, though, as contrasted to a third category of concerned people, those in the resource "business." Their response to what they recognize to be a new historical period is an intensified scramble for resources to which U.S. business, economic and security interests must adjust. These developments are foreseen:

- Continuing worldwide exponential growth of demand for raw materials.
- A rise in the price of many minerals and industrial commodities after decades of relative price stability.
- Growing dependence by the United States on foreign sources for many basic raw materials.
- An intensifying worldwide scramble by consuming nations to nail down source of supply, with the prizes going to those companies and countries with the greatest flexibility and foresight.⁸²

Whether future history proves the Cornucopian or the Malthusian resource projection to be the more valid, the outcome will be but little more than an academic question as long as the "patterns of thought" and "value attitudes" which condition our behavior in the present remain unaltered. These have developed in the West during the last two centuries. These intellectual and psychological patterns made possible the scientific, technical, and economic "progress" which is precipitating the so-called resource crunch. As Weisskopf says: "This same pattern presupposes that any problems created by external abuses and excesses can be solved with the help of science, technology and the economy."⁸³

There are many adherents to his thesis that this same peculiar rationalism and style of life is the root of our resource and other ailments--ailments that cannot be cured without a profound change in thought and in values.

4. Population

Of all the international economic and security research areas explored in this brief study, the area having to do with people as pressure sources was the most conceptually difficult. In cultivating our "perceptual prisms," human involvement in ecological reality was fractionated by disciplines into many spectral components: medicine, demography, psychology, sociology, and so on. Even the more generic problem area, "human ecology," tends to be partitioned.

The term "human ecology" has an interesting variety of meanings. It encompasses almost all aspects of science that have anything to do with Homo Sapiens, including human physiology, genetics, embryology, evolution, psychology, and sociology. Others use it in a much more narrow sense, although their specific interpretations of the term vary remarkably according to their academic backgrounds. Thus, when sociologists speak of the "Chicago school of human ecology," they are referring to work which began in the 1920s and which was concerned with the distribution in space within cities of different social groups. The search for some general laws that could be found to apply to the geographical distribution of such groups led, for example, to the "concentric-zone hypothesis" of Burgess which sees this distribution in modern cities in terms of a series of concentric zones around the central business district.⁸⁴ To others, human ecology is concerned almost solely with the interaction between the human species and pathogenic micro-organisms, and when used in this sense it would seem to be more or less synonymous with the epidemiology of infectious diseases.⁸⁵ A considerable number of books have appeared with the title "Human Ecology" and, as would be anticipated, their contents vary considerably.

In spite of the diversity of approaches to the study of the relationship of man to his environment, the sum total of work in this area still suffers from serious deficiency. Biologists who have turned to the subject of human ecology have been accused by sociologists of neglecting "completely the factor of culture, which makes human ecology differ in

certain fundamental ways from plant and animal ecology"; and there is ample ground for biologists to make the same sort of accusation in reverse with respect to the sociological ecologists.

It was only recently, on the biological time scale, that cultural processes first began to appear in the biosphere and superimpose themselves, as it were, on the processes of life which gave rise to them. Since that time, the two sets of processes have not ceased to interact in countless significant ways, and as culture has continued to evolve the intensity of this interaction has increased enormously; indeed, it is essentially the rapid intensification of this interplay that is responsible for the so-called "environmental crisis" which is causing so much concern among biological ecologists today. Our understanding of the human situation in scientific terms must surely remain dangerously incomplete so long as we fail to make a deliberate and serious study of this interaction between cultural and natural processes in its own right, and so long as our academic institutions, let alone students of national security processes, neglect this area of knowledge that lies in the no-man's-land between the natural sciences, on the one hand, and the social sciences and the humanities on the other.

There is no aspect of human ecology in which the importance of this interplay between the processes of culture and of nature is more evident than that which is the main subject of this study. In fact, more effort has probably been made in the fields of demography and human fertility than in any other to consider both sides of the picture at the same time. But even in this area we have a long way to go before the full significance of the interaction between social and biological processes is properly appreciated and understood.

The growth in numbers of people with their biophysical needs provides the primary, but not the only, set of problems for the decision-makers of the United States and of the world. Changes in the character of the people, in the nature of the political institutions, and in the quality

of the productive economy--adding up to what sociologists call structural changes in the framework of society--are important factors relative to how the growth in numbers affects our ecological management capabilities. These problems, simultaneously converging with those emerging from the physical environment, pose an epochal challenge to the managerial capabilities of our system of governance. As Dan Bell pointed out, it is at this point that the character of the people, the flexibility of the institutions, and the quality of leadership become decisive questions.⁸⁶

The unfortunate truth as presented in a current report of the National Academy of Sciences is that we are ill-prepared to study the impact of pressures on international economic patterns:

. . . we are far from understanding the processes involved in, and the instrumentalities required for, managing the variety of environmental changes that characterize the life of a dynamic society such as our own.⁸⁷

Because the ecological impact of human activities is a function of human values, our perceptions of and knowledge about our ecological setting, and our aspirations concerning it, the NAS report referenced above attributes central importance to research into individual and group behavior:

Without disciplined inquiry into man's social, economic, and political systems, as well as into his behavior as an individual, the knowledge base required for sound action in response to concerns about environmental quality will remain gravely inadequate. The need for research on individual and group behavior is no less pressing than that on the physical and biological systems on which man and his communities impinge.⁸⁸

Such multidimensional inquiries involving interactive physical, biological, and social systems are recognized in the NAS Report as a challenge to the intellectual habit as well as the ingenuity of natural scientists, engineers, and behavioral and social scientists alike. From

this review of the literature, there is little prospect of a successful implementation of strategies recommended by the Academy to do what they deem to be essential:

The character of the natural systems that interact with human values and social systems, the restrictions that the natural systems place on human actions, the opportunities for technological interventions, the decisions on what actions should be taken, and how--all these must be related and considered to realize the goals of managing environmental change and improving environmental quality.⁸⁹

The above-referenced NAS Report reflects ideas published three years earlier by the Committee on Public Engineering Policy of the National Academy of Engineering (COPEP). In response to a request from the National Science Foundation for suggestions as to areas of applied research which NSF might begin to support, COPEP recommended:

- That the National Science Foundation support applied research on a problem-oriented rather than a disciplinary basis;
- That the National Science Foundation influence the manner in which applied research is conducted through active encouragement of interdisciplinary research projects;
- That the National Science Foundation give special attention to social science research in social values and goals;
- That the National Science Foundation favor research proposals which will develop reliable social and environmental indicators.⁹⁰

If the recommendations based on a polling of the NAE membership and of a special ad hoc task force convened by COPEP are followed along with the suggested priority order, most of the NSF's applied research funds would go to studies of the biosphere and the interface between social and physical systems.⁹¹ Unfortunately, when it comes to the relationship of society to its physical environment--a relationship governed by the society's definitions of its resources and the rules evolved for

regulating social relations with respect to the environment--we stumble in darkness. As noted by Samuel Klausner, Director of the Center for Research on the Acts of Man, University of Pennsylvania:

We need documentation on society and its environment. We are short on facts and short on ways of thinking about the problem--on the ground rules for discovering facts We need new ways of thinking about social perception and social organization under changing environmental conditions.⁹²

This assessment seems valid despite the voluminous literature we have reviewed. Most of it is concerned with one or at best two or three facets of the multidimensional population "issue." Thus we find a plethora of literature addressed to man in the urban ecological niche,⁹³⁻⁹⁷ to the relationship of economies to ecological systems⁹⁸⁻¹⁰¹ and even to the politics of ecology.¹⁰²⁻¹⁰⁸ But there is a paucity of studies addressed to problems emerging from these simultaneously converging phenomena or to how we might approach a methodology for addressing such problems.

There is one body of literature dealing with the relation of population and social dynamics to ecology that deserves special attention in a consideration of emerging issues. That is the societal impact of anxieties induced by the population explosion, shortages of natural resources, and pollution. Viewing this problem from the standpoint of his knowledge of the functioning of man's emotional system, Murray Bowen, a psychiatrist, concludes that

. . . mankind is rapidly moving toward a crisis of unparalleled proportion . . . that man's failure to deal constructively with the crisis will be the result of his emotional blindness . . . and that it will be the end of civilization as we have known it over the past few thousand years.¹⁰⁹

Putting the issue in another way, Bowen believes that man can solve the technical and economic factors by eventually doing what he knows he has to do but that

this will be easy alongside the emotional factors. To solve the emotional part of the problem, he will have to eventually become a different creature than he is.¹¹⁰

This assessment is reflected by other authors concerned with the adaptability of man to ecological changes such as the "crowding" produced by population growth especially when biological and cultural adaptive capacities are exceeded by the rate at which environmental changes occur because of outmoded adaptive behaviors such as violent aggression.¹¹¹⁻¹¹⁶ But such studies are punctuated as in Sells' contribution to Naturalistic Viewpoints in Psychological Research by admissions concerning the tentativeness of the findings and by expressions of the need in ecological research for an interdisciplinary approach, field research, reliable techniques for recording behavior, and new techniques and conceptions of encoding the environment.¹¹⁷ The central question as it was put in recent hearings before a Subcommittee of the House Committee on Government Operations is: "Can man approach a kind of dynamic equilibrium with his environment so as to avert destructive imbalances [involving] the entire globe and the distant future?"¹¹⁸

Of course, the size of the human population is an important and, some say, determining factor making for such an imbalance. According to Philip Handler, there is every reason to expect that, by the end of the century, a brief 30 years from now, the world will have twice its present population. Unless forestalled by a worldwide holocaust, in the year 2000 the world population will surely be not fewer than six billion people, and may well exceed seven billion.¹¹⁹ Figure 9 shows the suddenness of this upsurge. Since the means for improved control of disease are already at hand, if the food supply keeps pace, a world population of seven billion will be reached even if present birth rates are considerably reduced. Another source of future difficulties is the fact (evident in Figure 10) that in the newly developing nations where abject

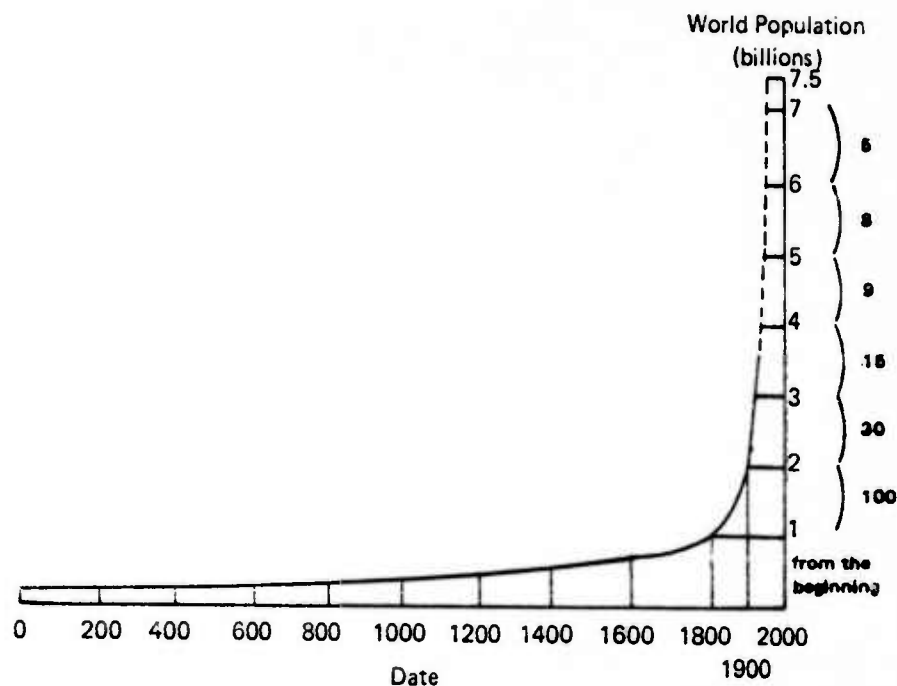


Figure 9 WORLD POPULATION GROWTH*

(Projected with assumption of constant fertility rates and declining mortality. Small numbers outside parentheses indicate the rapidly decreasing number of years required to increase world population by a billion people.)

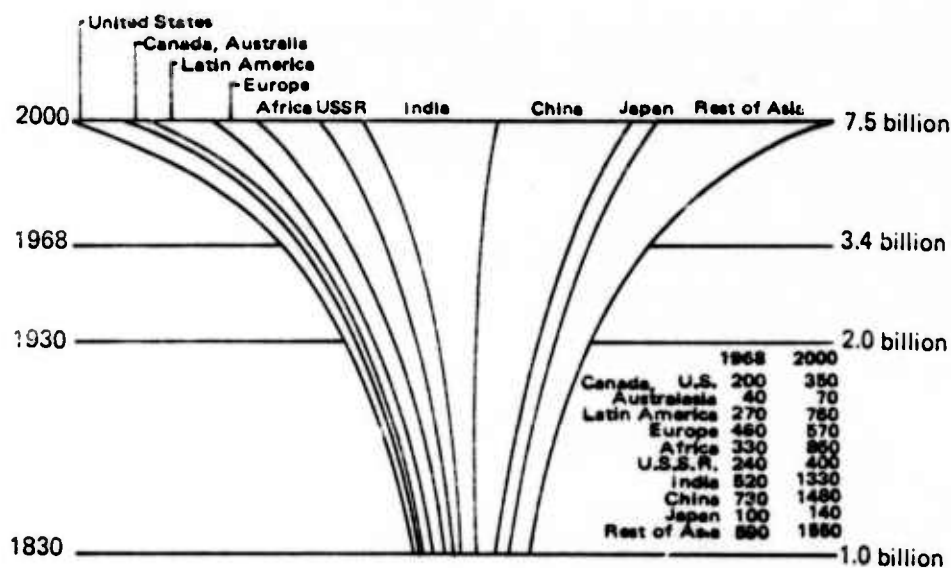


Figure 10 PROJECTED POPULATION OF DEVELOPED AND UNDERDEVELOPED NATIONS IN THE YEAR 2000†

* World Population: A Challenge to the United Nations and Its System of Agencies. UNA-USA National Policy Panel on World Population, May 1969.

† Ibid.

poverty is widespread, the mass of the population is uneducated and the industrial sectors of their economies are poorly developed.

Moreover, future demands on the biosphere are not to be measured by simple extrapolation from the present. Much of the present population is badly nourished while, because of improved communications and appreciation of the living standards of developed nations, popular aspirations for improved living conditions are high in almost all nations. Even a doubling of per capita consumption of protein, clothing, and shelter would leave present aspirations unfulfilled. If the projected doubling of the world's population is realized, and if political order is to be maintained, it is not unreasonable to expect that the demands of the biosphere by the end of the century will be from three or four times those of the present! The problem of achieving such increases, which are described with considerable detail in the Population Commission Report, becomes staggering when we realize that the end of the century is so close that this year's infants will then be in the heart of their child-bearing period. Moreover, regard for the human heritage requires that these needs be met without despoiling either the quality of man or the material base from which he draws life.¹²⁰

For the longer term, the population growth as shown in Figures 11 and 12 is highest in those world regions which:

- Are technologically underdeveloped,
- Have a high population to usable resource ratio,
- Have a low physical life expectancy, and
- Have low social expectations.

On the other hand, growth is lowest (or more stable) in those regions which:

- Are technologically advanced,
- Have a low population to usable resource ratio,

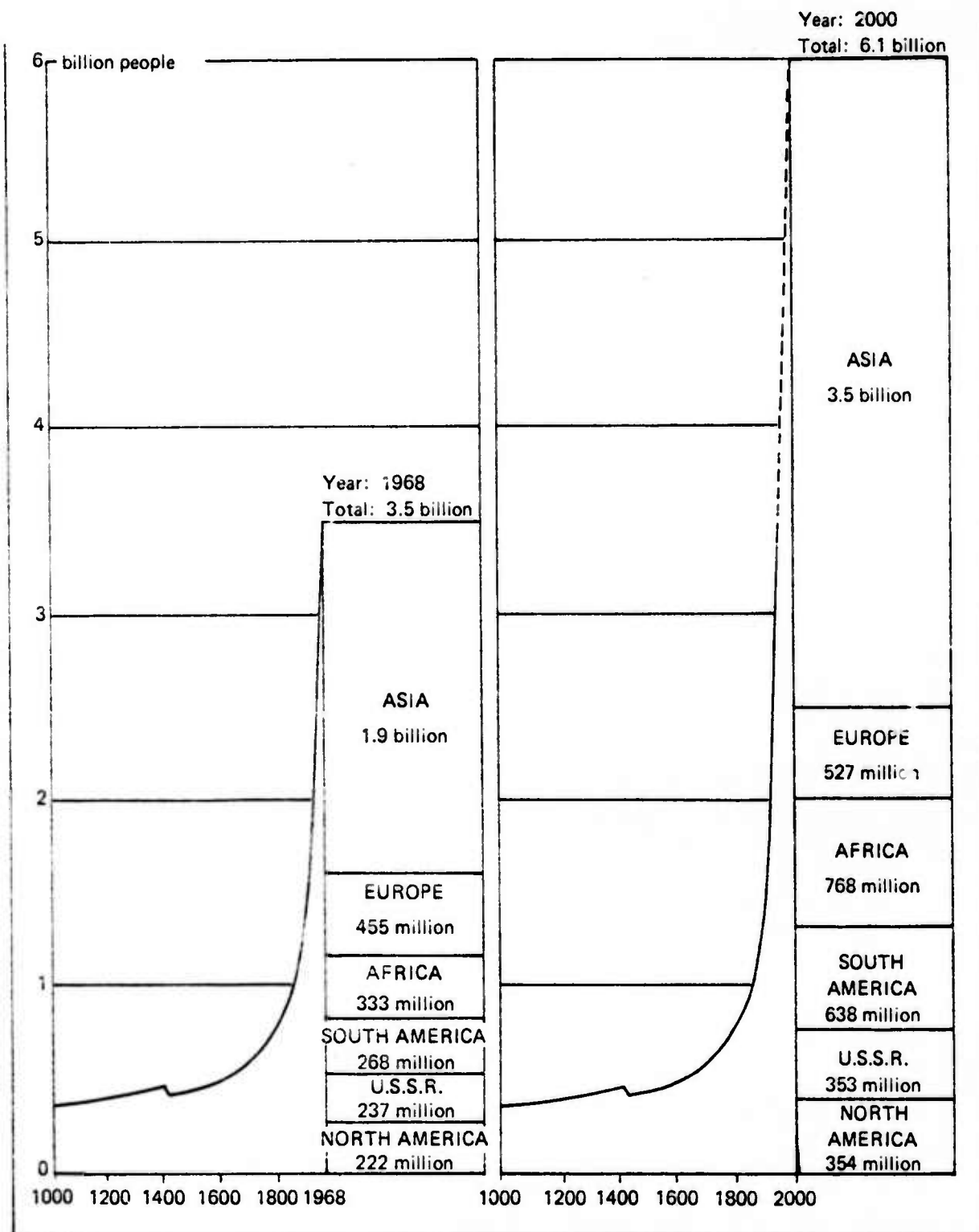


Figure 11 WORLD POPULATION GROWTH*

* John McHale, World Facts and Trends. (New York: Collier Books, 1972) p. 35.

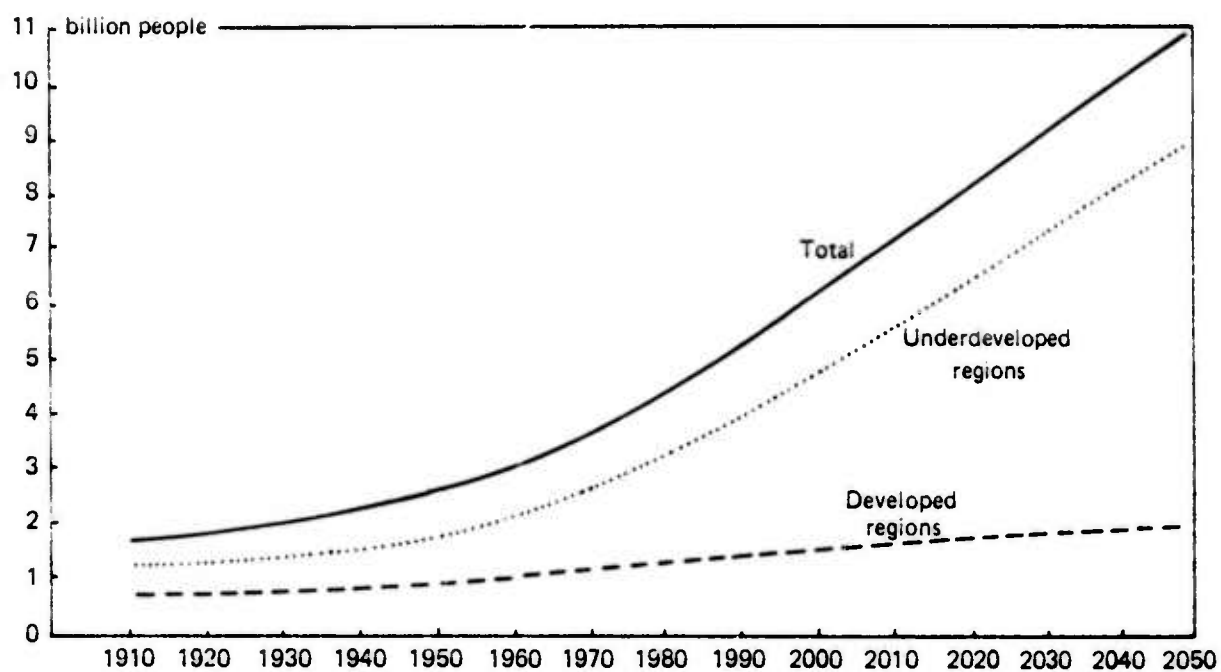


Figure 12 WORLD POPULATION GROWTH IN
DEVELOPED AND UNDERDEVELOPED REGIONS, 1910-1050*

* Ibid., p. 38.

- Have a high physical life expectancy, and
- Have higher social expectations--that is, in mobility, education, life style, etc.

Because of more rapid population and economic growth rates in the rest of the world, the United States share in world consumption of resources can be expected to fall in coming decades. At the same time, because of rapid increases in domestic consumption, U.S. dependence on the rest of the world will probably increase. While technological developments could alter this picture, these trends seem highly likely no matter which population and economic growth assumptions come to pass, within the range investigated. Sooner or later, we will also have to face the environmental problems generated by this growth on a worldwide scale.

Realignments of relative power positions and potentially grave issues of clashing national and regional interests will arise from the pressures producing these trends. As such worldwide problems become larger and increasingly interlocked, it becomes more and more an act of self interest and less of altruism on our part to help in evolving a sensible international economic order capable of dealing with the joint problems of economic development, international trade, resources, and the environment.

An equally alarmist note is struck in publications of UN agencies. One notes that by 2000 AD the population of the world will be 7,000 million, with three-quarters of them in the less industrialized countries. Owing to internal migration, urban growth is likely to be at least twice as rapid as total population growth. To house this population will require building in one generation more structures than have been built in the whole of human history. Thus the provision of shelter for the vast majority of the human race now has a priority only less urgent than the prevention of famine or the elimination of war.¹²¹

Although much of the relevant literature on the "population problem" is concerned with the impact of people on the environment, there

is also a considerable body of research on the influence of environmental conditions (including social pressures) on the genetically determined characteristics of populations. Patterns of fertility and mortality and the human population effects of urban ecology are examples of such research activity. It is largely the task of the human biologist to recognize and define the various environmental factors which determine such patterns.

One of the most important and clear-cut biological consequences of civilization has been the increase in population densities which began with the Neolithic development and which increased markedly with the appearance and growth of cities. These developments produced profound changes in the patterns of interaction between the human species and its microbiological parasites, with important effects on mortality patterns. Three factors arising out of this increase in population density were particularly important in influencing these relationships. They were (1) the great increase in the number of social contacts experienced by the individual each day, (2) the increased closeness of these contacts (because of crowded living conditions and poor ventilation), and (3) the greatly increased possibility of contact with human excreta either directly or indirectly (i.e. through contamination of food and drink).

Although there is ample justification on epidemiological and anthropological grounds for the view that it was environmental changes associated with the development of civilization that caused contagious diseases such as plague, cholera, typhoid, dysentery and tuberculosis to become important causes of death in human populations, it is surprising how many authorities apparently fail to appreciate this fact. So often it is assumed that pestilence, and indeed also malnutrition, had always been a feature of human existence until, in the case of Western society, the advances of medicine in the past half century or so removed them. In fact, for well over 90 percent of man's time on earth, before the Neolithic development, neither pestilence nor malnutrition is likely to have been a common cause of ill-health or death.¹²²

It is obvious from this literature review that the population-related research on human biology in modern society is in a very undeveloped and unidisciplinary stage with little notice taken of the various social and economic factors which influence the conditions of human life. The proper study of the biology of modern people is, of necessity, multidisciplinary in character, requiring the cooperation of geneticists, ecologists, sociologists, social anthropologists, demographers, social psychologists, medical scientists, economists and others. While the need for such integrative, multidisciplinary work in human biology is clear, it is equally apparent that it is not taking place as yet at nearly the scale that would be required for security analysis purposes.

Apart from the purely academic arguments, there are also sound practical reasons for encouraging integrative multidisciplinary research on human biology in modern society. The survival of the human species and the growth of human populations since the Neolithic development and in the face of changing environmental conditions have been made possible by the processes of cultural adaptation to biological maladjustment. Similarly, the future evolutionary and ecological success of the species in the face of an ever-accelerating rate of environmental change, associated with growing urbanization and industrialization, will depend entirely on the extent to which cultural adaptation continues to be effective. The success of cultural adaptation, in turn, will depend on the level of understanding in society of the increasingly complex interactions between natural processes on the one hand and cultural processes on the other. As pointed out above, the proper study of the biology of modern man is necessarily concerned with these interactions, and ecology, including human biology as a related subfield, may well contribute more than any other established academic discipline to the comprehensive understanding of the human situation and the continued survival and well-being of mankind.

5. Organizational Issues

The ecological viewpoint is fostering adaptive changes in the way the world's political subdivisions co-function and in the approaches of men of science, commerce, letters and so on to their tasks. In the first instance, with recognition of the global dimensions of the ecological crisis there came a call for global action. As to the second, the holistic world-view implicit in ecological thinking is challenging the 400-year-old reductionist approach, used especially in science but also in other fields of endeavor. Such fundamental changes raise equally basic organizational issues. In response to this issue many efforts are underway to develop not merely new forms of international cooperation, but also the systematic and coordinated engagement of all pertinent scientific disciplines, professional expertise, and skills. This is happening domestically as well.

The first breakthrough came in 1964 when the International Council of Scientific Unions (ICSU), with members from 57 nations, organized multidisciplinary teams of scientists under the auspices of the International Biological Programme (IBP) to study the biological basis of productivity in human welfare, with special emphasis on the interaction between man and his environment.

The second international initiative of major significance was taken by the United Nations Educational, Scientific and Cultural Organization (UNESCO). In the fall of 1968, UNESCO convened an Intergovernmental Conference of Experts on the Scientific Basis for Rational Use and Conservation of the Resources of the Biosphere. This conference, which adopted 20 major recommendations, recognized explicitly that many of the man-induced global changes in the biosphere required attention on a global scale, and that the multidisciplinary nature of the problems, which involve not only biological and physical but also social sciences, makes it necessary to call on the various disciplines of the scientific community to concentrate on environmental problems. The conference recommended

that a plan for an international and interdisciplinary program on the rational utilization and conservation of the resources of the biosphere be prepared for the good of mankind--a program that should be carried out on an intergovernmental basis, with the participation of nongovernmental organizations as required.

On 3 December 1968 the UN General Assembly at its twenty-third session passed a resolution that may yet turn out to be the most important milestone on the road toward responsible international action on behalf of the world's environment. Resolution 2398, which was initiated by the government of Sweden and adopted unanimously, called for the convening of a United Nations Conference on Human Environment, in the belief that it was desirable

to provide a framework for comprehensive consideration with the United Nations of the problems of human environment in order to focus the attention of Governments and public opinion on the importance and urgency of this question and also to identify those aspects of it that can only or best be solved through international cooperation and agreement.

In a Joint Resolution expressing the support of Congress, and urging the support of Federal departments and agencies as well as other persons and organizations, both public and private, for the international biological program resolved:

That (a) The Congress hereby finds and declares that the international biological program, which was established under the auspices of the International Council of Scientific Unions and the International Union of Biological Sciences and is sponsored in the United States by the National Academy of Sciences and the National Academy of Engineering, deals with one of the most crucial situations to face this or any other civilization--the immediate or near potential of mankind to damage, possibly beyond repair, the earth's ecological system on which all life depends. The Congress further finds and declares

that the international biological program provides an immediate and effective means available of meeting this situation, through its stated objectives of increased study and research related to biological productivity and human welfare in a changing world environment.¹²³

In a statement to the House as he introduced this resolution, then Representative Emilio Q. Daddario emphasized:

The IBP is not just another government venture, and it is not some abstract international dream. It is a very real, planned and coordinated effort to establish an ecological base for the management of our environment and for the prevention of the deterioration which is threatening our entire planet. It may be one of the most crucial programs, in spite of its mild-sounding title, to evolve in our time.

Mr. Daddario also pointed out:

Since World War II we have left ecology, the only scientific discipline which specialized in the total environment, to its own devices in a market in which it could not possibly compete. As a result, a science which might have matured to meet our problem solving needs in environmental matters has fallen behind the bold advances in many other areas of American science.¹²⁴

At about the same time (early 1967) McGeorge Bundy, representing the President, met in Moscow with Dr. Jerman Gvishiani, Deputy Chairman of the State Committee of the USSR for Science and Technology, to explore the possibility of establishing an international center for studies of the common problems of advanced societies. After five years of planning conferences and multinational negotiations under the Chairmanship of Lord Solly Zuckerman of the U.K., the Charter of the International Institute for Applied Systems Analysis--known at earlier stages as the East-West Institute--was signed on 4 October 1972. When the institute opened at Laxenburg, Austria, this year it had a distinct ecological focus running

through the themes of its research: Urban and Regional Planning (the city as an ecosystem with a given equilibrium state and its (in) stability properties; Environmental Systems (modeling of natural ecological systems); Energy Systems (re ecology); Municipal Systems (the city as an ecosystem); Water Resources (the ecological effects of pollution); and Ecological Modeling and Control as a major theme in which the behavior of ecological and resource systems is explored, techniques developed to measure those properties and to relate them to a planning network.

The objectives under this research theme point up the anachronism of traditional hierarchical organizational structures in governments or research institutions--in the face of ecological reality:

Objectives

- (i) review theoretical and empirical analyses appropriate for ecological, resource and anthropological systems; review methodologies designed to analyze their dynamic behavior;
- (ii) using a set of ecological and rational models described below, develop ways to interpret information contained within them;
- (iii) on this basis, define each of the behavioral attributes of the models--particularly that of stability and resilience--and give them numerical representation;
- (iv) design a policy framework that emphasizes maintaining open options and the increase of systems resilience rather than more traditional equilibrium-centered approaches;
- (v) develop methods to aggregate and disaggregate our understanding of complex dynamic systems in a form useful and usable for planners and policy people.¹²⁵

The foregoing is just a sample from a much larger set of how the world community is organizing in response to portended ecosystemic threats. The International Council of Scientific Unions has created a Special Committee on Problems of the Environment (SCOPE) to serve as a

nongovernmental resource and as an interdisciplinary council of scientists for the benefit of governments and intergovernmental organizations.

NATO got into the picture in 1969 when its Committee on the Challenges of Modern Society was activated following a proposal by President Nixon in a speech on 10 April 1969. The new effort was firmed up during a meeting in Washington with Secretary General Manlio Brosio in July of that year. It was decided early on that occasion that environmental problems were among the foremost "challenges" and hence a focal point for the new committee's activities. From the experience of this writer in coordinating the departmental inputs in preparation for the first meeting of the committee, it was clear that our executive departments were not organized to respond to broad issues such as ecology offers. The vertical hierarchical organizational approaches were as ill-suited for considering broad comprehensive issues as are the traditionally compartmented academic disciplines in the face of ecological reality. It remains to be seen, but the proliferation of environmentally involved U.S. organizations after 1969 may have exacerbated rather than relieved this situation.

This mismatch between complexly interrelated real-world phenomena and the compartmented, vertical institutional structures involved in their governance was highlighted by the President's Advisory Council on Executive Organization (better known as the Ash Council). In their detailing, for example, of the natural resource challenge to the United States, they noted especially the need "to manage our resources in ways which will assure ecological balance, and thus sustain the basis on which these public needs can continue to be fulfilled." They went on to question the adequacy of present government structures with their resource programs scattered through an array of agencies, each concerned with a historical mission addressed to but one facet of the resource meta-issue.¹²⁶

With reference especially to the subject of energy, the Ash memo fails to convey just how disorganized the situation really is. A clearer

idea is to be gained from Interior Secretary Roger C. Morton's testimony at a Congressional Committee hearing on fuel and energy resources:

There are some 61 departments and agencies of our government who in some way have an input into our energy policy and all of them have provided advice, often conflicting.

This in the face of a situation outlined at the same hearings by Under Secretary of State John N. Irwin, II:

Most estimates now place production of oil in the U.S. by 1980 at about 12 million barrels per day including two million barrels per day from the North Slope of Alaska. Demand, however, is projected to rise from the current level of some 16 million barrels per day to 24 million barrels per day in 1980. The U.S. could, therefore, find itself in the position of having to import as much as 50 percent of its petroleum requirements by the end of the decade. If we take into account the oil that may be needed to compensate for shortages of natural gas, our consumption could be much higher.¹²⁷

Even if the need for imports were to be satisfied by a reliable source of supply, policymaking by the variegated array of concerned agencies would be, at least, extremely difficult when one considers the disruptive influences thereon from the environmental interests. And, of course, there is no such thing as a "reliable source of supply." A more realistic view of what we face by way of oil importation is portended by Saudi Arabia's recent embargo of all oil shipments to the United States (600,000 barrels/day out of the 17 million barrels consumed daily by the United States) coupled with the cutbacks of oil shipments by other Arab nations amounting to at least 1.3 million barrels per day immediately following the events of the week of 14 October 1973.¹²⁸

When the energy supply issue is considered in its environmental context, the dimensionality of the resultant "meta" problem magnifies the organizational question by several orders of magnitude. And

the "environmental context" isn't even too well defined at this juncture. The Smithsonian Science Information Exchange recently compiled a catalog of environmental research activities with a total of 5,488 project descriptions--not intended as a complete collection--the collective import of which could be as ponderous for policymakers as is the energy supply side.¹²⁹ A recent SRI study demonstrates the dimensionality of the environmental problem as an object of research when the concern is with just one department (DOD), which happens to have 421 environmental research tasks.¹³⁰

The mismatch between organizational structures and ecological problems is evident also in the general area of technology assessment. Much of the assessment activity in the environmental domain has been prompted by problems after the fact. The National Academy of Engineering makes a distinction between such assessments and technology-initiated analyses. Assuming causal chains that converge toward a few end points, the Academy suggests that system analysis can handle such problem-initiated analysis as is involved in the reduction of subsonic aircraft noise, air pollution, low-cost urban housing, etc.

But technology-related analysis is concerned with prediction of the possible consequences of a given technology. Here analysts concede that as the causal chains diverge, predictability decreases with the degree of divergence. The number of foreseen consequences becomes multiplied by the number of policy alternatives considered for each. The proliferating chains of residue problems create many unforeseen consequences in addition to foreseen ones. The significance and number of the unforeseen problems are such that the efficacy of technology assessment is brought into question.

The dialectical character of technological change, rather than direct causality, also militates against realistic assessment. The Academy perceives the element of hope and fear in forecasting the future in its summary:

The cause-effect chain does not lead easily to well-defined conclusions when applied to technology-initiated studies unless the study is modified by focusing the technology toward one or at most a few potential areas of social concern or of social opportunity that might be significantly affected by the subject technology. If the selection of these areas is perceptive, the most significant future impacts (even second- and higher order impacts) of the technology will be identified. The uncertainty of this approach is that in making the selection of problems to be addressed, important social and political impacts could be overlooked.¹³¹

The above is, in effect, a recipe for selecting the obvious problems for which solutions can be conceived, and putting the others aside-- which is science's universal approach. The methods for analyzing even these selected problems are based on other assumptions derived from human judgment. A congressional committee has recognized that, aside from economic and easily quantifiable social effects, "other results are not so easily calculated into risk-benefit equations."¹³²

The difficulty of establishing criteria for controlling technological development is also recognized by a study of the National Academy of Sciences:

The fact is that, with respect to major technological applications, we lack criteria to guide the choice between efficient resource allocation. . . and other objectives.¹³³

Lacking a calculus of current costs and benefits, the Academy of Sciences casts about instead to determine on whose shoulders to place the uncertainties.

In any situation of imperfect knowledge, when the consequences of a contemplated action can only be surmised and when its costs and benefits cannot confidently be reduced to a net quantity, it becomes critical to decide where the burden of such uncertainties should fall.¹³⁴

As a consequence of the current situation, "local" managerial responses to particular data inputs find expression in ecological interventions which are likely to produce unanticipated and often undesirable systemic effects. The organizational issue, internationally and domestically, is obviously of great moment. From this brief review of some of the relevant literature it seems that the now traditional hierarchical partitioning of the management function, especially in matters ecological, is dysfunctional when it comes up against the complex interrelatedness of ecological systems. But the traditional organizational approach is a reification in practice of a particular world-view that has obtained for several centuries. The ecological perspective if it were to be widely diffused and accepted could find expression in a new and perhaps radically different managerial structure and process that might transform fundamentally the entire system of governance.¹³⁵ While this is neither the time nor the place to ponder what the characteristics might be of the alternative structures and processes that could be implied by an ecologically focused paradigm, it should be emphasized that the long-range organizational implications internationally and domestically of the ecological issue should be a matter of great concern to policymakers.

E. National Security Implications of Ecological Pressures

1. Introduction

From this survey of literature on energy, mineral resources and population pressures, certain implications for national security are quite obvious: rapidly growing dependence for critical energy and mineral resources upon highly unpredictable foreign sources, themselves caught up in the tumult of sociopolitical transition; and burgeoning populations with raised expectations, especially in the LDCs, tending to heighten the unpredictability of their behavior as well as their internal consumption rate for vital feedstocks. Accompanying these implications is a new spectre which will be haunting the future of America in the form of serious energy and resource shortages which could undermine not only the

operational capabilities of current and planned force structures, but also the very technico-economic infrastructure of society itself. Because the obviousness of such implications depends upon the simultaneous perception and consideration of numerous interactive and converging trends, they might go unappreciated if each factor is analyzed separately.

Less obvious are the implications derivable from exploration of ecological and organization-related literature. The message of ecology is that there are sometimes very subtle natural forces operating to change the "tranquillity of order" that is peace to the anarchy of disorder, and that these forces exceed in their inexorableness, ubiquitousness, and power the armamentaria musterable by any or all potential political adversaries. It follows from this lesson of ecology that just as a strategy for peace must consider nature as a prime adversary if it is to be at all realistic, a strategy of conflict would be doomed from its outset. A harmonious rapprochement is the only workable policy objective when confronted by nature which is at once most indomitable as an adversary and priceless as an ally. Xeno said something like this: Fortunate is he whose will is at one with Nature's laws; for all must bow to that will as they must to Nature. But for us to heed this message, a transformation of the world-view deeply ingrained in our culture would be mandatory. Another less ancient sage, Pogo, looking at the war for survival in nature from this point of view, put his finger on Western society's dilemma: "We has met the enemy and he is us."

Entailed in the obvious, let alone in the more subtle, issues implied in the ecologist's message is a degree of holistic complexity for the handling of which the reductionistically simplified contemporary organizational apparatus and methodology is at best ill-suited. This mismatch between ecological reality and the world-view expressed in our traditional governance structures and processes as discussed in the organizational issue literature has vital implications for U.S. defense planning procedures and for strategy formulation efforts for securing global U.S. interests. It also highlights a class of U.S./USSR asymmetries to which far too little attention has been addressed. These

implications can be discussed but briefly in this exploratory paper; each is a Pandora's Box full of interrelated sub-issues for a full elaboration of which a much more comprehensive research project would be necessary.

2. Implications for U.S. Defense Planning

Our adversaries' employment by choice of political ecology to achieve national objectives; constraints on the number and kind of options we may exercise in the domestic and international arena as determined by the operation of natural ecological processes; a fundamentally reformed calculus for the computation of national power--these are some of the implications suggested by the ecological perspective. However, to be sanguine as to the appreciation of these implications would be somewhat unrealistic. Experience demonstrates our proneness to respond in kind to individual threats and issues and a cultural antipathy to "big pictures"--i.e., comprehensive or global metathreats as epitomized by ecology. Consequently, the national intelligence community is organizationally and methodologically unprepared to perceive, let alone anticipate, ecological challenges to the nation's security. And if they were to succeed in the production of a "Global Ecology Estimate," to whom would it go for formulation of strategic planning and/or for action?

For example, if we had a methodology for considering power in the sense of the flow of energy as it impacts on all the cells of the net assessment matrix used in security studies, the energy dimension would be seen as determining the other dimensions. Obviously, pursuit of this ecology-induced concept would necessitate fundamental changes in the intelligence community's philosophy and modus operandi. For they would have to supply to planners not only information about potential adversaries' military, technological, political and economic capabilities, but also about their interactions in the awareness of the systemic qualitative effects of incremental, quantitative changes in the subsystems' dynamics plus information descriptive of energy flows and power subsidies throughout the international arena.

To summarize, the perspective of ecology implies an understanding of national security from the viewpoint of the internal conditions of a society relative to nature as well as to the more conventional external threats as the key determinant of survival. Ecology superimposes, as Leider says, a deterministic matrix over the free conduct of international relations¹³⁶ (and we might add internal relations as well).

But incorporation of the ecological perspective in strategic thinking will be slow in coming. Recognition of its importance is a necessary but not a sufficient basis for so expanding the domain of strategic thinking. The traditional Weltanschauung will have to change first. In the meantime, the ecological perspective enters the international arena in more immediately disruptive ways. These should be of concern in even traditional net assessment activities and within the context of the dominant current world-view of strategic thinkers:

- The probability that the ecological issue may appear by choice as a novel tactic for securing political objectives.
- The issue may be the determinant of action.

When the issue is used in the service of traditional politics, strategic advantage comes to rest with the side that commands capabilities which the opposition cannot counter. As long as the Soviet Union views it as a political issue, the gains come easy against an adversary who declares it to be a sanitary problem. The recent history of the use by the Soviet Union of conferences on the environment to get East Germany, North Korea, and North Vietnamese seated offers a case in point: On nonideological fronts, many nations may add ecology and environmental concerns to their list of bargaining tools over strategic bases, shipping right-of-ways, and so on.

Ecology becomes more of a national security issue when used in the role of a determinant of strategic action in the face of population increases, resource decreases, and threatening pollution. This is especially true in the developing world.

One thing is clear. No matter what a nation's power, the introduction of the ecological issue snarls the pursuit of traditional objectives to a previously unknown degree. Yet there is no stopping or dropping out. Nations must continue to take care of the economic and security needs of their people, but at the risk of protest, unwanted concessions, retaliation or outright interference.

Ecology will assume full status as a determinant of international action when nations accept the ecology-dictated reality of the earth as a finite planet. In the foregoing sections some of the bits and pieces as collected by scientists leading to that acceptance have been alluded to. At that point there will be an increase in conflict opportunities because the actions that stem from environmental contacts and ecological fears lead so readily to the clash of national goals and objectives. In such a future context it seems obvious that for our nation to stay afloat in the unsettled years ahead, we will have to reach for strategies for which there is no precedent.

As Robert Leider concluded his very insightful and pioneering report prepared at the National War College:

If the development of nuclear weapons represented the start of one age, an increased consciousness of the environment, and its limits may be the beginning of another era. There are parallels. The awesome power of the bomb altered international relations in ways that had not been expected. While the bomb was fitted into national strategies, they, in turn, had to adjust to the presence of the bomb. The environment represents an infinitely more powerful--though perhaps not as dramatic--force for destruction than nuclear might. It is not too early to include it in our strategies and to think about how strategies, unwittingly, may be affected by its awesome presence.¹³⁷

3. Implications for U.S. Global Interests and Interactions With LDCs

Security planning depends upon ensured flows of energy and resource feed stocks. Protection of these flows is a primary global interest of the United States. These flows also connect us with the LDCs. The United States has about 5.8 percent of the world's population living on approximately 6 percent of the earth's land surface while consuming something like 50 percent of the world's resources.¹³⁸

Philip Hauser estimated that in 1950, with a world population of 2.5 billion, the total world production of goods and services would have supported only 500 million people at the U.S. level and 1.5 billion at the European level. If all of the world's present population were brought to the U.S. level, Brown and his associates estimated the following quantities of resources would be required:

18 billion tons of iron
300 million tons of copper
300 million tons of lead
200 million tons of zinc
30 million tons of tin
etc.

"These totals," Brown notes, "are well over one hundred times the present world annual rate of production." Furthermore, the required quantities of copper, lead, zinc, and tin "are considerably greater than could be removed from all measured, indicated, and inferred world reserves of these metals."¹³⁹ Considering the growth of our population and its standard of living, defense planners and Americans in general will be confronted by these pressures, as Preston Cloud points out, with the hard choice of limiting objectives and alternatives or continuing to import, "at increasing rates, the raw materials on which the underdeveloped nations might base their own industrial growth."¹⁴⁰ The supplying of materials for our burgeoning population, Congressman Henry S. Reuss observed, may be attempted "only at the risk of raiding the rest of the world."¹⁴¹

The population problem in the LDCs is exacerbating this situation. Ayres and Kneese share the rapidly growing belief that "if we fail to bring world population under control soon--very soon--humanity's future problem may be totally insoluble."¹⁴²

Such dire forecasts revolve around the probability that, as human society makes greater and greater demands on available resources, margin for error decreases. As it decreases, a more and more interdependent, elaborate and fail-safe organization is required simply to prevent the system from collapsing at the first perturbation. With recognition of this need we may evolve the necessary organizational forms. The elemental need to prevent catastrophic breakdowns may conceivably result in the development of rigidly structured, rather inhuman "1984" type of social system which subordinates individual talents, needs, or desires to the survival of the social organism as a whole. "Or else," as Ayres and Kneese conclude, "the world may 'solve' its otherwise insolvable problems by war, famine, or anarchy."¹⁴³

4. Implications of U.S./USSR Asymmetries in Dealing With Ecological Pressures

A complete exploration of the implications of relative U.S./USSR capabilities vis-a-vis ecological issues would entail a net assessment study incorporating those elements discussed earlier that would be dictated by the new perspective but that are excluded from current comparative analyses. Considering the dimensionality dictated by the ecological perspective, such a net assessment would have to involve a comparison of the National Intelligence Survey (USSR) with the currently nonavailable (at least in the United States) survey of the United States. In this short paper we will confine remarks in passing to a few of the more obvious asymmetries arising out of the foregoing literature review and concentrate on one which may be of fundamental and strategic, even if rarely considered, importance.

When ecology assumes full status as a determinant of international action, the contest between nations will become one to determine which nation has the best capabilities for absorbing pollution and for utilizing the world's unequally distributed wealth. It is the opinion of Leider, for one, that:

. . . its unique geography and centrally controlled political and economic system endow the Soviet Union with the potential to emerge as the winner. Its enormous land mass represents an absorptive capacity beyond that of any other nation. Its width and depth act as a titanic filter, with more air, soil, water, and vegetation than anywhere else to purge, cleanse, recycle, and regenerate pollutants. At the same time, the Marxist system can sidestep (though it has shown no inclination to do so) the concept of profits and growth--two elements of the capitalistic system that bedevil the best efforts for coming to grips with environmental decay.¹⁴⁴

Another source looking at asymmetries in the energy picture finds that:

The Soviet Union is perhaps the only industrial power without energy worries, despite a doubling of demand for power every eight years. Russian sources estimate that the country possesses 37 percent of the world's oil, 40 percent of the natural gas, 25 percent of the hydroelectric resources, 54 percent of the coal, and 61 percent of the peat. While many industrial nations are planning shifts back to coal, the Soviet Union is moving massively the other way; by 1975, it is expected that 67 percent of its energy will be derived from oil and gas, compared with 37 percent in 1960. The only shortage is that of nuclear fuel; hence the Russians are placing particular emphasis on the breeder reactor, which produces more fuel than it consumes.¹⁴⁵

From the discussion earlier about mineral resources, it would seem that, relatively speaking, the Soviets are fairly well off on that score as well. There is little that can be done to modify such natural

ecological asymmetries except via the costly, fragile, and dependency-fraught route of importations. There may, however, be a possible tool for manipulating such asymmetries, i.e., information and knowledge, as suggested by Lamberton¹⁴⁶ and McHale.¹⁴⁷ Therefore, this is the source of asymmetries where this exploration will concentrate.

Philosophically, the Soviets are as hell-bent for "big pictures" as we are against them. The evolutionary naturalism of Haeckel to which some initial remarks were addressed in this paper finds expression in contemporary Soviet strategic doctrine. But, in aspiring to a capability for "managing" the process of societal (exosomatic) evolution as discussed earlier, they go Haeckel one better. It would be well-nigh impossible to weigh such "philosophical differences" for asymmetries.

However, the organizations and processes contrived by the Soviets for reifying their "evolutionary" aspirations are more palpable. This can be seen at the microlevel in research on the evolutionary aspect of integration and bioenergetic processes,^{148&149} and in the rapidly expanding interest in such topics as mathematical models of bacterial population biophysics.¹⁵⁰ At the macrolevel, perhaps the outstanding example of their proclivity for integrated research activity in pursuit of their evolutionary aspirations is their cybernetic program which was mentioned earlier. This program, addressed from a common base to the scientific management of biological, military, legal, educational, social, economic and other complex, dynamic purposeful systems, is itself managed via techniques evolved by one in its family of related subfields, i.e., the "science of science."

This field is addressed to the integration and to the solution of what they see as the central problems in the management of science: increasing the efficiency of operating scientific systems, optimizing the increase in the scientific potential of the nation, and determining science strategy and policy. The science of science approach is used to solve these complex problems as shown in Figure 13. As shown in Figure 13, the science of science is not merely a complex of disciplines or even

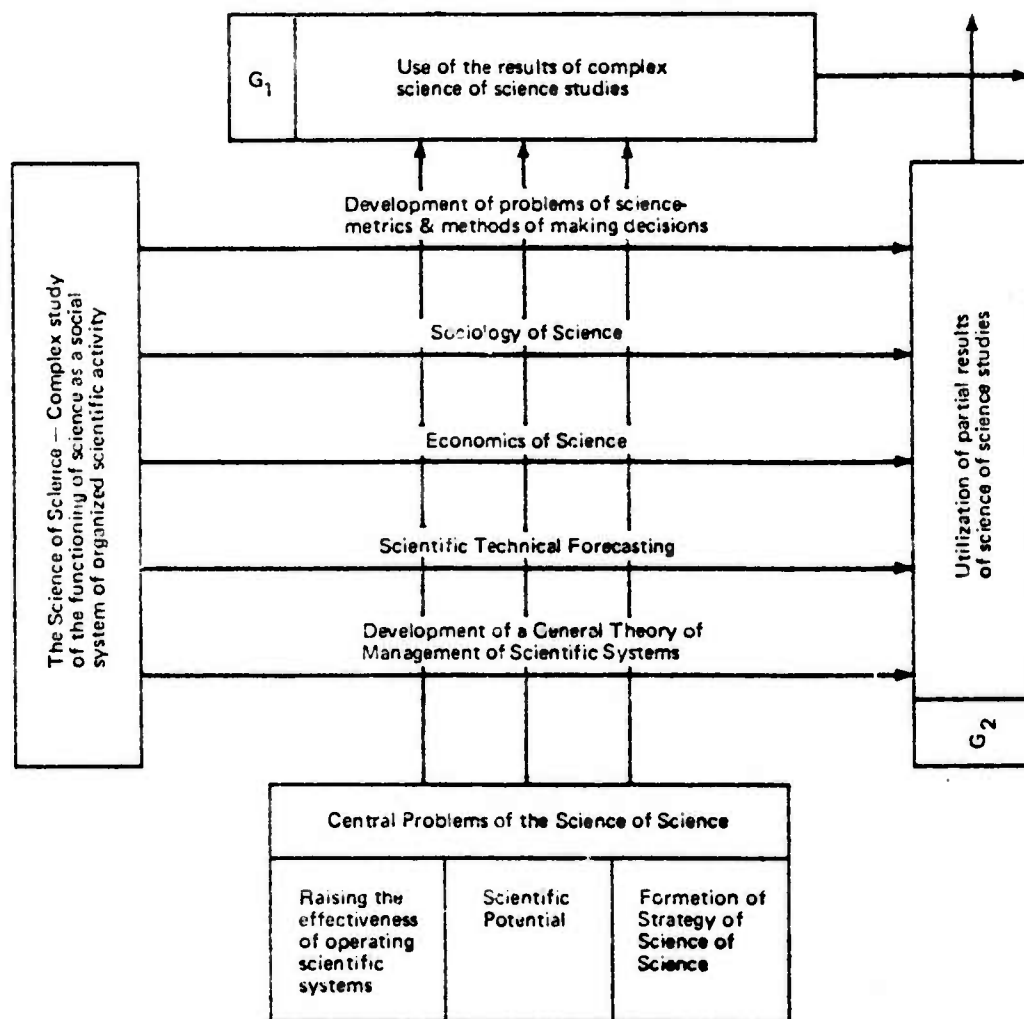


Figure 13 STRUCTURE OF THE COMPLEX RELATIONSHIPS OF THE SCIENCE OF SCIENCE*

* G. M. Dobrov, "The Science of Science", Technology Assessment, Vol. 1, No. 3, 1973, Fig. 4, p. 198.

a synthesis of information from various disciplines. Rather, it is a science like its parent, cybernetics, which emphasizes study of the process, the interactions of the various elements which determine the development of science as a complex system.¹⁵¹

This somewhat tendentious example of one class of Soviet approaches to the holistic study of the "structure and function of nature" is not offered as evidence of a U.S./USSR asymmetry in dealing with ecological problems. Rather, it is offered to convey some notion of the less obvious factors one must consider in the calculation of relative capabilities.

Then, too, there is another and ultimately more important reason for the discussion here of this and other metaissue-related organizational implications of ecology. The foregoing literature review tells of the finitude and uneven distribution of resources, the depletion of free energy sources, and of an exploding world population with growing appetites for those fixed supplies. Ecological reality seems thus to be a determinant of action in international security affairs in the ultimate sense of species survival.

But ecology in broad perspective also holds out a less dismal scenario. In response to perceived environmental challenges, some species are able to evolve into higher order forms by adaptation of structures and functions. Some have failed. De Chardin and other authors surveyed in this paper suggest that societal organisms may also evolve if their ecosituation is correctly perceived and if the adaptive responses thereto are appropriate. For this reason, world-views and organizational and process questions have been accorded equal status in this study with the usually treated pressures on international economic and national security issues. For they are the bases for asymmetry evaluations with the greatest implications in terms of social evolution. They also are among the few features in the ecological drama over which we can, if we will, exercise some influence.

Appendix

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Appendix

REFERENCES

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