Environmental Science

Challenge for the Seventies

NATIONAL SCIENCE BOARD
1971

Environmental Science

Challenge for the Seventies

REPORT OF THE NATIONAL SCIENCE BOARD

NATIONAL SCIENCE BOARD
NATIONAL SCIENCE FOUNDATION
1971

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 40 cents

LETTER OF TRANSMITTAL

January 31, 1971

My Dear Mr. President:

It is an honor to transmit to you this Report, prepared in response to Section 4(g) of the National Science Foundation Act, as amended by Public Law 90-407, which requires the National Science Board to submit annually an appraisal of the status and health of science, as well as that of the related matters of manpower and other resources, in reports to be forwarded to the Congress. This is the third report of this series.

In choosing environmental science as the topic of this Report, the National Science Board hopes to focus attention on a critical aspect of environmental concern, one that is frequently taken for granted, whose status is popularly considered to be equivalent to that of science generally, and yet one whose contribution to human welfare will assume rapidly growing importance during the decades immediately ahead.

The National Science Board strongly supports the many recent efforts of the Executive Branch, the Congress, and other public and private organizations to deal with the bewildering array of environmental problems that confront us all. Many of these problems can be reduced in severity through the use of today's science and technology by an enlightened citizenry. This is especially true of many forms of pollution and environmental degradation resulting from overt acts of man. Ultimate solutions to these problems, however, will require decisive steps forward in our scientific understanding and predictive skills, and in our ability to develop the wisest control and management technologies.

There is in addition a much larger class of environmental phenomena with enormous impact, today and in the future, on man's personal and economic well-being. These phenomena extend from fisheries to forests. They include the natural disasters of hurricanes and tornadoes; earthquakes and volcanoes; floods, drought, and erosion. They encompass problems in the conservation of our

resources of water, minerals, and wildlife. Included too are the more subtle effects of civilization on weather and climate, as well as many forms of natural pollution, such as allergens, environmental pests and diseases, and volcanic dust. Together, these phenomena share a common characteristic: they can be fully understood, predicted, and modified or controlled only by studying them in terms of the complex environmental systems of which they are a part. Such studies, however, have become possible only in recent years. Greatly expanded efforts will be required to understand the forces involved in the confrontation between man and his natural environment.

This Report is presented as a contribution to the decisions that need to be made if environmental science is to become a fully effective partner in society's efforts to ensure a viable world for the future.

Respectfully yours,

H. E. Carter

H. E. Carter
Chairman, National Science Board

The Honorable
The President of the United States

ACKNOWLEDGMENTS

The National Science Board wishes to express its appreciation of the generous contributions made by many individuals and organizations during the course of this study.

Especially valuable assistance was provided by Dr. Julian R. Goldsmith (University of Chicago), a former Member of the National Science Board and a special consultant to the Board Committee charged with the responsibility for preparing the draft of this report. Important help was also given by several other consultants, including Dr. Louis J. Battan (University of Arizona), Dr. John E. Cantlon (Michigan State University), Dr. Roger Revelle (Harvard University), and Dr. Gilbert F. White (University of Colorado).

Special mention should be made of a sixth consultant, the late Dr. Wilbert M. Chapman (Ralston Purina Company) who served with distinction until his final illness. The Committee was fortunate in being able to benefit from Dr. Chapman's great knowledge and experience, as well as his good humor and enthusiasm.

Several individuals helped greatly during the planning stage of this study. They include Dr. Edward A. Ackerman (Carnegie Institution of Washington), Dr. Walter M. Elsasser (University of Maryland), Mr. Joseph O. Fletcher (The Rand Corporation), Dr. Leon Knopoff (University of California at Los Angeles), Dr. Thomas F. Malone (University of Connecticut), Dr. H. W. Menard (Scripps Institution of Oceanography), Dr. Brian J. Skinner (Yale University), Dr. Norbert Untersteiner (University of Washington), and Professor Abel Wolman (Johns Hopkins University). Important advice and counsel were also given by Dr. Robert A. Ragotzkie (University of Wisconsin at Madison) and Dr. John F. Reed (University of Wisconsin at Green Bay). Thanks are also due to Dr. George Van Dyne (Colorado State University) for furnishing an ecosystem diagram from the International Biological Program, to Dr. Allan Cox (Stanford University) for information on the earth's magnetic field reversals, and to Dr. Frederick G. Shuman (National

Meteorological Center) and Mr. David S. Johnson (National Environmental Satellite Center) for extremely helpful discussions.

The Board is particularly indebted to many persons on the staff of the National Science Foundation. Special credit should go to Dr. Lawton M. Hartman (Special Assistant to the Director) who served as Executive Officer for the study. Others who provided notable help are Dr. Eugene W. Bierly (Program Director, Meteorology) who served as Staff Associate during a large part of the study, Dr. Charles F. Cooper (Program Director, Ecosystem Analysis), Mrs. Josephine K. Doherty (Associate Program Director, Ecosystem Analysis), Dr. John L. Brooks (Program Director, General Ecology), Dr. Dirk Frankenberg (Program Director, Biological Oceanography), Dr. William E. Benson (Head, Earth Sciences Section), Dr. Milton Levine (Study Director, National Register of Scientific and Technical Personnel), and Mrs. Lois J. Hamaty (Administrative Assistant, Office of the Director).

In addition the Board is grateful for the help of the National Academy of Sciences — National Research Council, the American Geophysical Union, the Ecological Society of America, the 1970 summer Study of Critical Environmental Problems (SCEP) sponsored by the Massachusetts Institute of Technology, the National Oceanic and Atmospheric Administration, and many others.

Finally, important contributions to this study were prepared by approximately 150 scientists, representing a significant sample of the intellectual leadership of environmental science. These individuals are identified at the end of the report. A second report, *Patterns and Perspectives in Environmental Science,* will be based on their contributions and issued separately as a Report to the Board.

Although the Board is privileged to thank these distinguished persons and organizations for their interest, help, and cooperation, it is essential to note that the synthesis of the opinions and voluminous information received, their interpretation, and their use in arriving at the conclusions stated in this report are the responsibility of the National Science Board.

Summary and Recommendations

Modern civilization has reached the stage where, henceforth, no new use of technology, no increased demands on the environment for food, for other natural resources, for areas to be used for recreation, or for places to store the debris of civilization, can be undertaken to benefit some groups of individuals without a high risk of injury to others. No environmental involvement of man can any longer be regarded as all good or all bad. Problems can be mitigated, but absolute solutions are probably unattainable. The best that can be sought, therefore, is to optimize, to try to achieve the wisest cost-benefit decision for society for each action contemplated. Such a strategy requires a strong base of scientific knowledge and understanding of the environment, ability to predict reliably its future course, and, especially, the ability to construct models through systems analysis of the environment and of man's interaction with it on a scale never previously achieved.

It is within this perspective that the present status of Environmental Science has been examined. **Environmental Science is conceived in this report as the study of all of the systems of air, land, water, energy, and life that surround man. It includes all science directed to the system-level of understanding of the environment, drawing especially on such disciplines as meteorology, geophysics, oceanography, and ecology, and utilizing to the fullest the knowledge and techniques developed in such fields as physics, chemistry, biology, mathematics, and engineering.** Included, therefore, are such diverse matters as climate, air turbulence, the air-sea interface, estuaries, forests, epidemics, earthquakes, and groundwater. These environmental systems contain the complex processes that must be mastered in the solution of such human problems as the maintenance of renewable resources (water, timber, fish), the conservation of non-renewable resources (fuel, metals, species), reducing the effects of natural disasters (earthquakes, tornadoes, floods), alleviating chronic damage (erosion, drought, subsidence), abating

pollution by man (smoke, pesticides, sewage), and coping with natural pollution (allergens, volcanic dust, electromagnetic "noise").

Environmental Science is now exceedingly vigorous, considered in relation to its development over many centuries. Notable advances are being recorded at an accelerating rate. New tools and techniques, borrowed from all of science and technology, are being brought to bear on the problems of observation, measurement, and analysis. Across all of environmental science there is a heightened awareness of the essential nature of the environment and the directions that scientific effort should take. Nevertheless — and it is the principal conclusion of this report —

> Environmental science, today, is unable to match the needs of society for definitive information, predictive capability, and the analysis of environmental systems as systems. Because existing data and current theoretical models are inadequate, environmental science remains unable in virtually all areas of application to offer more than qualitative interpretations or suggestions of environmental change that may occur in response to specific actions.

There are two primary reasons for this state of affairs. One involves the nature of environmental science itself, the other the resources available for its advancement.

(1) The natural environment is not a collection of isolated events and phenomena, but rather a vast, integral, mutually interacting system. The recent advent of new technology and technique (satellites, advanced computers, instrumentation of many types, and the methods of systems analysis) for the use of environmental science has, indeed for the first time, provided feasibility for attacking the scientific problems that this environmental system presents. The tasks ahead, however, are of unprecedented magnitude and difficulty.

(2) The trained scientific manpower available to meet this challenge is extremely limited in each of the essential aspects of environmental science. More serious is the fact that this manpower is spread exceedingly thin, both with respect to the manifold problems presented and to the institutions within

which research is conducted, new scientists are educated, and scientific results are applied to the solution of problems of the public interest. Indeed, the institutions of environmental science, as here defined, remain in an early stage of development.

This situation constitutes a crisis for the Nation. While environmental problems are so diverse and diffused that virtually every activity of civilization interacts with the environment, few persons can be aware of the full scope of challenge that lies ahead. The current mismatch between capability and need is at least comparable to any other challenge to science and technology that was encountered during this century.

To meet this situation the National Science Board offers five groups of recommendations:

1. NATIONAL PROGRAM

Several factors emphasize the urgency of establishing a national program for advancing the science of environmental systems: (a) New organizations formed at the highest level of the Federal Government, the Council on Environmental Quality and the Environmental Protection Agency, have been charged with responsibilities that include the assessment of the environmental impact of civilized man. These agencies must foresee secondary effects and compare quantitatively the multiple consequences of alternative courses of action. Such efforts are severely limited by the present level of understanding of the behavior of environmental systems. They would become progressively more feasible as advances in environmental science increase man's predictive power. (b) The use of energy and the processing of material by man are doubling every 14 years.* Correspondingly, the number and severity of environmental problems will increase, while the adequacy of *ad hoc* piecemeal expedients will decrease. (c) As population grows, and with it the artifacts of civilization, the human and economic losses due

*Both activities have shown 5% average annual growth rates for the last 20 years, as reported in *Man's Impact on the Global Environment: Assessment and Recommendations for Action,* MIT Press, Cambridge, Mass., 1970. The total consumption of fossil fuel in the United States also grows about 5% per year; the conversion of an increasing fraction of fossil energy to electrical energy leads to a higher annual growth rate in the utilities.

415-536 O - 71 - 2

to sporadic natural disasters, already great, will increase in scale. (d) At the same time, the intensification of man's needs for both renewable and non-renewable resources requires even greater manipulation and mastery of the natural and man-made systems that constitute the environment.

It is, therefore, recommended that this urgency be recognized through the early development of a comprehensive national program to expedite the progress of environmental science.

The problems with which environmental science must deal, however, do not respect local, State, or even national boundaries. It is thus further recommended that this national program explicitly provide for the essential Federal role in encouraging and supporting the work of environmental science, quite apart from the role the Federal Government is already exercising with respect to improving and protecting the environment (e.g., programs of soil conservation, sewage treatment, air and water pollution control, etc.). Both nationally and in matters of international cooperation the Federal Government must assume leadership in fostering scientific advance.

This national program should be based on three efforts:

(1) Emphasis should be given to projects, manned by coordinate teams, directed to intermediate scale or "mesoscale" problems, that is, problems on the scale of lakes and estuaries, urban areas, regional weather systems, and oceanic fisheries. Advances on this scale will provide immediate benefits to man.

(2) At the same time, the program must ensure continued effort on global problems, even though their solution may require the resolution of smaller scale issues. In the long run it is the global constraints that will shape and delimit the future development of civilization.

(3) Finally, the program should ensure the continued vigor of those aspects of disciplinary research and graduate education needed to provide the specialists and new knowledge required for environmental science.

The remaining recommendations form an important part of the total recommendation of a national program. The entire program should be established at the earliest practicable date, if progress during this decade and its culmination during the following decades are to be commensurate with the urgency now faced.

2. PRIORITIES

One of the inescapable conclusions of this report is that the number and complexity of scientific problems, both theoretical and experimental, that confront environmental science far exceed the capability of available manpower to attack all of them effectively at the same time. If these resources remain distributed as they are, scattered and fragmented, and if problems to be solved are selected largely on the basis of the perceptions of individuals or small isolated groups, progress in environmental science cannot meet the needs of expressed national goals and purposes.

Accordingly, it is recommended that early consideration be given to strengthening arrangements whereby priorities for environmental science can be set, matched to existing and required scientific and engineering manpower, and changed as circumstances warrant. In setting such priorities appropriate weight must be given to the feasibility of achieving scientific solutions in a reasonable time and to the social and economic costs and benefits that could accrue if solutions were attained.

3. ORGANIZATION FOR ENVIRONMENTAL SCIENCE

The scope encompassed by the national program, proposed above, the Federal role inherent in this broad effort, and the patent need for establishing priorities raise serious questions of the adequacy of present arrangements within the Federal Government for planning, coordinating, managing, and reviewing programs of environmental science. As for all science, environmental science

today is the responsibility of many agencies, often with conflicting interest under differing agency missions and responsive to many Congressional committees. At the same time the problems to be solved are broader, more difficult, and more dependent upon the coordinated use of scientific resources than those faced in the earlier development of nuclear energy, radar, and space exploration.

For these reasons, it is strongly urged that the Federal responsibility for environmental science, and for its promotion, organization, and support, be considered as important as the corresponding but separate responsibility for environmental quality. In particular, arrangements for Federal decision-making must be especially effective for the following activities:

(1) The setting of priorities affecting all research and development in environmental science supported by the Federal Government.

(2) The determination of appropriate and feasible time schedules for the projects of the national program and ensuring that projects are managed in accordance with such schedules.

(3) The provision of full coordination of the efforts of all Federal agencies engaged in the support or performance of research in environmental science, quite apart from efforts in application or regulation.

(4) The establishment of organizational and employment incentives suitable for the types of projects that are characteristic of environmental science through the support of national centers and specialized institutes.

(5) The encouragement of State and local governments and private supporting organizations to subscribe to the national program, as it is developed, and to the pattern of priorities adopted.

With respect to the organizations where the work of environmental science is done, several considerations are of the greatest importance.

Environmental science, as defined in this report, should be viewed as a distinctive type of activity lying between the extremes of traditional, basic science, on the one hand, and the organizations established by society for the application and use of science and technology. It shares the scientific motivations of the former and the multidisciplinary and organizational complexity of the latter.

Various types of organizational structures should thus be attempted, as experiments in the management of environmental science. Two conclusions are especially important:

(a) In academic institutions, which employ two-thirds of the manpower in environmental science, the need for strong departmental structures has historically hindered the development of effective interdepartmental programs. Within the last few years, however, new capability and experience in systems management, often combined with central funding for complex problems, have given a new vitality to multidisciplinary efforts. A few research institutes and national laboratories have also begun ambitious multidisciplinary studies of environmental problems. These experiments in organization should be continued, expanded, and followed closely.

(b) Industry possesses great capability in systems analysis and systems management, but rarely offers the broad array of scientific competence needed in environmental science. Government has additional strengths, particularly in the application of environmental science to environmental management. A more effective use of these resources can be made by combining the talents of industry, government, and universities in new types of research organizations and by seeking new approaches to the management of environmental science.

4. FUNDING FOR ENVIRONMENTAL SCIENCE

If progress in environmental science is to be made at an acceptable rate it is essential that additional manpower be made available

both through education and through transfer from other fields and activities. This will occur only if appropriate employment opportunities and incentives are provided. The **character** of funding is especially important to this end.

In addition to the opportunity provided by new types of organizations, as recommended above, provision should be made for continuity of funding of programs of environmental science as being one of the principal means for attracting the best talent.

It is further recommended that the funding of equipment, facilities, and logistics for environmental science be consistent with scientific needs and opportunities. The highest priority should be given to the needs of multidisciplinary teams engaged in the study of environmental systems.

5. DEVELOPMENT OF ADDITIONAL MANPOWER

While it is essential that the disciplinary strength of academic institutions be maintained and increased across all fields of science, these institutions also have a responsibility specifically with respect to the manpower of environmental science.

Although competent specialists transferring from related disciplines can constructively enter fields of environmental science through on-the-job training, the process can often be faster and more effective if retraining opportunities are available within the educational context. Hence, it is recommended that colleges and universities consider appropriate means for supplementary education in environmental science for scientific and technical personnel.

Of special importance to implementing a national program for environmental science is the existence of an informed citizenry, both as a source of future scientists and as the necessary basis for national understanding and motivation of the entire program. The colleges and universities thus have a special opportunity to contribute by

the development of new curricula in which to present the perspective of environmental science, as well as of new courses and programs, especially directed to the undergraduate.

Manpower needs related to environmental science are not confined to the scientists, engineers, technicians, and others who contribute to scientific progress. As environmental science advances, there will be an increasing need for "natural resource administrators" to serve in local, State, or Federal governments. The education of these public administrators involves two types of interdisciplinary training. On the one hand, scientists and engineers must gain a better understanding of the social, economic, legal, and political environment within which practical action must be sought. On the other hand, students of public administration must gain a better perception of the scientific process and a better understanding of how scientists can contribute effectively to the practical solution of environmental problems. It is recommended that substantial and adequate funding be made available for these purposes.

Even with the implementation of these recommendations only gradual progress can be anticipated. Environmental science is too difficult, too broad in scope, and too near the beginning for an effective match with societal need to be achieved during this decade. But, correspondingly, the stakes are too high to miss the opportunity for making the 1970's the base on which a constructive future for mankind will be established.

CONTENTS

415-536 O - 71 - 3

Introduction

This is a report on the status of a part of science. Frequent references within the report to the environment, to environmental problems, and to human welfare establish the relevance of the science, but in no sense is this a report on the status of these areas.

Many recent reports and a flood of legislation, proposed or enacted, reflect the growing national concern over the present or future state of the environment. Many reports have also been prepared to review the condition of various parts of what has been termed the "environmental sciences" and to recommend appropriate actions. It is the conclusion of the National Science Board, however, that there is yet another message related to the environment, one that has failed to date to receive the attention and discussion that it deserves, and one that is especially timely today. This message consists of two parts, a proposition and a question:

The proposition. — Although early naturalists saw nature as a whole, the natural environment has been increasingly viewed as a heterogeneous ensemble of more or less independent parts—the sky, the oceans, the dry land, . . . Inhabiting this complex array and supported by it were the living things, each following a "dust to dust" trajectory and carrying with it a sense of being separate and apart. Scientific study of these parts, abetted by the disciplinary traditions and departments of academic science, retained the separation and gradually led to many fields of inquiry, including those known by the recent expression "environmental sciences." One of the most important trends of recent years, however, and one that is shared more and more by the general public, is the developing recognition that the environment is in fact a single entity, a gigantic system. It includes the radiations and tidal influences arriving from the outside, the solid earth, the envelope of air and water, and life itself, and must be described in terms of its relationships and interactions as well as its individual components. Such an approach crosses the boundaries between disciplines,

bringing to bear whatever science is available and useful in studying one aspect of the environment. Hybrid fields such as geochemistry, cloud physics, and bioclimatology have emerged. Although the traditional disciplines remain relevant and necessary to the continued study of natural processes, it is their coherence rather than their identity that is useful in the study of environmental systems. For this reason the plural term "environmental sciences" is avoided in this report. In its place it is proposed to examine the status of

> ENVIRONMENTAL SCIENCE, defined here as the study of natural processes, their interactions with each other and with man, and which together form the earth systems of air, land, water, energy, and life.

It is this emphasis on the systems and subsystems, tying together the myriad elements of the physical world, that distinguishes environmental science from science as a whole. Of those engaged in research, development, and teaching in the natural sciences, however, only six percent of the doctorates and seven percent of all scientists are working in the disciplines most central to the study of environmental systems. Another ten percent work in related supporting areas and in applications of environmental science.

The question. — In recent years the environment, and especially its quality in relation to human welfare, has become a focus of public concern that has approached climactic proportions. At Federal, State, and local levels this concern has produced a number of action programs and restrictive regulations, all designed to ameliorate a situation that many have only recently recognized. The issue is seen to be a matter of an increasing rate of deterioration resulting from man's intervention. Since science provides information and concepts, increased options, and predictability that can contribute to informed public opinion and sound action programs, the question arises:

> To what extent does environmental science today possess the basic knowledge and understanding needed to help resolve problems of the public interest, to provide an objective basis for the setting of public policy and programs, and to anticipate the effects of increasing demands of population and industry upon an irreplaceable and vulnerable resource?

This report, therefore, is addressed to the status of environmental science, without primary regard for disciplinary subdivision, and to the issues that arise, as a matter of public policy, and that relate the contribution that science can make today or in the future to this aspect of the quality of life. Correspondingly, **the concern in this report is not with the state of the environment, nor with the state of the disciplinary structure of environmental sciences, but rather with the state of Environmental Science as a whole in 1970, in its relation to this important endeavor, and with the steps that need to be taken if it is to match the challenge that confronts it.**

The Board is aware that many important problems, such as the removal of sulphur from smoke, the recycling of industrial wastes, and the protection of open space, can be solved with technology and institutional change. The exclusion of these problems here should not be misunderstood; the Board agrees with the emphasis they have received in other reports and in social and political action. The emphasis here is on a class of problems whose solutions are much more difficult to achieve, in the sense that they require advances in the science of environmental systems as well as technology and institutional change.

Essential to the important service that environmental science can provide is the determination and willingness of society to establish the priorities and support the institutions that are necessary for the translation of environmental science and technology into sound political action and public decision. Although study of the social dimension of environmental science was deemed, for practical reasons, to be beyond the scope of this report, it is fully recognized that social judgments and political decisions are implicit in any evaluation of the adequacy of scientific programs and in the assessment of policy needs and action. The social and managerial sciences have a central role in the task of building a stable, healthy, and happy environment within which man can look to a constructive future. It is thus of the greatest importance that research in the social and managerial sciences be coupled with that in the natural sciences to the end that knowledge and understanding will be used effectively and wisely.

In arriving at the conclusions contained in this report, full consideration has been given to important contributions that have been prepared by a large segment of the scientific leadership of environ-

mental science. This voluminous material forms the basis of a second report, *Patterns and Perspectives in Environmental Science*, to be issued separately.

The Past Decade – Expanding Horizons

The period of the 1960's was unique in the history of American involvement — emotional, intellectual, and technological — with the natural environment. **It was a period of transition.** The previous era of individual opportunity to exploit continued to be replaced by one of increased public responsibility, and indeed necessity, to conserve. **It was a period of preparation.** New tools, concepts, and procedures emerged that would ultimately form a powerful supplement to methods used for generations in man's efforts to observe and understand the complex world about him. And **it was a period of promise,** for it marked a new threshold in man's capacity to view his total environment in perspective, to live with it, and to manage his interactions with it more wisely.

PUBLIC PERCEPTIONS

In the 1900's Americans were deeply aroused by dwindling forest and mineral resources, and they established large-scale conservation programs. In the 1930's they acted dramatically to halt erosion and to provide better management of their waterways. In the 1960's the citizen became acutely aware of other instances of the deterioration of his environment and of real or imagined dangers for the future, of the dirty habits of many of his fellowmen, of the loss of aesthetic values for large segments of his environment, of the finite nature of many of the resources he must depend upon, and in a general way of the potential irreversibility of much that he is doing in the name of civilization.

The citizen became cognizant, for the first time as a member of society, that the technology he had created had the potential to place him in jeopardy: the automobile, although he had experienced smog before; the power plant, although the problems of sulfur oxides are not new; the factory, although industrial wastes had

long degraded the Nation's streams. He recognized the urgent need for sewage treatment plants, although eutrophication of lakes had already destroyed fisheries. The idea was new that the city was altering his weather, or that pesticides could kill hundreds of miles from the site of application. How much of this increased awareness has been due to more rapid environmental change, to deeper dissatisfaction with the state of society, or to heightened sensitivity as a byproduct of affluence is not clear.

To attempt to offset the unfortunate trends that seemed to threaten the citizen from all sides, a new effort was initiated, together with a new expression, *technology assessment,* through which the effects of technology can, in principle, be anticipated, thereby avoiding unwanted consequences. This ambitious design, however, can only succeed when environmental science, through fact and scientific understanding, can provide a sound basis for such assessments.

The concerned citizen often has parochial interest, and he demands quick action. This leads to the selective solving of environmental problems that are local and often straightforward. Many individuals lack a sense of personal involvement in large-scale problems to which they may be contributors: the growth of the world's population, the precarious balance between people and food supply, the implications of *per capita* economic growth, and the growing gap between developed and developing nations. Similarly, the public has only a vague awareness of the need for a much greater capability to predict changes in the complex systems that relate man to his environment.

SCIENTIFIC PERCEPTIONS

The outlook of the scientist, to the extent that he differs from other citizens through training and experience, has followed a somewhat different course. For years he has been conscious of interactions among many aspects of the environment, of the "subsystems of the universe." In fact, the view that many parts of the environment, especially those that affect man, are the result of gigantic confrontations involving natural forces has been held both by scientists and their early counterparts from the beginning of man's history. The 1960's, however, marked a distinctive period in three important respects.

(1) The physical extent of the environment, in the sense of including all parts of nature that interact with man, expanded to encompass the entire universe. Two extreme examples would include:

> Processes occurring in the far reaches of space, discovered through astronomy and radio astronomy but still little understood, generate cosmic radiation that in turn is continuously causing gene mutations in living things on earth, including man.
>
> In the earth's central core other processes, also poorly understood, produce the magnetic field, familiar to man for centuries as a means for navigation. Less familiar are recent findings that the effects of solar disturbances on the earth's atmosphere (and therefore man's immediate environment) may be modified and influenced by this magnetic field.

From the center of the earth to the distant galaxies the physical universe, in a most important sense, is congruent with the natural environment. The differences between environmental science and all natural science are primarily those of viewpoint and method, leading in turn to differences in the phenomena to be studied. These phenomena are illustrated in the following sections.

(2) A distinction between the environment and the universe arises from the focus on man, and has attained broad recognition only in recent years. For centuries the major efforts in science, in most of its branches, have been directed to the discovery of the building blocks of nature, to securing an understanding concerning how these building blocks behave and what they are made of, and to the generation of a theoretical structure of natural law and its validation. This effort, a continuing one to be sure, has been enormously successful. Apart from forming an essential ingredient of the intellectual heritage of mankind, this body of science has made possible the explosion of technology that has resulted in the advances in standard of living and human health enjoyed in many nations today.

In contrast, science of the environment is of a different character. An element of the environment is not a matter that can be studied successfully or completely in isolation. Neither does it represent natural laws that differ from those that science generally has sought. Indeed the emphasis in environmental science is now seen to be

415-536 O - 71 - 4

necessarily placed on the ways in which many elements relate to each other and synergistically produce the kinds of phenomena with which man must cope. The following examples are illustrative:

Weather and climate are continually varying and infinitely complex phenomena that combine radiation from the sun, heat from deep in the earth, and radiation into space, all of these altered by absorption, reflection, and scattering in the atmosphere, and including the effects of clouds and particulates; reflection to various degrees from the surfaces of water, vegetation, and land; evaporation and the transfer of heat from water and land and the similar effect of transpiration from plants; temperature differences between the tropics and the poles; the orbital movement of the earth about the sun and the effect of the earth's inclined axis; and many others.

Solid rock, made "plastic" under extreme pressure and temperature, rises from the earth's mantle in gigantic convective currents, sometimes melting and forming lava, emerges from mid-ocean ridges to form enormous "plates" that may produce mountain ranges when they collide, and that generate earthquake prone regions or deep trenches when one plate dives beneath another. The demonstration of this process of seafloor spreading and continental drift in what we now know to be a "living" dynamic earth is one of the revolutionary achievements of science during the 1960's.

The finite life of seafloors leads to the concept of geological cycling on a very large time-scale, ocean sediments eventually being returned to the continental masses or to the earth's mantle. This geological cycle interacts with the much faster ecological cycle of organic production and decay. A small portion of organic production is buried each year in the sediments, and accumulates over the millions of years that seafloors persist. Each year a small amount of organic matter is folded into the mantle or lower crust, burned, and expelled as volcanic gas. This interaction of geologic and ecologic cycles is part of the process that regulates the amounts of carbon dioxide and oxygen in the atmosphere.

Interactions of a different character produce great cyclonic storms. For example, atmospheric disturbances having an unknown origin, apparently near the east coast of Africa, traverse the Atlantic and somehow intensify into hurricanes. The hurricanes themselves simultaneously involve the interaction of large scale tropical weather systems, intermediate scale cyclonic behavior, and small scale interactions between atmosphere and ocean. The resulting hurricane forms an essential mechanism for the transfer of heat from tropical to temperate latitudes, brings needed rainfall to many areas, and causes unneeded destruction to human life and to structures that man has created.

Also complex are the interactions that result in oceanic food resources (Figure 1). They include the transport of warm water on the surface of the sea through the action of atmospheric winds, its replacement by cold bottom water with its dissolved nutrients, with the warm water cooling and sinking as it approaches the polar regions to repeat the cycle. Also involved are the growth of microscopic plants in the surface layers resulting from this process of "upwelling," with the simultaneous action of solar radiation, water, nutrients, and carbon dioxide present in the water or entering from the atmosphere, and then a complicated array of food chains as small animals prey upon the plankton, small fish prey upon these small animals, and so on until the process culminates in the fish that man habitually eats. In this process it is now recognized that the populations of the lower species of these food chains are substantially controlled from the top through predator-prey relationships, a reversal of views that were held only a decade ago. Finally, the resources contained in the bodies and wastes of all living things are eventually decomposed by bacteria and other organisms, thus releasing these resources for further use.

(3) The method of approach to investigation emphasizes another distinction between the efforts of traditional science and those of environmental science. It is in a sense analogous to systems engineering, defined by tools, techniques, and procedures which proved their power in major technological developments during and since World War II. There has been a broad effort to bring these methods to bear across almost the entire field of environmental science. This circumstance forms a distinctly new departure in the search for scientific knowledge and understanding.

NOTE TO FIGURE 1

The distribution of the world's fisheries. The four figures of this report represent four different kinds of situations in environmental science. In this case, the final output of the system is a clearly identified resource, obtained primarily from the coastal oceans. Much less clear are the future responses of this system to exploitation, and the future opportunities that may derive from a better understanding of the system. One critical factor is the *total* fish production of the oceans, which has recently been estimated to be only four times greater than the 1968 catch, for corresponding species. Another is the vital role played in estuaries and along coastlines, where pollution threatens the nurseries of many commercial species. A third is the role of upwelling, as discussed in the text. Weather is important to the success of fishing, and further improvements in local weather forecasting await a better understanding of larger scale meteorological phenomena. Altogether, the systems of air, water, and life are intimately interwoven in the production of fishery yields.

LEGEND

COASTAL AREAS—About 50% of Global Commercial Harvest

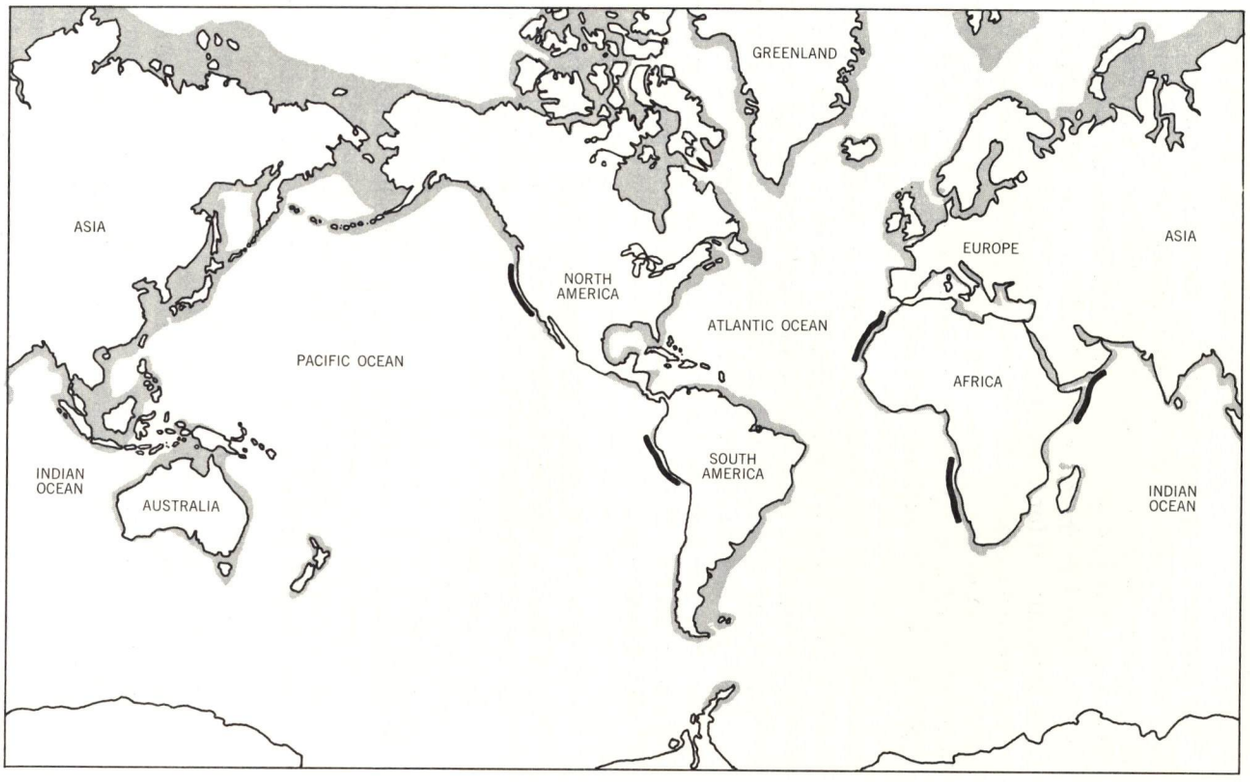
UPWELLING AREAS—About 50% of Global Commercial Harvest

Less than 1% of Global Commercial Harvest

Prepared by the National Science Foundation

Figure 1

DISTRIBUTION OF THE WORLD'S FISHERIES



TECHNOLOGY FOR ENVIRONMENTAL SCIENCE

The advances of the last decade — a maturing of concept, a shift of perspective towards the systems aspects of the environment, and a determination to attack scientific problems of a diversity and complexity that had not previously been attempted — have been directly related to the advent of significant new technology. New types of equipment for measurement and data-gathering, communication, and data analysis have marked a giant step forward in the ability of environmental scientists to handle environmental problems. Much of this equipment is well-known, as are many of its applications. Major examples include:

A variety of instruments developed in other fields have enormously expanded our sensitivity to the environment, enabling us to identify, trace, and otherwise evaluate an extraordinary array of phenomena. Included here are mass spectrometers, gas analyzers, X-ray diffraction apparatus, electron and ion microprobes, radioactivity counters, particle counters, amino-acid analyzers, chromatographs, and scanning electron microscopes.

A variety of satellites, including those for the study of the solar surface and the space between the sun and the earth, the series of operational meteorological satellites and those developed especially for atmospheric research, the planned satellite for the study of the earth's resources, communications satellites to contribute to global data handling, and "stationary" satellites operating at synchronous altitude, taken together, have provided an enormous and expanding capability for observations on a global scale, a capability that is entirely new in the history of man's attempts to understand his environment.

Automatic data-handling equipment provides central filing or display from sensors of all kinds located, for instance, on mountain tops, lake bottoms, trees, bears, whales, birds, or airplanes. Remote sensing includes the use of Doppler and other ultra-sensitive radars, acoustic "radars," and the first application of laser "radars" in meteorology and seismology, and the expanded use of infra-red and multi-spectral sensors in studies of vegetation, land, atmosphere, and water surfaces. Data gathering has been coupled with data processing, and in one major international study of marine upwelling the entire complex has gone to sea.

Special mention should be made of the development of new types of deep sea drilling techniques and their use on the unique, prototype vessel, *Glomar Challenger*. This facility has brought to light in only a few years information that has literally revolutionized man's understanding of physical processes occurring in the earth's crust.

The rapidly increasing volume of data about the environment has brought with it the opportunity to study for the first time the systems aspects of many features of the environment. This effort is being made through the use of mathematical modeling and simulation techniques and their attempted application to the solution of environmental questions. The development of this technology is essential if satisfactory answers to many of the problems of current public concern are to be found.

This technology implies another, for the enormous computational complexity represented by environmental systems has required the increasing use of larger, faster, and more powerful computers. Of special significance may be the development of the parallel processor computer to replace sequential operations by simultaneous operations on vast amounts of diverse input data.

The exploitation of new technology in environmental science is just beginning. It forecasts an era of unprecedented productivity.

The Present Day — A Problem of Timing

Although recent years have witnessed a tremendous increase in awareness, on the part of scientists and non-scientists alike, of the nature, complexity, and extent of the natural environment, the mutual interactions of its parts, and its interactions with man, while powerful new tools for the study of the environment have been introduced with outstanding initial successes in the exploitation of prototypes, there should be no misunderstanding concerning the status that has so far been achieved. Simply stated, environmental science today is rarely able to provide the quantitative information, interpretations, and predictions needed to match the needs of society. The current situation can best be viewed in two ways.

MULTIPLICATION OF PROBLEMS

Environmental science is perhaps the oldest of man's scientific activities. The most ancient records of mankind contain evidence of careful observations of many types of natural phenomena, efforts to predict or forecast coming events that would affect his activities or well-being, or efforts to control or at least to modify the course of natural events. These efforts were usually made, however, within a framework of simple beliefs. The complexity of the natural environment, on the other hand, is such that, although observations and measurements have continued to be made to the present day, observational data of immediate concern to man remains sporadic, incomplete, and inadequate to serve as a basis for sound scientific investigation. For example and with respect to general understanding across the entire field of environmental science, one need only recall the comment of the late Professor John von Neumann to the effect that the atmosphere represents the second most difficult challenge to scientific understanding, man and society presumably occupying first place. Environmental science has become in many respects more difficult as more has been learned. The following examples serve to illustrate this situation.

415-536 O - 71 - 5

The earlier presumption that exchange of carbon dioxide between the atmosphere and the oceans could account for the fate of carbon dioxide produced by burning fossil fuel has proven false. About as much of the carbon dioxide produced has gone into the vegetation as into the oceans, and the interaction in both cases is more complicated than anticipated.

The discovery of several systems of counter currents in the deep ocean has demonstrated that oceanic circulations are considerably more complex than they had previously been thought to be.

Measurements of the exchange of heat and water vapor between the ocean and the atmosphere, important to understanding the behavior of both, indicate considerably greater complexity than had previously been thought. Results from the "Barbados Oceanographic and Meteorological Experiment" (BOMEX) will require fundamental revisions of theoretical formulations.

Ecology texts show bacteria and fungi in water and soil acting as decomposers of organic material, distinct from the animals (consumers) and the green plants (producers). It is now known that decomposition is often accomplished through the combined, and often interdependent, action of microflora and small animals. Furthermore, many green plants live in intimate physical bonding of their roots with fungi, the latter serving as the major means for removing water and nutrients from the soil. These complex relations cannot be unravelled adequately today because the many species of fungi and small animals are poorly known.

Eddy currents have long been known to be important to circulations in both oceans and lakes, and atmospheric turbulence, including the special case of clear air turbulence, is now seen to play a most significant role in atmospheric energy exchange. Both types of phenomena, however, are exceedingly difficult to measure and to fit into a general circulation theory.

Observations from the Applications Technology Satellite (ATS-III) have uncovered types of cloud structures and clusters of such structures that are new and for the present remain unexplained.

The very achievements of environmental science in recent years thus render the solution of major scientific questions both more remote and more urgent.

STATUS OF UNDERSTANDING

Conversely, there exists a significant body of knowledge and understanding across environmental science that is daily being brought to the service of mankind. The weather is in fact being forecast, however well or poorly these forecasts are regarded. In certain instances, notably in the California Current, the tuna catch is being successfully predicted. The ionosphere, in spite of its great variability, is being used for reliable long-range radio communication through the use of adaptive techniques. The characteristics of mineral-bearing structures are known and this information is being used for exploration. Much is known and understood about such diverse topics as forest-watershed management, the controlled use of forest fire, environmental disease, and the physiological effects of high altitude.

The fundamental scientific laws of the universe are necessarily identical to those operating in the environment. Yet the environment is so diverse and so complex that in many instances it has not yet been possible to enunciate general principles of practical utility. Nevertheless significant progress has been made in the identification and interpretation of the phenomena, processes, and inhabitants of the natural environment. Large and complex problems can be partitioned and simplified, and partial solutions and understanding can come from the study of these smaller portions of the whole. Ultimately, however, the larger systems must be understood, since it is at such scales that many problems of interest to human welfare are found. At present, scientific understanding of such systems is almost entirely qualitative. Several examples illustrate this aspect of the state of knowledge:

> It is not possible to predict in any definitive manner in many situations the transport of pesticides, pollens, airborne radioactive particles, mercury, lead, or other materials, nor are the mechanisms of concentration of these substances in the food web well understood. Neither are the detailed nor the long-term chronic effects of low level concentrations of pollutants

on man, other animals, or plants adequately known; and the resulting changes in the relative balance among species in a natural landscape are virtually unexplored.

It is not possible today to predict earthquakes or volcanic eruptions. The mechanisms whereby hurricanes and tornadoes are generated cannot be explained, nor can their movement be predicted except in terms of extrapolation from historical statistics. Nor is there any appreciable understanding today about why or how electric charge separates in clouds and forms lightning.

There is inadequate theory today for assessing with confidence the long-term climatic effects of carbon dioxide, heat, or particulate matter introduced into the atmosphere by today's technology, or the possible effects of aircraft contrails, or the consequences of jet exhaust at stratospheric altitude.

The currents in lakes and oceans cannot be described in detail, nor can the transport or ultimate destination of wastes or other materials introduced into these bodies of water be adequately appraised.

It has been demonstrated that the ability of a landscape to retain its nutrient elements is related to its plant and animal species; shifts in the latter may alter the nutrient balance in the system, yet the relationship is poorly understood. Indeed it is usually not possible to predict or assess quantitatively the effects of external influences on any ecosystem.

Although a great deal has been learned about the nature of emissions from the solar surface, it is not yet possible on the basis of fundamental physical principles to predict solar flares, nor their intensity, nor all of their effects on the earth's environment.

There is today little understanding of why the earth has a magnetic field, how the earth's core generates such a field, nor why the field reverses polarity from time to time. In connection with the last, it is known from studies of the magnetism of ancient rocks (Figure 2) that the earth's field has reversed at least 40 times in the past 10 million years. The next reversal, which will occur at an unknown time, at an unknown rate,

and with unknown consequences, is believed to be overdue.

Although great progress has been made and accretions to man's understanding of his environment are being made daily, important questions of all types remain unanswered. Details concerning these and many other items relating to the status of environmental science will be presented in a separate report, *Patterns and Perspectives in Environmental Science.*

ENVIRONMENTAL PREDICTION

The maturity of a science can often be judged by the precision with which successful predictions can be formulated and computed. Given the appropriate initial conditions, how will a given system under study evolve or develop with time? The path of Apollo 12 or the orbits of the planets can be predicted with great precision, using only Newton's laws and the universal law of gravitation. But prediction in this sense is not possible in every science, either for practical reasons, related to complexity, or because of the inherently statistical or random nature of the phenomena being studied. It is precisely in this area that a major scientific controversy exists with respect to environmental science. A great deal of effort is currently being placed on approaches to prediction of environmental regimes. Because of the many contributing factors involved, these efforts generally take the form of systems modeling or simulation, based on established physical laws, and the use of these mathematical models to project the state of the environmental regime at some time in the future.

A problem, however, has been encountered in efforts to predict the state of the atmosphere, that is, weather forecasting. Much publicity has been given to the prospects for "accurate" forecasts (and this term is generally not defined) at least one to two weeks in advance, on a global scale. Major programs have been undertaken to achieve this end. Some scientists, however, question the innate predictability of the atmosphere, except on a long-term, statistical, climatic basis. To these scientists the upper limit is perhaps five days. While it can be predicted with fair confidence that thunderstorms, tornadoes, or other severe storms will occur over a general area, little can be said about where individual storms will form, for they appear to be governed by causes of a statistical nature.

NOTE TO FIGURE 2

Reversal in polarity of the earth's magnetic field. These data derive from measurements of the direction (N-S) of magnetism frozen into lava as it hardens, and the dates of many lava flows. The same phenomenon has recently been confirmed in the spreading seafloor. This figure is an example of a phenomenon of global extent that is known to occur, but has never been witnessed. The effects of reversal are unknown. There is possibly a transient weakening of the shield that protects the earth from a part of cosmic and solar flare radiation. A shortening of life span as well as an increased mutation rate would be possible effects on life.

LEGEND

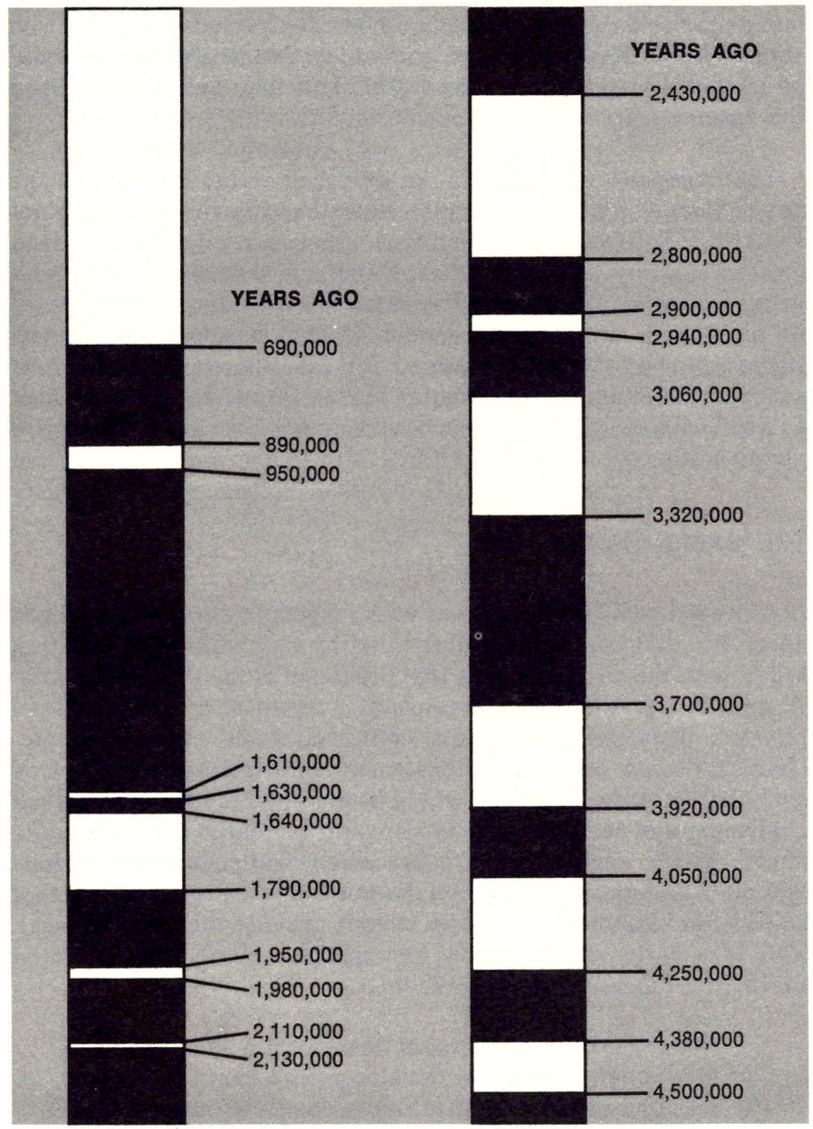
Field as at Present

Field Reversed

Prepared from data provided by Professor Allan Cox, Stanford University

Figure 2

CHRONOLOGY OF EARTH'S MAGNETIC FIELD REVERSALS



At the same time, there has been a relative neglect of efforts to improve short-term, local or regional forecasting. Efforts to achieve successful long-range forecasting should certainly continue because of the large potential benefits that could result. However, it should be recognized that large economic benefit and advantages to the lives of human beings would accrue from the ability to predict more precisely atmospheric conditions for periods ranging from about an hour to several days in advance. **Far greater effort should be placed on research leading to this end than has hitherto been the case.**

The capability to predict is not balanced across all parts of the environment. While the situation described above exists with respect to the atmosphere, the status of oceanic prediction is even less satisfactory. Although intensive efforts are being made to develop models of life-centered systems or ecosystems for purposes of prediction, no complete model of any ecosystem yet exists (Figure 3). For the solid earth or for the solar-terrestrial region reliable prediction is still a matter for the future. In this important subject of scientific prediction environmental science remains a young science.

THE BASIC ISSUE

A central problem thus exists with respect to environmental science, one that can best be illustrated by comparing the situation today with the circumstances that prevailed at the time of Sputnik. A decade ago the state of relevant science and technology — physics, chemistry, propellants, control systems engineering, mechanical design, communications, manufacturing capability — was such that an immediate effort could be mounted to meet a perceived challenge, and technological goals could be stated for the decade ahead. **Today again there is a perceived challenge, more serious and more generally shared than the one a decade ago, and one that science, environmental science, cannot provide the tools to meet.** This is a matter of the utmost importance — both for the United States and for the world as a whole.

> There is a clear and urgent need for the establishment of a national program to develop environmental science to the point where it can contribute decisively and authoritatively the information, the interpretations, and the predictions that are needed for wise public decision on all matters relating to the environment within which man is constrained to live and to look forward to a constructive future. At the same time, there is a corresponding need for vigorous and expanded programs of research on the social, behavorial, economic, political, and administrative arrangements and institutions that are essential, if the results of environmental science are to be effectively applied and if the crucial physical and biological issues are to be recognized.

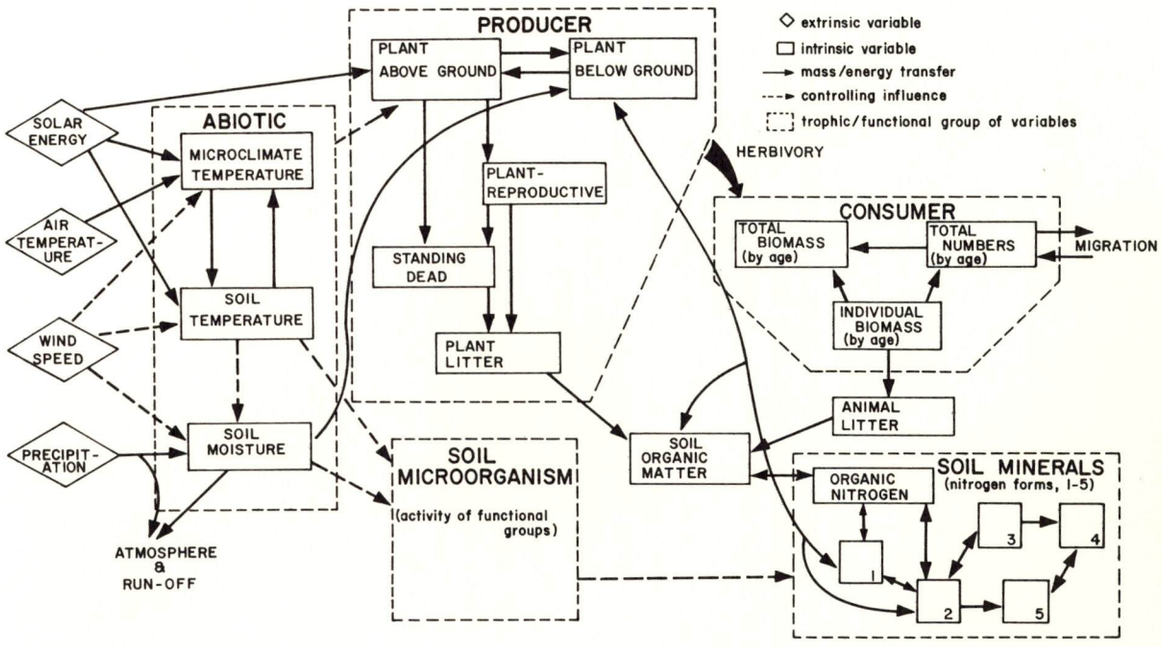
On the other hand, it must not be inferred that all actions to improve or protect the environment should be deferred until everything is understood. Enough is known today for many things to be done. Even though it is not known what concentrations of sulfur oxides are produced by what levels of emission under various meteorological conditions, it is known that lower emission at the source will improve the situation. Sulfur oxide concentrations can be measured and correlated empirically, even without the ability to explain them, to a degree sufficient to permit the objective enforcement of certain control measures.

NOTE TO FIGURE 3

A systems model for a grassland ecosystem. This diagram represents a giant step forward in the conceptual approach to the study of an ecosystem, and has proven invaluable in the design of research, team organization, and analysis of data. Nonetheless, the level of sophistication shown here is well below that needed for application in practical problems. The complexities arising from the several hundred species and several thousand relationships are still overly simplified, as are the interactions of the system with human intervention. This figure represents very well the general level of adequacy that exists in all subfields of environmental science, and demonstrates the youth of the field.

Figure 3

A SYSTEMS MODEL FOR A GRASSLAND ECOSYSTEM



Courtesy of the Grasslands Biome Project, International Biological Program.

IV

The Future — Three Levels for Action

Efforts to advance environmental science during the coming years will necessarily follow three directions, each essential to the public purpose. These directions concern efforts to solve global problems; corresponding efforts related to local, regional, or "mesoscale" phenomena; and basic scientific investigation to solve many of the elementary questions that underlie much of environmental science. The second of these is probably essential for success in the first; the third is essential for the first two. All three share a common scientific purpose: to obtain the information, understanding, predictive capability, and basis for developing appropriate control technology or management techniques that will serve the needs of society. The three differ substantially in required magnitude of effort and, consequently, in cost.

> It is of the most fundamental importance, therefore, that major attention be given to the priorities that will determine the distribution of available resources across these three efforts, and that continuing concern for priorities be maintained for the foreseeable future. Mechanisms for this purpose should be centralized among all agencies and organizations that support research in environmental science.

The stakes involving environmental science are so high that its progress on many fronts should not be entrusted to the initiative of individual private investigators, one unrelated to another, nor to major programs where the scientific objectives have not been clearly defined.

DISCIPLINARY SCIENCE — A CONTINUING NEED

While environmental science is fundamentally **science** addressed

to the interactions among complex processes in complex systems, it should not be inferred that only investigations of systems and subsystems are involved. Indeed there are innumerable problems that need to be solved before needed information can be obtained for the systems work, whether the systems are addressed to prediction, to potential environmental modification or control, or to gaining understanding, three alternatives that are intimately connected. Examples of such basic research extend from solar physics to the geochemistry and geophysics of the solid earth, from biological studies of countless species still unknown in tropical forests or the ocean bottoms to the chemical environment of ozone in the upper atmosphere, or from the fundamental nature of water, still a mysterious substance, to the detailed mechanisms that determine the growth of hailstones or the way in which cloud seeding agents operate. **These are problems of discipline-oriented research. They need to be vigorously supported — as basic research — if environmental science is ultimately to achieve the position of a fully effective partner in man's efforts to live securely and successfully with his environment.**

INTERMEDIATE SCALE SYSTEMS

It is in the area of regional or local environmental systems that the major efforts of environmental science will be made. There are two reasons. First, the kinds of scientific knowledge and understanding that are necessary for a sound approach to the elucidation of global systems must come from thorough investigation of the subsystems which, taken together, form the global environment. Secondly, the subsystems of the environment are those with which man is most immediately concerned both for his economic and personal well-being. From severe storms to the natural or man-made ecosystems that sustain mankind, from fisheries to the condition of lakes and estuaries, from volcanoes to rainfall and water supplies the subsystems of the environment present a catalogue of major scientific challenges that will require heavy efforts and heavy expenditures by many nations and for many years to come.

It is of the greatest importance, however, if the most effective progress is to be made, that these problems be in fact treated as systems problems. Major examples include: the biome studies and ecosystem modeling efforts of the International Biological Program

(IBP); the Barbados Oceanographic and Meteorological Experiment (BOMEX), noted previously, of the Global Atmospheric Research Program (GARP); and the proposed Geochemical Sections Program (GEOSECS), to be undertaken as part of the International Decade of Ocean Exploration (IDOE) and to be addressed to sampling as many chemical substances as possible, from the surface of the ocean to the bottom, in the major ocean basins of the world. The magnitude that studies of this kind will frequently attain is well illustrated by BOMEX (Figure 4) which involved nearly 100 experiments performed by 1,500 scientists, technicians, sailors, and airmen, using 28 aircraft, 12 ships, operational meteorological satellites, two research satellites, buoys, and land-based facilities on the Barbados. This effort was primarily addressed to gaining a deeper understanding of air-sea interactions, an important determinant of the condition of the world's weather and oceans. **Many efforts of this type will need to be undertaken, if environmental science is to achieve the status required to match societal need. These efforts should be fully and enthusiastically supported.**

GLOBAL SYSTEMS

Approached at very general levels to include such characteristics as average carbon dioxide levels, total plant productivity, and total emissions of particulates, models of global systems can be relatively simple and still useful for determining overall constraints to human activity. **More detailed models of greater predictive power must await the development of better syntheses at the intermediate scale, even though global models are needed now to answer questions on the future effects of human action.** In the meantime, a number of global programs to improve the information base are already useful. Three major examples will serve to illustrate the value of such information, both in public service and in the advancement of science.

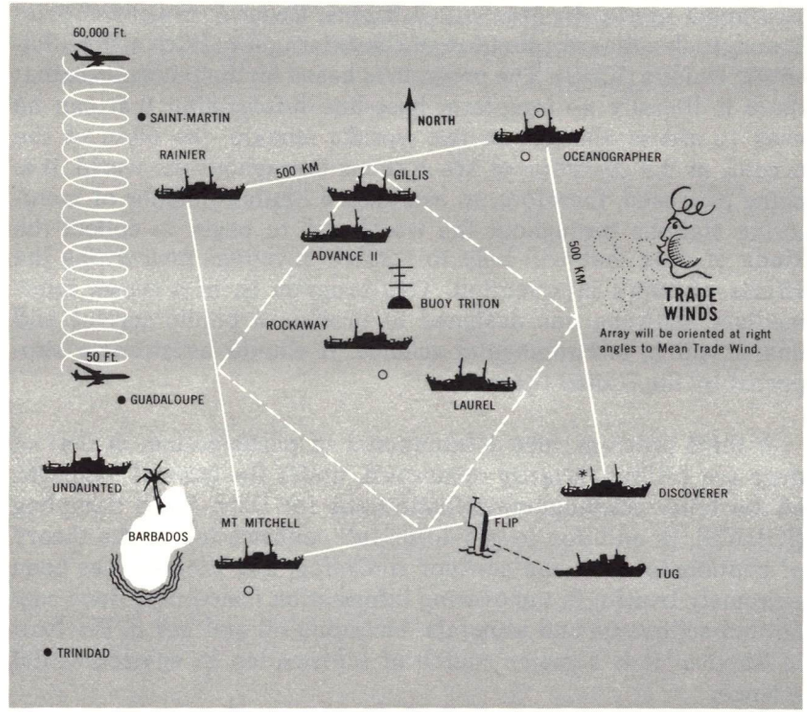
A highly successful international undertaking, under the direction of the World Meteorological Organization, is known as the World Weather Watch (WWW). This program is designed to pool the world's weather data and to make available to all nations the best weather forecasts that the present state-of-the-art can provide. It is a public service program, based on the applications of environmental science. This program will be improved as new scientific

NOTE TO FIGURE 4

Deployment for the 1969 BOMEX project. This figure represents the consequence of designing a group of experiments of sufficient scope and precision to test hypotheses and obtain useful new data from an intermediate scale system. The event is unique in human history. Of the four situations in environmental science represented by the four figures of this report, this one is the most "mature." This experiment was participated in by the Departments of Commerce, Defense, Interior, State, and Transportation, the National Aeronautics and Space Administration, Atomic Energy Commission, the National Science Foundation, the National Center for Atmospheric Research, and more than 10 universities.

Figure 4

INITIAL ARRAY FOR BARBADOS OCEANOGRAPHIC AND METEOROLOGICAL EXPERIMENT (BOMEX)



● Land Based Station
○ Current Stations
∗ Thermistor Array Moorings

Courtesy of the National Oceanic and Atmospheric Administration.

results become available, especially from GARP with which it is associated under the World Weather Program, and can be incorporated within it. It is not clear today that the types of weather observations that provide the input to this system are the best ones. There is reason to believe, for example, that certain types of data obtained by satellite may be more reliable, provide better coverage, and lead to a better scientific basis for global forecasts. When this and many other questions are resolved, WWW will be correspondingly strengthened.

A second program, one that appears to be exceedingly promising, is known in the United States as the Global Network for Environmental Monitoring (GNEM). Planning for this program is being conducted jointly by the United States, Sweden, and the Soviet Union, under the coordination of the International Council of Scientific Unions (ICSU). The program is based on the recognition that there is literally no long-term base-line information that can be used to assess changes in the world's climate, the state of the oceans, or the condition of life systems throughout the world. It is being proposed, therefore, to establish a limited number of monitoring stations throughout the world and to begin to collect the kinds of data that will help to resolve questions concerning the effects of man's intervention. This program is, in a sense, intermediate, between one designed to provide a public service and one of aid in environmental science. It should be strongly supported by the United States.

A third program, also international in participation, is that of deep sea drilling, already mentioned, under the general oversight of the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES). In addition to providing full confirmation of the theory of continental drift and seafloor spreading, this program has been extremely fruitful in uncovering information concerning deep sea-bottom sediments and minerals, including oil and gas in the Gulf of Mexico. It is a major source of information in environmental science.

> As understanding of the environment and predictive capability increase, while at the same time population growth and associated demands and effects on the environment multiply, there will be constantly increasing pressures to manage the environment to the benefit of man, to modify or control elements of the environment (e.g., through weather modification, reduction of earthquake severity, etc.), and to mitigate many of the more subtle effects of man's interference (e.g., the effects of urbanization, other than pollution, on local or regional weather patterns, associated ecosystems, etc.). The corresponding technologies, planning approaches, and management techniques are ultimately dependent upon advances in environmental science. Simultaneously, however, they introduce a host of social, legal, economic, and political problems of the greatest difficulty. While three scales of future activity in environmental science have been noted above, it is also essential that major efforts be devoted to gaining needed insights into the structure, behavior, and needs of related social systems and institutions through increased emphasis across the social sciences.

V

Resources for Environmental Science

The fact that environmental science today is generally unable to match the needs of society for definitive interpretations or quantitative answers to pressing problems must ultimately reflect the priorities that society has placed in the past on the various activities of environmental science. These priorities can be judged from a review of present resources.

MANPOWER — THE CRITICAL RESOURCE

Information concerning scientists in the United States who are engaged primarily in research and development, the administration of research and development, or teaching in the natural sciences is available from recent surveys of the National Register of Scientific and Technical Personnel of the National Science Foundation. Thus in 1968 a total of 153,068 scientists could be identified with these activities **in all of the natural sciences.** They were working in 780 primary employment specialties of science. This same source contains a corresponding total of 68,032 scientists holding a doctorate. These totals were analyzed and divided into three groups: 87 specialties of Environmental Science, corresponding generally to the systems emphasis adopted for this report; 86 Applied and Supporting Specialties of Environmental Science; and 607 specialties of Other Natural Sciences. The definitions that generally form the basis for these three groups, together with the results of the analysis, are shown in Table 1.

Of special importance in Table 1 is the average number of doctorates per specialty, obtained by dividing the number of doctorates by the number of specialties for each of the three groups. Thus for Environmental Science, as interpreted in this report, the value is 46, smaller by a factor of 2 than the corresponding ratio for non-environmental "Other Natural Sciences." **The thinness with which**

NOTES TO TABLE 1

(1) Includes the Solar-Terrestrial System (aeronomy, ionosphere, aurora and airglow, solar physics, etc.), Climatology, Atmospheric Science (atmospheric dynamics, mesometeorology, micrometeorology, atmospheric electricity, etc.), Air-Sea Interactions, Oceanography, Biological Oceanography, Marine Geology (including ocean-bottom processes and shore and near shore processes), Solid-Earth Geophysics, Solid-Earth Geochemistry, Petrology, Sedimentology, Geomorphology (including glacial geology), Hydrology (including erosion and sedimentation; evaporation and transpiration; snow, ice, and permafrost; soil moisture; etc.), Ecology, Renewable Resources (including fish and wildlife, forestry, and range management), and Geography (excluding cultural geography, historical geography, military geography, and political geography).

(2) Includes many agricultural sciences, meteorological applications (including weather analysis and forecasting), exploration and extraction geology and geophysics, pollution sciences, mineralogy, paleontology, geodesy, instrumentation, etc.

(3) Includes, following the classification of the National Register, Chemistry, Earth and Marine Sciences, Atmospheric and Space Sciences, Physics, Mathematics, Computer Sciences, Agricultural Sciences, and Biological Sciences.

Table 1

SPECIALTIES OF ENVIRONMENTAL SCIENCE AND ASSOCIATED SCIENTISTS ENGAGED IN RESEARCH AND DEVELOPMENT, ITS ADMINISTRATION, OR TEACHING—1968

	Number of Specialties	Number of Scientists		Average Number of Ph.D.'s per Specialty
		Total	Ph.D.	
Environmental Science (1)	87	10,506	4,044	46
Applied and Supporting Specialties of Environmental Science (2)	86	12,516	6,185	72
Other Natural Sciences	607	130,046	57,803	95
Total Natural Sciences (3)	780	153,068	68,032	

Source: National Register of Scientific and Technical Personnel, National Science Foundation, 1968 survey.

this specialized manpower is spread across the activities of environmental science is further emphasized by the fact that the MEDIAN number of doctorates is 20 for the 87 specialties considered.

The number of doctorates has been given special attention, in spite of significant and extensive contributions made by those with lesser degrees, since the doctorate generally represents, by virtue of the nature of the educational process during its terminal years, the intellectual leadership in generating scientific advance. This is especially true today, because of the level of knowledge and understanding that has been attained in all of the basic contributing disciplines that necessarily form the underpinning for such advance. The number of doctorates has thus been chosen as an important index of resource status.

Two-thirds of the 4,044 doctorates reported in environmental science were employed in colleges and universities. The distribution is the following:

	Percent of doctorates
Colleges and Universities	68
Governments	20
Other (largely industry)	12

In spite of this heavy preponderance in academic institutions, there are significant concentrations in some specialties within government (especially renewable resources, geophysics and geochemistry, atmospheric science, and the solar-terrestrial system) and within industry (particularly geophysics and geochemistry, and the solar-terrestrial system).

Another dimension of this distribution among types of employers, probably the most significant aspect of the manpower situation in environmental science, is demonstrated in Table 2. Adopting the generally held view that a high quality organization in research and development generally requires a "critical size" or minimum number of scientists, communicating with each other, and arbitrarily choosing 7 as this number, the **maximum possible number** of such groups of doctorates has been determined for each of the 87 specialties included in environmental science for the three principal employer types. **Thus in 19 specialties no group of "critical size" could have been formed in 1968 in colleges and universities,**

while for 63 specialties this situation existed in government and industry respectively. However, these results are optimum, since in the situation actually prevailing the scientists in these 87 specialties were distributed among many universities, many government agencies, and many industrial corporations and research organizations. The distribution shown in Table 2 clearly confirms the existence of a severe manpower shortage in environmental science and a scattering of resources throughout the Nation, a circumstance that strongly reflects employment opportunity and hence public priorities.

That the situation described above is beginning to correct itself is suggested by comparing the 1968 and 1970 surveys for specialties that retained their identity. Apart from the solid-earth sciences, where a change of structure and nomenclature precludes the comparison, it was possible to examine changes between 1968 and 1970 for 66 of the 87 specialties of environmental science:

	Percent Change
All scientists	+11
Doctorates	+18

These changes, noted for a two-year period, are the result of several causes. First, they reflect growing numbers of persons completing their academic training, especially doctoral, in aspects of environmental science. Secondly, they result from significant numbers of scientists who changed their fields of work and entered environmental science as the employment situation deteriorated in their original occupations. Thirdly, the indicated growth may be overstated because of the choice of a different name of employment specialty by a respondent to conform to the growing popularity of certain areas of environmental science, while no change occurs in the nature of the work performed. This is especially true for many biologists, biological oceanographers, and others who choose Ecology as the generic expression to describe their work.

It is noteworthy, however, that the number of doctorates in environmental science appears to be increasing more rapidly than the total number of scientists. This trend has been especially strong for a number of specialties that only recently have begun to receive substantial support, notably those related to the atmosphere and the oceans.

NOTES TO TABLE 2

(1) This tabulation is based on the proposition that in general a research group of high quality will contain at least seven members as a "critical size" (See the report *Graduate Education—Parameters for Public Policy,* NSB 69-2, issued by the National Science Board in 1969).

(2) Obtained by dividing the number of *doctorates* in a specialty by 7. Thus, for example, of the 87 specialties identified with environmental science, there were in 1968 sufficient doctorates, engaged in research and development or teaching in colleges and universities, in 29 specialties to form only *one* group of critical size each, provided that the scientists associated with a single specialty were located in one place. In fact, however, these scientists were scattered among a number of colleges and universities.

Table 2

MAXIMUM POTENTIAL NUMBER OF GROUPS OF CRITICAL SIZE ENGAGED IN RESEARCH AND DEVELOPMENT, ITS ADMINISTRATION, OR TEACHING IN ENVIRONMENTAL SCIENCE—DOCTORATES DISTRIBUTED BY TYPE OF EMPLOYER—1968 (1)

Maximum No. of Groups of Critical Size (2)	Number of Specialties		
	College or University	Government	Other
0	19	63	63
1	29	12	16
2	12	7	5
3	7	2	2
4	3	0	0
5	3	0	0
6	3	0	0
7	2	0	0
8	0	0	0
9	1	0	0
10 or more	8	3	1
	87	87	87

Source: Based on information from the National Register of Scientific and Technical Personnel, National Science Foundation, 1968 survey.

Manpower shortage is not confined to those needed to provide the science base, to conduct environmental research, and to generate systems understanding. As the science base is established, the need for technicians, engineers, and administrators to implement policy and programs also becomes greater. **The function of government, in relation to questions of environmental management, is largely to legislate policy and to administer the application of controls. Such an administrative role for government requires knowledgeable scientist-administrators.** They must be sufficiently trained in science to be perceptive of the characteristics of theory and data base resulting from research. They must be perceptive too of the political and sociological environment within government. They should have formal education in the social sciences, law, and administration, as well as in science. A specifically trained "science-natural resource" administrator is thus needed. This should be a person who would operate at the final implementation level of mission agency policy regarding the environment. The education of these persons can be accomplished in two ways: by adding the natural sciences and science policy to the curricula of schools of public administration, and by expanding the programs of engineering schools to include the social sciences and elements of public administration.

FUNDING FOR ENVIRONMENTAL SCIENCE

With the present situation regarding scientific manpower in environmental science, where essentially all manpower appears to be gainfully employed, funding specifically to cover the costs of personnel in environmental science has generally matched the need. The total manpower, however, is increasing. Whether the influx of this additional, needed manpower occurs through education or through transfer from other activities, it creates new opportunities for the funding of environmental science.

Many of the scientists who contributed to this study, however, expressed the judgment that it is more difficult than it should be to obtain adequate funding for facilities and specific items of major equipment and for the logistics necessarily associated with their use. This observation applies particularly to such matters as oceanographic ships, specifically designed for the purpose, radars of several types, surveillance aircraft and associated instrumentation, expeditions, surveys and monitoring arrangements, and many others. One of the major achievements of recent years has been the advent of new and powerful instrumentation that should be brought to bear as quickly as possible on pressing measurement needs of environmental science. **It is a poor economy to encourage highly trained and qualified personnel to enter this field of work without ensuring the essential tools that can help to expedite progress.**

THE ORGANIZATION OF ENVIRONMENTAL SCIENCE

The large number of specialties among the contributing sciences, the small number of scientists in many of these, and the wide dispersion of individuals among the universities, agencies of government, and industry raise formidable problems whenever and wherever "critical size" is required for work on environmental systems. Research programs such as those of the IBP and GARP require extraordinarily complex institutional arrangements among many universities, agencies, and industries.

Types of Arrangements

Within universities the interdepartmental nature of environmental science ensures an awkward relationship with discipline-oriented research. Neither the institution nor the individuals can tolerate excessive crossing of boundaries, and interdepartmental arrangements usually fail to incorporate the mix that is needed for study of environmental systems. One possible benefit on a national scale is that different schools achieve different mixes. On the whole, however, the total number of strong programs in environmental science is indeed small. Although the Nation has approximately 200 universities awarding doctorates in science and engineering, none of the following areas is well developed in more than 20: meteorology, oceanography, system-level ecology, geophysics, geochemistry, and hydrology.

Scientists in government are divided among State and Federal agencies. At both levels many excellent research teams are found that work in soil science, geology, forestry, and fisheries and wildlife. It is fair to state, however, that most of these teams are fully

occupied with the problems of resource development, long-term maintenance, and protection of the public interest. Their concern is with environmental management, and the needs are so intense that little effort can be devoted to environmental science. Fortunately, these particular areas are also well developed at many universities, where more basic aspects of environmental problems can be pursued.

Scientists in industry, as noted previously, have flourished where their interests are needed. Most of the Nation's research in petroleum geology, fertilizer processing, and pesticides takes place in industry. More recently industry has taken the lead in the employment of scientists in the specialties of air and water pollution. Research teams in industry can be tightly organized to work on well-defined problems. Their major concern, of course, is with the health of industry, and with the technological means for reducing the societal costs to which the public and government object.

In summary, although most environmental scientists are in universities, they are divided among many schools and many departments where problems of organization are severe. Although such problems may be less difficult in government and industry, each has a "critical size" of competence in only a few areas.

> The end result is that ENVIRONMENTAL SCIENCE is poorly organized. On the campus it is difficult to maintain any organization at all. Among the Federal agencies a duplication of effort in environmental science tends to develop as each agency pursues its statutory mission. In industry the emphasis is usually on traditional science and technology. Even in companies strong in systems research the fight for survival generally means contracts and industrially-oriented research, rather than the long-term, large-scale view of natural systems.

Poor organization has led to several penalties in environmental science. Standards of performance vary from organization to organization and from field to field. Duplication of effort tends to occur, even in different departments on the same campus, but more seriously in different departments or agencies of State and Federal governments. Finally, information systems, such as mapping surveys and monitoring programs, often fail to collect the most useful

kinds of information. Indeed many information systems are finally designed with little input from potential users.

If environmental scientists were twice as numerous, and if the total level of support were correspondingly greater, more rapid progress could be anticipated in the solution of environmental problems. For the 1970's, however, neither the manpower nor the levels of support can confidently be expected to increase by this large a factor. Thus, better organization emerges as the primary means by which significant progress in environmental science can be made within a decade.

How the organization of environmental science should be improved depends strongly upon the nature of the scientific problem itself. Here again the differences among environmental problems must be stressed. For all of them, however, some degree of disciplinary science, applied science, technology, and institutional change are necessary. If this is all that were involved, the recommended organization would be one that is strongly problem-oriented, with teams embracing each of the above aspects, combined in many ways in many places, and each with a well-defined environmental problem to solve. Indeed, many such efforts are already underway as a part of the effort to improve the human environment.

> There remains, however, an extensive set of problems whose solutions require major advances in environmental science, namely, the SCIENCE OF ENVIRONMENTAL SYSTEMS, as defined in this report. Furthermore, any serious program in technology assessment, environmental protection, or environmental forecasting requires the strength that can be developed only from the advancement of such environmental science. For all of these needs the science itself is relatively universal, in the sense of being common to many types of problems. It is THIS kind of science that is so woefully inadequate for present societal needs, so difficult to organize, and so likely to remain undone. An immediate and intensive effort must be made to foster management organizations for research in environmental science that facilitate teamwork, concentrate on thinly-spread manpower, and promote the conceptualization of environmental systems.

Governments at the local, State, and national level have responded rapidly to the sense of environmental crisis, creating a variety of new institutions. Most of these are oriented to problems arising from pollution, or to those associated with resource allocation. They are directed more to the applications of science than to its development, and more to the solution of well-defined individual problems than to broad-scale advances in the basic scientific capability for solving such problems. **These immediate efforts are important and necessary developments if man is to improve relations with his environment, but they are not sufficient to ensure long-term or permanent gains.**

A Federal mechanism is also urgently needed specifically to provide for the promotion and support of environmental science as a whole. Such a mechanism should be responsible for ensuring that the knowledge, understanding, and predictive power concerning environmental systems be developed in accordance with perceived needs to solve environmental problems and to improve human welfare. Such an activity would supplement, not duplicate, those of organizations concerned with the managerial aspects of the environment or with the forecasting of environmental events. By being responsive to their priorities, however, such a mechanism would speed the development of the scientific tools that these institutions require.

CONTRIBUTORS

A Report to the National Science Board, issued separately, will be based on the material prepared by the following individuals:

WILLIAM C. ACKERMANN, Illinois State Water Survey
CLIFFORD AHLGREN, Quetico-Superior Wilderness Research Station
DURWARD L. ALLEN, Purdue University
DAYTON L. ALVERSON, National Marine Fisheries Service, U. S. Department of Commerce, Seattle
DAVID ATLAS, The University of Chicago
PAUL T. BAKER, The Pennsylvania State University
ROGER G. BARRY, University of Colorado
PAUL C. BEAVER, Tulane University
W. BOYNTON BECKWITH, United Air Lines
WILLIAM S. BENNINGHOFF, University of Michigan
JACOB BJERKNES, University of California at Los Angeles
F. HERBERT BORMANN, Yale University
ROSCOE R. BRAHAM, JR., The University of Chicago
WALLACE S. BROECKER, Lamont-Doherty Geological Observatory
JOHN L. BROOKS, National Science Foundation
LINCOLN P. BROWER, Amherst College
KIRK BRYAN, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, Princeton
REID A. BRYSON, The University of Wisconsin at Madison
SIR EDWARD C. BULLARD, University of Cambridge
T. C. BYERLY, U. S. Department of Agriculture
TOBY N. CARLSON, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, Coral Gables
DAVID C. CHANDLER, University of Michigan
STANLEY A. CHANGNON, JR., Illinois State Water Survey
GABRIEL CSANADY, University of Waterloo
ALLAN C. DeLACY, University of Washington
ROBERT E. DILS, Colorado State University
HANS DOLEZALEK, Office of Naval Research
WILBUR G. DOWNS, The Rockefeller Foundation
RICHARD C. DUGDALE, University of Washington
JOHN A. DUTTON, The Pennsylvania State University
W. THOMAS EDMONDSON, University of Washington
KENNETH O. EMERY, Woods Hole Oceanographic Institution
CESARE EMILIANI, University of Miami
ROBERT D. FLETCHER, Department of the Air Force, Scott Air Force Base, Illinois
THEODORE T. FUJITA, The University of Chicago
DONALD FUQUAY, Forest Service, U. S. Department of Agriculture, Missoula

DAVID M. GATES, Missouri Botanical Garden
R. CECIL GENTRY, National Oceanic and Atmospheric Administration, U .S. Department of Commerce, Coral Gables
STANLEY P. GESSEL, University of Washington
JAMES GILLULY, Geological Survey, U. S. Department of the Interior, Denver
RAYMOND M. GILMORE, Natural History Museum, San Diego
EDWARD D. GOLDBERG, Scripps Institution of Oceanography
JOHN R. GOLDSMITH, Department of Public Health, State of California, Berkeley
FRANK B. GOLLEY, University of Georgia
DAVID W. GOODALL, Utah State University
ARNOLD L. GORDON, Lamont-Doherty Geological Observatory
WILLIAM E. GORDON, Rice University
ROBERT F. GROVER, University of Colorado Medical Center
JOEL W. HEDGPETH, Oregon State University at Newport
CHARLES L. HOSLER, The Pennsylvania State University
HENRY G. HOUGHTON, Massachusetts Institute of Technology
CARL B. HUFFAKER, University of California at Berkeley
ROBERT R. HUMPHREY, The University of Arizona
PATRICK M. HURLEY, Massachusetts Institute of Technology
EDWIN S. IVERSEN, University of Miami
CLAYTON E. JENSEN, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, Rockville
PHILIP L. JOHNSON, National Science Foundation
RALPH G. JOHNSON, The University of Chicago
ARCHIE M. KAHAN, U. S. Department of the Interior, Denver
HIROSHI KASAHARA, University of Washington
ROBERT W. KATES, Clark University
WILLIAM W. KELLOGG, National Center for Atmospheric Research
GEORGE C. KENNEDY, University of California at Los Angeles
EDWIN KESSLER, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, Norman, Oklahoma
J. E. KIRBY, JR., Humble Oil & Refining Company
JOHN A. KNAUSS, University of Rhode Island
LEON KNOPOFF, University of California at Los Angeles
EDWIN V. KOMAREK, Tall Timbers Research Station
HELMUT E. LANDSBERG, University of Maryland
NOEL E. LaSEUR, The Florida State University
EDWARD R. LEMON, U. S. Department of Agriculture and Cornell University
HELMUT H. LIETH, The University of North Carolina at Chapel Hill
GENE E. LIKENS, Cornell University
RAY K. LINSLEY, Stanford University
C. GORDON LITTLE, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, Boulder
FRANK B. LIVINGSTONE, The University of Michigan
JAMES P. LODGE, National Center for Atmospheric Research
EDWARD N. LORENZ, Massachusetts Institute of Technology
JOHN LYMAN, The University of North Carolina at Chapel Hill
GORDON A. MACDONALD, University of Hawaii
BASSETT MAGUIRE, JR., The University of Texas at Austin
PAUL S. MARTIN, The University of Arizona
THOMAS R. McGETCHIN, Massachusetts Institute of Technology

CARL E. McILWAIN, University of California at San Diego
WILLIAM G. MELSON, Smithsonian Institution
HENRY W. MENARD, Scripps Institution of Oceanography
RICHARD S. MILLER, Yale University
J. MURRAY MITCHELL, JR., National Oceanic and Atmospheric Administration, U. S. Department of Commerce, Silver Spring
CLIFFORD H. MORTIMER, The University of Wisconsin at Milwaukee
WALTER H. MUNK, University of California at San Diego
GARTH I. MURPHY, University of Hawaii
JEROME NAMIAS, Scripps Institution of Oceanography
JAMES V. NEEL, The University of Michigan
MORRIS NEIBURGER, University of California at Los Angeles
JACK E. OLIVER, Lamont-Doherty Geological Observatory
LOUIS J. OLIVIER, Pan American Health Organization
LOUIS C. PAKISER, JR., Geological Survey, U. S. Department of the Interior, Menlo Park
EUGENE N. PARKER, The University of Chicago
WILLIAM G. PEARCY, Oregon State University
ALLEN D. PEARSON, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, Kansas City
SVERRE PETTERSSEN, London, England
GEORGE W. PLATZMAN, The University of Chicago
ROBIN D. POWELL, Veterans Administration Hospital, Iowa City
JOSEPH M. PROSPERO, University of Miami
COLIN S. RAMAGE, University of Hawaii
GILBERT S. RAYNOR, Brookhaven National Laboratory
RICHARD J. REED, University of Washington
GEORGE C. REID, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, Boulder
JOSEPH L. REID, Scripps Institution of Oceanography
ELMAR R. REITER, Colorado State University
HERBERT RIEHL, Colorado State University
WALTER O. ROBERTS, University Corporation for Atmospheric Research
GEORGE D. ROBINSON, The Center for the Environment and Man, Inc.
EMANUEL D. RUDOLF, The Ohio State University
RICHARD J. RUSSELL, Louisiana State University
JOHN H. RYTHER, Woods Hole Oceanographic Institution
ELVIO H. SADUN, Walter Reed Army Medical Center
LYLE S. ST. AMANT, Louisiana Wild Life and Fisheries Commission
FREDERICK SANDERS, Massachusetts Institute of Technology
FREDERICK SARGENT II, Western Washington State College, Bellingham
RICHARD A. SCHLEUSENER, South Dakota School of Mines and Technology
THEODORE W. SCHULTZ, The University of Chicago
J. ALLEN SCOTT, National Institutes of Health, U. S. Department of Health, Education, and Welfare
FRANCIS P. SHEPARD, Scripps Institution of Oceanography
JOANNE SIMPSON, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, Coral Gables
ROBERT H. SIMPSON, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, Coral Gables

JOSEPH SMAGORINSKY, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, Princeton
TERAH L. SMILEY, The University of Arizona
RAY F. SMITH, University of California at Berkeley
STANFORD H. SMITH, National Marine Fisheries Service, U. S. Department of Commerce, Ann Arbor
FOREST W. STEARNS, The University of Wisconsin at Milwaukee
ARTHUR C. STERN, The University of North Carolina at Chapel Hill
HENRY M. STOMMEL, Massachusetts Institute of Technology
EARL L. STONE, Cornell University
JOHN D. H. STRICKLAND, University of California at San Diego (Deceased)
WILTON STURGES, III, University of Rhode Island
JOHN C. F. TEDROW, Rutgers University
MARTIN A. UMAN, Westinghouse Electric Corporation
JOHN VERHOOGEN, University of California at Berkeley
FRANK H. WADSWORTH, Institute of Tropical Forestry, U. S. Department of Agriculture, Puerto Rico
PAUL E. WAGGONER, The Connecticut Agricultural Experiment Station
JOHN M. WALLACE, University of Washington
HELMUT K. WEICKMANN, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, Boulder
JOHN M. WEIR, The Rockefeller Foundation
KARL F. WENGER, Forest Service, U. S. Department of Agriculture
FRANS E. WICKMAN, The Pennsylvania State University
FORD WILKE, National Marine Fisheries Service, U. S. Department of Commerce, Seattle
HAROLD G. WILM, Water Resources Council
HATTEN S. YODER, JR., Carnegie Institution of Washington
PAUL C. YUEN, University of Hawaii

Consultants

LOUIS J. BATTAN, The University of Arizona
JOHN E. CANTLON, Michigan State University
WILBERT M. CHAPMAN, Ralston Purina Company (Deceased)
JULIAN R. GOLDSMITH, The University of Chicago
ROGER REVELLE, Harvard University
GILBERT F. WHITE, University of Colorado

Executive Officer

LAWTON M. HARTMAN, National Science Foundation

U. S. GOVERNMENT PRINTING OFFICE : 1971 O - 415-536

NATIONAL SCIENCE BOARD

H. E. CARTER (Chairman, National Science Board), Vice Chancellor for Academic Affairs, University of Illinois

ROGER W. HEYNS (Vice Chairman, National Science Board), Chancellor, University of California at Berkeley

R. H. BING, Rudolph E. Langer Professor of Mathematics, The University of Wisconsin

HARVEY BROOKS, Gordon McKay Professor of Applied Physics and Dean of Engineering and Applied Physics, Harvard University

ROBERT A. CHARPIE, President, Cabot Corporation

LLOYD M. COOKE, Director of Urban Affairs, Union Carbide Corporation

ROBERT H. DICKE, Cyrus Fogg Brackett Professor of Physics, Department of Physics, Princeton University

WILLIAM A. FOWLER, Institute Professor of Physics, California Institute of Technology

DAVID M. GATES, Director, Missouri Botanical Garden

NORMAN HACKERMAN, President, William Marsh Rice University

PHILIP HANDLER, President, National Academy of Sciences

CHARLES F. JONES, Vice Chairman of the Board, Humble Oil & Refining Company

THOMAS F. JONES, JR., President, University of South Carolina

W. D. McELROY, Director, National Science Foundation

JAMES G. MARCH, Visiting Professor, Institute of Organisation and Industrial Sociology, Copenhagen School of Economics and Social Science

ROBERT S. MORISON, Professor of Science and Society, Program on Science, Technology, and Society, Cornell University

GROVER E. MURRAY, President, Texas Tech University

E. R. PIORE, Vice President and Chief Scientist, International Business Machines Corporation

FRANK PRESS, Chairman, Department of Earth and Planetary Sciences, Massachusetts Institute of Technology

JOSEPH M. REYNOLDS, Boyd Professor of Physics and Vice President for Instruction and Research, Louisiana State University

FREDERICK E. SMITH, Professor of Advanced Environmental Studies in Resources and Ecology, Graduate School of Design, Harvard University

ATHELSTAN F. SPILHAUS, Fellow, Woodrow Wilson International Center for Scholars, Smithsonian Institution

H. GUYFORD STEVER, President, Carnegie-Mellon University

RICHARD H. SULLIVAN, Assistant to the President, Carnegie Corporation of New York

F. P. THIEME, President, University of Colorado

VERNICE ANDERSON, Secretary, National Science Board

NSB 71-1

Systems approach toward nationwide air-pollution control

III. Mathematical models

Although there is disagreement over the many approaches and designs of a pollution-control network, it seems inevitable that any lasting system must have a cost-effective basis

Robert J. Bibbero Honeywell Inc.

The future air-pollution control system that is described in Parts I and II of this article will be equipped with sensors to monitor the current status of local air pollution and meteorological factors such as wind, stability, or mixing depth. The system will be furnished not only with data on the location and strength of pollution sources and synoptic weather conditions, but with any other information needed to forecast air quality for a period of 24 hours or more. Once these statistics have been compiled, however, it is the job of the mathematical model to convert the data into pragmatic decisions for controlling the air resource.

Parts I and II of this article (Oct. and Nov. IEEE SPECTRUM) have already described the sensors and data-processing procedures necessary for the success of any nationwide air-pollution control system. Once the parameters have been established, however, to obtain optimum and purposive decisions that relate to defouling the air resource one must turn to mathematical modeling.

The symbolic relationship between the proposed mathematical air-pollution control model, its inputs, and its outputs is diagramed in Fig. 1. The model is needed in order to synthesize all of the known or assumed causal information into a meaningful pollution forecast. Knowledge of the status of receptors—those people and things affected by air pollution—permits prediction and display of the effects.

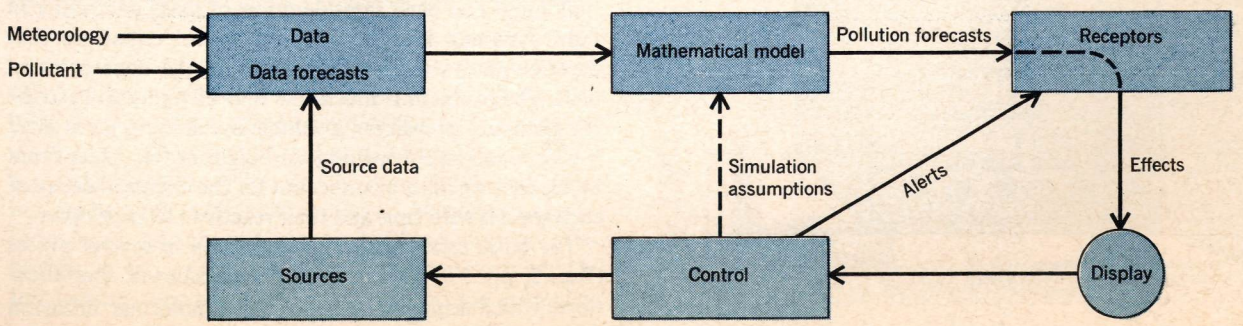
Whenever the refinement is justified, a mathematical model may also be used to facilitate the optimizing of control actions, through simulation, in order to evaluate the effects of alternate means of source control. Introduction of cost factors permits this evaluation to be on a cost-effective basis. If the model is not hopelessly complex, the decision process may be mechanized through linear programming routines. Decision simulation may proceed in real time or decisions may be predetermined off-line.

To act in these capacities, the model must be implemented in real time; that is, a solution must be obtained sufficiently in advance of the predicted effects to take corrective action. In the case of real-time simulation for control decisions, even more lead time is called for. Considering the complex causes and relationships that generate air pollution, a computerized model is strongly suggested.

Figure 2 states in more detail the input–output relationships of the model and suggests, qualitatively, its internal structure. The model may be entirely or partly empirical, based on statistical correlations (regression), or it may be analytical and derived from explicit physical relationships. A simple empirical model might be the correlation between degree-days (a measure of mean temperature for heating purposes) and SO_2 concentration averages. Generalization of this kind of relationship to places or time periods other than those for which the correlation was made would be very suspect because of the many other factors (e.g., ventilation, topography, fuel) that could influence the ambient sulfur concentration. This is true even if the correlation for a particular community, season, and averaging period is quite high. Nevertheless, such relationships at a given time may be the only kind that are available, as is now true for photochemical oxidant prediction. Such statistical relationships, if properly validated for each locality and intended use, comprise a valuable predictive tool.

An elementary analytical and physical model represent-

FIGURE 1. Air-pollution control model.



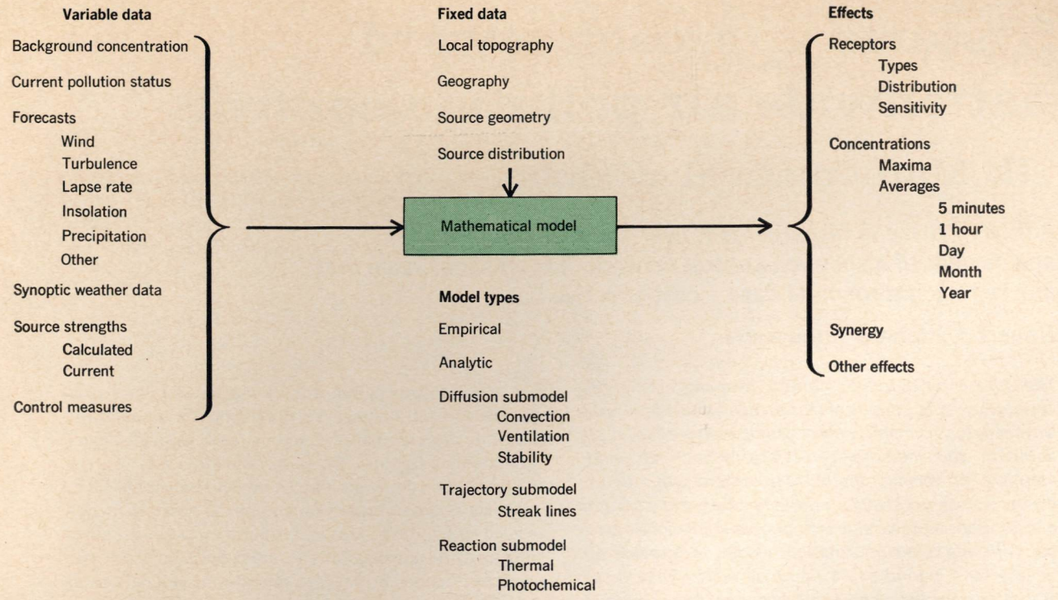


FIGURE 2. The input-output relationships of a mathematical model

ing gaseous diffusion from an area source (which may be a city with many closely spaced houses or buildings burning fuel) is shown in Fig. 3. The "box" model is considered to enclose the city, bounded by the ground (earth) as its base and the height of an assumed mixing layer Z (which may be fixed by a temperature inversion) as its top. Within the box, mixing is assumed to be thorough. The box itself is considered to be of unit width and oriented so that its length S lies in the direction of the wind, which passes freely through its ends with an average velocity u. The ventilation rate, defined as the volume of air passing through a unit width of the box, is then equal to uZ. If Q is the area source strength, or the mass emission rate per unit area, then QS is the rate for a unit width corresponding to the ventilation rate. With some mathematical manipulation, it can be shown (R. C. Wanta, Ref. 1, vol. 1, pp. 216–217; also Ref. 2) that the equilibrium concentration X_e of a gaseous pollutant in the box equals the emission-to-ventilation ratio, or

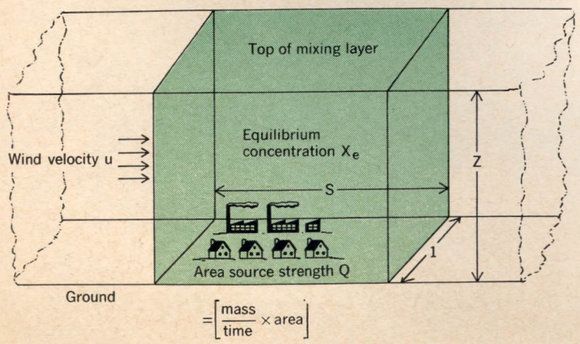
$$X_e = \frac{QS}{uZ} \quad \text{(mass per unit volume)} \qquad (1)$$

using any consistent units. Also, 90 percent of the equilibrium concentration is reached within a certain time, 2.3 S/u. For particulates, which settle with time, these expressions must be modified accordingly.

The box or prism model may be used for rough-order-of-magnitude assessments of a city's pollution concentration, using approximate numbers for mixing height, wind vector, and source strengths. On the other hand, it is far from answering the primary question asked of a mathematical model: "What will be the pollutant concentrations at any point in the air quality region, given all the data on sources and meteorological conditions?" In theory, a complete answer to this question can be given only by continuously tracking the pollutants emitted from individual sources and computing the concentration of each species at every point as they are transported by the wind, spread by diffusion, mixed by turbulence, and reflected or channeled by surfaces such as the ground or buildings. The basic consideration of mass continuity in fluid dynamics leads to complex vector equations that describe the time-varying changes in the concentration field. The problem is much like that of trying to describe the changing intensity of a soluble dye at every point after it is dropped into a swirling, turbulent brook, except that in our case we must also account for the chemical decay of each species with time and their reactions to each other.

The basic equations have been given in several places (Ref. 3, pp. 176–177), and after a number of simplifications, which neglect the small rates of molecular diffusion

FIGURE 3. Area-source "box" diffusion model.



as compared with the much greater turbulent eddy diffusion coefficients (K_x, K_y, and K_z), we are given an expression of the form

$$\frac{\partial C_i}{\partial t} + u(z) \cdot \nabla C_i = \frac{\partial}{\partial x} K_x \frac{\partial C_i}{\partial x} + \frac{\partial}{\partial y} K_y \frac{\partial C_i}{\partial y} + \frac{\partial}{\partial z} K_z \frac{\partial C_i}{\partial z} + R_i(C_1, \cdots, C_n) \qquad (2)$$

In this expression, C_i is the time-averaged concentration of the species i, $u(z)$ is the average wind velocity at height Z, and R_i represents the rate of production of i by chemical reactions between species.

Since the chemical reaction term $R_i(C_1, \cdots, C_n)$ is usually nonlinear, most solutions to Eq. (2) have been limited to inert components, where the term equals zero. Even with this stringent limitation, exact solutions of (2) have been difficult to implement because of the serious problems in defining the diffusion coefficients K_x, K_y, K_z. The difficulty is that the K's depend on the size and velocity of turbulent eddies, and these in turn depend on so many factors and interactions that they become very complicated functions of their positions in the field. Many assumptions for K-values have been made by numerous sources[4] and applied to Eq. (2), but few have successfully solved the atmospheric diffusion problem other than for highly simplified situations.

Useful attempts have been made to circumvent this difficulty by utilizing the statistical properties of turbulence, rather than employing a purely analytical solution. The most popular scheme is to assume that the plume on a single species of effluent (neglecting any chemical reaction) from each source spreads out randomly as it is blown downwind, so that the pollutant concentration along any axis across the plume's cross section is distributed according to the familiar Gaussian or bell-shaped curve. This situation is illustrated in Fig. 4. The expression that describes this distribution is a form of the so-called Sutton diffusion equation (G. H. Strom, in Ref. 1, vol. 1, pp. 254–256). Given the standard deviation of concentration in the vertical and horizontal directions (the value of the vertical standard deviation σ_z is usually larger than the horizontal, σ_y), the equation can be solved for the ground-level concentration C of an inert pollutant at any distance y from a source of virtual height h. (The virtual height includes the thermal rise of the plume above the stack top[5]; Q and u have the same meaning as before.) Hence,

$$C = \frac{Q}{\pi \sigma_y \sigma_z u} \exp\left[-\frac{y^2}{2\sigma_y{}^2} - \frac{h^2}{2\sigma_z{}^2}\right] \qquad (3)$$

An astute reader will observe that we have merely traded the problem of determining the diffusion coefficients K for the similar problem of evaluating the new statistical variables σ_y and σ_z. However, a number of field studies have been conducted, resulting in expressions capable of defining the standard deviations in terms of diffusion parameters, which in turn depend on the stability (lapse rate) and mixing depth as well as the gustiness of the wind. These factors will vary, of course, as a function of the terrain. Although rather extensive evaluation has been conducted at Brookhaven National Laboratories (where the ground is somewhat flat and wooded) as well as in the rolling country of Porton, England, the terminology used to describe stability and the numerical values obtained have not been in perfect agreement (see Strom, pp. 256–257). Thus there is still a problem in finding the correct numbers to put into the diffusion equations, and it would be expected that the diffusion parameters for cities would be very different from those for exurban sites.

Despite these difficulties, diffusion models have been useful. One well-established use has been to compute the maximum concentration of pollutants at any point on the ground, downwind from a stack. Equation (3) can be manipulated to give this result. If the statistics σ_z and σ_y are the same functional form of the diffusion parameters, the expression is

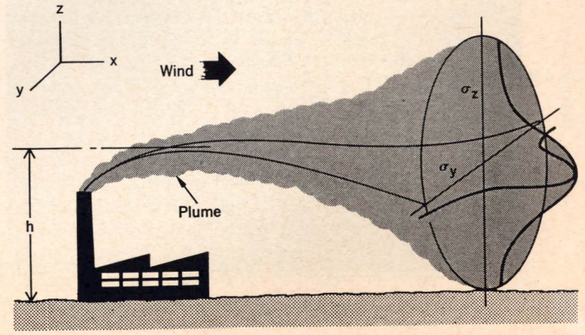
$$C_{\max} = \frac{2Q}{\pi u e h^2} \frac{\sigma_z}{\sigma_y} \qquad (4)$$

where e is the base of natural logarithms.

For settleable particulates, these equations must be modified. Furthermore, the role of chemical reactions, which is of overriding importance in the case of photochemical smog, has been neglected in the simple forms shown.

At this point, we should examine the results of some of the applications of these diffusion equations. Much success has been achieved using the Sutton equation and its variants to locate and design stacks for industrial power plants. Diffusion models have also been used routinely by NAPCA (now APCO) to determine the average distribution of pollutants in urban areas and to establish air quality control region (AQCR) boundaries. Moreover, at least nine separate tests of models have been conducted on a more rigorous scale in various cities. These have been reported in detail in papers by Wanta (Ref. 1, pp. 220–223) and Seinfeld (Ref. 3, pp. 178–184). In most cases, Eq. (3) or a simplified version of it comprised the basic model. On the basis of source and meteorological data, future concentrations were predicted for the pollutants SO_2, NO_x, and CO or CO_2 in some cases. The only chemical reaction considered was the decay of SO_2. Generally, the resolution of the model in space measured a kilometer or more and, in terms of time, from 1 or 2 hours to a month. Under these conditions, Pooler[6] in 1961 was able to predict half of the monthly averages of SO_2 at 123 stations in Nashville, Tenn., within a factor of 1.25. In 1964, Clark refined the time scale to 2 hours and was able to predict 24-hour averages of NO_x at 14 of 19 stations in

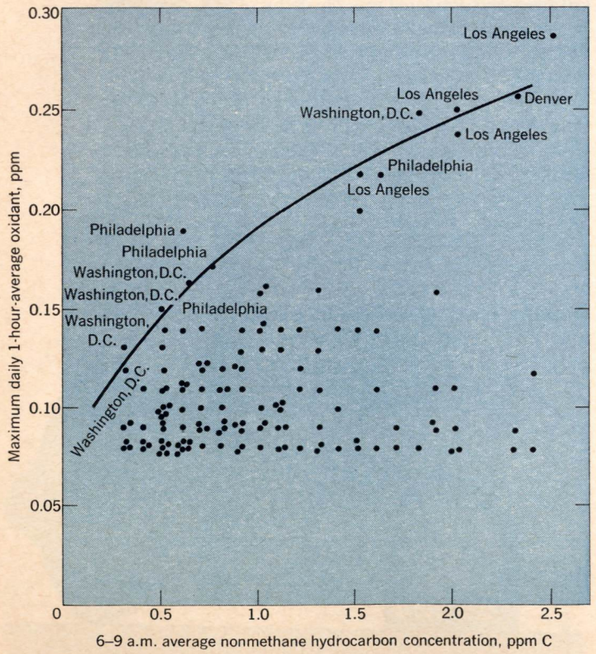
FIGURE 4. Gaussian diffusion from point source.



Cincinnati, Ohio, to within 0.02 ppm. Turner[7] reduced this error by half 58 percent of the time using Eq. (3), and in 1967 Koogler was able to report 90 percent of 8-hour SO_2 averages correctly within 0.01 ppm, employing the same model. Perhaps the most extensive tests of the Gaussian diffusion model have been conducted by Miller and Holzworth[8] in three different cities, with 2-hour-average predictions at an accuracy comparable to Koogler's.

Considering the coarseness of the input data and the resolution obtained, these results appear quite promising. Nevertheless, they are severely limited by their inability to account for the time variation of source strengths and their limitation to simple sources and inert contaminants. In the most ambitious model used to date, Lamb[9] in 1968 returned to the diffusion equation, a special form of Eq. (2), and applied it to compute CO concentration at 1200 grid points (as close to each other as 200 meters) for a single day in Los Angeles. Lamb's model utilized simple chemical reaction rates and included absorption of components by the ground. His point, line, and area sources were variable in space and time. Stability (inversion height) and the K values of Eq. (2) were considered constant. In the numerical solution of Lamb's integral equations, the sources were considered to emit a puff of pollutant at each time step: these puffs were dispersed by the x,y components of surface wind computed at each grid point, and followed until fully dispersed (Ref. 3, pp. 178–184). The effects of all these dispersed emissions were then totaled to obtain concentration as a function of time and location.

FIGURE 5. Maximum daily oxidant as a function of morning hydrocarbons. (Courtesy Journal of the Air Pollution Control Association)



The model's predictions did not correlate perfectly with measurements at various stations. Its faults have been ascribed to lack of a vertical wind component, giving concentrations too high at the convergence of trajectories and results too low during the afternoon, suggesting an influx of sources from outside of Los Angeles. In order to improve this model substantially it will also be necessary to include nonlinear chemical-reaction terms (Ref. 3, pp. 178–184). It has been reported that such a model is under development at Systems Development Corporation under the sponsorship of APCO.[10]

In practice, chemical reactions in the atmosphere have been taken into account by means of the purely statistical or correlation models mentioned previously. In general, the polluted air mass over a city is unstable chemically as well as physically. Both thermal and photochemical reactions between atmospheric contaminants occur. Thermal reactions include the formation of acid mists from SO_2 (catalyzed by oxide particulates) and salts from acids and metals, etc., some of which may be promoted by the surface effects of particulates. The most troublesome reactions are photochemical. These result in the production of oxidants through ultraviolet irradiation of certain reactive hydrocarbons mixed with nitrogen oxides.

Laboratory studies of polluted atmospheres have given sufficient information about these reaction rates to construct a simulation model. But, as noted previously, it has not been possible to integrate this into an analytical diffusion model. However, it is known that an empirical relationship exists between the concentration of hydrocarbons (nonmethane) in early morning hours and the maximum hourly average oxidant concentration that may occur later that day. Since it is also known that many other factors, such as nitrogen oxide concentration, sunlight, and meteorological ventilation, can and do intervene, the relationship between these two factors is a statistical one,[11] as seen in Fig. 5. Though limited and unsatisfactory, such data may be put to use in a negative way. That is, given the morning hydrocarbon reading it can be predicted that the maximum level of oxidant will *not* exceed some upper limit, defined by the limits plotted in Fig. 5.

Furthermore, the data can be manipulated to express an air quality standard. If the maximum allowable daily one-hour-average oxidant value is 0.1 ppm, for example, then the 6–9 A.M. average nonmethane hydrocarbon concentration must not be allowed to rise above 0.3 ppm.

Requirements for data processing

Ultimately, we hope to solve mathematical models similar to that described by Eq. (2) in sufficient detail to permit forecasts of air pollution within urban regions. These forecasts must be computed rapidly if the information is to be usefully applied to preventive control and management of pollution sources. Even if we know the K values, the chemical reactions and their rates, and the characteristics of wind and turbulence around urban areas and buildings, the simultaneous numerical solution of the many partial differential equations is formidable. Though we do not know the exact nature of the ultimate model or what simplifications may be introduced, it is legitimate to ask what order of processing capability may be demanded.

If the Gaussian diffusion model represented by Eq. (3) were to be used, this question could be answered with some confidence. Turner[7] computed 24-hour forecasts for Nashville with this model, employing 2 minutes of time on an IBM 7090 machine. It is possible to scale his methods to a hypothetical area the size of New York City by assuming 200 grid points rather than the 99 used for Nashville, four topographical levels instead of one, and a doubled time resolution. This yields a progressing time multiplier of 16. The IBM 7090 cycle time is 1400 ns; a typical modern minicomputer such as the Honeywell DDP-516 cycles at 960 ns, a 1975 mini may cycle at 750 ns, whereas a large 1975 processor may cycle as fast as 40 ns. Of course, it is not possible to compare the processing time of "benchmark" problems by cycle time alone, since the total machine architecture and software organization equally influence this parameter. But if we assume that all these factors vary proportionally, the processing time for the hypothetical New York City prediction problem would be

Present minicomputer (e.g., Honeywell DDP-516)	22 minutes
1975 minicomputer	17 minutes
1975 large processor	< 1 minute

Assuming the ability to compute predicted pollution concentrations, the next step is to compute optimum control measures by evaluating alternate control strategies. An approach to solving this problem has been made by applying a linear programming routine.[12] This was applied to a model of the St. Louis air shed and allowed 200 control measures (such as fuel switching, leaf collection, automobile and process controls, etc.) to be applied against the constraints of availability, maximum effectiveness of each measure, and total requirements for pollution reduction. The model accounted for the five major pollutants and a large number of sources (unspecified in Ref. 12). The output of the computation was a set of control methods that eliminated the desired weight of pollutants from the air shed, at the least total cost.

Although this model is useful as a tool for air-pollution control and is simple enough to be applicable generally to other air sheds, it does not contain enough detail to determine localized or neighborhood effects or to solve short-term problems. Correction of all these limitations would produce a much larger and more sophisticated model. The present one was programmed for an IBM 360 computer. Although the running time was not given, it can be guessed that an optimization problem might run to the equivalent of 100 iterations of the Gaussian diffusion model. On this assumption, the resultant running time for the assumed 1975 large processor discussed will be of the order of 1½ hours. It is probable, therefore, that optimum solutions for various hypothetical pollution situations will be predetermined and stored for future use, or that suboptimal shortcut procedures will be developed.

The computation picture based on solutions to the inert Gaussian diffusion equations may be far too optimistic if the analytic diffusion model is implemented. An estimate[13] for one such complicated model runs to one hour computing time per day of forecast on a large parallel processor such as Illiac IV. Although machines of this power might not be in abundance in 1975, they will certainly be available and it has been suggested that one may be time-shared; thus one machine can service 20 or more cities.[14]

The need for real-time data has been discussed earlier, but before concluding this section, it should be conceded that opinion on this subject, relative to existing monitoring networks, is by no means unanimous. Mitre Corporation recently completed a study of this topic based on interviews with federal and state air-pollution officials.[15] It was found that only 28 percent of them believed it necessary to have a national monitoring network capable of reporting in less than 6 hours, whereas 62 percent thought it necessary at the regional and local level. Those in favor of real-time data cited episode and source control as their primary needs, mentioning medical (alerts to hospitals and patients) and industrial accident control as well. Those opposed to rapid air-pollution data dissemination apparently believed so because of the lack of effective control action that can be taken in a short time, especially at the federal level. Since this attitude realistically reflects the situation in many cases, it can be expected to change as the legal and technical steps for source control are taken.

Even in today's networks, however, the study conceded the need for telemetering of warning signals (high concentrations) from remote, unattended stations and the need for large processors to manage data at central stations. It also foresaw the need for data exchange between local networks to combat interregional or national pollution transport, and for this reason a uniform data format compatible with the federal climatological network is recommended. (SAROAD is such a code.)

Source control and abatement

At the operative end of the nationwide air-pollution system is the source-control subsystem, and its ultimate technical objective is to correct the predicted adverse trends in atmospheric pollution. The word "control" is used here in two senses, meaning both the legal emission standards and ordinances reflecting the social power over pollution-emitting sources and the physical devices that actully reduce emission. We shall discuss mainly the concepts and means of implementing the legal standards, including measuring devices at the sources to see that these controls are enforced.

Although the physical controls are of immense technical and monetary interest to industry, representing perhaps 90 percent of the funds that must be expended to clean the air, they represent little that is not well known. Much of the expenditures for air-pollution control will go for such mundane devices as bag filters, cyclones, gas scrubbers, and absorbers. Electronic precipitators for removing particulates, especially, are immensely expensive, as mentioned earlier, and of somewhat greater technical interest, but have been used since the beginning of this century. Tall stacks, of course, do not reduce total emissions, but according to Eq. (4) they will reduce the concentration of ground pollution by the square of their height; however, they are no less expensive, costing from $3000 to $7500 per meter. The greatest area for innovation may be actual changes in the pollution-causing processes themselves. If materials can be used more efficiently or recycled, the end result may be a saving rather than an expense to the manufacturer.[16,17]

Legal control may be exerted prior to or following the establishment of a man-made source of air pollution. Physical controls and tests to prove the ability to meet emission standards may be required as a prerequisite for construction or operation. Once a source is permitted to

SPACING OF LINES ON RINGELMANN CHART

Ringelmann chart no.	Width of black lines (mm)	Width of white spaces (mm)	Percent black
0	All white		0
1	1	9	20
2	2.3	7.7	40
3	3.7	6.3	60
4	5.5	4.5	80
5	All black		100

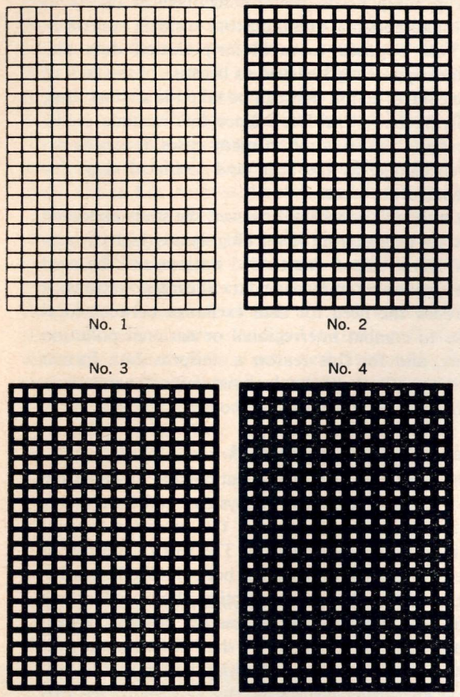
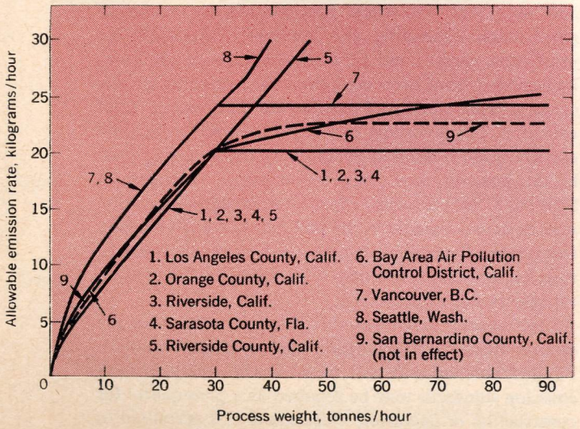


FIGURE 6. The Ringelmann chart. (Courtesy Academic Press)

FIGURE 7. Process-weight emission rule for particulate emissions. (Courtesy Chemical Engineering[22])



come into existence, its emissions must be brought into line with the regional air quality standards by continual monitoring and inspection. If it is found wanting in this respect, additional controls or a change in process may be required.

Prior controls

Ideally, air-resource management starts with community planning. All aspects of land-use planning—such as transportation; zoning for industry, commerce, or residential use; waste disposal; and park and open-space reservation—should be considered in planning to meet quality standards for the air, and conversely. A survey of the local background of contaminants should be made prior to land development. Such factors as future growth of population, increased automobile use, location of new electric power plants, and introduction of new mass transportation methods have obvious impact on future air quality. The effect of these changes as well as the expected values of pollution with current land usage can be employed by the use of mathematical diffusion models, as previously described.

Given a single source with a constant rate of emission and stack height, there is a combination of wind direction and velocity, atmospheric stability, and distance for which the ground concentration of pollutant will be greatest [Eq. (4)]. This concentration can be numerically set equal to the desired air quality in order to obtain an emission standard for this stack. In the case of several large and many small sources, the problem of allocating the total emission may become very complex, but this is precisely the basic problem of fairly dividing up use of the public's air resource. (Croke and Roberts,[18] for example, have suggested emission standards based on land area owned, rather than by individual stack or industrial plant.) A computer program that has for inputs the yearly inventory of source strengths and a long-range analysis of meteorological variables, with the capability of computing the time and place of maximum pollution, has been suggested by Stern (Ref. 1, vol. 3, p. 620). The program would then print out the contribution of each source to this "worst pollution day" and permit allocation as before.

The means by which the sources in a region can control their emissions to predetermined maximums may be optimized from a cost standpoint by the use of linear programming models and similar economic models discussed earlier. Studies of this nature will lead to a rational basis for land-use and zoning decisions, and for rules governing construction permits and licenses. Where local interests conflict with quality standards based on public health and welfare, an educational program or intervention by a higher political entity, through the imposition of state or federal emission standards, may be required. Likewise, these may be necessary in the event of pollution transport between local regions.

Emission standards and zoning regulations, established by local ordinance or statute, imply the existence of a local control activity to implement them. Engineering analysis of plans, with special attention to emission points, stack heights, process-flow sheets and quantities, and proposed control methods and monitoring instruments or access, form the rationale for approval of construction permits. At this time, the data base for a source-emission inventory is established. A data bank, which may or may not be mechanized, depending on the needs of the system, is part of the activity.

Posterior control of stationary sources

Little or no control can be exerted over stationary air-pollution sources, once they are established, without the specific legal and financial authority necessary to create and support an enforcement agency to act at the local level. The President's Council on Environmental Quality, in its annual report to the U.S. Congress,[19] indicates that most of the state programs, as well as those at the local and regional level, are inadequate in this respect. There are 144 local agencies receiving federal grants, but only 44 percent are adequately funded for a minimal program, as are only six out of the 55 funded state and territorial programs.

Prior to August 1971, there was in effect only one federal emission standard—that established for new automobiles—although performance standards for certain categories of new stationary plants have now been published.[20] In 1970, all states had air-pollution legislation, but only 42 actually had any kind of regulation to control emission. For example, 33 states had open-burning regulations (compared with 19 in 1968) but only six states regulated vehicle emissions.[21]

It is clear that the legal basis for regulation and control of sources, though accelerating, is still very inadequate and spotty. Nevertheless, patterns of source-control regulations have been established in those areas where they have been pioneered, and it is believed that new regulations for stationary sources will continue to follow these trends.

Particulates. Regulations for the control of particulates have been based on four different concepts: opacity, concentration, process weight, and emission potential.

The classic standard that is applied to the control of black smoke, and the only regulation in many communities, is that of the Ringelmann chart, first introduced in 1897 (see Fig. 6). It is a subjective measure, performed by visually comparing black smoke plumes with four cross-hatched charts exhibiting various proportions of black line width to white spacing. The charts are stationed at such distance as to merge the black lines into a uniform gray. The basic concept was expanded, first in Los Angeles, to include the "equivalent opacity" of white and colored plumes, a comparison that is even more subjective. Nevertheless, it has been possible to train inspectors to agree within a half Ringelmann "number," and the method is still firmly entrenched in enforcement practice despite its obvious shortcomings.

Other particulate regulations specify the concentration (mass per unit volume) of effluent gas. These are based on a "model smoke ordinance" developed by the ASME in 1948. Typically, the limits range from 0.2 to 0.3 grain per standard ft^3 (7–10.5 per m^3) (at 60°F and 1 atmosphere), depending on the definition of particulate, the sampling method, and the gas composition.

Another rule governs the emission of dust as a function of the weight of material processed in order to circumvent attempts to avoid the concentration rule by diluting the gas stream. The process–weight concept is demonstrated in Fig. 7. It can be seen that permissible emissions under this rule can be increased by using two or more small units, rather than one large device.

The concept of control of both gases and particulates by "emission potential," depicted in Fig. 8, has been adopted by New York State. The abscissa of each curve represents the potential rate at which contaminants would be emitted if there were no gas-cleaning devices. The rules increase in stringency depending on the toxicity class of the material; thus, about 15 percent of iron oxide potential can be emitted but only 1 percent of beryllium.[22]

It is clear that this type of standard, recognizing the effect on the receptor, is most rational. Some regulations go even further by distinguishing between fine and coarse particles, which have different physiological and physical effects. It is possible that the development of a convenient, accurate, objective instrument, which would correlate with the more important receptor effects, would create a new standard means of measuring particulates and replace the visual tests.

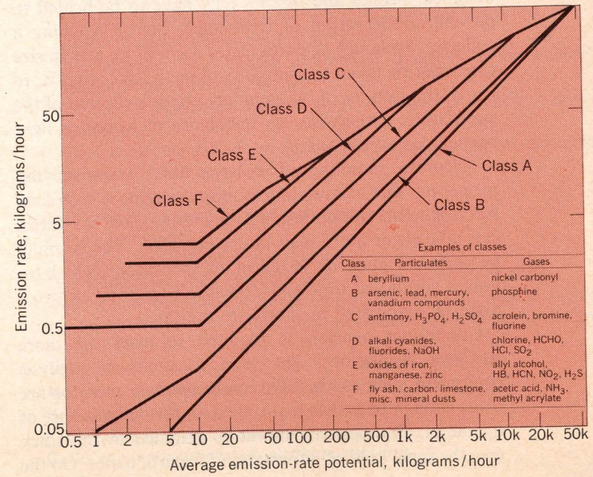
Gases. Most standards for the emissions of gases from stationary sources have been directed against SO_2, although other gases and vapors, including fluorides, hydrocarbons, solvents, and other sulfur compounds, are also controlled. In California, the rules give an operator the option to monitor ambient ground-level concentrations, rather than adhere to a fixed stack concentration limit. The ambient limits (Fig. 9) must be monitored by at least three continuous SO_2 analyzers and one recording wind station.[22]

Some emission standards are combined with a design standard, such as stack height or adjusted height (corrected for temperature of flue gas). Stack height criterions result from the diffusion models discussed earlier. Other regulations control emissions indirectly by specifying fuel standards; for example, the volatile content of coal, the olefin content of gasoline, and the sulfur content of heating fuels.

Source testing and monitoring

If, in the long term, the application of air-pollution controls to old and new sources is the response of the national system to intolerable ambient levels, then source testing and monitoring represent the feedback that closes the control loop. Source emissions are tested by the plant

FIGURE 8. "Emission potential" standard. (Courtesy Chemical Engineering[22])



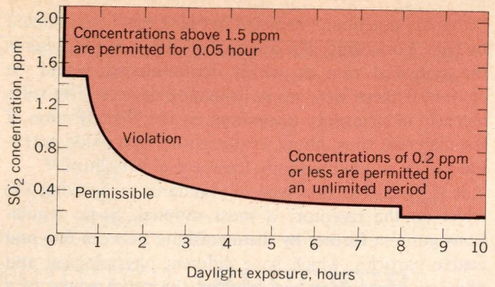


FIGURE 9. Ambient ground-level limits on gaseous emissions. (Courtesy Chemical Engineering[32])

operator or by a control agency for many reasons: survey, licensing or inspection, checking the efficiency of collectors, monitoring process malfunctions or accidents, compliance with legal standards, or for record. Such monitoring is now usually accomplished in the stack, by roof monitor, or at other effluent locations. Control agencies may, in addition, monitor or test sources with in-stack or remote sensors to answer complaints or to detect violations. In connection with alleged offenses, the method must meet local legal criterions.

Source testing must take into account all the technical problems of obtaining a valid and representative sample. Pertinent factors include cyclic or random fluctuations of the effluent, both in quantity and composition, and physical or chemical instability of the sample. Each problem must be solved in the context of the particular process, plant, and installation. The temperature and the dew point of flue gases are significant. In general, particulates pose greater sampling problems than gases because of agglomeration and variations in particle size.

Flow rates, as well as composition, directly determine a plant's contaminant emissions. Flow measurement by means of Pitot tubes in ducts and stacks must cope with plugging by particulates. Locations of sample or duct traverse points must follow good practice for these instruments. Because of the dirty, hot, or corrosive nature of effluents, special sampling equipment must often be designed. Probes and nozzles may have to be heated to prevent condensation of the sample before reaching a collector. In sampling particulates 3 μm or greater in size care must be taken to sample "isokinetically"; that is, to match the velocity of the sampling nozzle with that of the gas stream. Otherwise, an imbalance of heavy or light particles enters the nozzle.

Accurate sampling of a large duct, ensuring the proper number of sampling points, changing nozzle sizes for isokinetic conditions, flow metering, and so forth, can take 10 or more man-hours per trial. The samples so collected must be tested in the laboratory, which involves additional time and expense. Therefore, approximate or automated methods are indicated.

Continuous analysis is required to meet the more stringent regulations. The time constants of analysis equipment such as the SO_2 conductimetric monitor are short enough to gather real-time data for the guidance of operators. Photoelectric monitors installed in the stack give the same kind of information for particulates. On the other hand, some monitoring equipment, such as tape samplers, requires a definite sample period and average over this time lag. Monitoring devices relying directly on pollution effects may have very long time constants; examples are lead sulfate candles, lead acetate tiles, rubber strips, paint, and metal. These may take months or a year to measure contamination.

In general, the stack-mounted analysis equipment in current use is similar to the air quality monitoring equipment discussed earlier, except that the former measures higher concentration ranges. Wet-chemical analyzers, including both photometric and conductimetric systems, are used for SO_2 and H_2S. Flame photometric techniques are also used. Carbon monoxide is monitored by nondispersive infrared instruments; particulates, by photoelectric and infrared opacity meters and tape samplers. Recorders, and sometimes level alarms, are usually incorporated in these instruments.

A novel method of stack sampling for SO_2 is the correlation spectrograph, mentioned in Part II as a long-path sensor. The instrument measures the intensity of the ultraviolet spectrum of stack gases sampled by a slotted tube in the stack, comparing it with a photographic mask of the SO_2 spectrum. The photocell monitor is calibrated to read in parts per million, and is protected from the flue gases by means of an air curtain.

Although modern photoelectric and spectroscopic devices may solve many of the problems of source monitoring, equipment capable of reading stack-emission compositions at a distance is even more attractive. In this way, not only are installation and sampling problems obviated, but the possibility of time sharing as well as portable application for law-enforcing agencies is introduced. Remote-reading stack monitors are by no means a new idea. The Ringelmann smoke chart is a remote comparison device, and several other portable visual smoke guides and viewing devices are available.

To replace visual particulate measures, a pulsed-laser instrument (lidar) has been developed by the Stanford Research Institute and is undergoing evaluation. The Mark V acts similarly to radar, utilizing a pulsed, *Q*-switched ruby laser with a beam width of 0.35 mrad.[23] Reduction in light backscatter due to the smoke plume is the measurement criterion, since the echo is a function of particle size and color as well as concentration. More advanced lidars have been built and tested.

Active, single-ended, spectrographic devices, not dependent on sunlight as a source, are being studied. The infrared backscatter instrument has also been mentioned; another concept monitors emission spectrums from hot stack gases by means of a spectrophotometer. Raman spectroscopy is being investigated for stack monitoring, as referenced earlier. The difficulty with these remote systems at present, aside from the need to prove their feasibility, consistency, and acceptability as legal standards, is their cost and complexity. Less spectacular remote means, including time-lapse photography, are coming into use pending further developments.

Another requirement would involve a simple means to track down violators of pollution regulations and to locate offending sources. Tracking small windborne balloons at night, when an odor plume travels under an inversion, is one technique. The tracker must first locate the point of strongest detectable odor, release and track the balloon, and record the wind direction. Two or three

such measurements can pinpoint the odor source by triangulation. More direct means, such as the remote sensors discussed, are clearly desirable.

Short-term and episode control

Federal law requires AQCR plans to provide adequate authority to deal promptly with emergency air-pollution conditions, and some areas have so defined alert concentrations and procedures. The governors of most states have the power to take action in the event of dangerous air-pollution episodes. Alert plans call for action to be taken upon observing high concentrations of certain pollutants or combinations for as little as an hour or even less (see Table I). The designation of greatly increased numbers of air quality regions and implementation of their approved plans implies that a large number of areas will have the capability to respond within hours or less to transient but dangerous air-pollution levels.

In the present stage of development of the national air-pollution control system, however, the pace is generally much more leisurely. All regions have not implemented alert plans. The need for rapid transmission of air-monitoring data to a central data center is minimized or even doubted by some officials, as has been discussed. There have been, fortunately, few episodes in this hemisphere where widespread fatalities and illness can clearly be laid to air pollution, so that no "clear and present danger" is generally feared.

Nevertheless, the factors referenced in Part I of this article, including increased population, greater industrial activity, and more automobiles, are pointing to higher levels of contamination concentration over a *longer-term period*, while the criterions, especially those based on health effects, move toward recognition of lower levels of tolerance.[24] (It is allowed that a temporary respite, perhaps through 1980, may be obtained by stringent enforcement of federal automobile and stationary-source controls. Perhaps by that time we will achieve more basic means of restraint.) Consequently, potentially dangerous episodes should become increasingly prevalent through both increased base concentration levels and statistical fluctuations, as well as by more rigorous definitions. It follows that the mature national air-pollution control system shall have a fully developed capability to predict, detect, and react to dangerous air-pollution concentrations, acting within a time scale of hours or fractions of an hour.

In addition to this capability, which will be designed to combat the rare, natural coincidence of source-strength fluctuation and unfavorable weather, the high-speed response of a monitoring system will be effective against industrial accidents and violations of control regulations.

The quick-reaction system envisioned will depend very much on high-speed data-processing equipment and refined mathematical models that will permit prediction and prevention of dangerous concentrations, not merely their detection after the fact. Furthermore, the system will depend on a more widespread network of monitoring instrumentation than is currently deployed (Ref. 24, p. 38), and may utilize continuous central monitoring sources through permanently installed telemetering and measuring instruments as remote-acting stack monitors.

Equally important, a quick-reaction system must have a fully developed command and control structure in as real a sense as that of a military air-defense system. Information must not only be collected, but displayed without delay to personnel capable of making rapid decisions (with computer aid) on the course of action that will avert the predicted emergency.

It is understood, then, that although some portions of the envisioned system may now exist in the more highly developed air quality control systems, both here and abroad, all the necessary components do not and cannot exist until further research and development are carried out. An outline of the functions of such an ideal system is presented in Table II. These can be compared with the characteristics of some existing systems described in the next section.

I. Alert stages for toxic air pollutants —Los Angeles County (parts per million)

Gas	1st Alert	2nd Alert	3rd Alert
CO	100 for 1 hour	100 for 2 hours	—
	200 for ½ hour	200 for 1 hour	200 for 2 hours
	300 for 10 min	300 for 20 min	300 for 1 hour
NO_x	3	5	10
SO_x	3	5	10
Ozone	0.5	1.0	1.5

Current system status

An overview of some continuous aerometric networks currently being used and developed by state and local

II. Outline of quick-reaction system functions

1. Alert decision
   A. Resulting from predictions of probable dangerous pollutant levels, a decision is made to exert control over emission sources. [Note: Existing systems (e.g., Los Angeles) alert on the basis of current rather than predicted levels, plus meteorological forecasting of pollution potential in the New York–New Jersey area; see Table I.]
   B. Requirements for decision function are
      (i) Prediction model.
      (ii) Law and doctrine.
      (iii) Display of current and predicted levels, including meteorology and geographic display.
      (iv) Mobilized command and control organization.
2. Tradeoff decision
   A. Objective is to determine the least costly effective control action.
   B. Control actions available by law to the control team are
      (i) Point source abatement or shutdown.
      (ii) Stationary area source abatement (heating, process combustion, open burning, etc.).
      (iii) Mobile source abatement (e.g., auto traffic diversion or reduction).
   C. Determine the minimum cost objective according to the cost-effectiveness model or doctrine.
3. Command and control
   A. Objective: to exert control over emissions.
   B. Requirements:
      (i) Data central and status display.
      (ii) Personnel who are authorized to take competent action.
      (iii) A communications net to controlled sources. Also a public information net to control area emissions, give out information, etc.
4. Feedback
   A. Quality monitoring and trend prediction.
   B. Violation detection.
      (i) Patrol with mobile remote sensors.
   C. Source instrumentation and telemetering.

III. Continuous aerometric methods

	System	New York State	Pennsylvania [Planned]	New Jersey	Delaware
Mission	Coverage	[725 linear km]	[10 air basins]	[State]	[State]
	Population ($\times 10^6$)	—	—	—	—
	Major system objectives	monitor/alert/criterions	monitor/alert/criterions/control/model development	monitor/alert/criterions	—
Sample system design	Variables: Chemical	8	7	10	7
	Meteorol.	8	5	7	2
	Poll interval (minutes)	15	1	—	3
	Basic averaging time	15 min	1 hour	15 min	15 min
	Number of stations	11 [50]	1 [25]	18 + 3 mobile	4
	Sample density (stations/2.6 km²)	—	—	—	—
	Site design (primary criterions)	geography/pop. levels	diffusion model/10 air basins	—	—
Data handling	Data transmission	digital/dial-up line	digital/leased voice line	analog	—
	Data processor	B-3500	Spectra 70 + control computer	Spectra 70-45 + PDP-8	—
	Display	CRT + TTY	graphics map + printout	printout	printout
	Mathematical models: Episode prediction	—	[diffusion models]	—	—
	Control optimizing	—	—	—	—
Control decision	Alert criterions	SO_2/CO/particulate levels	—	—	—
	Control procedure	—	—	—	—
Auxiliary	Emission inventory	—	[computerized]	—	—
	Data-exchange format	—	—	—	—
	References	25	26	27	28

Note: Square brackets signify plans or goals.

Allegheny County (Pittsburgh)	Chicago	Los Angeles County	New York City	Philadelphia	Rijnmond (Rotterdam)
1100 km²	650 km²	1035 km²	520 km²	325 km²	325 km²
1.6	6.2	6.9	11.4	—	—
monitor/control/historic data	monitor/alert/control	monitor/alert/control	monitor/alert/criterions/hist.	monitor/alert	alert/control
7	1(SO_2)	6	3(5)	6	1(SO_2)
4	2	4	3	[total]	2
3	15	demand or 1 hour	5–30	5	1
5 min	15 min	1 hour	5 min–4 hours	—	1 hour
7[18]	8	12	10[30]	6	31
0.02	0.03	0.003	0.05	0.05	0.25
topography/large sources	topography/industry/pop.	—	pop. density/geography	—	diffusion model/sources
digital/voice line	digital/TTY line	digital/wire + microwave	analog (PWM)/voice line	analog/voice line	analog (PFM)/phone (120 Hz)
IBM 1801	—	CPU	PDP-8	—	Philips P-9201
printout (reads red over standard)	printer [CRT]	real-time graphic, hourly printout	TTY printer	—	printer
COH—met. regression model	[2–24-hour forecast diffusion model]	analytical diffusion model	—	—	statistical (mean deviation)
—	[optimizing short- and long-term model]	—	—	—	—
meteorology forecast + SO_2/CO/particulate levels	SO_2(0.30 ppm), 48-hour stagnation	O_3/CO/SO_2/NO_x	meteorology forecast + SO_2/CO/particulate levels	—	meteorology forecast + SO_2
source abatement	fuel change or shutdown	3-stage alert (burning, traffic)	3-stage alert	—	source curtailment
[computerized]	large sources [computerized]	—	—	—	major sources known
SAROAD	—	—	SAROAD	—	NA
29, 30	31, 32	33	34–37	—	38, 39

air-pollution control activites will give some idea of how far we are along the road toward a nationwide monitoring and control function. This survey will disregard the National Air Sampling Network (NASN) and the Continuous Air Monitoring Program (CAMP) of the federal government, despite the fact that these *are* nationwide, because these projects are intermittent or limited in scope. (CAMP has only six stations in as many cities and is intended to provide historical and research data, rather than to serve the "real-time" needs of public information and source control.)

Several typical state and local continuous monitoring networks are described in Table III, with the Rijnmond (Rotterdam) network, developed for the Netherlands government, included for comparison.

Network characteristics can be conveniently broken down into four groups for purposes of this tabulation. These are the network mission, the sampling design, the data-handling methods, and the control action decision. The actual performance of control activities, such as fuel switching, are not part of the aerometric network, but the compliance of sources on a legal or voluntary basis is, of course, essential to the entire undertaking. The network may also take on supplementary functions, such as storage of source-emission inventories and of data in standardized format (SAROAD) for nationwide exchange.

The objectives of the networks are reasonably consistent. All have, as one goal, monitoring for unhealthy concentrations, which is not surprising in view of the requirement to establish an alert procedure in order to qualify for federal funds. (Most network funds, for example two thirds of the city of Philadelphia's total, are derived from the Federal Clean Air Act.) There is a strong tendency to spread out the objectives to longer-range items, such as criterions or mathematical-model development, to help justify expensive data processors.

In measurement and sampling, there are two schools of thought. One utilizes SO_2 as a "tracer," or index of general pollution, whereas the other finds it necessary to monitor individual chemical variables. Those relying on SO_2 are either less concerned with automobile-derived photochemical smog or anticipate a strong correlation between pollution components. This difference is also reflected in the number of meteorological variables considered necessary.

The most striking inconsistency lies between the design of the sampling systems, particularly the station density, and the criterions for "representativeness" of the samples. Studies of SO_2 pollution in several areas of the world have agreed that the spacing between sampling stations should not exceed 0.8 km to obtain reasonably accurate estimates of the daily average. One standard, that of the West German Federal Republic, approaches this measure by requiring one station per square kilometer for pollution surveys. The actual densities tabulated for U.S. networks are at least two orders of magnitude below this criterion. Attempts have been made to justify this parsimony theoretically by appeal to diffusion models and by placing sensors near large sources. It has been shown in the Allegheny County system, for one, that this does not work.[30] In Rijnmond, however, where the topography and source parameters appear less complicated, it may prove possible to obtain accurate results with about one tenth the theoretical coverage. If this proves to be the case, it will serve as economic justification for greater application of diffusion modeling in support of sampling network design.

The data-handling systems should show few surprises,

since the current numbers of sensors do not require any novel techniques. In view of a debate on manual or analog versus digital data transmission, it is noteworthy that most networks have chosen or have switched to the digital technique.[33] The use of general-purpose computers for data processing is practically universal. In several systems, elaborate diffusion models are planned and, in at least one case, these are for short-term pollution forecasting and "feed-forward," real-time control of abatement procedures. But, to date, it has not been reported that any of these models have been implemented.

Conclusion

A cost-effective approach to air-pollution control, although by no means unanimously approved, seems inevitable over the long term. Optimizing the use of our air resource as a sink will require a higher order of pollution monitoring than has been planned to date, and an order-of-magnitude improvement in urban meteorology and forecasting. In turn, this means more effort in the development of sensors, mathematical models of pollution dispersion, and the design of urban systems. It is apparent that current network sampling systems will require much expansion and a period of intensive development and testing before the point is reached where air pollution can be predicted and averted. We have made a beginning in this laudable ambition, but like Alice's queen in the "Looking Glass" story, we must run as fast as we can just to stay in one place.

The author appreciates the encouragement and thought-provoking discussion of many concerned persons within the Honeywell organization, including Irving G. Young, Robert L. Wilson, James M. Lufkin, and James E. Myers, as well as the substantial support provided by Ethlyn Thomson, librarian, and Marie Williamson, secretary. This article will form part of a book on this subject by the author and Dr. Young that will be published by Wiley–Interscience in the fall of 1972.

REFERENCES

1. Stern, A. C., ed., *Air Pollution*, 2nd ed. New York: Academic, 1968.

2. Smith, M. E., "International symposium chemical reactions lower atmosphere," Advance Papers, Stanford Research Institute, San Francisco, Calif., 1969, pp. 273–286.

3. Seinfeld, J. H., "Mathematical models of air quality control regions," in *Development of Air Quality Standards*, A. Atkisson and R. S. Gaines, eds. Columbus, Ohio: Merrill, 1970.

4. Pasquill, F., *Atmospheric Diffusion*. Princeton, N.J.: Van Nostrand, 1962.

5. Carson, J. E., and Moses, H., *J. Air Pollution Control Assoc.*, vol. 19, pp. 862–866, Nov. 1969.

6. Pooler, F., *Internat'l J. Air Water Pollution*, vol. 4, no. 3/4, pp. 199–211, 1961.

7. Turner, D. B., *J. Appl. Meteorol.*, vol. 3, pp. 83–81, Feb. 1964.

8. Miller, M. E., and Holzworth, G. C., *J. Air Pollution Control Assoc.*, vol. 17, pp. 46–50, Jan. 1967.

9. Lamb, R. G., "An air pollution model of Los Angeles," M.S. Thesis, University of California, Los Angeles, 1968.

10. Wayne, L. G., in *Development of Air Quality Standards*, A. Atkisson and R. S. Gaines, eds. Columbus, Ohio: Merrill, 1970, p. 199.

11. "Air quality criteria for hydrocarbons," AP-64, U.S. Dept. of Health, Education, and Welfare, NAPCA, Mar. 1970, chap. 5.

12. Kohn, R. E., "Linear programming model for air pollution control: A pilot study of the St. Louis air shed," *J. Air Pollution Control Assoc.*, vol. 20, pp. 78–82, Feb. 1970.

13. Schwartz, S., and Siegel, G. B., "Models for and constraints on decision making," in *Development of Air Quality Standards*, A. Atkisson and R. S. Gaines, eds. Columbus, Ohio: Merrill, 1970, p. 40.

14. Stern, D. M., Honeywell Inc., personal communication.

15. Katz, E. L., and Morgan, T. R., "Analysis of requirements for air quality monitoring networks," presented at Air Pollution Assoc. Annual Meeting, St. Louis, Mo., June 14–18, 1970.

16. Bailey, S. J., "Control practice in the electric power industry," *Control Eng.*, vol. 18, pp. 42–44, Sept. 1971.

17. Gent, M. R., and Lamont, J. W., "Minimum-emission dispatch," *Proc. 7th Power Industry Computer Applications Conf.*, Boston, Mass., May 24–26, 1971.

18. Croke, E. J., and Roberts, J. J., "Air resource management and regional planning," *Bull. Atomic Scientists*, pp. 8–12, Feb. 1971.

19. "Environmental Quality," First Annual Report, Council on Environmental Quality, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., August 1970, pp. 83–88.

20. *The Federal Register*, Mar. 31, 1971 (36FR5931).

21. Degler, S. E., "State air pollution control laws" (rev. ed.), Bureau of National Affairs, Washington, D.C., 1970.

22. Yocum, G. E., *Chem. Eng.*, vol. 69, July 23, 1962.

23. Johnson, W. B., "Lidar applications in air pollution research and control," *J. Air Pollution Control Assoc.*, vol. 19, pp. 176–180, Mar. 1969.

24. Black, G., "Air quality and the systems approach," staff discussion paper 104, Program of Policy Studies in Science and Technology, NASA Grant NGL 09-010-030, George Washington Univ., Washington, D.C., July 1970, pp. 17–18, 33, 39.

25. Hunter, D. C., "The air quality monitoring program in New York State," presented at Air Pollution Control Assoc. meeting, New York City, June 22–26, 1969.

26. Brodivicz, B., Sussman, V., and Murdock, G., "Pennsylvania's computerized air monitoring system," *J. Air Pollution Control Assoc.*, vol. 19, pp. 484–489, July 1969.

27. Wolf, P. C., "Carbon monoxide measurement and monitoring in urban air," *Environ. Sci. Technol.*, vol. 5, pp. 212–217, Mar. 1971.

28. Wilkins, P. E., "Monitoring for compliance,' Monitor Labs, Inc., San Diego, Calif., 1970, pp. 10–11.

29. Bloom, B., Allegheny County Air Pollution Control Board, personal communication.

30. Stockton, E. L., "Experience with a computer oriented air monitoring program," *J. Air Pollution Control Assoc.*, vol. 20, pp. 456–460, July 1970.

31. Stanley, W. J., "A real time air pollution monitoring program, Dept. of Air Pollution Control, Chicago, Ill.

32. Cramer, H. E., "Meterological instrumentation for air pollution applications," in *Environmental Pollution Instrumentation*, R. L. Chapman, ed. Pittsburgh: Instrument Society of America, 1969, pp. 15–16.

33. Mills, J., "Continuous monitoring," *Chem. Eng.*, vol. 77, pp. 217–220, Apr. 27, 1970.

34. Heller, A. N., and Ferrand, E. F., "The Aerometric network of the City of New York," Environmental Protection Administration, Dept. of Air Resources, New York, N.Y.

35. Klein, S., "New York City steps up war on foul air," *Machine Design*, p. 38, Dec. 19, 1968.

36. *The New York Times*, May 5, 1970.

37. Eisenbud, M., "Environmental protection in the City of New York, *Science*, vol. 70, pp. 706–712, Nov. 13, 1970.

38. Cabot, F., "So goes SO_2," *Ind. Res.*, pp. 70–72, Sept. 1970.

39. "A new approach to the prediction and control of air pollution," Philips Gloeilampenfabrieken, Endhoven, Netherlands, 1960.

BIBLIOGRAPHY

Bibbero, R. J., and Young, I. G., *Systems Approach to Air Pollution Control*. New York: Wiley-Interscience (to be published).

Hamburg, F. C., "Some basic considerations in the design of an air-pollution monitoring system," *J. Air Pollution Control Assoc.*, vol. 21, pp. 609–613, Oct. 1971.

Machol, R. E., ed., *System Engineering Handbook*. New York: McGraw-Hill, 1965.

Singer, S. F., ed., *Global Effects of Environmental Pollution*. New York: Springer-Verlag, 1970.

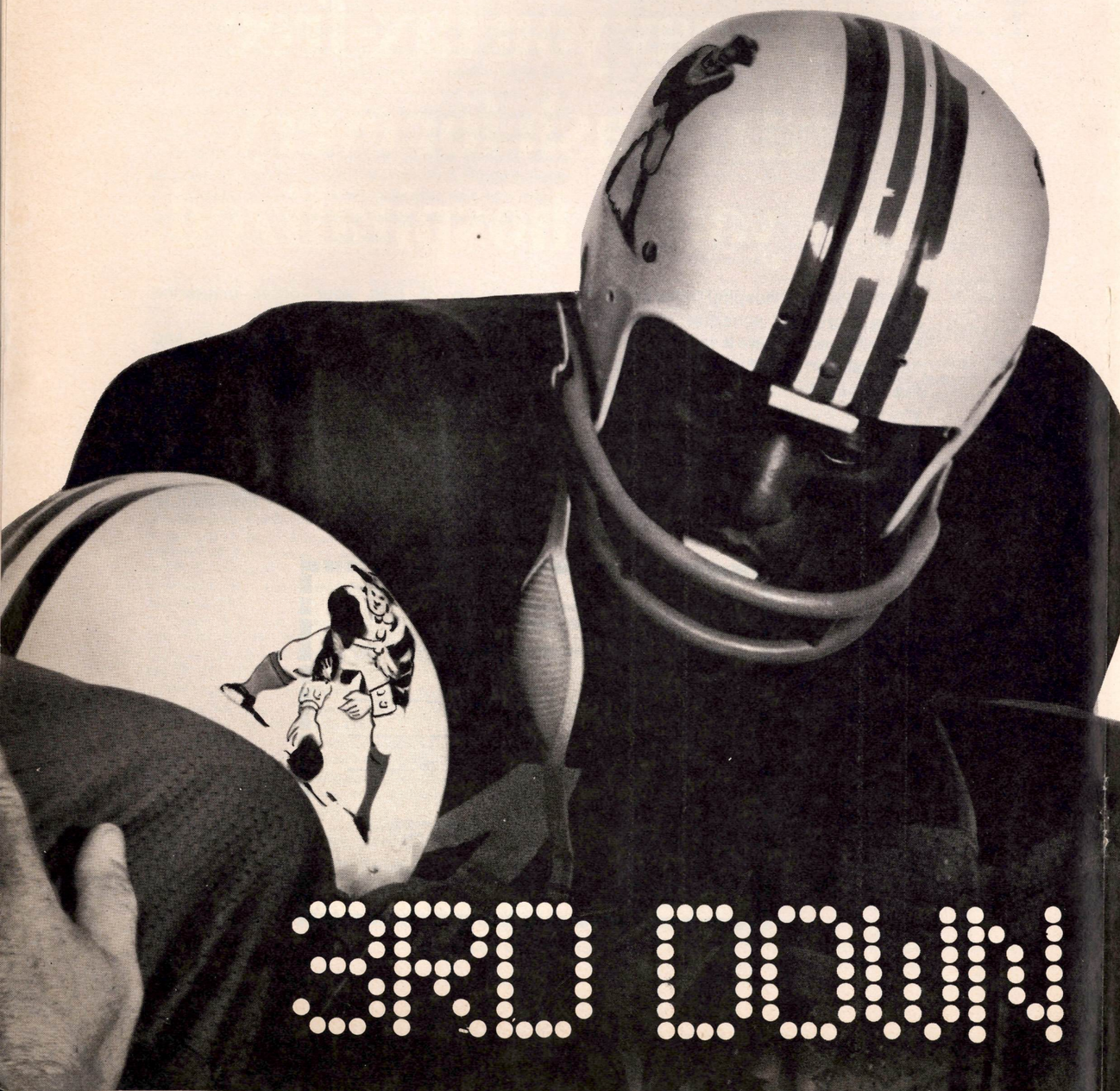
Stern, A. C., ed., *Proc. Symp. on Multiple-Source Urban Diffusion Models*. U.S. Environmental Protection Agency, Air Pollution Control Office, Superintendent of Documents, GPO, Washington, D.C., 1970.

Reprints of this article (No. X71-124) are available to readers. Please use the order form on page 8, which gives information and prices.

Sports people are using to give you a better score.

Scoreboards have come a long way from those old hand manipulated signs you strained to see, and the clock that might (or might not) tell you the precise time left to play.

Now RCA Solid State products help give you the score instantly, accurately on highly visible computer-controlled scoreboards. You see them in the stadiums at Oakland, Cincinnati, Philadelphia, Pittsburgh, Mexico City and other places around the world.



RCA Solid State products

Behind these scoreboards are RCA Solid State triacs and silicon controlled rectifiers for light switching. And RCA transistors and integrated circuits are ready to provide data processing, amplification, precision timing and triggering. They turn lights on and off. They act as timers. They control display lighting. Beyond the scoreboards, RCA semiconductor devices also regulate the banks of stadium lights.

Scoreboard, sign and lighting manufacturers are just a few of the many businesses that have taken advantage of RCA Solid State products. Because of product performance, accuracy and reliability. Display systems are now all-electronic. Nothing mechanical to wear out or break down.

RCA Solid State applications people can work with you, too, to help give your product that competitive edge, more marketability. Or to help you develop a new product. And to do it with real cost effectiveness.

We'd like to tell you about the full extent of our capabilities. Write today for our capabilities and applications brochure.

If you would like to discuss your product development needs, call Dan Del Frate, Marketing Manager, at 201-722-3200; or write him at RCA Solid State Division, Dept. S-71, Somerville, N. J. 08876.

We know the score in many fields.

RCA Solid State

products that make products pay off

Circle No. 9 on Reader Service Card.

Economic conditions in the U.S. electrical, electronics, and related industries: an assessment

In the decade ahead, engineering opportunities will increase, but at a slower rate, with supply of and demand for electrical engineers generally in balance. Recommendations are made for U.S. Government action in several areas to improve the engineering climate

William O. Fleckenstein

Chairman, IEEE Ad Hoc Committee To Assess U.S. Economic Conditions in the Electrical, Electronics, and Related Industries*

Derived from a report of the Ad Hoc Committee To Assess U.S. Economic Conditions in the Electrical, Electronics, and Related Industries, this article reports on the group's principal findings for the 1970s. Their study sees a slowing of the demand for engineers with the rate increasing at about 2 percent a year, with supply and demand for electrical engineers reasonably in balance Government spending in domestic areas will probably not offset military and space decreases until at least 1980. The electrical/electronics industry will show an average annual growth of about 7.5 to 8 percent per year. Government action to provide a better data base on manpower and industrial output, reduce trade barriers, stabilize the economy, and foster research and development through tax incentives is urged.

A select committee, appointed by President James H. Mulligan, Jr., has quickly assembled for the members of IEEE a summary assessment of present and future conditions affecting the economy. Contained in the eight-point summary are recommendations that would require government action including establishment of a more useful statistical base for future studies of this kind.

Background material supporting the summary is contained in the pages that follow. The charge to the committee and a list of its members are contained in the editorial box on the following page.

In summary, the deliberations of the committee have yielded the following views on the decade of the 1970s:

1. The demand for engineers will be increasing at a rate of about 2 percent per year, a slower pace than in past years.

2. Supply and demand of electrical engineers will be reasonably in balance, perhaps with some shortages.

3. Government spending in the domestic areas will not offset decreases that have occurred or are expected in military and space programs until late in the decade, if then.

4. The electrical/electronics industry will show a 7.5 to 8.0 percent average annual growth, with some areas showing growth substantially above this amount.

5. There is a need to reduce the number of individual sources of data on manpower and characteristics of the industry, and to establish a more comprehensive and reliable data base to serve a multiplicity of users.

6. There is a need for aggressive governmental action to reduce trade barriers so that competition can be as open and fair as possible.

7. There is an enormous demand for capital that can best be met by a stable economy and incentives to investment.

8. To maintain our technical leadership, more support for research and development, probably in the form of tax incentives, is needed. A level of R&D expenditures in relation to Gross National Product (GNP) at least com-

* This committee report is published as a service to IEEE members. As noted in the article, the views expressed here are those of the individuals comprising the Committee and not necessarily those of the Institute or of the organizations they represent.

Genesis and background of the report

Early in 1971, Dr. J. H. Mulligan, Jr., President of IEEE, requested the author to organize a committee to assess "economic conditions in the U.S. electronics, electrical, and related industries." The objectives of the committee were to review available historical data in the industry, assess the principal forces of change that are or will be acting, and make judgments as to what trends are likely in the five- to ten-year period ahead. The study was to focus on those segments of the industry that are of key interest to IEEE members. The assessment was intended to be broad in scope, and quickly available. It relies on the judgments of knowledgeable people, rather than on an in-depth, time-consuming study.

With this charge in mind, an *ad hoc* committee was established whose members have a wide range of backgrounds that include technology, marketing, finance, economics, and various industrial interests. The members are: V. J. Adduci, president, Electronic Industries Association; E. Q. Daddario, senior vice president, Gulf and Western Precision Engineering Company; D. E. Eckdahl, vice president, manufacturing operations, National Cash Register Company; W. O. Fleckenstein (Chairman), executive director, Switching Systems Engineering Division, Bell Telephone Laboratories, Inc.; T. W. Folger, vice president of research, Kidder, Peabody and Company; W. F. Glavin, group vice president, Xerox Corporation, and president, Xerox Data Systems; D. L. Grove, vice president and chief economist, IBM Corporation; C. L. Hogan, president and chief executive officer, Fairchild Camera and Instrument Corporation; A. R. McCord, group vice president, Texas Instruments Inc.; J. M. Kinn (Secretary), Director, IEEE Educational Services.

The committee hoped initially that sufficient historical data might exist to allow a breakdown of the industry into major segments, probably by Standard Industrial Classification (SIC), and a compilation of significant factors for each segment. These factors might include sales, employment of engineers and scientists, capital expenditures, imports, and exports. From such data, forecasts based on anticipated forces and trends were planned that would summarize the committee's judgment on the future of the industry.

Numerous sources of data were used, including publications of Electronic Industries Association (EIA), National Electrical Manufacturers Association (NEMA), National Science Foundation (NSF), Department of Labor, Department of Commerce, and many others. In addition, representatives of a number of other industry organizations, including Aerospace Industries Association (AIA), Business Equipment Manufacturers Association (BEMA), and Scientific Apparatus Manufacturers Association (SAMA), were consulted. Each of these organizations compiles information appropriate to its own purpose, but does not endeavor to compile all data within a given industrial category.

The committee concluded that there exists no comprehensive data base for the electrical/electronics industry that is reasonably complete and nonoverlapping. Specialized segments exist, for example, EIA and NEMA, but there is no feasible means for making a "generation breakdown" that would allow recombining the data into a broad characterization of the industry. Although volumes of data are available from such sources as the U.S. Department of Labor and the U.S. Department of Commerce, the data do not exist in a form that is usable for a study of this kind. This problem will be encountered by any major scientific or engineering group attempting to make similar projections.

The lack of reliable data was a major concern to the committee and it is recommended that steps be taken as quickly as possible to explore the possibility of having a centralized government agency take the lead in establishing requirements for a data base that would be useful to professional societies, educational institutions, and industrial associations as well as the Government itself.

Faced with these limitations in source data, the committee proceeded on an important but more limited course. Estimates were made of engineering employment, including electrical engineering employment, of growth rates in certain segments of the industry, particularly those most heavily represented by IEEE membership, and of effects of other significant forces such as government spending, international trade, and capital investments.

parable to that of the mid-1960s would be more appropriate.

The results summarized in the foregoing derive from information that is grouped in the following categories covering engineering employment, government expenditures, growth in the industry, international considerations, and financial considerations.

Engineering employment

A significant result of the committee work is a forecast of engineering employment through 1975. Frequently, such forecasts are made by applying to an economic forecast some historical relationship between engineering employment and an economic factor. We found, however, that the direct relationship of engineering employment to economic aggregates—for example, gross economic indicators—was largely determined by trend. That is, both engineering employment and such economic variables as real GNP show strong upward trends over a long period of time. Therefore, they show a high correlation—but so would engineering employment be highly correlated with any time series that had a strong trend component. In fact, if the two series are related in some causal fashion so that knowing one you could predict the other, then the year-to-year percentage changes would also be highly correlated. However, the analysis showed that there was practically no relationship between year-to-year percentage changes in engineering employment and in real GNP. For that matter, unlike variable growth rates in GNP, the growth rates for engineering employment exhibit a strong negative trend, as summarized by five-year growth rates in Table I.

The analysis also tested a variety of other economic indicators and a number of leads and lags. The final conclusion was that the direct relationship of engineering employment to economic aggregates is overwhelmingly dominated by trend, and, therefore, is not useful for making any discriminating forecasts.

Using another approach, we related real output to engineering employment for each of a number of industry groups. Measures of real output and engineering employment data[1] were available for the 1950–66 period for the following industry groups: durable manufacturing; nondurable manufacturing; construction; mining; transportation, communications, and utilities; wholesale and retail trade, finance, insurance, real estate, services, and all other private sectors; and government. The sum of these seven groups accounts for the total output and employment. By regression techniques we were able to develop a forecasting equation for the ratio of engineers to output in each of the industry groups. This ratio varies from industry to industry, and within an industry it varies as a function of time. Given a forecast output for an industry group, one could estimate engineering employment. The forecast of total engineering employment is simply the summation of the forecasts by group. The method was tested for the period 1967–70, for which period data were not available on engineering employment by industry group. The sum of the forecasts by group agreed reasonably well with the total number of engineers believed to be employed in these years. To provide the best possible base for the forecasts, a level adjustment was applied to each 1970 industry employment estimate, so that their total coincided with the actual total engineering employment for that year.

Forecasts of industry output for the years 1971–1975 were developed, using a sophisticated input/output model that, in turn, depended on a forecast of the economy. These estimates of output by industry sector, together with the regression equations relating engineering employment to output, made it possible to forecast engineers employed by industry group and in total. The resulting demand for engineers is shown in the upper portion of Fig. 1. Note that this forecast is designed to capture not only the impact of the economy, but also the changing industry composition of the total output of the economy and the changing productivity of engineers within each industry group. The forecasted distribution of engineers by industry category is shown in Table II.

The extrapolation of the forecast to 1980 was made by a different and much simpler method. The compound growth rate that resulted from the rather complex method described was used to extend the numbers to 1980.

Gross statistics of this kind do not pick up "minor" perturbations in total employment that can cause significant dislocations for a small percentage of the population. Thus, we did not see a dip in employment of engineers around 1970. In addition, since the supply of engineers is gradually increasing, this factor tends to mask the dip.

It should be emphasized that the forecasts derived here are based on the referenced historical data[1] and are neces-

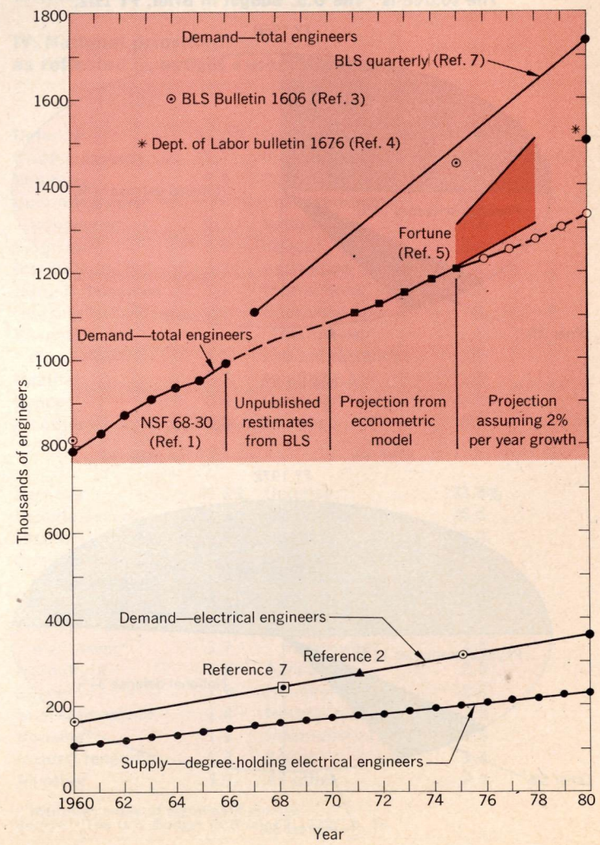
I. Growth rates of engineering employment and GNP in percent per year

	1950–55	1955–60	1960–65	1965–70
Employed engineers	8.1	5.9	3.9	2.4
Real GNP	4.3	2.2	4.8	3.2

II. Distribution of engineers by industry category, percent

	1955	1965	1975
Nondurable manufacturing	9.1	7.7	7.6
Durable manufacturing	42.9	46.3	52.0
Services	15.8	15.3	14.6
Construction	6.2	4.8	4.0
Mining	2.3	1.8	1.6
Transportation, communications	6.2	5.4	5.2
Government	15.3	14.8	15.0

FIGURE 1. Engineering employment, showing sources of data.



sarily dependent on the accuracy of these data.

It is useful to compare the demand curve derived here for all engineers with results presented by others. Various results obtained by others[1,7] are shown on the upper portion of Fig. 1. These data suggest that our forecasts may be conservative.

Data for electrical engineers are much more difficult to obtain. The demand curve for electrical engineers shown in Fig. 1 was plotted using available data that appeared to be mutually consistent. These data include members in the labor force who are characterized by the Bureau of Labor Statistics (BLS) and others as "electrical engineers," although many of them are not degree holders.

A question naturally arises as to our judgment in accepting these data on electrical engineers as reasonable since our derived demand curve for all engineers is lower than data from the same estimators. Our reasons are these: We believe that the relationship between our demand curve for all engineers and the demand curve shown for electrical engineers (showing a slightly increasing proportion of engineers being electrical) is likely to be correct. In addition, the source data for electrical engineers in some cases do not include closely related categories such as system analysts, programmers, and aerospace engineers that are categories included in the various estimates for "total engineers."

Still greater difficulty is encountered in attempting to determine demand for degree-holding electrical engineers. Indeed, there are no reliable data that the committee has seen indicating the *demand* for degree-holding electrical engineers. An estimate of the *supply* of degree-holding electrical engineers was arrived at in the following manner.

1. Information was obtained from the Bureau of Census indicating that there were 106 787 electrical engineers with four years or more of college education in the work force in 1960. (A reasonableness check of this number can be made by taking Department of Commerce figures quoted by John D. Alden,[2] for example, that 43 percent of engineers in 1960 were nondegree people, and assuming that the same ratio would apply to electrical engineers.)

2. Data on degrees granted, or estimated for the future, were obtained and are shown in Table III.[2,8] Although the discontinuity in B.S. degrees from 1970 to 1971 is unrealistic, and the advanced-degree data appear somewhat high, the error rate is believed to be negligible.

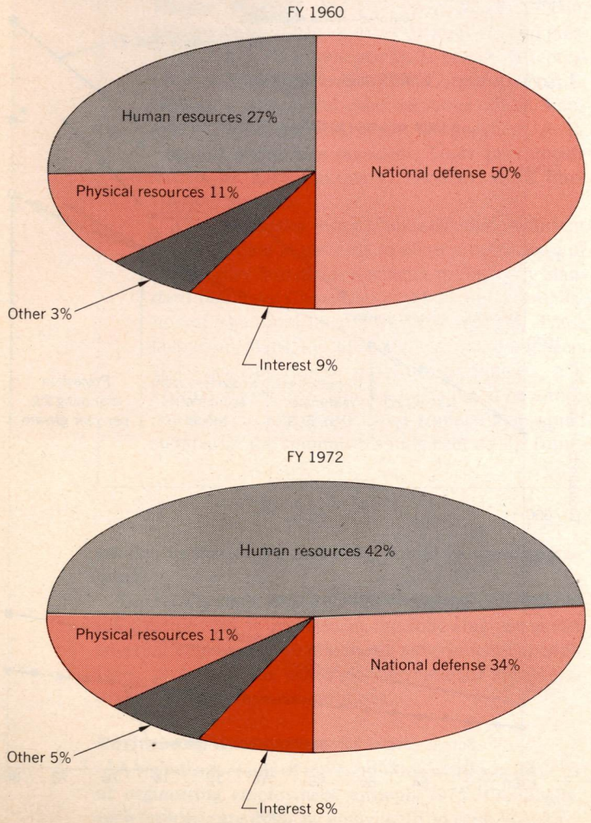
3. Starting with the figure 106 787 in 1960, the following formula was used to calculate the changes in the supply of degree-holding electrical engineers:

$$N_{t+1} = N_t - 0.024N_t + 0.9\,(BS_t - MS_{t+1}) + (MS_t - D_{t+3}) + 0.75D_t$$

where N_{t+1} = number of degree-holding electrical engineers in the work force in the year $t + 1$, N_t = number of degree-holding electrical engineers in the work force in the year t, BS_t = number of B.S. degrees granted in electrical engineering in the year t, MS_t = number of M.S. degrees granted in electrical engineering in the year t, MS_{t+1} = number of M.S. degrees granted in electrical engineering in the year $t + 1$, D_t = number of Ph.D. degrees granted in electrical engineering in the year t, and D_{t+3} = number of Ph.D. degrees granted in electrical engineering in the year $t + 3$. The following assumptions were included in deriving the results shown in Table III. It is assumed that 10 percent of bachelor-degree recipients who do not go on to graduate school in electrical engineering enter the labor force outside the electrical engineering classification; some are foreign students who return home. It takes one year to get the M.S. degree and three additional years to obtain the Ph.D. It is assumed that 100 percent of those obtaining M.S. degrees enter the work force, and 75 percent of those obtaining Ph.D. degrees leave the university and enter the regular work force. Of this work classification, 2.4 percent are lost each year owing to death, retirements, and transfers to other types of work (informal discussions with the Census Department suggest that this number is slightly low for electrical engineers). In line with point 5 of the summary, it is more specifically recommended that, in view of the difficulty in obtaining reliable statistical information covering the number and employment status of engineers (or electrical engineers), some action should be initiated by the IEEE or a group of professional societies to fill this need in the future.

The Joint Societies Employment Advisory Committee (JSEAC) might be an appropriate body to stimulate such an activity. It is our understanding that the National Science Foundation has funded related studies in the past.

FIGURE 2. Changing composition of the federal budget. The source is "The U.S. Budget in Brief, FY 1972."



Perhaps coordination between the professional societies and the NSF could lead to the development of a more accurate and comprehensive data base for the future.

Government expenditures

The shift in government priorities from defense and space programs to domestic programs is well known. The magnitude of this shift is illustrated in Fig. 2, which shows the composition of the federal budget in fiscal years 1960 and 1972, and in Table IV, which shows in somewhat more detail the rank order of priorities based on federal expenditures as a function of time. This transition has not been smooth, nor is it expected to be in the years immediately ahead.

It is expected that defense expenditures will decrease for the foreseeable future, and that the space program will continue to remain at the present level for a few years, and then edge upward to approximately $5 billion as the shuttle program develops and the Mars and Venus programs are determined. There will be substantial increases in expenditures for transportation, housing, education, health services, environmental control, and law enforcement. However, we do not expect that in the near future the decrease in defense expenditures for electronics will be offset by increases in socially oriented programs. This is not owing to any fundamental lack of need for technology in domestic programs, but rather to the difficulty in defining clear-cut goals that will generate broad support. It also results, in part, from the fact that defense expenditures have a higher percentage of total workers in the engineering and science category than in other industrial segments.

The early training of engineers and much of their professional experience are focused on what might be termed "physical" technology. In many parts of our society technologists are looked to largely as a means of applying new physical technology to solve specific problems and improve productivity. This view of the role of engineers has often led to the restriction of the application of technology to limited classes of problems.

To accomplish the transition that is being sought to solve socially oriented problems, it will be necessary for engineers to expand their understanding of society's needs to the point where they can participate in the optimum allocation of resources to meet those needs and contribute to meeting them through operational as well as physical technology.

We see this changing role of the technologist as essential but one that will come somewhat slowly and require his substantial education in the needs and operational mechanisms of our society. Therefore, we cannot foresee significant growth in technical manpower applied to socially oriented programs that are government funded until late in the decade.

With respect to public policy, the committee believes that the falloff in R&D as a percentage of GNP is an undesirable trend. Rather, a government policy that recognizes that the continuous development of new technology is an essential ingredient to the long-term health of the economy is most important. Such emphasis is required not only to provide the increasing productivity that is essential to the domestic economy, but also to maintain a suitable trade balance. The committee agreed that ways need to be found to provide economic stimulus and support to private industry to invest in R&D as the major means for providing the long-term growth required to maintain economic health. Such support might be pro-

III. Number of electrical engineering degrees granted by level and year

Year	Bachelor	Master	Doctor
1960	10 631	1 993	203
1961	10 200	2 400	250
1962	9 745	2 701	295
1963	10 393	2 816	386
1964	11 261	3 163	460
1965	11 670	3 566	511
1966	11 007	3 872	569
1967	10 843	3 942	688
1968	10 451	4 125	677
1969	11 375	4 019	851
1970	11 921	4 150	873
1971	10 200	4 340	870
1972	11 400	5 160	959
1973	11 700	5 640	1 070
1974	12 120	6 150	1 182
1975	12 500	6 630	1 293
1976	12 900	7 115	1 405
1977	13 240	7 625	1 517
1978	13 580	8 130	1 650
1979	13 930	8 600	1 750
1980	14 280	9 070	1 850

Source: 1960–1970, Ref. 2; 1971–1978, Ref. 8, plus the assumption that the proportion of EE's in future years will average the same as in past years; 1979–1980, estimated.

IV. National priorities as reflected in budget expenditures

FY 1960		FY 1965	
Defense	49.8%	Defense	41.9%
Income security	19.7	Income security	21.7
Veterans	5.9	Commerce and transportation	6.2
Commerce and transportation	5.2	Veterans	4.8
Agriculture	3.6	Space*	4.3
International aid	3.3	Agriculture	4.1
Natural resources	1.1	International aid	3.7
Housing*	1.1	Education and manpower*	1.9
Education and manpower*	1.1	Natural resources	1.7
Health*	0.8	Health*	1.5
Space*	0.4	Housing*	0.2
All other	8.0	All other	8.0
FY 1970		**FY 1972**	
Defense	40.8%	Defense	33.8%
Income security	22.3	Income security	26.5
Health*	6.6	Health*	7.0
Commerce and transportation	4.7	Commerce and transportation	4.8
Veterans	4.4	Veterans	4.6
Education and manpower*	3.7	Education and manpower*	3.8
Agriculture	3.2	Agriculture	2.5
Space*	1.9	Housing*	2.0
International aid	1.8	Natural resources	1.9
Housing*	1.6	International aid	1.8
Natural resources	1.3	Space*	1.4
All other	7.7	All other	9.9

* Identifies areas of significant change.
Source: "The U.S. Budget in Brief, FY 1972," p. 29.

V. IEEE U.S. membership distribution by SIC code, with forecast of growth rate in dollar value of shipments

SIC Code		IEEE U.S. Membership	1970–1980 Growth Rate, percent per year
36	Electric machinery equipment and supplies	47 310	
3662	Radio and television transmitting, signaling, detection equipment and apparatus	17 740	7.0
3679	Electronic components and accessories (not elsewhere classified)	5 960	
3612	Power, distribution, and specialty transformers	3 030	6.0
3611	Electric measuring instruments and test equipment	2 880	6.7
3651	Radio and television receiving sets, except communications type	2 510	6.0
3661	Telephone and telegraph apparatus	2 460	10.0
All others		12 730	
35	Machinery, except electric	11 700	
3573	Electronic computing equipment	7 180	10.5
3511	Steam engines, turbines, and turbine-generator sets	975	7.5
3572	Typewriters	515	3.9
3574	Calculating and accounting machines, except electronic computing equipment	315	5.5
All others		2 715	
49	Electrical, gas, and sanitary services	11 040	
4911	Electrical companies and systems	8 890	
4931	Electrical and other services combined (electrical less than 95 percent total)	1 880	6.0
All others		270	
37	Transportation equipment	9 330	
3721	Aircraft	5 880	−3.7
3729	Aircraft parts and auxiliary equipment (not elsewhere classified)	1 100	−0.3
3714	Motor vehicle parts and accessories	765	
3722	Aircraft engines and engine parts	625	−1.1
All others		960	
73	Miscellaneous business services	6 510	
7391	Commercial R&D labs	4 690	
7392	Business, management, administrative, and consulting services	940	
7399	Business services (not elsewhere classified)	730	
All others		150	
38	Manufacturers of instruments—professional; scientific, controlling; photo and optical goods; watches and clocks	6 170	
3811	Engineering, lab, scientific, and research instruments and associated equipment	2 870	6.7
3821	Instruments for measuring, controlling, and indicating physical characteristics	1 120	5.4
3861	Photo equipment and supplies	880	
3822	Automatic temperature controls	710	5.6
All others		590	
48	Communications companies	5 360	
4811	Telephone	3 750	9.0
4832	Radiobroadcasting	470	7.1
4833	Television broadcasting	455	9.0
All others		685	
Miscellaneous categories		27 580	27 580
	Total	125 000	125 000
	Composite growth rate (weighted)		6.1

Source: Membership estimated from 50 percent sample; value of shipments estimated from Ref. 9.

vided in the form of tax incentives. In addition, the provision of federal grants to industries whose R&D activities show promise in the solution of domestic social problems would seem appropriate. The latter activity might be modeled after the Canadian policy that allows that government to share 50 percent of the cost of such private R&D.

Growth in the industry

As noted, a suitable and comprehensive data base sufficient to forecast industry growth with reasonable accuracy does not exist. Consequently, we shall look at major segments of the industry of particular interest to IEEE members, indicate judgments on particularly strong areas of growth, and suggest forces that are operating and are therefore likely to create emphasis in certain areas of technology. A number of sources of information[9–13] were used; the estimates reflect the judgments of the committee.

Table V shows the distribution of IEEE membership in the United States by Standard Industrial Classification (SIC) code based on a 50 percent membership sample.

VI. Industry forecasts, 1970–1980

Group	Percent Increase per Year
Computers, computer peripherals, and memories	11
Communications (except radio and television)	9
Process and industrial controls	12
Test, measuring, scientific, and medical instruments	11
Transportation electronics (nonmilitary)	12
Semiconductor industry	9

Also indicated for certain sectors are growth rates in dollar value of shipments obtained from a U.S. Department of Commerce publication.[9] The growth rates obtained cover segments of the industry that represent an estimated 43 percent of IEEE U.S. membership. Based on these projections, a weighted growth rate of 6.1 percent is obtained. The forecast for electronic manufacturing sectors is higher and the committee's judgment is that an overall annual average growth rate for the electrical/electronics industry of between 7.5 and 8.0 percent is more likely over the next decade.

The combination of forces at work suggests that certain segments of the industry will grow more rapidly than the overall growth rate indicates. Among the more important of these forces are those being created by changes in labor, social values, and technologies.

The labor-related forces include unavailability of people to perform menial labor, welfare availability that competes with low-level jobs, minimum-wage requirements, and an apparent long-term trend of labor costs increasing more rapidly than other components of cost. All of these forces suggest the need for a more rapid rate of technical innovation and a more rapid rate of increase in capital expenditures in the future.

Social forces include environmental control, on which companies are beginning to spend substantial sums of money; the large body of law building up that will require a more vigorous response by industry; and the increasing application of technology needed to achieve the desired results. Improvements required in medical care, education, transportation, and law enforcement are examples of other social areas demanding increasing use of technology.

In technology, the rapid change in materials and device technology is leading toward components and systems for which costs per function are continuing a downward trend relative to other costs.

An analysis of these forces suggests that there will be a strong movement to automate the operational aspects of businesses in the decade ahead. In addition, instrumentation and process control will see heavy growth. Table VI indicates areas in which the committee believes strong growth rates will be encountered during this period. The arguments put forth lead almost directly to those disciplines that we believe are likely to receive special emphasis in the next decade.

Device technology is continuing toward more complex operations in which a large number of batch-processing operations are carried out in sequence. This trend will continue to place strong emphasis on materials and process technology, including physics and chemistry, materials engineering, mechanical design, and electrical design. Integrated semiconductor technology will see heavy growth in both linear and nonlinear applications, and particularly in memory applications. Optoelectronics is also an area in which significant growth can be expected.

Computer-aided design, which has received considerable emphasis in the past decade, will become much stronger in the decade ahead. This technique not only includes analysis, but, more important, the portions of the "design" job that can be sufficiently formalized to automate. In addition, simulation of the performance of systems and subsystems will become increasingly important.

Sensing and control instrumentation, all aspects of computer technology, and communications—particularly digital communications—are key aspects of almost all of the growth areas noted.

International considerations

Competition from outside the U.S. has been an increasing problem for U.S. industry in recent years. Principal reasons are an exchange-rate structure that has overpriced the dollar, lower labor rates abroad that do not reflect lower productivity, changing technological conditions, and government policies. The following will cover broad changes in technological development and their implications, and some recommendations for possible governmental action. It should be noted that this review, including the section that follows, was carried out prior to the recent establishment of economic controls by President Nixon.

With regard to current and continuing trends in the area of foreign trade, and more specifically in the matter of U.S. competitiveness with foreign industry, two principal technologically oriented factors stand out. The first, and perhaps the most fundamental trend, is that concerned with the size of the technological gap between the U.S. and other technically strong countries such as Japan and Germany. There is little question that the technological growth rates of these and other countries have exceeded that of the U.S. in the recent past. It is likely that the magnitude of the "gap" will continually decrease, although at a gradually diminishing rate. This narrowing of the technological gap between the U.S. and the other countries is likely to be enhanced by the recent withdrawal of federal R&D support that has so significantly sustained and stimulated the U.S. level of technological growth in the past.

The second factor is a consequence of general advancement in technology and rapidly increasing labor costs; both are causing industry to move increasingly toward products involving low labor content but high material and technology content. This combination, coupled with the expanding and deepening technical capability across the international spectrum, is changing the economic tradeoffs that multinational companies use in making geographical determinations on product design as well as manufacture.

As an expected consequence of these trends, it is highly probable that increasing use will be made of international technical capability by U.S. multinational industry, on the presumption that the ultimate market location will establish not only the site for product *manu-*

facture but also the site for product *design*. Undoubtedly, although more than counterbalanced by other influences, this particular trend suggests a negative influence on engineering employment prospects within the U.S.

The most desirable and probably the most effective approach for broadening U.S. technical employment opportunities, insofar as they may be influenced by international trade factors, involves developing the maximum amount of trade between nations. Under such conditions, where head-to-head competition is a reality, each country's technological skills of all kinds—research, engineering, and manufacturing—are challenged, provided there is reasonable parity of capability, a condition increasingly coming into being. In meeting such a challenge, the technologies involved are strengthened and employment opportunities increased.

To achieve this enhanced international interchange, an appropriate U.S. Government trade posture is essential. Several important aspects of that posture include elimination of reduction of quotas, governmental support for exporters, reduction of trade barriers, and relaxation of controls on foreign direct investment.

Quotas are not the answer to the declining trade surplus or to the question of import competition. Rather, they lead to still higher costs and prices that freer trade and greater competition would serve to combat. International competition not only offers consumers access to inexpensive imports, but it restrains price increases in the domestic industries that face such competition. Moreover, the imposition of quotas can only invite retaliatory measures by other countries.

Efforts to expand U.S. exports could be assisted by a U.S. policy that would offer exporters the kind of financial assistance and tax treatment now used by some other governments to support their exporters. A current proposal for a Domestic International Sales Corporation (DISC) under consideration by the U.S. Government is commendable in this connection.

Tariff and nontariff barriers around the world continue to be a significant impediment to U.S. export expansion. However, nontariff barriers are one of the most critical and difficult problems facing U.S. trade policy. Both tariff and nontariff barriers should come under aggressive attack by U.S. trade negotiators. It would seem difficult to assume this posture in an environment of restrictive trade at home.

The overall international trade questions cannot be viewed in isolation from the other components of U.S. foreign economic policy. This is particularly true of the foreign investment question that has assumed steadily increasing importance during the last decade. Direct U.S. investment has become larger and is growing faster than exports. In the decade ahead, it is important that this growth continue and that it be supported by U.S. Government policy, as U.S. investors will have to compete with increasingly aggressive investors from Japan and Western Europe for the substantial returns that can be realized. The U.S. Government's preference for controls on foreign direct investment to meet short-term balance-of-payments goals should be examined in light of the fact that foreign investment is a major long-range source of foreign receipts.

In view of the need for tying the numerous threads of U.S. foreign economic relations into a unified policy, the President's action to establish the Council on International Economic Policy as a new mechanism that will plan and coordinate all U.S. foreign economic policy is appropriate. This step will give foreign economic policy the priority and cohesiveness essential to achieving the most advantageous foreign economic posture in the 1970s.

Financial considerations

In the 1970s, as in the 1950–70 period, trends in the securities markets will have an effect upon the employment of technically trained personnel in the United States. In the 1950–70 period, many new technological enterprises were started with a generous flow of funds from the financial markets, including a plentiful supply of venture capital. Since World War II, the financial markets have looked kindly upon new technological enterprises. In addition, established firms have found the money markets willing to supply funds for new technological ventures. Also affecting the employment of engineers are the expected levels of capital spending by all industry, since engineering manpower is required to design new plants and modernize existing facilities. Levels of capital spending are closely related to the trends of corporate profits and are dependent on many other factors; among the most important are the *availability* and *price* of money to fuel capital expenditures.

Examination of the sources and uses of corporate funds since 1960 shows that since 1966 there has been a rapidly increasing reliance by corporations on external sources to finance plant equipment expenditures and to meet other financing needs. The primary internal sources of corporate capital—undistributed corporate profits and depreciation—have not kept pace with corporate needs for funds. Expressed as a percentage of Gross National Product, corporate profits after taxes fell precipitously in the late 1960s to a low in 1970 and 1971 not seen since the days of the Great Depression. Depreciation as a percentage of GNP rose during the 1960s, but the combination of corporate profits and depreciation has been declining as a percentage of total GNP and is currently around the level of the recession year of 1960. However, this relationship should improve as the economy recovers from the recent recession.

On the other hand, corporate expenditures on plant and equipment rose dramatically both in absolute amount and as a percentage of GNP during most of the 1960s, falling off only in the 1969–71 recession. There are reasons to believe that capital investments should remain high during the 1970s. The United States must modernize and automate its industries if it is to offset rapidly rising labor costs and remain competitive in the international arena. To combat the pollution of our environment, enormous capital expenditures are going to be required by many industries. The inflationary trends alone dictate a tendency toward higher capital expenditures because the same dollar a few years later will not buy the same amount of actual physical plant and equipment. The replacement cost of plant and equipment is continuously rising. In general, it can be said that inflation is a great consumer of capital. As our society becomes more technologically complex, the amount of capital investment per employee will continue to rise.

The other side of the coin is the supply of capital and the price at which it will be supplied. Studies have shown that long-term interest rates are closely related to expected inflation rates. An approximate formula for predicting long-term interest rates in an inflationary environment is that each percentage point of expected inflation rate adds a percentage point to long-term interest rates. We cannot predict what interest rates will be, but, in general, we do believe that interest rates will be higher in the early 1970s than they were during most of the 1960s, owing to expected higher rates of inflation. Both factors—inflation and strong demand for funds—will be operating in the early 1970s to produce high interest rates.

Because of the increasing reliance of corporations on external financing, we also see that the financial markets will be called upon for more capital in the 1970s than during most of the 1960s. We do not predict a capital shortage that would cause any prime customer or major solvent corporation to be unable to obtain sufficient funds from the financial markets, but we doubt that the new enterprise or the small technological company can count on being as readily received and financed in the 1970s as it was in the 1960s, except where the expected growth rate of earnings is very promising. Also, owing to the higher price that we foresee capital will command in the 1970s, a number of capital improvement projects may not prove as economical as they might if undertaken in the 1950s and 1960s. Although the level of capital spending will be high in the 1970s, we conclude that the financial markets may exert a downward influence upon the level of capital spending.

With regard to basic financial considerations, insofar as they affect electrical/electronics engineers and the industry, the committee made four conclusions:

1. The most obvious and greatest assistance to the financial markets would be the restoration of an atmosphere of stability with only moderate inflation in the U.S. economy—much less than the current 5 to 7 percent annual rate. There is nothing like a stable dollar to foster stable financial markets. The allocation of the country's resources can be much more wisely and fairly distributed without the conditions of worrisome inflation.

2. The United States must provide for more realistic replacement of our worn-out assets through a more realistic depreciation program. Current production must be charged with costs of replacement and modernization of its production equipment, and we are only inviting disaster unless this condition is met. The recent liberalization of depreciation rates is a commendable step; we recommend a continuing review of depreciation schedules. In addition, tax programs such as an investment-tax credit would also provide incentive for capital projects and help increase the internal generation of funds to finance capital expenditures.

3. To allow the operation of stable financial markets, we must have a stable monetary policy. The severe swings of interest rates or of money supply serve only to disturb the financial markets.

4. As suggested in a previous section, if the United States really wants to exert every effort to maintain its technical leadership in the free world, it is recommended that consideration be given to using special tax incentives to encourage scientific research and development. Several alternatives are available, such as increased tax deductions for research and development by corporations and special tax treatment for individual capital gains and losses incurred in venture capital or small business investments.

In addition to the individual efforts of the committee members (listed in the box), support and counsel were received through them from colleagues in their various organizations. Without this assistance, much of the work would have been impossible.

REFERENCES

1. "Employment of scientists and engineers in U.S.," Bureau of Labor Statistics, NSF Bulletin 68-30.
2. Alden, J. D., "Manpower trends in electrical engineering in the United States," *Proc. IEEE*, vol. 59, pp. 834–838, June 1971.
3. "Tomorrow's manpower needs," Bulletin 1606, U.S. Dept. of Labor, Bureau of Labor Statistics.
4. "College educated workers, 1968–80," Bulletin 1676, U.S. Dept. of Labor.
5. Gooding, J., "The engineers are redesigning their own profession," *Fortune*, June 1971.
6. "The occupational outlook for engineers and technicians," *Engineering Manpower Highlights*, Engineers Joint Council, Nov. 1970.
7. "Quarterly occupational outlook—Summer 1970," Bureau of Labor Statistics.
8. Engineering Manpower Commission, U.S. Office of Education, and Commission on Human Resources and Advances Education, quoted in EMC Bulletin No. 17, Sept. 1970.
9. "U.S. industrial outlook 1971, with projections through 1980," U.S. Dept. of Commerce.
10. "The U.S. economy in 1980," U.S. Dept. of Labor.
11. "Projections of gross output by industry," National Planning Association.
12. "World electronic industries—new opportunities for growth and diversification in the 1970's," Stanford Research Institute (informal discussion of study with K. W. Taylor, SRI).
13. *Electronic Market Data Book 1971*, Electronic Industries Association.

W. O. Fleckenstein (F) is executive director of the Switching Systems Engineering Division at Bell Telephone Laboratories, Holmdel, N.J. He has previously served the Bell System as general manager of R&D for Western Electric in Princeton, N.J., and as an executive director in the Bell Laboratories, responsible for development of data communication, private branch exchange, telegraph, key telephone, and private line systems. During his 19 years with Bell Laboratories, Mr. Fleckenstein has made important contributions to development of the first data sets and participated in the early development of electronic switching systems, in which area he has been granted a number of patents. He had been director of a group editing a four-volume series on "Physical Design of Electronic Equipment," now being published.

He majored in communications at Lehigh University, earning the bachelor of science degree in electrical engineering, with highest honors, in 1949, and winning the Dupont Memorial Prize. In 1959, he received honorable mention from Eta Kappa Nu as an "outstanding young electrical engineer."

Mr. Fleckenstein was chairman of the Technical Program Committee for the 1970 IEEE International Convention, and is a member of the Board of Directors and the Executive Committee of IEEE.

New product applications

Power package for small vehicles uses improved battery-charging system

Increasing use of electric propulsion for small vehicles has shown a need for more economical battery service. Typical applications include golf carts, riding mowers, garden tractors, and fork-lift trucks. In Fig. 1 a battery-charger unit is shown installed in a 1972 model riding mower.

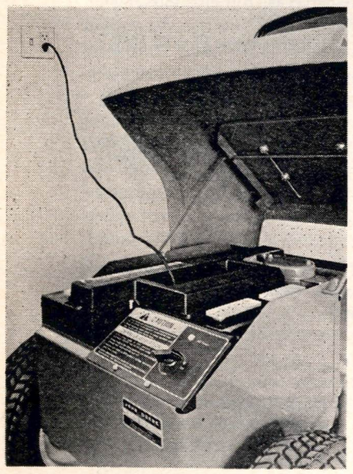


FIGURE 1. Power package installed.

The typical vehicle power system shown in the block diagram of Fig. 2 encompasses all the necessary functions that must be included in any application, and some or all of the units at lower right will be required in more sophisticated vehicles. Heart of the power package is the recharging unit, shown outside its protective enclosure in Fig. 3.

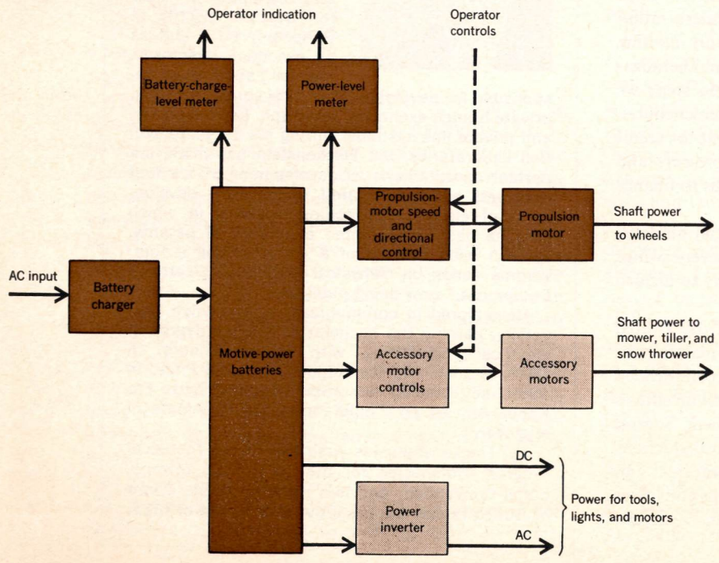
Typical charge-voltage-versus-current characteristics of a battery at the end of charge are shown in Fig. 4. The end-of-charge voltage is a strong function of battery age and temperature. Conventional charges show a constant-voltage characteristic, so that the final charge current is given by the intersection of the charger curve with the battery characteristic curve. For a new 80°F battery, final charge current is an acceptable 5 amperes. An old 120°F battery receives a final charge of 18 amperes that is excessive. Increased temperature, gassing, and water consumption reduce battery life. A new battery at 0°F receives a final charge current of only 0.4 ampere and may not be fully charged. Besides, a fixed charge time is usually set at the discretion of an operator, and may result in excessive undercharge or overcharge. The effect may be insufficient battery performance and potential battery sulfation. A means must also be provided to maintain charge during long storage periods.

The new Gould reactance-limited charger shows the voltage–current characteristic given in Fig. 4. The narrower final-charge-current range, from 4 to 11 amperes, reduces problems of over- and undercharging of batteries at temperature and age extremes. The Gould charger uses a compensated voltage-sensing circuit that automatically starts a timer when battery-charge voltage reaches a point when the battery is about 85 percent recharged. The timer provides a fixed-time end of charge. The start of the timer is automatically adjusted for battery temperature.

Write for details to Gould Inc., P.O. Box 3140, St. Paul, Minn. 55165.

Circle No. 55 on Reader Service Card

FIGURE 2. Essential functions of power package, and ancillary (lower right).



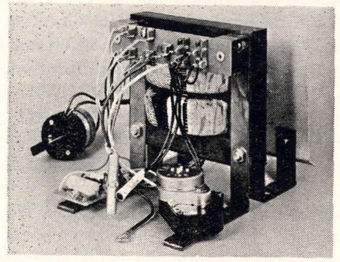
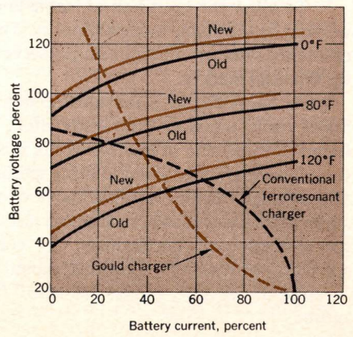


FIGURE 3. Elements of charger.

FIGURE 4. Battery-charger characteristics for various battery temperatures.



New product applications

Synchronous reluctance motors required for constant-speed applications

Manufacturing processes requiring true synchronous speed from no load to pull-out torques, directly proportional to applied frequency, can employ synchronous reluctance motors. Typical applications include the production of polypropylene and polyethylene films. In the manufacture of synthetic fibers, the characteristics of the finished product are controlled by drawing or stretching the yarn an exact amount. Synchronous motors are also required in bottle making in which exact timing from the moment the gob of glass is cut until the molds open must be accurately controlled.

Representative motors built by Task Corp. are shown in Fig. 1 and Fig. 2. The company does not produce standard NEMA frame motors but furnishes high-performance units for industrial, aircraft, and special applications that incorporate mechanical modifications such as special housings, shafts, round frames, or pancake designs.

Because neither slip rings nor dc excitation are employed, the units are said to have the simplicity, durability, and easy maintenance of squirrel-cage machines. Electrical insulation is furnished by using a proprietary epoxy impregnant that is capable of maintaining high dielectric strength and withstanding continuous operating temperatures to 220°C.

Sizes available range from subfractional horsepower to 10 hp and frequency ranges up to 400 Hz. Operating ranges up to 150 to 1 are possible.

Detailed information can be obtained from Task Corp., a subsidiary of Joy Mfg. Co., 1009 E. Vermont, Anaheim, Calif. 92803.

Circle No. 56 on Reader Service Card

FIGURE 1. Motor with special cooling.

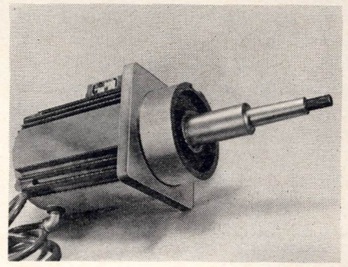
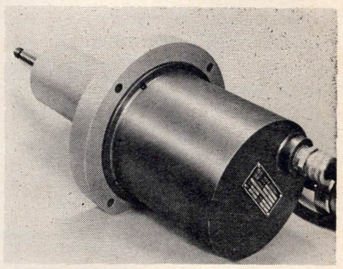


FIGURE 2. Motor with shielded case.



Broadband amplifiers designed for two-way cable communications

Compatibility of existing CATV systems with dual-direction systems of the near future is possible using new equipment recently made available. The TRA-108A trunk return amplifiers, for which a block diagram is shown in Fig. 1, have been designed and optimized for return amplification in the bandwidth range from 5 to 108 MHz.

In application, the signal enters at the left and after preamplification passes through a gain control to the AGC network. The controlled signal proceeds through the hybrid IC postamplifier to the output at the right. The pilot signal, which is a nominal 115-MHz carrier, is picked off and fed through the pilot detector. Its output is applied to the dc amplifier that has an internal reference voltage. Output from this amplifier is used to control pin diodes in the AGC network. The network is designed to compensate the cable losses with temperature rise in respect to frequency, providing more compensation at the high end of the band.

For return amplification in the bandwidth range from 5 to 30 MHz, the TRA-30A model, shown in the block diagram of Fig. 2, is available. It is similar to the 108A, except that the pilot frequency is at 31.5 MHz. The AGC network functions in a manner similar to that for the higher frequency. The equipment differs mainly in the fact that the amplifiers use discrete components instead of hybrid integrated circuits. Amplifier gain and the position of the AGC network can be controlled manually.

Complete details of this equipment and other devices for use with CATV can be obtained from Jerrold Electronics Corp., 401 Walnut St., Philadelphia, Pa. 19105.

Circle No. 57 on Reader Service Card

FIGURE 1. Model TRA-108A unit uses hybrid IC amplifiers.

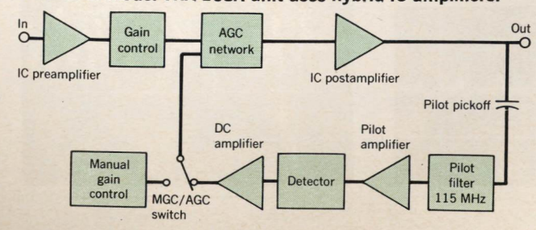
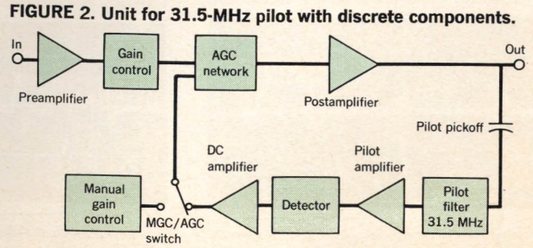


FIGURE 2. Unit for 31.5-MHz pilot with discrete components.



New product applications

Simultaneous transmission of 18 data signals uses single line

Low-speed data transmission with the 25C system requires one voice-frequency telephone circuit. Depending on the customer's requirements, the circuit can be divided into 18 channels handling 110 bits of information per second, the equivalent of nearly 2000 words a minute, or a single channel can be used at a speed of 600 bits a second.

A typical application might be the interconnection of processing, purchasing, sales, warehousing, and accounting functions through a common EDP computer center using relatively low-cost voice-frequency lines.

For single-channel applications, a data subset is available for desk-top use. The data shelf assembly shown under adjustment in Fig. 1 provides up to eight transmit and eight receive data channel units. The same channel units are used in both the subsets and the rack-mounted assemblies. These are also common to all data speeds, with speed selection determined by attaching filters, which are screw-attached and easily changeable, thus reducing the number of maintenance parts.

Modulation is by frequency-shift keying, using solid-state circuits. The units interface with all standard systems including EIA, unipolar, TTL logic, and 20-mA teleprinter. Monitoring circuits prevent false information by clamping the output if signal level falls too low.

When desired, an optional assembly provides voice communication in addition to data transmission. There should be a separation of approximately 200 to 300 Hz between the voice channel and the first data channel.

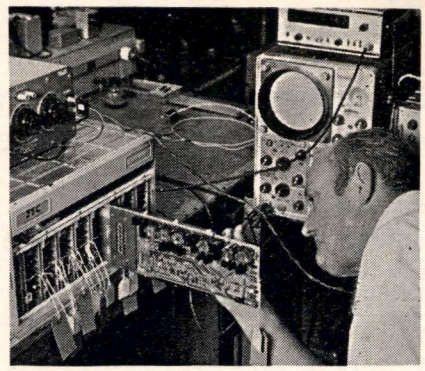


FIGURE 1. Test technician aligning unit.

Information about the data transmission system can be obtained from GTE Lenkurt, 1105 County Road, San Carlos, Calif. 94070.

Circle No. 58 on Reader Service Card

Broadband ultrasonic transducers used for flaw detection and gaging

A new high-resolution ultrasonic pulser/receiver covering the frequency range from 0.1 to 30 MHz, used with an oscilloscope and piezoelectric transducers, provides precision measurements. Measurements of ultrasonic velocity and attenuation can be utilized to determine material properties and homogeneity. Typical applications include homogeneity in metals, glass, ferrites, and other ceramics. Thickness gaging and detection of cracks, lack of bond, or delamination in opaque materials are also possible, employing a variety of techniques.

Specialized applications are suggested in the series of illustrations that show pulse-echo patterns used in flaw detection and thickness gaging. In Fig. 1, a 30-MHz contact delay-line transducer is used to detect a 3-mm-diameter flat-bottom hole that is 3 mm below the surface in aluminum. The echo occurring at the interface between the delay line and the aluminum is followed by a series of reverberations of the ultrasonic pulse between the hole and the surface. Smaller defects even closer to the surface can be detected.

In Fig. 2, the same transducer is used to gage the thickness of a 0.25-mm steel sheet. There is a clear separation between the 30-MHz broadband pulses even with a reverberation time of 80 ns. The same thickness-gaging measurement is shown in Fig. 3 using a sharply focused immersion transducer with a center frequency at about 50 MHz. The ultrasonic energy is highly concentrated at the focal point, making this type of transducer suitable for thickness gaging of small areas or detecting small discontinuities in thin materials that can be immersed in water.

A brochure containing a technical description of use can be obtained from Panametrics, 221 Crescent St., Waltham, Mass. 02154.

Circle No. 59 on Reader Service Card

FIGURE 1. Pulse-echo defect indication.

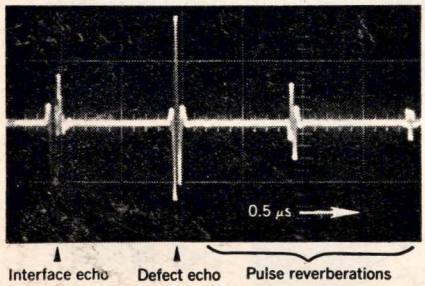


FIGURE 2. Pulse-echo thickness gaging.

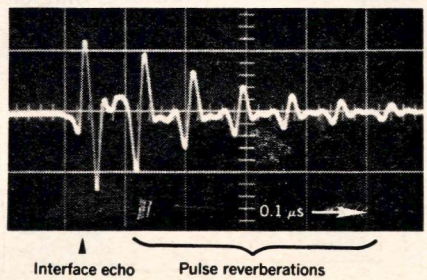
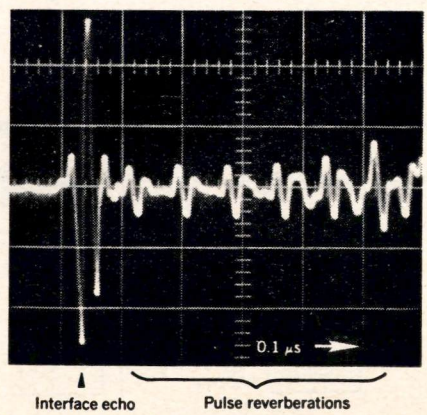
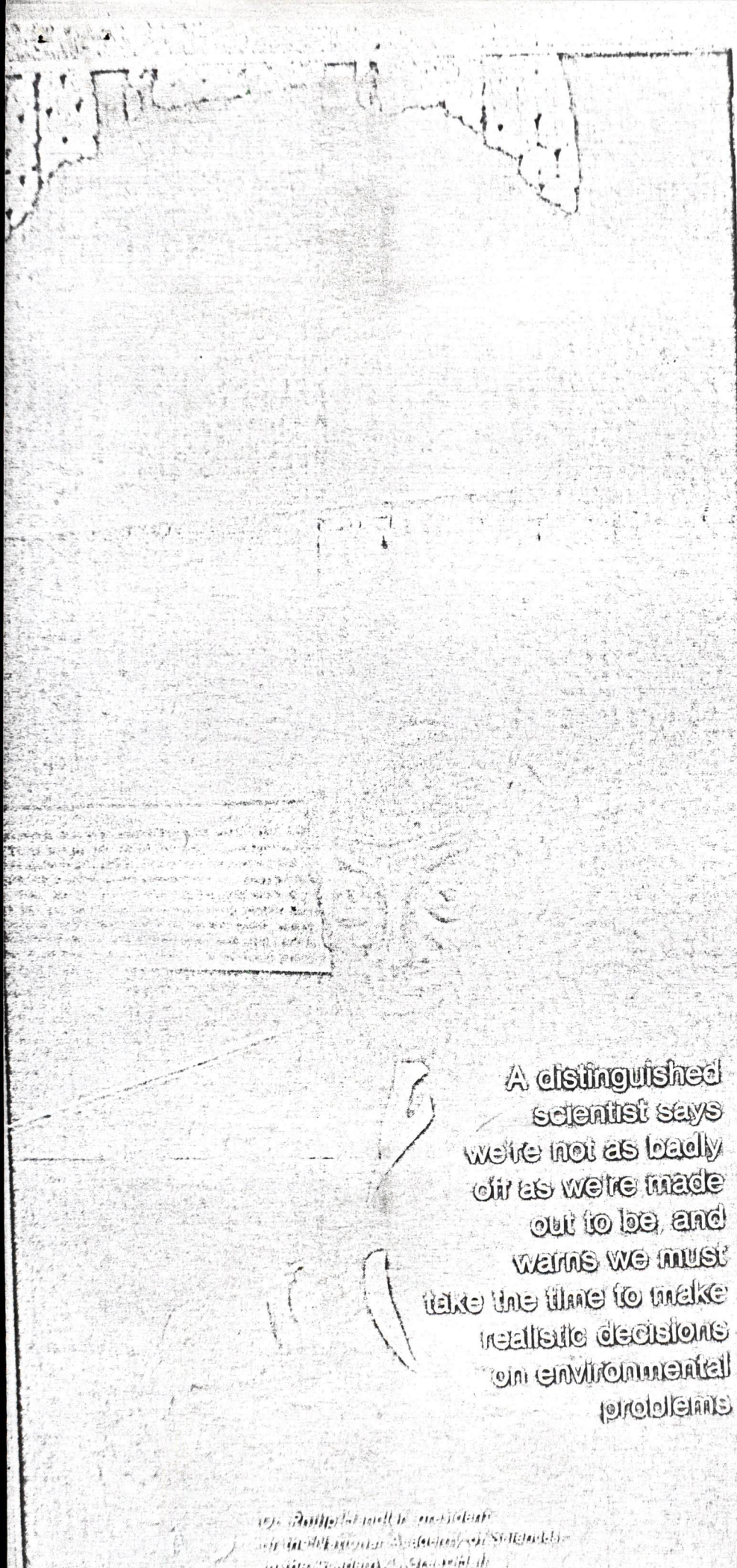


FIGURE 3. Focused gaging transducer.



Nation's Business • April 1971

Exaggeration: The Other Pollution Peril



A distinguished scientist says we're not as badly off as we're made out to be, and warns we must take the time to make realistic decisions on environmental problems

If you've been concerned by claims that pollution immediately imperils our environment, you'll be interested in the views of Dr. Philip Handler, president of the National Academy of Sciences.

In this interview with NATION'S BUSINESS, Dr. Handler contends that while pollution problems are indeed grave, they may well be less acute than they so frequently are made out to be. And he cites a danger of emotional overreaction which he says can lead to insufficiently considered controls.

He feels we have the time for proper research which will enable us to enact reasonable antipollution laws to protect the environment without unnecessarily endangering the economy.

The privately endowed Academy which Dr. Handler heads is the nation's most distinguished organization of scientists.

Under its charter, signed in 1863 by Abraham Lincoln, the Academy is dedicated to the furtherance of science and its use for the general welfare. On request of any govern-

PHOTOS: LEROY WOODSON JR.

ment department, it conducts independent investigations of scientific problems on a nonprofit basis.

Dr. Handler, 54, is a biochemist noted in his profession for basic research with enzymes at Duke University.

Since his election in 1969 to a six-year term as head of the Academy, he has gained a reputation for speaking out.

He has strongly criticized the Administration on some aspects of federal spending for science, and on occasion has opposed prevailing opinion in the scientific community—as he does here on some important pollution questions.

Dr. Handler, you are one of the few scientists who say environmental pollution problems are being exaggerated. Yet many of your colleagues contend the pollution situation has reached the danger point. If the experts disagree, where does this leave average citizens?

Well, I hope it leaves them open-minded, willing to look about themselves and willing to read.

The evidence of environmental deterioration is all too evident and there are local instances where the damage is beyond tolerance and perhaps dangerous to man. I don't differ from my colleagues with regard to the long-term seriousness of these problems. But I also view them as varying widely in the magnitude and urgency of the threat to man.

I wish to avoid undertaking supposedly mitigating measures which generate new and even less understood problems. The basic problems are severe enough without unnecessary exaggeration.

Finding lead or mercury in modest amounts in some foodstuff is trouble enough without hysteria. Contending with the consequences of an excess of an old friend like phosphate in detergents should not be relieved by substituting a new devil of unknown properties.

Could you give examples of exaggerated claims about pollution?

Probably the best known is Lake Erie. Erie is surely filthy around its periphery. But the center of the lake is not a "dying body of water" as has been claimed.

The amount of fish protein taken from the lake by commercial fisheries last year was close to the all-time high. They weren't catching the same species as in the past. The game fish that used to be at the top of the food chain are not thriving now; fish below them on the food ladder now dominate. But they are quite adequate for many purposes, so the commercial fishermen take them.

A lake producing all that protein cannot be called dead, and surely affords the opportunity to reverse the damage.

Lake Washington, near Seattle, was called a dying body of water a few years ago. By dint of enormous political effort the situation was turned around; that is, the amount of untreated sewage going into the lake was markedly reduced.

Since this happened, I am told, the lake has difficulty in supporting salmon, the game fish that was at the top of the food ladder. Smaller fish have taken over, much as in Lake Erie, but for quite different reasons.

Please understand that no one in his right mind would favor going back to polluting Lake Washington. My point is that ecosystems are very complex; some are very fragile, others self-sustaining. Any steps that the government takes in the public interest must first be carefully weighed for all possible consequences.

Despite our pollution, our public health is excellent by historic standards. The world was less hygienic through most of history than it is now. The behavior of the citizens of London and Paris until the last century would offend any American today. They had open sewers in the streets and thought nothing of tossing slops out of windows.

We have come a long way since, but we now may desire a cleaner environment than we can afford in view of our other aspirations—perhaps even cleaner than necessary.

You believe then, that management of the environment involves a series of either/or questions? For example, that society either accepts some pollution from power plants, or there won't be enough electrical power to maintain the present standard of living?

Exactly. The world has to be viewed through realistic glasses. In managing the environment, we must learn to make judgments by weighing risks versus benefits.

Do scientists and the government lack the knowledge to set antipollution standards and to regulate the quality of the environment?

Yes and no. There are serious holes in our knowledge of the mechanisms and effects of many types of pollution. It will take coordinated research efforts in the laboratory and in the field to obtain the data needed to establish truly appropriate regulations concerning pollution.

An indication of what is needed was provided by a recent National Academy of Sciences and National Academy of Engineering study, which estimated that around 2,600 man-years would be required to take a reasonable first step in understanding the basis for waste management in coastal regions.

This really isn't a huge effort: only about 500 men for about five years. Other programs would be needed in other areas.

When the new Environmental Protection Agency, the Council for Environmental Quality and the National Oceanic and Atmospheric Administration have grown into their jobs, such programs will become imperative to them. And they will seem rather cheap.

If it will take several years to establish realistic antipollution regulations, how should we proceed in the immediate future?

We need time to acquire the understanding upon which to base such regulations. Meanwhile there are obvious excesses and enough understanding for this go-round of regulation. I'm not sure how much time is required to design or install the necessary technology.

As we repair old wrongs, presumably industry must bear the costs of undoing its own polluting. But that must be done fairly, enforced equitably across the country. Within the U. S. no company should be given a competitive edge by penalizing its rivals.

It isn't quite so clear how to proceed when we want domestic con-

Exaggeration: The Other Pollution Peril *continued*

cerns to avoid polluting while their international competitors proceed unchecked.

In any case, current understanding will undoubtedly suffice to permit reasonable and wise decisions with respect to most major environmental problems.

Which types of pollution do you consider most serious? Do you have a priority list?

No, I don't have one that is carefully worked out.

Probably the matter of primary importance is assurance of an abundant water supply of high quality. We cannot exaggerate our requirement for a healthful, clean water supply.

How big a job is it going to be to straighten out the most serious water pollution problems?

It is a huge, expensive but probably feasible task. A large fraction of our supply comes from major rivers and lakes—water that we necessarily use over and over again. Going back to Lake Erie, the edges are badly polluted. But the task of cleaning it up isn't impossible.

Apparently, this is also true of most of our great rivers. The Mississippi still is bearing fish throughout most of its length. Rivers like the Hudson are difficult but not hopeless.

My point is to sound a note of hope. A great deal can be accomplished by utilizing current technology to stop the most serious sources of pollution.

What is next on your priority list?

Air. We cannot exaggerate our requirement for a healthful, clean air supply.

But I am not aware of any large, heavily populated area in the United States which is in acute trouble for its air supply. The exception is the occasional temperature inversion, when the air essentially becomes stagnant and the concentration of undesirable gases and particulates rises seriously.

The automobile exhaust emission problem can be managed in a few years, probably. Technologies will surely be developed for abatement of the undesirable visible and invisible exhausts of industrial smokestacks.

By now you gather that I do not underestimate the magnitude or seriousness of these problems. What I wish also to convey is that we yet have the time, and already have much of the technology, to manage them; that the way to a better tomorrow is more, not less technology.

How does the pesticide problem rate on your priority list?

I may get myself in trouble with my constituency but I find the stress with respect to pesticides exaggerated.

I join my nature-loving friends in their concern for the handful of bird species that seem to be endangered. But the alternatives, at the moment, are even worse. To do without available pesticides, the price to man would be too high.

We have no choice but to learn how to use the pesticides we have—to use them sparingly and wisely, rather than foolishly abolishing them entirely.

Will it be possible to develop new classes of pesticides?

Yes, I very much hope so. We hope to learn how to operate biological control systems. That is, use natural attractants to collect specific species of undesirable insects and then destroy them or render them infertile.

Haven't such systems already been started?

It has been done for a few species. There is no theoretical reason why we couldn't extend the list. In the end, if we can do that with key pests, we can protect our crops and health, and avoid doing damage by an excess of pesticides. Hopefully such procedures will not lead to some other, presently unpredicted, catastrophe.

At the moment we have succumbed to the pressure to ban DDT. We have placed on the market what is called the second generation of pesticides, which work on a quite different principle. These are the compounds like malathion and parathion. Unlike DDT, they are highly toxic to man; they blinded and even killed numbers of people in 1970. I hope we can avoid such tragedy in 1971.

The public, says Dr. Handler, must look hard at measures proposed in the name of a cleaner environment.

You said earlier that you hope the average citizen will keep up-to-date on pollution information. Should he also take an active part in deciding what antipollution regulations the nation actually needs?

Yes. But the process is necessarily complex. Only an informed citizenry will vote the bonds necessary to improve sewage disposal systems or water supplies; will accept the higher costs of almost everything that will come from the wide variety of effort required if the environment is to be protected as so many demand.

But I hope they will not vote to return to "good old days" that never were.

Are you thinking of a vote in which the entire population participates—a referendum?

In some instances we could have a referendum. In general I would rather use the classical technique of electing wise men to public office and abiding by their decisions. By and large they have shown greater wisdom than have referenda.

It is also evident that we are to

learn to live with class suits, with citizens' challenges to government action, etc. Indeed, the history of the use of Section 102 of the Environmental Policy Act, which makes such challenges possible, will be a fascinating chapter in our national life.

How do you evaluate the President's recent State of the Environment Message and his recommendations for antipollution laws?

Those were well-considered and, in my view, in the right direction, but I don't think it is for me to comment on the legal mechanics.

A joint report by the National League of Cities and the U. S. Conference of Mayors says $37 billion may be needed over six years to completely modernize sewage and waste water facilities. Do you have any cost estimates?

I have yet another number in mind. I can't guarantee its validity, but I've heard repeatedly that it would take about 15 per cent of the gross national product to clean up the environment in all its aspects and then to continue to protect it from pollution. In today's economy that would amount to an annual $150 billion, a sizable sum. And this investment would have to continue on a sustained basis.

This would be a 15 per cent add-on cost and would be at the expense of the GNP. There would be fewer goods and services to go around for the same level of effort.

But this investment would be a major new source of jobs. Another offsetting advantage would be a decline in the social costs of environmental deterioration, a real enough phenomenon but difficult to manage in the national accounts.

Will the recycling of solid wastes ever be important commercially?

It simply must become commercially attractive. Either that or our standard of living is going to decline.

We have to make recycling work on two counts. First, we must find an acceptable method of disposing of this enormous amount of solid waste. We speak of our society as a high consumption society, but we don't really consume. We pass everything through. And then we have to find some place to unload it.

The second reason is the variety of materials which sooner or later will be in short supply. We have no choice but to re-use them. Applicable processes now exist for some. It is a matter of installing plants and being willing to pay for the increased cost of materials. But we must not slowly convert the oceans into a dilute solution of our rarest metals.

Has pollution of the oceans become a real problem?

The National Academy of Sciences recently reported pesticides are beginning to build up in the oceans. Not in amounts which are cause for alarm, but this is the kind of thing we must keep tabs on.

It is hard to believe we have contaminated the oceans, since such vast quantities of pollutants are required. But we need to admit the possibility.

At this point, I don't think there is any single pollutant in the deep oceans that we need to worry about although there may be problems along the continental coasts.

Is the danger from oil spills as great as it's sometimes made out to be?

During World War II, more than 50 tankers were sunk off Florida's east coast in a two-year period; the beaches were covered with oil, and it backed up in shallow waters. Yet sea life thrives there normally.

Nobody advocates oil spills, of course, but I think the resiliency, the ability of nature to repair itself, is greater than some environmentalists seem to feel.

How would you summarize the pollution situation?

Those who, in my view, exaggerate the nature or magnitude of the pollution problem nevertheless are on the side of the angels. They want a clean, healthy United States. To argue with that is nonsense. And they have generated a climate in which effective action should be possible.

Our problems are to accurately assess environmental hazards, learn the processes which are involved, and reach realistic public decisions about their management.

Public panic is as completely unwarranted as concern is justified.

END

66 M

Senate SST Hopes Fade; Ozone Peril Called Grave

By CHRISTOPHER LYDON
Special to The New York Times

WASHINGTON, May 17 — Senate backers of the supersonic transport acknowledged today that the chances for a revival of the SST were dwindling rapidly under the weight of its projected costs.

In five hours that had been set aside to debate the House's $85-million appropriation for further SST development, no defender of the plane was heard. Later this afternoon, Senator Henry M. Jackson, Democrat of Washington, asked his colleagues to reconsider the matter, but he spoke briefly and with little of the passion he had devoted to SST debates in the past.

Senator Warren G. Magnuson, his fellow Washington Democrat and a strong SST supporter, did not speak on the matter at all.

Meanwhile, a professor of chamistry at the University of California at Berkeley declared today that a full fleet of 500 SST's operating seven hours a day would destroy half of the earth's protective ozone layer—not the roughly 2 per cent that other scientists viewed as a potential skin cancer hazard in a report issued last winter.

Dr. Harold Johnston, who made the findings, said they had already been submitted to President Nixon's Science Advisory Committee and that they had been accepted for publication in Science.

While earlier disputes about SST and ozone dealt with the effect of water vapor from the SST exhaust on the chemical reaction that generates ozone, Dr. Johnston's study identifies nitrogen oxides in the SST fumes as the more destructive agent, speeding up the change of ozone to oxygen by a factor of 4,600.

It would take less than a year of full-fleet operations, Dr. Johnston said in a telephone interview, for SST's to deplete half of the stratospheric ozone that shields the earth from the sun's ultraviolet radiation. Scientists argued in the SST debate last March that even a 1 per cent reduction of ozone would increase radiation enough to cause an additional 10,000 cases of skin cancer a year in the United States.

Senate opponents of the SST indicated today that they were aware of Dr. Johnston's study but that they had not intended to introduce the subject so soon before a vote that they already expect to win.

The Senate has reserved two hours more Wednesday morning for debate on the SST. A vote is scheduled Wednesday evening on Senator William Proxmire's amendment to delete all SST funding.

But Senator Magnuson was said to be convinced already that the cause was hopeless and that Congress should move without further delay to terminate the program. Senator Magnuson was reported to be prepared to support a substitute appropriation of $155-million to pay off the Government's debts to contractors and airlines that had invested in the program.

In the House, Representative Sidney R. Yates, a leader of the SST opposition, said that if the Senate killed the development funding he would move to instruct House members of a joint conference committee to accede to the Senate position.

Opponent Is Confident

Although he lost just such an effort to instruct SST conferees last year, Mr. Yates, an Illinois Democrat, said he felt confident this time, largely on the basis of the recent estimate by William M. Allen, the Boeing company's board chairman, who said last week that a revised SST program would cost up to $1-billion more than the program Congress killed last March.

In the Senate discussion today, there was no effort to rebut Mr. Allen's cost projections.

Senator Allen J. Ellender, a Louisiana Democrat who is chairman of the Appropriations Committee and has supported the SST before, said he would vote against restoration until the new costs were measured. But he added: "If the amount of the new contract is increased as much as $50-million or $100-million, this Senator from Louisiana is going to be against the SST from now on."

Clark MacGregor, who directs White House lobbying on Capitol Hill, said yesterday that the Boeing Company, a prime SST contractor, was sharply reducing Mr. Allen's cost estimates. But there was no sign of a new figure today, and a spokesman for John A. Volpe, the Secretary of Transportation, said that his department did not expect to have an alternative cost estimate soon.

Senator Proxmire, the Wisconsin Democrat who leads the anti-SST forces, said that in addition to the extra start-up costs in the prototype program, Boeing was asking the Government to finance the heavy costs of mass production.

"This is very likely to be a $5-billion program," Senator Proxmire said. "We should keep asking ourselves where that money is coming from."

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY
Washington, D. C. 20506
395-3586

FOR IMMEDIATE RELEASE MAY 7, 1971

- -

REPORT ON 2, 4, 5-T

Dr. Edward E. David, Jr., Science Adviser to the President and Director of the Office of Science and Technology, today released a report of the President's Science Advisory Committee on the herbicide, 2, 4, 5-T. The report was prepared by a special Panel on Herbicides of the President's Science Advisory Committee.

The Panel was given responsibility for examining all of the various kinds of scientific information which formed the basis of Government practices and regulations of a number of herbicides used domestically and abroad. The report reflects a detailed review of the chemistry of 2, 4, 5-T, what is known of its toxicity to man and to other environmental elements, knowledge of residues in the environment and their significance, as well as a discussion of the uses of 2, 4, 5-T and their importance.

The report examined in detail the amount and types of scientific information available specifically for this herbicide. In addition, this review represents an outstanding case study of Government regulation of pesticide including the scientific resources available to the Government to aid in its policy decisions.

The recommendations in the report deal with a number of scientific details of background research and testing of pesticides. Th ouch specifically on the subject of teratogenesis. They also deal with tems of regulation, scientific understanding, and monitoring as they apply pesticides in general but as exemplified by the experience with 2, 4, 5-T.

- -

Copies of the report "Report on 2, 4, 5-T" are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C., 20402 at a cost of 40 cents a copy.

A check or money order made payable to the Superintendent of Documents must accompany your order.

STORMFURY Panel.

Members:

Dr. Herbert A. Simon - Chairman
Dr. Solomon J. Buchsbaum
Dr. Myron Tribus
Mr. Carl Savit - OST Staff Representative
(Several prospective members have been contacted and are awaiting proper clearances).

Project STORMFURY is a research effort to study the structure and dynamics of major cyclonic storms and to modify these storms through selective seeding. Work to date has been done almost entirely on hurricanes of the Tropical North Atlantic, Caribbean, and Gulf of Mexico. Two successive seedings of Hurricane Debbie demonstrated some success.

A decision-theory analysis made by the Stanford Research Institute suggests quite strongly that operational seeding of at least some hurricanes should begin immediately; that the risk of not seeding is greater than that of seeding. A contrary body of opinion by conventional meteorologists holds that additional experimental data is required.

It has been provisionally decided to move the project to the Western Pacific as soon as practicable in order to increase experimental opportunities. Experimentation could then be performed on the frequent typhoons without the political constraints of the present arena.

A PSAC presentation on Project STORMFURY arranged by NOAA was made by the project staff from Miami, by the Stanford Research Institute group, and by DOD at the meeting on January 18, 1971. This was a technical presentation and identification of the underlying scientific and policy questions.

After this presentation it was concluded that a PSAC Panel should be set up to study the principal issues including:

a) whether there is sufficient experimental data to justify moving STORMFURY into the operational phase,

b) whether there is an adequate legal and political framework for the conduct of hurricane modification operations affecting the U. S. If not, how can such a framework be developed?

The first meeting of the Panel is scheduled for Friday, February 26, in the Executive Office Building, Room 285.

Item 1b

D R A F T

January 21, 1971

POLICIES GOVERNING OPERATIONAL USE OF HURRICANE MODIFICATION MEASURES
(Preliminary Issues Paper)

1. On the basis of the evidence now available from experiments in the modification of hurricanes, the scientists involved believe that there is a substantial probability that peak wind velocities of hurricanes can be reduced, on average, and only a small probability that abatement measures will increase peak wind velocities.

2. Using estimates made by these scientists of the probabilities involved, and the natural variances in hurricane behavior, there is a substantial expected gain from attempting modification, and this gain does not disappear even when penalties are attached to actions that have an apparent adverse effect. The conclusions of the analysis are not unduly sensitive to the exact assumptions made about the underlying probabilities.

3. In the analyses that have been made, maximum wind velocity has been used as the sole figure of merit. Little or nothing is known as yet about the possible effects of modification measures upon hurricane paths (although there is some reason to believe these effects will be slight), upon temporal duration of high winds, upon ocean waves and flooding, or upon rainfall.

4. The experiments will be shifted from the Atlantic to the Pacific Ocean on 1972, and requests have already been received from several governments to make them operational.

In this situation, the decision whether to go operational needs to be examined in the light of the following questions:

1. Whether the existing evidence regarding effects on maximum wind velocities is sufficient to justify a decision to make an operational experiment of any kind until further data from off-shore experiments are available.
2. Whether evidence needs to be gathered and analysed on other figures of merit--wind durations, flooding, and rainfall--before any operational experiments are undertaken.
3. What procedures should be instituted to obtain broad public understanding and/or consent before operational experiments are undertaken.
4. What special groundrules should be established: (a) for operational experiments on foreign shores, and (b) for off-shore experiments on hurricanes that may later strike foreign territory.

SPECIAL ANALYSIS O

FEDERAL ENVIRONMENTAL PROGRAMS

Reprint of Pages 219 to 229 From
Special Analyses, Budget of the United States, 1972

Detail may not necessarily add to totals because of rounding

OFFICE OF MANAGEMENT AND BUDGET
January 1971

SPECIAL ANALYSIS O

FEDERAL ENVIRONMENTAL PROGRAMS

This analysis identifies Federal funding for selected environmental activities. It covers:

- Pollution control and abatement activities;
- Sewer and water programs;
- Selected activities to protect and enhance the environment; and
- Activities to understand, describe, and predict environmental conditions.

Pollution Control and Abatement

Federal funding for pollution control and abatement activities in 1972 will increase significantly over 1970 and 1971:

[In millions of dollars]

	1970 actual	*1971 estimate*	*1972 estimate*	*Percent increase over 1971*
Budget authority	1,432	1,828	3,127	71
Obligations	1,071	2,036	3,088	52
Outlays	751	1,176	2,014	71

The largest share of the increase is for grants to State and local governments for construction of municipal waste treatment facilities. Grants were made for 1,050 treatment facility projects in 1970; 1,650 grants are expected in 1971, and 2,000 in 1972. Grants also provide support for pollution control agency operations and for planning. Budget authority for grants will increase by 89% over 1971, from $1,108 million to $2,089 million. Outlays will increase by 112%, from $533 million to $1,131 million.

Table O–1. **POLLUTION CONTROL AND ABATEMENT ACTIVITIES**

(in millions of dollars)

Type activity	Budget authority			Outlays		
	1970 actual	1971 estimate	1972 estimate	1970 actual	1971 estimate	1972 estimate
Financial aid to State and local governments	874	1,108	2,089	288	533	1,131
Research, development, and demonstration	344	390	426	296	378	398
Federal abatement and control operations	80	123	122	72	98	117
Manpower development	16	19	20	12	15	19
Reduce pollution from Federal facilities	72	113	250	32	88	185
Program direction and other	48	62	135	52	61	110
Separate transmittal [1]	----	13	85	----	4	56
Total	**1,432**	**1,828**	**3,127**	**751**	**1,176**	**2,014**

[1] Not reflected in preceding activity lines are proposals that will be transmitted subsequently for $13 million in budget authority for 1971, and $85 million for 1972 for EPA for implementing air quality and solid waste legislation and other activities.

Funding will also increase for:

- Research, development, and demonstration activities which include efforts to determine and describe pollution sources and effects and to develop and demonstrate technology for monitoring and controlling pollution (work is performed in Federal laboratories and under contracts and grants with educational institutions, industry, and others);
- Direct Federal pollution control operations including planning, monitoring, and surveillance; standard setting and enforcement; and technical assistance; and
- Manpower development, ranging from training of treatment plant operators to researchers at the graduate level.

Budget authority will increase by 121%, from $113 million to $250 million, primarily in the Department of Defense, for remedial projects to reduce pollution from Federal facilities—as required by Executive Order 11507, February 4, 1970. This is a major step toward the goal of having all essential Federal projects underway by December 31, 1972.

Agencies involved.—Major Federal activities to control and abate pollution were consolidated in the Environmental Protection Agency (EPA) on December 2, 1970, by Reorganization Plan No. 3. However, several other agencies carry on important pollution control activities, as indicated in table O–2.

Table O–2. **POLLUTION CONTROL AND ABATEMENT ACTIVITIES—BY AGENCY (in millions of dollars)**

Agency	Budget authority			Outlays		
	1970 actual	1971 estimate	1972 estimate	1970 actual	1971 estimate	1972 estimate
Environmental Protection Agency [1]	1,046	1,297	2,440	388	695	1,359
Defense—Military	89	126	193	39	83	147
Atomic Energy Commission	120	125	127	116	126	125
Agriculture	60	96	77	91	93	107
Defense—Civil	3	11	56	3	11	56
Interior	36	47	68	37	48	65
Transportation	17	49	60	11	27	54
Commerce	19	28	29	22	28	34
General Services Administration	1	1	19	----	1	1
National Aeronautics and Space Administration	21	17	16	15	17	13
National Science Foundation	7	13	17	7	12	14
Other agencies	12	18	25	23	36	38
Total	**1,432**	**1,828**	**3,127**	**751**	**1,176**	**2,014**

[1] Funding shown above for EPA has been adjusted to include activities actually carried out by Departments of Health, Education, and Welfare; Agriculture; Interior; Atomic Energy Commission; and Federal Radiation Council prior to Dec. 2, 1970. The budget authority adjustment is $42 million in 1970 and $14 million in 1971, and the related outlay adjustment is $37 million in 1970 and $17 million in 1971

Funding for EPA will increase sharply in 1972. Budget authority for activities now carried on by EPA will increase by 88% in 1972 from $1,297 million to $2,440 million. Outlays will increase by 96% from $695 million to $1,359 million. EPA's program of grants for waste treatment facilities will be doubled—from $1 billion to $2 billion annually with the goal of assisting States and localities in reducing the Nation's backlog of treatment facilities needs. Other major increases will provide for implementing the new air quality and solid waste legislation, for increasing grants for State and local pollution control agency operations, increasing planning activities, increasing research on water supply purity, expanding cost-sharing arrangements with private industry to develop technology for controlling sulfur oxides, expanding the program for developing low-pollution motor vehicles, and increasing EPA's efforts directed toward identifying the magnitude of pollution problems and determining benefits and costs associated with alternative corrective actions.

Other agencies also carry out important pollution control and abatement activities. For example, the *Department of Defense* will expand its effort to reduce pollution from its industrial production facilities and military bases and step up research on abating pollution from naval vessels and jet engine run-up facilities.

The *Atomic Energy Commission* will continue its major program of research, development and monitoring relating to effects of ionizing radiation.

The Department of Agriculture makes grants and loans for waste treatment facilities in smaller localities and conducts research on agriculturally related pollution such as pesticides, animal and crop processing wastes, and fertilizer and plant nutrients. Increases in 1972 are largely for reducing pollution from facilities in national forests. Pesticide registration activities, formerly conducted in the Department, were transferred to EPA.

The *Department of the Interior* will continue research relating to pollution sources and effects, will expand activities to reduce pollution from facilities in the national parks, and will increase research in methods of converting coal to low pollution fuels. Water pollution control and certain pesticides activities were transferred to EPA.

The *Corps of Engineers* will construct dikes for the containment of polluted material dredged from Great Lakes harbors.

The *Department of Transportation* will increase funding significantly for work on reducing aircraft engine noise, studying environmental effects of supersonic aircraft and reducing pollution from Coast Guard installations.

The *Department of Commerce* provides grants for waste treatment facilities under economic development programs and the National Oceanic and Atmospheric Administration conducts research on sources and effects of pollution and engages in environmental monitoring.

The *General Services Administration* will have increased funding in 1972 for pollution reduction at Federal installations.

The *National Aeronautics and Space Administration* activities consist primarily of research and development on reduction of aircraft noise.

Most pollution abatement activities of the *Department of Health, Education, and Welfare* have been transferred to the Environmental Protection Agency, including air pollution, solid waste, pesticides standards, water hygiene, and certain radiation activities.

Media polluted and pollutants.—Pollution control and abatement activities are generally focused on reducing pollution in air or water or reducing adverse effects of particular pollutants such as pesticides or radiation. Table O–3 summarizes the total Federal effort in terms of media polluted and also identifies funding associated with selected pollutants. Among the media, *water* pollution currently receives the greatest share—80%—of total Federal pollution control obligations. This large share is a result of grants and loans for construction of municipal waste treatment facilities.

Air pollution control efforts account for 11% of the total. Principal Federal efforts in 1972 will be directed toward research, development, and demonstration; grants to State and local air pollution control agencies; and direct Federal operations such as monitoring, standard setting, and enforcement. Funds to implement new air quality legislation will be proposed in a subsequent request to the Congress. Activities relating to pollution of *land* are for research and other activities concerned with effects of acid mine drainage, nutrients, pesticides, and other substances.

Federal pollution control activities relating to radiation, pesticides, solid wastes, and noise are largely confined to research relating to effects, control technology, and standard setting and enforcement. Funds to implement new solid waste legislation will be contained in a subsequent request.

Table O–3. **POLLUTION CONTROL AND ABATEMENT ACTIVITIES—BY MEDIA OR POLLUTANT** (in millions of dollars)

Media or pollutant	Obligations		
	1970 actual	1971 estimate	1972 estimate
Media polluted:			
Water:			
Construction grants and loans	491	1,256	1,974
Other	186	296	425
Air	189	234	341
Land	35	42	46
Other (e.g., living things, materials)	100	97	110
Multi-media (i.e., more than one of above)	69	98	107
Total [1]	1,071	2,023	3,003
Selected pollutants: [2]			
Solid wastes	20	39	50
Pesticides	30	42	54
Radiation	116	124	129
Noise	36	43	66

[1] Excludes $13 million in 1971 and $85 million in 1972 for EPA which will be proposed in a separate transmittal (see footnote for table O–1).
[2] These funds are *included* in the "media" breakdown above.

Excluded from the funding shown above for pollution control and abatement activities are:

- activities to reduce or avoid the use of pesticides. Funding for such activities is expected to be approximately $57 million in 1972 for both research and education programs, largely carried out by the Department of Agriculture; and
- activities that are carried on for some other primary purpose but which also contribute to the reduction of pollution. For example, extensive activities to hold soil in place to preserve soil productivity, such as those financed by the Department of Agriculture, and other erosion control activities by Corps of Engineers and Department of Transportation (highways), have been excluded from this analysis even though these activities also serve to reduce sediment pollution of water.

Sewer and Water Programs

Federal programs of grants and loans for the construction of sewer and water systems are directed toward a variety of objectives, including economic development, urban and rural development, and in some cases, pollution control.

[In millions of dollars]

	1970 actual	1971 estimate	1972 estimate	Percent increase over 1971
Budget authority	252	500	[1] 124	--------
Obligations	409	422	[1] 389	--------
Outlays	364	382	446	17

[1] Budget authority and obligations for water and sewer grants will decline in 1972 as grant programs administered by HUD and Agriculture are merged into Special revenue-sharing programs.

Grants and loans to finance water system and sewer line construction are made by five Federal agencies. The *Department of Housing and Urban Development*, as a part of its community development efforts, provides assistance for basic sewer and water facilities. $100 million in new grant reservations will be made by December 31, 1971. On January 1, 1972, the program will be folded into the Urban Community Development Special Revenue-Sharing Program. Public facility loans, about 67% of which are used to finance sewer and water facilities, will be increased by 62% in 1972.

The *Department of Agriculture* provides grants and loans for basic sewer and water facilities in rural communities with population not in excess of 5,500 people. Approximately one-half of the $25 million budgeted for grants will be obligated prior to January 1, 1972, and the remainder will be folded into the Rural Community Development Special Revenue-Sharing Program. Agriculture's loans, about 78% of which are used for water and sewer facilities, will be increased by 18%.

The *Department of Commerce* provides assistance to municipalities as a part of its economic development efforts. Budget authority will not increase, but outlays for this program will increase by 27% from $62 million in 1971 to $79 million in 1972. Other agencies providing sewer and water system grants are the *Appalachian Regional Commission* and the *Department of the Interior* (for the Trust Territory).

Grants and loans made by Environmental Protection Agency, Agriculture, Commerce, and Housing and Urban Development for waste treatment plants and interceptor sewers are included in the section on pollution control and abatement.

Table 0-4. **SEWER AND WATER PROGRAMS (in millions of dollars)** [1]

	Budget authority			Outlays		
	1970 actual	1971 estimate	1972 estimate	1970 actual	1971 estimate	1972 estimate
Purpose:						
Sewer grants	102	205	44	72	88	116
Sewer loans	4	3	4	14	17	18
Water system grants	142	287	71	112	138	168
Water system loans	4	4	5	165	139	144
Total	252	500	124	364	382	446
Agencies:						
Housing and Urban Development	135	350	0	133	168	192
Agriculture	25	52	27	164	140	163
Commerce (economic development)	81	84	84	60	62	79
Other agencies	11	14	13	6	12	12
Total	**252**	**500**	**124**	**364**	**382**	**446**

[1] Funds provided by the above agencies which are for construction of waste treatment facilities or interceptor sewers, often counted as part of "sewer and water programs," are included in the section on pollution control and abatement for purposes of this analysis. Funds shown in above table are for water supply systems and collecting sewers. They are *not* included in tables O–1, 2, or 3

Selected Environmental Enhancement Activities

Federal funding will increase for environmental protection and enhancement activities such as providing recreational areas and open space, fish and wildlife preservation, and beautification programs.

[In millions of dollars]

	1970 actual	*1971 estimate*	*1972 estimate*	*Percent increase over 1971*
Budget authority	628	875	1,108	27
Obligations	586	748	1,018	36
Outlays	553	730	846	16

Protection and enhancement activities.—The Federal Government provides grants to State and local governments for acquiring land for recreational purposes, for preserving open space and historic properties, and for fish and wildlife refuges. Aid is also provided for research and planning; construction and maintenance of recreational facilities and wildlife refuges; and for promoting beautification such as highway landscaping. Similar activities are also carried on directly by several Federal agencies. Funding for many of these activities will increase sharply. For example, budget authority for grants to State and local governments to acquire recreational and open space lands will increase by 61%, from $140 million in 1971 to $226 million in 1972. Grants for development of recreational areas will increase by 127%, from $120 million in 1971 to $272 million in 1972.

Table 0-5. **SELECTED ENVIRONMENTAL PROTECTION AND ENHANCEMENT ACTIVITIES (in millions of dollars)**

Activity	Budget authority			Outlays		
	1970 actual	1971 estimate	1972 estimate	1970 actual	1971 estimate	1972 estimate
Financial aid to State and local governments:						
Purchase recreation and open space lands	80	140	226	51	75	107
Develop recreational areas, related activities	55	120	272	53	53	100
Historic properties	3	7	6	2	7	7
Preserve fish and wildlife	51	56	63	45	60	69
Beautification (e.g., highways)	62	116	112	62	79	87
Subtotal	252	440	679	214	275	371
Direct Federal activities:						
Purchase nationally important areas	85	138	98	68	158	151
Develop recreational facilities, related activities	158	181	197	163	177	193
Historic properties	1	2	2	1	2	2
Park roads and trails	56	37	48	34	36	44
Preserve fish and wildlife	66	66	73	63	71	73
Beautification	10	10	11	10	10	11
Subtotal	376	434	429	339	454	474
Total	**628**	**875**	**1,108**	**553**	**730**	**846**

Agencies involved.—The *Department of the Interior* accounts for approximately 61% of the environmental protection and enhancement activities described in this section. Interior's budget authority for these programs will increase by 13%, from $552 million in 1971 to $624 million in 1972. Most Interior activities are carried out by the Bureau of Outdoor Recreation, including the land and water conservation fund; the Bureau of Sport Fisheries and Wildlife; and the National Park Service. The 1972 budget for the land and water conservation fund provides a major increase for grants to State and local governments to help them meet the increasing demand for local recreation areas, especially those located in or near major cities. Federal land purchases financed from the fund are made by several Federal agencies to preserve nationally important natural and historic areas, including endangered species habitats. Newly authorized areas for which funds are provided to begin initial acquisition in 1972 are Apostle Islands National Lakeshore, Sleeping Bear Dunes National Lakeshore, Voyageurs National Park, Gulf Islands National Seashore, Chesapeake and Ohio Canal Historic Park, and Andersonville National Historic Site. Emphasis will also be placed on acquisition of lands in older natural preservation areas and parks such as Everglades National Park. The Bureau of Sport Fisheries and Wildlife provides assistance to State and local governments for fish and wildlife restoration and establishes Federal refuges. The National Park Service emphasizes resource protection, construction and maintenance of visitor facilities at national park system areas and park roads, trails, and highways.

The Department of Housing and Urban Development provides grants to help States and localities acquire and develop open space lands. In 1972, the open space program will be reoriented to help meet the growing recreational needs in urban areas. New emphasis will be given to the development of small neighborhood parks in and around cities. To support this initiative, budget authority will increase by 167%, from $75 million to $200 million.

The Department of Transportation provides assistance to State and local governments for highway beautification activities, including control of advertising and junkyards, landscaping, and scenic easements. Budget authority for such DOT activities will increase by 11%, from $97 million to $108 million.

The Department of Agriculture carries out a variety of environmental enhancement activities, particularly through the Forest Service. The 1972 budget authority will increase by 16%, from $83 million in 1971 to $96 million in 1972.

The Corps of Engineers provides facilities for water based recreation at reservoirs and other public works.

The Department of Commerce provides assistance to State and local governments through its economic development programs for the development of recreational areas.

Table 0-6. **SELECTED ENVIRONMENTAL ENHANCEMENT ACTIVITIES, BY AGENCY** (in millions of dollars)

Agency	Budget authority			Outlays		
	1970 actual	1971 estimate	1972 estimate	1970 actual	1971 estimate	1972 estimate
Interior	366	552	634	307	452	517
Housing and Urban Development	75	75	200	43	72	100
Transportation	42	97	108	51	60	69
Agriculture	81	83	96	80	81	94
Defense—Civil	43	46	47	43	46	47
Commerce	12	13	14	20	9	8
Other agencies	8	10	10	9	10	10
Total	**628**	**875**	**1,108**	**553**	**730**	**846**

Understanding, Describing, and Predicting the Environment[1]

Federal agencies conduct a wide variety of activities to understand, describe, and predict environmental conditions. Objectives range from the provision of routine weather forecasts to the scientific understanding of complex ecological systems. Funding for these activities will increase in 1972.

[In millions of dollars]

	1970 estimate	*1971 estimate*	*1972 estimate*	*Percent increase over 1971*
Budget authority	719	867	950	10
Obligations	710	880	956	9
Outlays	702	810	917	13

Activities.—Over half of the funding for this category supports environmental observation and measurement to describe and predict weather and ocean conditions and disturbances such as earthquakes.

[1] This section excludes activities reported under Pollution control and abatement.

Budget authority will increase by 9%, from $486 million in 1971 to $528 million in 1972 for research, development, and operational activities in this category. Funding will also be increased, but less sharply, for:

- Locating and describing natural resources;
- Survey activities to describe the physical environment for the purpose of preparing maps and charts; and
- Weather modification.

Additional emphasis will be placed upon research to develop a better understanding of the impact of the environment on man, for which budget authority will be increased by 42%, from $33 million in 1971 to $47 million in 1972; and on ecological and other basic environmental research, for which budget authority will be increased by 51% from $49 million in 1971 to $74 million in 1972.

Table 0-7. **UNDERSTANDING, DESCRIBING AND PREDICTING THE ENVIRONMENT, BY TYPE ACTIVITY** (in millions of dollars)

Activity	Budget authority			Outlays		
	1970 actual	1971 estimate	1972 estimate	1970 actual	1971 estimate	1972 estimate
Observe and predict weather and ocean conditions, disturbances:						
Research and development	120	139	154	105	128	152
Operations	299	347	374	305	343	375
Locating and describing natural resources:						
Research and development	100	145	140	95	110	124
Operations	61	74	75	60	74	74
Physical environmental surveys:						
Research and development	4	4	4	4	4	4
Operations	54	60	66	54	57	65
Weather modification	12	16	17	12	16	17
Research on environmental impact on man	26	33	47	25	30	38
Ecological and other basic environmental research	44	50	75	41	48	68
Total	**719**	**867**	**950**	**702**	**810**	**917**

Agencies involved.—In this overall category, the *Department of Commerce* accounts for about one-fourth of all Federal activities. The Department's activities are carried out by the National Oceanic and Atmospheric Administration which was created on October 3, 1970, by Reorganization Plan No. 4, and includes the former Environmental Science Services Administration and activities transferred from the Departments of the Interior, Defense, and Transportation and the National Science Foundation. NOAA carries on a wide range of environmental observation and prediction activities, including weather, river and marine forecasting; mapping and charting; development of instrumentation; data dissemination; and related research. Budget authority will increase by 4%, from $226 million in 1971 to $235 million in 1972, with increases providing for improved public weather services; hurricane and tornado warnings; weather modification experiments; earthquake and seismic research; satellite procurement; and development of ocean data buoys.

Table 0–8. **UNDERSTANDING, DESCRIBING AND PREDICTING THE ENVIRONMENT, BY AGENCY** (in millions of dollars)

Agency	Budget authority			Outlays		
	1970 actual	1971 estimate	1972 estimate	1970 actual	1971 estimate	1972 estimate
Commerce [1]	193	226	235	190	219	245
Defense—Military	178	194	185	178	194	185
National Science Foundation	60	92	161	61	88	136
National Aeronautics and Space Administration	87	129	117	75	88	106
Interior	103	117	131	102	116	129
Agriculture	51	53	52	51	54	52
Health, Education, and Welfare	17	21	25	17	20	23
Transportation	17	18	22	17	18	22
Smithsonian Institution	9	10	16	8	9	14
Other agencies	3	7	7	2	6	6
Total	**719**	**867**	**950**	**702**	**810**	**917**

[1] Funding shown above for Commerce has been adjusted to include activities actually carried out by the Departments of Defense, Interior, and Transportation and National Science Foundation prior to Oct. 3, 1970. The budget authority adjustment is $25 million in 1970 and $9 million in 1971, and the related outlay adjustment is $15 million in 1970, $14 million in 1971, and $7 million in 1972

Within the *Department of Defense*, both the Navy and the Air Force carry out weather and ocean observation and prediction, and mapping and charting activities important to military operations. Funding for these DOD activities will decline slightly in 1972.

The *National Science Foundation* supports research activities important to the understanding of environmental problems. Budget authority will increase by 75%, from $92 million in 1971 to $161 million in 1972, with the increases providing for greater emphasis in nearly all areas of environmental research through such programs as the International Biological Program, and the International Decade of Ocean Exploration.

The *National Aeronautics and Space Administration* conducts activities concerned with the application of satellite technology to atmospheric sciences and measurement of earth resources.

The *Department of the Interior* carries out such activities as geologic investigations, topographic mapping, weather modification, and water resources research. Increases in 1972 will provide principally for expansion of Interior's work on application of remote sensing data from aircraft and spacecraft to earth resource measurement.

The *Department of Agriculture* conducts such activities as soil and river basin surveys, research and surveys relating to forest and timber management, and basic ecological research.

The *Department of Health, Education, and Welfare* conducts a variety of activities relating to environmental impact on man, principally research at the Department's National Institute of Environmental Health Sciences.

The *Department of Transportation* conducts oceanographic and meteorological research and surveys, largely through the Coast Guard.

The *Smithsonian Institution* conducts a variety of programs dealing with environmental impact on man and is developing baseline ecological information. Increases in 1972 will provide for substantial expansion of ecological research.

Other Environmental Activities

The meaning of the term "environment" is still subject to widely varying definitions. This first special analysis of Federal funding for environmental activities has been limited to selected areas. Among the areas of federally funded activity important to environmental understanding and environmental quality *not* included in this analysis are:

- Environmental education;
- Preventing or correcting environmental degradation resulting from public works or natural resource exploitation;
- Management of public lands;
- Population control and population distribution;
- Programs that are justified and conducted for some other primary purpose (e.g., R. & D. on improved methods for producing energy and undergrounding high-voltage electric transmission lines) but which may have significant environmental quality or natural resource conservation benefits; and
- Federal activities conducted outside the United States, including scientific activities overseas financed with special foreign currency.

Current Panels.

1. PSAC Panel on Chemicals and Health

2. Membership

Dr. John W. Tukey (Chairman)
Dr. John D. Baldeschwieler
Dr. John A. Baldwin
Dr. Nyle C. Brady
Dr. John J. Burns
Dr. Theodore L. Cairns
Dr. Alfred Gilman
Dr. Richard Hall
Dr. Roland N. McKean
Dr. Norton Nelson
Dr. Oscar N. Ruebhausen
Dr. Laurence H. Tribe
Dr. James Whittenberger
Dr. Bryan Williams

Advisers

Dr. Herbert E. Carter
Dr. J. Clarence Davies
Mr. Charles Elkins
Dr. Philip Handler
Dr. Colin M. MacLeod
Dr. Jesse Steinfeld
Dr. Charles Edwards

3. Terms of Reference

A very large number of chemical substances are purposefully introduced into society which impinge directly on man. Therapeutic drugs are perhaps the most obvious. In addition, however, there are more than 60,000 registered pesticide formulations on the Federal rolls and there is an uncertain but very long list of food additives which are used to improve certain qualities of food substances.

Large segments of the population are subjected to these chemicals for very long periods of time. In spite of this level of exposure, the understanding in any depth of the physiological hazards and toxicity of many of these chemicals is generally not available. The technology of development of these chemicals has not been matched by corresponding biological understanding of them. Of particular concern are potentially deleterious effects on health resulting from long-term exposures to low levels of these chemicals, alone or in combination.

Occasional incidents call this matter to public attention. Recent examples have included cyclamates, pesticide residues, and oral contraceptives. Thus far, each case has been treated individually--usually in a manner reactive to a variety of pressures of the moment and rarely if ever reflective of a sufficient background of objective information. At the same time, the number of chemical substances in use continues to

increase as do the corresponding chances of human exposure. It appears desirable that the whole situation be addressed at once with a view towards ascertaining whether the public health and well-being are adequately safeguarded, and if not, what actions should be set in motion.

A PSAC panel is being established to explore this situation. It should consider such questions as:

1. How much assurance of safety should we require?
2. What kinds and levels of research must be performed to reach a desired level of understanding?
3. What resources will be required? What will be required in terms of organizational and financial arrangements, including research facilities?
4. How are the results of research best put to use in the decision-making process? How should the research and research results be related to the regulatory process? What organizational and institutional arrangements are needed for social decision-making and education at the various levels of decision-making within the Federal Government and in the community-at-large?

NOTE: There are many other substances that result from man's activities that may affect man directly, such as asbestos fibers, air pollutants, etc. To the extent reasonable, the study may consider these, too, although it is recognized that the actions to control these substances may be quite different from those required to control the previously described substances.

4. Status of Work - Accomplishments

The Panel met for the first time on December 15, 1970, and has held a total of two (2) meetings. During the course of these two meetings, the Panel has received briefings on the following subjects:

1) Economics of the development of drugs (including oral contraceptives).

2) Economics of the development of pesticides.

3) The industry view of how Government imposed obligations and regulations perturb the economic outlook for these substances.

4) Laboratory and clinical research and its relation to the understanding of the safety of chemical substances in man's surroundings - (The Panel was briefed on the disparity between the current level of understanding of biological processes and the type of toxicological testing generally applied to chemical substances in the past).

5) A review of current Government programs of basic and directed research in this area.

6) A review of Government programs aimed at development of new products (such as oral contraceptives).

7) A preview of forthcoming legislative initiatives.

8) A review of new Government laboratories.

6. Other Remarks

Enclosure - "Background Paper on Toxicological Research and the Development of Chemical Agents"

INACTIVE PANELS

1. Name of Panel

PSAC Panel on Herbicides

2. Membership

Dr. Colin M. MacLeod (Chairman)
Dr. John D. Baldeschwieler
Dr. Nyle C. Brady
Dr. Emmanuel Farber
Dr. Paul Kotin
Dr. Brian MacMahon
Dr. Norton Nelson
Dr. L. Dale Newsom
Dr. John W. Tukey
Dr. James G. Wilson
Dr. David Pimentel, Consultant

3. Terms of Reference

The Panel on Herbicides was established to examine the technical aspects of current defoliation agents, procedures and programs. The panel examined the available data on health-related effects of the herbicides 2, 4, 5-T and similar compounds currently in use for defoliation (2, 4-D, picloram, orange, white and blue mixtures) in order to advise the Science Adviser:

..... Whether the steps taken to control the use of 2, 4, 5-T in this country and overseas are adequate.

..... Whether restrictions of additional defoliants are called for at the present time.

..... Whether the herbicidal research programs in being or proposed by the several departments of government are sufficient to provide a sound basis for future judgments concerning constraints on the use of herbicides needed to protect the health of the public.

(Inactive Panels (Cont'd.)

4. Status of Work

Two reports were written, Report on 2, 4, 5-T and Report on 2, 4-D. Each of these reports has been reviewed by the various interested Government agencies. It is expected that the report on 2, 4, 5-T will be published shortly. It is hoped that the report on 2, 4-D will follow.

5. Accomplishments

As a result of the examination of these two herbicides, the following Government actions have ensued:

a) Additional research on the teratogenesis effects of the herbicide, 2, 4, 5-T was performed.

b) Policies governing both the domestic and military use of phenoxy herbicides were reviewed and revised. Restrictions were imposed in some cases.

c) New proposed legislation for pesticides has reflected one of the Panel's recommendations (temporary restriction on the use of a pesticide on the occasion of new and unexpected research finding, which implicate the chemical as a human health hazard).

1. Name of Panel

OST Task Force on Hazardous Trace Substances

2. Membership

Dr. Norton Nelson (Chairman)
Dr. Roy Albert
Dr. Samuel Epstein
Dr. Michael Fleischer
Dr. Paul Hammond
Dr. Harold Hodge
Dr. Adel Sarofim
Dr. Thomas Winter, CEQ
Dr. William Drury

3. Terms of Reference

A number of groups within and without the Government have been concerned with aspects of substances which exist in the environment in trace quantities and which may be injurious to man's health or to other environmental organisms.

A group of advisers were asked to assess the scientific information available in this area and to consider needs of the Federal Government.

The Task Force will review the work in progress of other groups (such as the National Academy of Sciences) and the (Council on Environmental Quality). In addition, it will design and test an instrument for providing scientific information on biological effects, environmental effects, natural background distribution, and man-imposed perturbations on the distribution of hazardous substances. The Task Force will approach this by working through at least three case studies -- cadmium, arsenic, and polychlorinated biphenyls.

4. Status of Work

The first meeting was held on December 21, 1970. A second meeting occurred on February 5, 1971. Work has proceeded part way on drafts on all three studies.

5. Accomplishments

Reports in preparation, expected to be completed in two to three months.

L Laster
11 February 1971

1. Panel on Biological and Medical Science

2. Dr. Ivan L. Bennett, Jr., Chairman
Dr. William R. Adey
Dr. Peter S. Bing
Dr. Eugene Braunwald
Dr. Detlev W. Bronk
Dr. James D. Ebert
Dr. Clifford Grobstein
Dr. Philip Handler
Dr. Colin M. MacLeod
Dr. George E. Pake
Dr. William R. Pritchard
Dr. Lloyd H. Smith
Dr. Albert J. Stunkard
Dr. Lewis Thomas
Dr. James V. Warren
Dr. Harland G. Wood
Dr. James B. Wyngaarden
Dr. Leonard Laster, OST

3. The panel was charged with studying biomedical research and its relation to education and delivery of health care.

4. The report of the panel entitled "Scientific and Educational Basis for Improving Health" is complete and awaits Dr. David's decision regarding its transmission to the President.

5. Completion of the report entitled "Scientific and Educational Basis for Improving Health."

6. With the completion of the panel's report, the new chairman must now make a decision regarding more intensive and analytical studies of some of the issues raised in the report. When that decision has been made, the panel may well be reconstituted for the new effort.

1. Name of Panel

OST Panel on Technology Forecasting and Environmental Health

2. Membership

Dr. Vinton Bacon
Dr. James R. Bright
Dr. Harrison Brown
Dr. Terry Davies, CEQ
Dr. Richard Dooley
Dr. Sheldon Friedlander
Dr. Harold Gershinowitz
Dr. Hans H. Landsberg
Dr. Norton Nelson
Dr. Roger Noll
Dr. William W. Payne, NIEHS

3. Terms of Reference

It has been apparent to all who have considered the proper direction for biological research aimed at uncovering the health hazards of environmental agents that some type of rational scheme would be highly desirable in order to rank in priority fashion those substances which deserved attention. It is clear that while some information necessary in this direction is available, an organized environmental forecasting program has not been developed. There is, indeed, an urgent need for a forecasting program capable of timely and effective warning of technology-induced perturbations of any environmental factor which may have health implications.

A Panel was established to examine the potential of using the tools of technology forecasting to predict the advent and shape of forthcoming technologies. A major aim would be to use this information to herald new materials, new or augmented uses of materials, and new distributions of materials. This information in turn could be used direct needed biological and toxicological research on these materials.

4. Status of Work

Two meetings were held February 7 - 8, 1971. Background papers were prepared in behalf of a report to the Director of OST - anticipated in approximately one month.

5. Accomplishments

The consensus of this group has been that a single, major forecasting effort should be established ("National Environmental Forecasting Institute"). The functions of this entity would be primarily analytic. It would not primarily be responsible for collecting data since that function itself tends to become preoccupying. Gaps in available data should be recognized and the proposed forecasting entity would be expected to stimulate the collection of data from time to time. A Material Forecasting Institute would serve a variety of user groups within the Federal Government (and, perhaps, without) and would be sensitive to their needs. In the case of health, user groups might well include the National Institute of Environmental Health Sciences (of NIH), the FDA, and the Environmental Protection Agency. These several user groups might well perform some additional forecasting efforts, aimed at specialized end-points, and would also be expected to use the forecasts for their own assessment exercises.

1. Name of Panel

PSAC Panel on the Environment

2. Membership

Herbert A. Simon (Chairman)
William C. Ackermann
John D. Baldeschwieler
Ivan L. Bennett, Jr.
Nyle C. Brady
William Drury
Leonard Dworsky
Michael Ference, Jr.
Murray Gell-Mann
John C. Geyer
Edward D. Goldberg
Milton Harris
A. Richard Kassander, Jr.
William W. Kellogg
Edwin S. Mills
Louis H. Roddis, Jr.
Gerald F. Tape
Lewis Thomas
John W. Tukey
Thomas Winter (CEQ Observer)

Contemplated changes - Ivan Bennett, Michael Ference, and Lewis Thomas have not participated in Panel meetings and are proposed for removal from the membership list. A physician should be added to the Panel.

3. Terms of Reference

Established in 1968 with a broad mandate to maintain an overview of all environmental issues, the Panel has increasingly concentrated on pollution problems, maintaining an overview of issues and submitting recommendations to the Science Adviser on specific problems it identified. No changes are currently planned, except that issues require more "in-depth" work than before.

4. Status of Work

Review of organizational proposals, and needs for legislative and budgetary actions. The Panel reviewed the issue of phosphates in detergents and provided a memo to the Science Adviser on this subject. The Panel has continuously pushed on the subject of pesticides, and has provided advice to OST staff since incorporated in the Administration's proposed legislation.

The Panel has expressed its views on the non-conventional vehicle program (which it originally suggested) and the lead tax. The Panel asked OST to establish a task force to consider appropriate actions in relation to heavy metals. Dr. Burger now has such a task force.

Proposed activities include consideration of:

Agricultural pest control

Water pollution control strategy.

Impact on industry of pollution control regulations and possible measures for alleviation.

5. Accomplishments

Produced a proposed draft for an environmental report that was used to some extent by CEQ.

Provided agenda suggestions and backup for the Cabinet level Environmental Quality Council.

As noted above, stimulated the non-conventional vehicle program.

6. Other Remarks

The Panel provides a useful overview of where we stand, and whether we are doing the right things in relation to environmental programs. Because of its diverse makeup, it tends to provide a balanced view that is useful in budgetary and program discussions.

JLBuckley, OST staff

FOR RELEASE AT 12 NOON, EST February 8, 1972

Office of the White House Press Secretary

THE WHITE HOUSE

PRESIDENT'S 1972 ENVIRONMENTAL MESSAGE

FACT SHEET

Major Initiatives Still Awaiting Final Legislative Action:

(1.) Regulation of toxic substances;
(2.) Comprehensive improvement in pesticide control authority;
(3.) Noise control;
(4.) Preservation of historic buildings [2 bills];
(5.) Power plant siting;
(6.) Regulation of environmental effects of strip and underground mining;
(7.) Ocean dumping regulation;
(8.) More effective control of water pollution through a greatly expanded waste treatment grant program and strengthened standard-setting and enforcement authorities[4 bills];
(9.) A National Land Use Policy Act;
(10.) Substantial expansion of the wilderness system;
(11.) Expanded international cooperation to deal with oil pollution;
(12.) Prevention of oil spills through navigation aids;
(13.) Amendments to Land and Water Conservation Fund [2 bills].

1972 ACTION PROGRAM

TIGHTENING POLLUTION CONTROL

Disposal of Toxic Wastes

A Toxic Wastes Disposal Control Act to ensure that the increasing use of land and underground disposal of toxic wastes does not pose a hazard to health. Under the proposed bill, which would amend the Federal Water Pollution Control Act, States would regulate disposal of toxic wastes on and under the land, including "deep well" disposal, pursuant to guidelines established by the Environmental Protection Agency, with a provision for Federal enforcement action if a State fails to establish its own program.

Sediment Control

A Sediment Control Act would call for States to establish regulatory programs to control sediment affecting water quality from earth-moving activities such as building and road construction.

Sulfur Oxides Emission Charge

A charge on sulfur emitted into the atmosphere from combustion, refining, smelting and other processes. The charge is designed to supplement regulatory provisions of the Clean Air Act in controlling sulfur oxides emissions, one of the most harmful of air pollutants. The charge would begin in 1976 and apply in all regions where the air quality did not meet national standards for sulfur oxides during 1975.

more

(OVER)

A charge of 15¢ per pound of sulfur would be levied in areas failing to meet the primary (health protection) ambient air quality standards established under the Clean Air Act, with a 10¢ per pound charge levied in areas that meet the primary standard but fail to meet the more stringent secondary (damage to property and vegetation) sulfur oxide standards. No charge would be levied in areas meeting both primary and secondary standards.

Clean Energy Generation and Conservation

1. Eighty-eight million dollars in 1973 budget for additional development of a broad spectrum of new technologies for producing clean energy.

2. Issuance by the Department of Housing and Urban Development of revised standards for Federally insured apartments and other multi-family structures requiring insulation that will reduce up to 40% of heat losses from such structures, with fuel savings exceeding the additional insulation costs within a 5-year period.

3. Council on Environmental Quality and Office of Science and Technology to conduct survey with other Federal agencies to determine additional actions they might take to conserve energy.

Recycling

The Treasury Department is clarifying the availability of tax exempt treatment industrial revenue bond financing for the construction of recycling facilities built by private concerns to recycle their own wastes.

MAKING TECHNOLOGY AN ENVIRONMENTAL ALLY

Integrated Pest Management

1. Research, development, and demonstration programs on integrated pest management, a systematic approach to pest control that involves judicious use of selective chemical pesticides in conjunction with maximum use of natural pest control techniques, such as predators, sterilization and pest diseases.

2. Expansion of current research and development activities in integrated pest management through a new, large-scale program involving the U. S. Department of Agriculture, the National Science Foundation, and the Environmental Protection Agency, and conducted by leading universities.

3. Expanded U. S. Department of Agriculture program of field testing of promising new methods of pest detection and control.

4. Federal encouragement for development of university training programs and State certification of crop protection specialists needed to ensure widespread implementation of integrated pest control techniques.

5. Expansion of USDA field scout program to cover nearly 4 million acres of crops this growing season. This program permits elimination of many unnecessary pesticide applications by using the scouts to determine when such applications actually are needed.

6. Development of standards by the Departments of Labor and Health, Education, and Welfare under the Occupational Safety and Health Act to protect farm workers from pesticide poisoning.

Increased Research on Pollution

1. Request in 1973 budget for an increase of $23 million in research to reduce aircraft noise, and new funds to reduce street traffic noise.

2. Request in 1973 budget for an additional $12 million for research on health effects of pollution, regional air pollution modeling, and improved pollution measurement and instrumentation.

IMPROVING LAND USE

Strengthen Land Use Policy Bill

Amendments to the pending Administration Land Use Policy bill would require States to control siting of major transportation facilities and impose sanctions on States failing to implement adequate land use programs.

States not implementing adequate programs by 1975 would be subject to incremental 7 percent annual reductions in Federal funds allocated to them under the airport and highway assistance programs and the Land and Water Conservation Fund. Funds so withheld would be allocated among States with acceptable programs.

Controlling Development of Wetlands

Amendments to the Internal Revenue Code to limit in coastal wetlands certain Federal tax benefits for new development, thereby discouraging unnecessary development in these environmentally critical areas.

PROTECTING OUR NATURAL HERITAGE

Predator Control

1. Executive Order barring the use of poisons for predator control on public lands, except in emergencies.

2. Proposed legislation to shift the emphasis of the current direct Federal predator control program to one of research and technical and financial assistance to the States to help them control predators with means other than poisons.

Endangered Species

New legislation to permit earlier identification and protection of endangered species, so that action can be taken before a species is so depleted that regeneration is difficult or impossible. The new legislation would also for the first time make the taking of endangered species a Federal offense.

Migratory Species

Secretary of State authorized in conjunction with the Department of the Interior to seek agreement with Mexico to add 33 families of birds -- including eagles, hawks, owls, and many wading birds -- to the protected list established by the two countries.

Legacy of Parks

1. Legislation submitted to the Congress to create a Big Cypress Fresh Water Reserve, empowering the Federal Government to acquire requisite legal interest in 547,000 acres of private lands in the Big Cypress Swamp in Florida to protect the unique Everglades National Park.

2. New legislation to establish in the San Francisco Bay region a Golden Gate National Recreation Area, combining a number of existing parks, undeveloped military reservations, and private lands. The area would encompass 24,000 acres of beaches, rugged coastline, and readily accessible parklands; the area would extend approximately 30 miles along the Pacific Coast north and south of the Golden Gate Bridge in San Francisco.

3. As a result of activities of the Property Review Board, established by the President in 1970, 20 additional parcels of public lands are being made available for park and recreation use. The 20 properties announced today for inclusion in the legacy of parks program include all or portions of the Alvord Estate in Phoenix, Arizona; Camp Elliott in San Diego, California; San Luis Obispo, California; Outer Marker Annex, Palm Beach, Florida; Gap Filler Annex, Winter Garden, Florida; Boca Grande Light Station, Gasparilla Island, Florida; Panama City Jetties, St. Andrews Bay, Florida; Federal Correctional Institute, Tallahassee, Florida; Crooked River Light, Carabelle, Florida; Dinner Key Air Station, Miami, Florida; Veterans Administration Hospital, Topeka, Kansas; Veterans Administration Center Reservation, Leavenworth, Kansas; Veterans Administration Hospital, Bedford, Massachusetts; Federal Correctional Institution, Milan, Michigan; Chillicothe Station, Ross County, Ohio; Former Naval Air Station, Tillamook County, Oregon; Roosevelt Roads, Puerto Rico; Fort Hood, Killeen, Texas; Veterans Administration Hospital, Waco, Texas; Fort Douglas, Salt Lake City, Utah.

These 20 parcels constitute 2,853 acres with an estimated fair market value of $4.6 million. Combined with 63 parcels already made available during the past year, this program will provide 14,585 acres of parkland, in 31 States and Puerto Rico with an estimated fair market value of more than $56 million.

Wilderness Areas

1. Proposal of 18 new wilderness areas that would add 1.3 million acres to the wilderness system. These 18 areas are in addition to 18 areas already proposed by this Administration, and pending before the Congress.

The 18 proposed new areas and their acreages are as follows:

- Weminuche, National Forest, Colorado, 346,833 acres
- Eagles Nest, National Forest, Colorado, 87,755 acres
- Emigrant, National Forest, California, 105,376 acres
- Aqua Tibia, National Forest, California, 11,920 acres
- Mission Mountains, National Forest, Montana, 73,207 acres
- Glacier, National Forest, Wyoming, 182,510 acres
- Blue Range, National Forest, Arizona, New Mexico, 177,239 acres
- Aldo Leopold, National Forest, New Mexico, 188,095 acres
- St. Marks, National Wildlife Refuge, Florida, 17,746 acres
- Wolf Island, National Wildlife Refuge, Georgia, 4,168 acres

- Moosehorn, National Wildlife Refuge, Maine, 4,598 acres
- San Juan Islands, National Wildlife Refuge, Washington, 355 acres
- Cape Romain, National Wildlife Refuge, South Carolina, 28,000 acres
- Bosque del Apache, National Wildlife Refuge, New Mexico, 32,500 acres
- Bryce Canyon, National Park, Utah, 16,303 acres
- Black Canyon, National Monument, Colorado, 8,780 acres
- Colorado, National Monument, Colorado, 7,700 acres
- Chiricahua, National Monument, Arizona, 6,925 acres

TOTAL 1,300,510 acres

2. The Secretaries of Agriculture and the Interior will accelerate identification of areas in the Eastern United States having wilderness potential, in order to increase the opportunities for wilderness experience within the regions where most of our people live.

Off-Road Vehicles

1. Executive Order directing Secretaries of Agriculture, Interior, Army and the Board of Directors of the Tennessee Valley Authority to issue regulations for controlling the use of these vehicles on Federal lands. Regulations to designate specific areas where their use is or is not permitted, prescribe operating conditions that will be necessary to minimize damage to the natural resources of the Federal lands, and ensure compatibility with other recreational uses, taking into account noise and other factors.

EXPANDING INTERNATIONAL COOPERATION

United Nations Fund for the Environment

Proposal for a United Nations Fund for the Environment to help stimulate international cooperation on environmental problems, which would bring to bear new resources on worldwide problems through activities such as monitoring and cleanup of the oceans and atmosphere. Recommendation that the fund establish an initial funding goal of $100 million for the first five years, with the United States providing its fair share on a matching basis.

Control of Marine Pollution

The United States is preparing for a 1973 Intergovernmental Maritime Consultative Organization (IMCO) Conference to draft a convention barring intentional discharges to the sea of oil and hazardous substances from ships. In conjunction with the Law of the Sea Conference scheduled for 1973, the United States is examining measures to control the effects of developing underseas resources. In the preparatory work for the 1972 U. N. Conference on the Human Environment, progress has been made on an agreement to regulate the dumping of shore generated wastes, and further work in this area has been scheduled by IMCO.

PROTECTING CHILDREN FROM LEAD-BASED PAINT

In addition to other Federal activities, Department of Health, Education, and Welfare will use grants and technical assistance to initiate programs in more than 50 communities to test children in high-risk areas for lead concentrations.

more

INVOLVING OUR YOUTH

1. The President's Environmental Merit Awards Program, initiated last October by the Environmental Protection Agency in cooperation with the U. S. Office of Education, awards national recognition to successful student projects which lead to environmental understanding or improvement. More than 2,000 high schools throughout the entire 50 States are already participating in the program.

2. The Department of Agriculture's expanded field scout demonstration program, designed to permit more effective pest control with substantially less pesticides, will employ over 2,000 high school and college students.

3. The Environmental Protection Agency recently initiated in its Seattle Regional Office a pilot program to use young people in its monitoring and other activities, with the program to be expanded if it proves successful.

4. ACTION volunteers and youth employed through the Neighborhood Youth Corps, Job Corps and college work-study programs will work with city governments to help alleviate lead-paint hazards.

# # # #

FOR RELEASE AT 12:00 NOON (EST) February 8, 1972

Office of the White House Press Secretary

THE WHITE HOUSE

EXECUTIVE ORDER

ENVIRONMENTAL SAFEGUARDS ON ACTIVITIES
FOR ANIMAL DAMAGE CONTROL ON FEDERAL LANDS

By virtue of the authority vested in me as President of the United States and in furtherance of the purposes and policies of the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.) and the Endangered Species Conservation Act of 1969 (16 U.S.C. 668aa), it is ordered as follows:

Section 1. Policy. It is the policy of the Federal Government to (1) restrict the use on Federal lands of chemical toxicants for the purpose of killing predatory mammals or birds; (2) restrict the use on such lands of chemical toxicants which cause any secondary poisoning effects for the purpose of killing other mammals, birds, or reptiles; and (3) restrict the use of both such types of toxicants in any Federal programs of mammal or bird damage control that may be authorized by law. All such mammal or bird damage control programs shall be conducted in a manner which contributes to the maintenance of environmental quality, and to the conservation and protection, to the greatest degree possible, of the Nation's wildlife resources, including predatory animals.

Sec. 2. Definitions. As used in this order the term:

(a) "Federal lands" means all real property owned by or leased to the Federal Government, excluding (1) lands administered by the Secretary of the Interior pursuant to his trust responsibilities for Indian affairs, and (2) real property located in metropolitan areas.

(b) "Agencies" means the departments, agencies, and establishments of the executive branch of the Federal Government.

(c) "Chemical toxicant" means any chemical substance which, when ingested, inhaled, or absorbed, or when applied to or injected into the body, in relatively small amounts, by its chemical action may cause significant bodily malfunction, injury, illness, or death, to animals or man.

(d) "Predatory mammal or bird" means any mammal or bird which habitually preys upon other animals or birds.

(e) "Secondary poisoning effect" means the result attributable to a chemical toxicant which, after being ingested, inhaled, or absorbed, or when applied to or injected into, a mammal, bird, or reptile, is retained in its tissue, or otherwise retained in such a manner and quantity that the tissue itself or retaining part if thereafter injested by man, mammal, bird, or reptile, produces the effects set forth in paragraph (c) of this section.

more

(OVER)

(f) "Field use" means use on lands not in, or immediately adjacent to, occupied buildings.

Sec. 3. Restrictions on Use of Chemical Toxicants.

(a) Heads of agencies shall take such action as is necessary to prevent on any Federal lands under their jurisdiction, or in any Federal program of mammal or bird damage control under their jurisdiction:

(1) the field use of any chemical toxicant for the purpose of killing a predatory mammal or bird; or

(2) the field use of any chemical toxicant which causes any secondary poisoning effect for the purpose of killing mammals, birds, or reptiles.

(b) Notwithstanding the provisions of subsection (a) of this section, the head of any agency may authorize the emergency use on Federal lands under his jurisdiction of a chemical toxicant for the purpose of killing predatory mammals or birds, or of a chemical toxicant which causes a secondary poisoning effect for the purpose of killing other mammals, birds, or reptiles, but only if in each specific case he makes a written finding, following consultation with the Secretaries of the Interior, Agriculture, and Health, Education, and Welfare, and the Administrator of the Environmental Protection Agency, that any emergency exists that cannot be dealt with by means which do not involve use of chemical toxicants, and that such use is essential:

(1) to the protection of the health or safety of human life;

(2) to the preservation of one or more wildlife species threatened with extinction, or likely within the foreseeable future to become so threatened; or

(3) to the prevention of substantial irretrievable damage to nationally significant natural resources.

Sec. 4. Rules for Implementation of Order. Heads of agencies shall issue such rules or regulations as may be necessary and appropriate to carry out the provisions and policy of this order.

RICHARD NIXON

THE WHITE HOUSE,

February 8, 1972.

#####

EMBARGOED FOR RELEASE UNTIL
12:00 NOON, TUESDAY
FEBRUARY 8, 1972

FEBRUARY 8, 1972

OFFICE OF THE WHITE HOUSE PRESS SECRETARY

THE WHITE HOUSE

PRESS CONFERENCE OF
SECRETARY OF INTERIOR,
ROGERS C. B. MORTON
RUSSELL E. TRAIN, CHAIRMAN,
COUNCIL ON ENVIRONMENTAL QUALITY
AND
WILLIAM D. RUCKELSHAUS, ADMINISTRATOR,
ENVIRONMENTAL PROTECTION AGENCY

THE BRIEFING ROOM

AT 11:05 A.M. EST

MR. BALL: You have the message from the President to Congress in which he outlines a comprehensive plan for the environment. This is the third message the President has sent to the Congress on this subject. The other two messages were in 1970 and 1971.

There are a number of items out -- a message, a fact sheet, two Executive Orders on implementing programs on Federal lands. a transmittal letter covering additions to the National Wilderness Preservation System, and remarks by the President. I believe you have them all. These, along with the contents of the briefing, are embargoed until noon.

Here to brief you today are Secretary of the Interior Rogers Morton; Russell Train, Chairman of the Council on Environmental Quality; and William Ruckelshaus, Administrator of the Environmental Protection Agency. Mr. Train.

MR. TRAIN: The President sent to the Congress today a wide-ranging program for environmental protection containing a number of major new initiatives in this area, and also calling upon the Congress to act now on the 18 proposals which he submitted just a year ago today and which still await action.

Today's environmental message covers three main areas: pollution control, land use control, and protection of our natural heritage of wildlife and open space.

The major new proposals submitted by the President today include these, along with others: Legislation to regulate the land disposal of toxic wastes. This includes controls over deep well injection of waste, as well as putting waste on the land itself; attacks on sulphur oxide emissions to protect air quality; legislation to control sediments from construction activities. This is the first time that any realistic, practical proposal has been made to deal with off-point sources of pollution.

Amendments to strengthen the National Land Use Policy Act which the President submitted to Congress last year. These amendments will require the States to specifically deal, as a State, with the siting of airports and highways; and secondly, those amendments will provide for reductions in Federal funds -- airport funds, highway funds and land and water funds -- for those States that do not develop approved land-use programs.

MORE (OVER)

Tax reforms to protect the Nation's wetlands, and finally, a ban on the use of poisons for predator control on Federal lands. There are a number of other proposals in this very extensive message, such as major new funding for clean energy research, the establishment of the new Golden Gate Recreation Area in the San Francisco Bay Region, legislation to strengthen the protection of endangered species, and proposals for the establishment of 18 new wilderness areas, the regulation of the use of off-road vehicles on the public lands of the United States, a proposal for the establishment of a $100 million United Nations fund for international environmental cooperation.

These are some of the major proposals in a very extensive message. This is the third annual environmental message that the President has sent to the Congress, part of an overall comprehensive strategy that has emphasized institutional reform, the organization of the Environmental Protection Agency headed by Bill Ruckelshaus, the establishment of the Senate Oceanic and Atmospheric Administration, the proposed new Department of Natural Resources, and the establishment of our council. It includes new statutory authority in this entire field.

As you know, we already have strong, new air quality legislation now on the books. It includes vigorous enforcement and administration through EPA. It involves a basic reform throughout Government in the decision-making process as it affects the environment.

Gentlemen, I think that covers what I want to say. The President does refer very strongly to the extensive program already before Congress. I invite your attention to that portion of the message, because we will be pressing in the weeks ahead for Congressional action on these proposals.

Q Mr. Train, I have a question for Secretary Morton with regard to predator control. One of the sensitive interfaces between Government and citizens is the use of Federal lands for grazing livestock. I wonder if this predator control prohibition will apply to the Bureau of Land Management land now leased for sheep and cattle production, and what you are proposing for the lessees to do if their small animals are suffering from predators.

SECRETARY MORTON: The lands are not leased, but the grazing permits are issued to permit a certain number of animal units to use the land. The proposed Executive Order and legislation, of course, applies to all public lands. Therefore, it would apply to the BLM lands.

The phase-out of the use of poisons is accompanied by a grant-in-aid program to the States so that predator control can continue, but without the use of poisons. The Federal emphasis will be on research to try to develop methods by which the ecology of agriculture and the ecology of the plains can live together.

I think there will have to be an adjustment period, undoubtedly, but the facts are that even with the use of poisons that has been going on now for a great many years under the Act that we have been operating under, it has not really

substantially reduced the population of coyotes, for example, and perhaps has done more harm than good in that the coyote population has spread into areas that before they did not range in.

We will observe this during the transition period and work with the hope, and hopefully come up with new biological methods by which these two ecologies can live together without any substantial damage to agriculture.

Q Then the prohibition on poisons is immediate?

SECRETARY MORTON: Yes, on Federal land.

MR. TRAIN: We have a report, which is available today, on predator control which was prepared for the Department of the Interior and Council on Environmental Quality, and provided the basic data upon which this proposal is now going forward.

SECRETARY MORTON: It is called the Cain Report. We have copies in the Public Information Office at Interior, and the Council also has some.

Q Mr. Train, this is just a small point, but I notice in the Executive Order on off-road vehicles it mentions that the Secretary of the Interior shall consult with the Atomic Energy Commission. Can you explain that? Why the Atomic Energy Commission?

MR. TRAIN: Frankly, I have not a clue.

SECRETARY MORTON: I think it is because of a good deal of public land that they operate in the Hanford Reserve, but I would have to check that.

MR. TRAIN: It is there for a reason. (Laughter)

Q Mr. Train, you recently proposed, without success, an Executive Order restricting clear cutting of timber in national forests. I wonder, did you urge the President to deal with that problem in this message, or do you now think there is no problem?

MR. TRAIN: This was one of a large number of matters under consideration in the development of this message. The proposed Executive Order on clear cutting has been referred now to the President's committee headed by former Secretary of the Interior Fred Seaton on timber and the environment. That committee, I think you know, came into being subsequent to our undertaking the study on clear cutting, and clear cutting is definitely a part of their overall responsibilities for making recommendations with respect to timber management policy. They are undertaking that and will be reporting later this year.

Q I have a question for Secretary Morton on the predator control program. You said the prohibition would be immediate on the use of poisons, but that a period of adjustment would have to follow?

SECRETARY MORTON: By that I mean an adjustment of agriculture living with a different kind of predator control in those areas where it has been practiced rather heavily.

The only predator control that will take place under the new program will be carried out by State hunters and trappers. This will be a monitored program, and obviously the sheep people, particularly, are going to have to make some changes in their husbanding practices and take some preventive measures that would come up in the short term.

I believe in the long term the sheep people and other livestock people who are affected by predators will be far better off than they are today, and I think the whole poisoning issue will be laid to rest, and then we can do the biological research to blend with these ecologies.

Q The order provides for exceptions in cases of emergency. How will those applications be made; by a Federal permit?

SECRETARY MORTON: Yes. That will have to be carried out by Federal agencies, primarily the Department of the Interior and Agriculture in the emergency situations that are spelled out in the exceptions.

Q There is nothing immediate to replace the poisons; no other type of control?

SECRETARY MORTON: No, no other poisons.

No, that is not exactly right, because the whole program has had hunting and trapping, which has been a part of it.

Q That would continue?

SECRETARY MORTON: Some of that would continue under State supervision. We are extremely disturbed over the long pull of putting these poisons out over the public lands and having the residual effect that it has. We are moving away from that sharply.

Q Can any one of the three of you give us an estimate of when the gasoline fumes are going to be cut down markedly, and also the aircraft noise?

MR. TRAIN: They are both going down now, but let Bill get at that directly.

MR. RUCKELSHAUS: The three major pollutants coming from the automobile are hydrocarbons, carbon monoxide and nitrogen oxide. As you know, in the Clean Air Act amendments of '70, there is established a 90 percent reduction of carbon monoxide and hydrocarbons by 1975, and a 90 pereent reduction of nitrogen oxide by 1976. There are interim standards up until that time for graduated reductions of those pollutants from the automobile up until 1975 and 1976.

All of the information we now have indicates that there is a downward trend in the curve of pollutants from automobiles because of the emission devices that have been placed on them, starting in 1968. We expect that this trend will continue on the basis of all projections, until 1990, at which time, if the projections as to the number of automobiles and if nothing further is done, it will go up again. But that is a projection based on fact that may not be applicable in 1990.

As far as noise in the aircraft is concerned, that is under the jurisdiction now of the Department of Transportation and the FAA. We have a bill pending before Congress that was introduced last year on noise abatement that addresses itself to aircraft noise. This would continue, with consultation with the Environmental Protection Agency, the present noise reduction program that the Department of Transportation has.

MR. TRAIN: The President has asked for an additional $23 million in 1973 over and above present funding for aircraft noise suppression research. That is in the message.

Q Gentlemen, in light of the recent Ritchie decision regarding the National Environmental Policy Act and the responsibility of Federal agencies under it, has there been any consideration of possibly amending NEPA to better define what is required in environmental impact statements?

MR. TRAIN: There has been some discussion of this, and we are presently engaged in discussions with some four different committees on the Hill on this overall subject.

Q Can you be more specific as to what possible amendments have been considered?

MR. TRAIN: I do not think anyone is thinking at this time of any very extensive amendments to the National Environmental Policy Act.

MR. RUCKELSHAUS: There was a suggestion of an exclusion from the Act for regulatory activities relating to the environment. This is only at this time in the negotiation stage with Congress. There is no absolutely firm Administration position.

The question is: To what extent should regulatory activities be exempted? In the Kalur case here in the District of Columbia, the Corps of Engineers had to issue an environmental impact statement on each individual discharge permit. That would be some 30,000 permits issued. We seriously question whether this is a proper allocation of manpower at the Federal level in the environmental field, to do what we think is essentially a redundant action in looking at a discharge permit and its impact on the environment when you have public hearings, and whether you should at that time issue environmental impact statements as to those particular permits. This is the area that gives us the most concern in the EPA.

Q Mr. Ruckelshaus, I believe that your agency was due to put out emission standards for aircraft last October.

MR. RUCKELSHAUS: September. (Laughter)

Q They have not appeared yet. I wonder if you could give us some clue as to when they will appear, and what aircraft, what commercial aircraft users and manufacturers might have to do to their planes to make them qualify.

MR. RUCKELSHAUS: I think it is a little difficult at this time to answer the second part of your question.

We originally had some proposals for reduction in aircraft emissions. We were given nine months in which to make a study and relate the aircraft emissions to the total problem of air pollution. The difficulty we had was that the study itself did not turn out to be as complete as we would have liked in relating the aircraft emissions to the total problem of air pollution.

We have had to, in effect, re-look at our findings from the original study that we made. We now have almost completed a proposal which will be published for comment from other governmental agencies and the public at large before we come out with a final standard.

So until we can reach a conclusion internally as to what that proposal should be, it would be premature for me to say exactly what impact that will have on aircraft and various engines. We just found that the nine-month period we were given under the statute was not sufficient for us to adopt a standard we really felt was a good one.

THE PRESS: Thank you.

END (AT 11:22 A.M. EST)

FOR RELEASE UPON DELIVERY TO THE SENATE
OR TO THE HOUSE OF REPRESENTATIVES

March 2, 1972

Office of the White House Press Secretary

- -

THE WHITE HOUSE

TO THE CONGRESS OF THE UNITED STATES:

An all-directions reform of our health care system -- so that every citizen will be able to get quality health care at reasonable cost regardless of income and regardless of area of residence -- remains an item of highest priority on my unfinished agenda for America in the 1970s.

In the ultimate sense, the general good health of our people is the foundation of our national strength, as well as being the truest wealth that individuals can possess.

Nothing should impede us from doing whatever is necessary to bring the best possible health care to those who do not now have it -- while improving health care quality for everyone -- at the earliest possible time.

In 1971, I submitted to the Congress my new National Health Strategy which would produce the kind of health care Americans desire and deserve, at costs we all can afford.

Since that time, a great national debate over health care has taken place. And both branches of the Congress have conducted searching examinations of our health needs, receiving and studying testimony from all segments of our society.

The Congress has acted on measures advancing certain parts of my National Health Strategy:

-- The Comprehensive Health Manpower Training Act of 1971 and the Nurse Training Act of 1971, which I signed last November, will spur the greatest effort in our history to expand the supply of health personnel. Additionally and importantly, it will attract them to the areas of health care shortages, helping to close one of the most glaring gaps in our present system.

-- The Congress also passed the National Cancer Act which I proposed last year. This action opens the way for a high-intensity effort to defeat the No. 2 killer and disabler of our time, an effort fueled by an additional $100 million in the last year. A total of $430 million is budgeted for cancer programs in fiscal year 1973, compared to $185 million in fiscal year 1969.

-- The Congress responded to my statement of early 1970 on needed improvements in veterans medical care by authorizing increased funds in 1971 and 1972, increases which have brought the VA hospital-to-patient ratios to an all-time high and have provided many additional specialty and medical services, including increased medical manpower training.

-- The Congress also created a National Health Service Corps of young professionals to serve the many rural areas and inner city neighborhoods which are critically short on health care. By mid-summer, more than 100 communities around the Nation will be benefiting from these teams.

more

(OVER)

These are important steps, without doubt, but we still must lay the bedrock foundations for a new national health care system for all our people.

The need for action is critical for far too many of our citizens.

The time for action is now.

I therefore again urge the Congress to act on the many parts of my health care program which are still pending so that we can end -- at the earliest possible time -- the individual anguishes, the needless neglects and the family financial fears caused by the gaps, inequities and maldistributions of the present system.

The United States now spends more than $75 billion annually on health care -- and for most people, relatively good service results.

Yet, despite this huge annual national outlay, millions of citizens do not have adequate access to health care. Our record in this field does not live up to our national potential.

That sobering fact should summon us to prompt but effective action to reform and reorganize health care practices, while simultaneously resisting the relentless inflation of health care costs.

MORE THAN MONEY IS NEEDED

When the subject of health care improvements is mentioned, as is the case with so many other problems, too many people and too many institutions think first and solely of money -- bills, payments, premiums, coverages, grants, subsidies and appropriations.

But far more than money is involved in our current health care crisis.

More money is important -- but any attempted health care solution based primarily on money is simply not going to do the job.

In health care as in so many other areas, the most expensive remedy is not necessarily the most effective one.

One basic shortcoming of a solution to health care problems which depends entirely on spending more money, can be seen in the Medicare and Medicaid programs. Medicare and Medicaid did deliver needed dollars to the health care problems of the elderly and the poor. But at the same time, little was done to alter the existing supply and distribution of doctors, nurses, hospitals and other health resources. Our health care supply, in short, remained largely the same while massive new demands were loaded onto it.

The predictable result was an acute price inflation, one basic cause of our health economic quandary of the past 11 years.

In this period, national health expenditures rose by 188 percent, from $26 billion in fiscal 1960 to $75 billion in fiscal 1971. But a large part of this enormous increase in the Nation's health expenditure went, not for more and better health care, but merely to meet price inflation.

If we do not lessen this trend, all other reform efforts may be in vain.

That is why my National Health Strategy was designed with built-in incentives to encourage sensible economies -- in the use of health facilities, in direct cost-control procedures, and through more efficient ways to bring health care to people at the community level. That is also why we have given careful attention to medical prices in Phase II of the Economic Stabilization Program.

Several months ago, the Price Commission ruled that increases in physician fees must be kept to within 2-1/2 percent. Rules also were issued to hold down runaway price increases among hospitals, nursing homes and other health care institutions. All of these efforts were directed toward our goal of reducing the previous 7.7 percent annual price increase in total health care costs to half of that level, 3.85 percent this year.

These actions should buy us some time. But they are, at best, a temporary tourniquet on health care price inflation.

We must now direct our energies, attentions and action to the long-range factors affecting the cost, the quality and the availability of medical care.

My overall program, of course, is one that would improve health care for everyone. But it is worthy of special note that these recommendations have a particular importance and a high value for older Americans, whose health care needs usually rise just as their incomes are declining.

WE SHOULD BUILD ON PRESENT STRENGTHS

When we examine the status of health care in America, we always must be careful to recognize its strengths. For most Americans, more care of higher quality has been the result of our rising national investment in health, both governmental and private.

We lead the world in medical science, research and development. We have obliterated some major diseases and drastically reduced the incidence of others. New institutions, new treatments and new drugs abound. There has been a marked and steady gain in the number of people covered by some form of health insurance to 84 percent of those under 65, and coverages have been expanding. Life expectancy has risen by 3.4 percent since 1950 and the maternal death rate has declined 66 percent. Days lost from work in the same period are down 3.5 percent and days lost from school have declined 7.5 percent -- both excellent measures of the general good state of our health.

All of this is progress -- real progress.

It would be folly to raze the structure that produced this progress -- and start from scratch on some entirely new basis -- in order to repair shortcomings and redirect and revitalize the thrust of our health system.

To nationalize health care as some have proposed, and thus federalize medical personnel, institutions and procedures -- eventually if not at the start -- also would amount to a stunning new financial burden for every American taxpayer.

The average household would pay more than $1,000 a year as its share of the required new Federal expenditure of more than $80 billion each and every year. Such a massive new Federal budget item would run counter to the temper of the American taxpayer.

Also, such a massive new Federal budget item would run counter to the efforts of this Administration to decentralize programs and revenues, rather than bring new responsibilities to Washington.

And, finally, such a massive new Federal budget requirement would dim our efforts to bring needed Federal actions in many new areas -- some of which bear directly on health, such as environmental protection.

Clearly we must find a better answer to the deficiencies in our health care system. Unfortunately, such deficiencies are not difficult to identify:

-- In inner cities and in many rural areas, there is an acute shortage of physicians. Health screening under various government programs has found that appalling percentages of young people, mostly from deprived areas, have not seen a doctor since early childhood, have never seen a dentist and have never received any preventive care.

-- General practitioners are scarce in many areas and many people, regardless of income or location, have difficulty obtaining needed medical attention on short notice.

-- Our medical schools must turn away qualified applicants.

-- While we emphasize preventive maintenance for our automobiles and appliances, we do not do the same for our bodies. The private health insurance system, good as it is, operates largely as standby emergency equipment, not coming into use until we are stricken and admitted to the most expensive facility, a hospital.

-- Relative affluence is no ultimate protection against health care costs. A single catastrophic illness can wipe out the financial security of almost any family under most present health insurance policies.

To remedy these problems, however, will require far more than the efforts of the Federal Government -- although the Federal role is vital and will be met by this Administration.

It is going to take the complementing efforts of many other units, of government at the State and local levels; of educational and health organizations and institutions of all kinds; of physicians and other medical personnel of all varieties; of private enterprise and of individual citizens.

My National Health Strategy is designed to enlist all those creative talents into a truly national effort, coordinated but not regimented by four guiding principles:

Capitalizing on existing strengths: We resolve to preserve the best in our existing health care system, building upon those strong elements the new programs needed to correct existing deficiencies.

Equal access for all to health care: We must do all we can to end any racial, economic, social or geographical barriers which may prevent any citizen from obtaining adequate health protection.

Balanced supply and demand: It makes little sense to expand the demand for health care without also making certain that proper increases take place in the numbers of available physicians and other medical personnel, in hospitals and in other kinds of medical facilities.

Efficient organization: We must bring basic reorganizations to our health care system so that we can cease reinforcing inequities and relying on inefficiencies. The exact same system which has failed us in many cases in the past certainly will not be able to serve properly the increased demands of the future.

MAJOR ACTIONS AWAITED

Three major programs, now awaiting action in the Congress after substantial hearings and study, would give life to these principles.

-- The National Health Insurance Partnership Act,

-- The Health Maintenance Organization Assistance Act,

-- and H.R. 1, my welfare reform bill which also would amend Medicare and Medicaid in several significant ways.

The National Health Insurance Partnership Act

This proposal for a comprehensive national health insurance program, in which the public and private sector would join, would guarantee that no American family would have to forego needed medical attention because of inability to pay.

My plan would fill gaps in our present health insurance coverage. But, beyond that, it would redirect our entire system to better and more efficient ways of bringing health care to our people.

There are two critical parts of this Act:

1. The National Health Insurance Standards Act would require employers to provide adequate health insurance for their employees, who would share in underwriting its costs. This approach follows precedents of long-standing under which personal security -- and thus national economic progress -- has been enhanced by requiring employers to provide minimum wages and disability and retirement benefits and to observe occupational health and safety standards.

Required coverages would include not less than $50,000 protection against catastrophic costs for each family member; hospital services; physician services both in and out of a hospital; maternity care; well-baby care (including immunizations); laboratory expenses and certain other costs.

The proposed package would include certain deductibles and coinsurance features, which would help keep costs down by encouraging the use of more efficient health care procedures.

It would permit many workers, as an alternative to paying separate fees for services, to purchase instead memberships in a Health Maintenance Organization. The fact that workers and unions would have a direct economic stake in the program would serve as an additional built-in incentive for avoiding unnecessary costs and yet maintaining high quality.

The national standards prescribed, moreover, would necessarily limit the range within which benefits could vary. This provision would serve to sharpen competition and cost-consciousness among insurance companies seeking to provide coverage at the lowest overall cost.

Any time the Federal Government, in effect, prescribes and guarantees certain things it must take the necessary follow-through steps to assure that the interests of consumers and taxpayers are fully protected.

Accordingly, legislative proposals have been submitted to the Congress within recent weeks for regulating private health insurance companies, in order to assure that they can and will do the job, and that insurance will be offered at reasonable rates. In addition, States would be required to provide group-rate coverage for people such as the self-employed and special groups who do not qualify for other plans.

2. Another vital step in my proposed program is the Family Health Insurance Plan (FHIP) which would meet the needs of poor families not covered by the National Health Insurance Standards Act because they are headed by unemployed or self-employed persons whose income is below certain levels. For a family of four, the ceiling for eligibility would be an annual income of $5,000. FHIP would replace that portion of Medicaid designed to help such families. Medicaid would remain for the aged poor, the blind, the disabled and some children.

Health Maintenance Organizations

Beyond filling gaps in insurance coverage, we must also turn our attention to how the money thus provided will be spent -- on what kind of services and in what kind of institutions. This is why the Health Maintenance Organization concept is such a central feature of my National Health Strategy.

The HMO is a method for financing and providing health care that has won growing respect. It brings together into a single organization the physician, the hospital, the laboratory and the clinic, so that patients can get the right care at the right moment.

HMO's utilize a method of payment that encourages the prevention of illness and promotes the efficient use of doctors and hospitals. Unlike traditional fee-for-service billing, the HMO contracts to provide its comprehensive care for a fixed annual sum that is determined in advance.

Under this financial arrangement, the doctors' and hospitals' incomes are determined not by how much the patient is sick, but by how much he is well. HMO's thus have the strongest possible incentive for keeping well members from becoming ill and for curing sick members as quickly as possible.

I do not believe that HMO's should or will entirely replace fee-for-service financing. But I do believe that they ought to be everywhere available so that families will have a choice between these methods. The HMO is no mere drawing-board concept -- more than 7 million Americans are now HMO subscribers and that number is growing.

Several pieces of major legislation now before the Congress would give powerful stimulus to the development of HMO's:

1. The Health Maintenance Organization Assistance Act would provide technical and financial aid to help new HMO's get started, and would spell out standards of operation;

2. The National Health Insurance Partnership Act described above requires that individuals be given a choice between fee-for-service or HMO payment plans;

3. H.R. 1 contains one provision allowing HMO-type reimbursement for Medicare patients and another that would increase the Federal share of payments made to HMO's under State Medicaid programs.

I urge that the Congress give early consideration to these three measures, in order to hasten the development of this efficient method for low-cost, one-stop health service. Meantime, the Administration has moved forward in this area on its own under existing legislative authorities.

Last year, while HMO legislation was being prepared, I directed the Department of Health, Education, and Welfare to focus existing funds and staff on an early HMO development effort. This effort has already achieved payoffs:

To date, 110 planning and development grants and contracts have been let to potential HMO sponsors and some 200,000 Medicaid patients are now enrolled in HMO-type plans. Also, in a few months, 10 Family Health Centers will be operating with federally-supported funds to provide prepaid health care to persons living in underserved areas. Each of these Centers can develop into a full-service HMO. I have requested funds in 1973 to expand this support.

To keep this momentum going I have included in the fiscal year 1972 supplemental budget $27 million for HMO development, and requested $60 million for this purpose in fiscal year 1973.

I will also propose amendments to the pending HMO Assistance Act that would authorize the establishment of an HMO loan fund.

The National Need for H.R. 1

One of the greatest hazards to life and health is poverty. Death and illness rates among the poor are many times those for the rest of the Nation. The steady elimination of poverty would in itself improve the health of millions of Americans.

H.R. 1's main purpose is to help people lift themselves free of poverty's grip by providing them with jobs, job training, income supplements for the working poor and child care centers for mothers seeking work.

For this reason alone, enactment of H.R. 1 must be considered centerpiece legislation in the building of a National Health Strategy.

But H.R. 1 also includes the following measures to extend health care to more Americans -- especially older Americans -- and to control costs:

Additional Persons Covered:

-- Persons eligible for Part A of Medicare (hospital care) would be automatically enrolled in Part B (physician's care).

-- Medicare (both Parts A and B) would be extended to many disabled persons not now covered.

H.R. 1 as it now stands, however, would still require monthly premium payments to cover the costs of Part B. I have recommended that the Congress eliminate this $5.80 monthly premium payment and finance Medicare coverage of physician services through the social security payroll tax. This can be done within the Medicare tax rate now included in H.R. 1. If enacted, this change would save $1.5 billion annually for older Americans and would be equivalent to a 5 percent increase in social security cash benefits.

Cost Control Features:

-- Medicare and Medicaid reimbursement would be denied any hospital or other institution for interest, depreciation and service charges on any construction disapproved by local or regional health planning agencies. Moreover, to strengthen local and regional health planning agencies, my fiscal year 1973 budget would increase the Federal matching share. In addition, grants to establish 100 new local and 20 new State planning agencies would bring health planning to more than 80 percent of the Nation's population.

-- Reviews of claim samples and utilization patterns, which have saved much money in the Medicare program would be applied to Medicaid.

-- The efficiency of Medicaid hospitals and health facilities would be improved by testing various alternative methods of reimbursing them.

-- Cost sharing would be introduced after 30 days of hospitalization under Medicare.

-- Federal Medicaid matching rates would decline one-third after the first 60 days of care.

-- Federal Medicaid matching rates would be increased 25 percent for services for which the States contract with HMO's or other comprehensive health care facilities.

These latter three revisions are aimed at minimizing inefficient institutional care and encouraging more effective modes of treatment.

RESEARCH AND PREVENTION PROGRAMS

My overall health program encompasses actions on three levels: 1) improving protection against health care costs, 2) improving the health care system itself, and 3) working creatively on research and prevention efforts, to eradicate health menaces and to hold down the incidence of illnesses.

A truly effective national health strategy requires that a significant share of Federal research funds be concentrated on major health threats, particularly when research advances indicate the possibility of breakthrough progress.

Potentially high payoff health research and prevention programs include:

Heart Disease

If current rates of incidence continue, some 12 million Americans will suffer heart attacks in the next 10 years.

I shortly will assign a panel of distinguished professional experts to guide us in determining why heart disease is so prevalent and what we should be doing to combat it. In the meantime, the fiscal year 1973 budget provides funds for exploring:

-- the development of new medical devices to assist blood circulation and improved instruments for the early detection of heart disease; and

-- tests to explore the relationship of such high-risk factors as smoking, high blood pressure and high blood fats to the onset and progression of heart disease.

Cancer

The National Cancer Act I signed into law December 23, 1971, creates the authority for organizing an all-out attack on this dread disease. The new cancer program it creates will be directly responsive to the President's direction.

This new program's work will be given further momentum by my decision last October to convert the former biological warfare facility at Fort Detrick, Maryland into a cancer research center.

To finance this all-out research effort, I have requested that an additional $93 million be allocated for cancer research in fiscal year 1973, bringing the total funding available that year to $430 million.

In the past two and one-half years, we have more than doubled the funding for cancer research, reflecting this Administration's strong commitment to defeat this dread killer as soon as humanly possible.

Alcoholism

One tragic and costly illness which touches every community in our land is alcoholism. There are more than 9 million alcoholics and alcohol abusers in our Nation.

The human cost of this condition is incalculable -- broken homes, broken lives and the tragedy of 28,000 victims of alcohol-related highway deaths every year.

The recently established National Institute of Alcohol Abuse and Alcoholism will soon launch an intensive public education program through television and radio and will continue to support model treatment projects from which States and communities will be able to pattern programs to fight this enemy.

Meanwhile, the Department of Health, Education, and Welfare and the Department of Transportation are funding projects in 35 States to demonstrate the value of highway safety, enforcement and education efforts among drinking drivers. The Veterans Administration will increase the number of its Alcohol Dependence Treatment Units by more than one-third, to 56 units in fiscal year 1973.

Drug Abuse

Drug abuse now constitutes a national emergency.

In response to this threat and to the need for coordination of Federal programs aimed at drug abuse, I established the Special Action Office for Drug Abuse Prevention within the Executive Office of the President. Its special areas of action are programs for treating and rehabilitating the drug abuser and for alerting our young people to the dangers of drug abuse.

I have proposed legislation to the Congress which would extend and clarify the authority of this Office. I am hopeful that Senate and House conferees will soon be able to resolve differences in the versions passed by the two branches and emerge with a single bill responsive to the Nation's needs.

The new Special Action Office, however, has not been idly awaiting this legislation. It has been vigorously setting about the task of identifying the areas of greatest need and channelling Federal resources into these areas.

The Department of Defense, for example, working in close coordination with the Special Action Office, has instituted drug abuse identification, education, and treatment programs which effectively combatted last year's heroin problem among our troops in South Vietnam. Indications are that the corner has been turned on this threat and that the incidence of drug dependence among our troops is declining.

The Veterans Administration, again in coordination with the Special Action Office, has accomplished more than a six-fold increase in the number of drug dependency treatment centers in fiscal year 1972, with an increase to 44 centers proposed in fiscal year 1973.

In fiscal year 1972, I have increased funds available for the prevention of drug abuse by more than 130 percent. For fiscal year 1973, I have requested over $365 million to treat the drug abuser and prevent the spread of the affliction of drug abuse.

This is more than eight times as much as was being spent for this purpose when this Administration took office.

Sickle Cell Disease

About one out of every 500 black infants falls victim to the painful, life-shortening disease called sickle cell anemia. This inherited disease trait is carried by about two million black Americans.

In fiscal year 1972, $10 million was allocated to attack this problem and an advisory committee of prominent black leaders was organized to help direct the effort. This committee's recommendations are in hand and an aggressive action program is ready to start.

To underwrite this effort, I am proposing to increase the new budget for sickle cell disease from $10 million in fiscal 1972 to $15 million in fiscal 1973.

The Veterans Administration's medical care system also can be counted on to make an important contribution to the fight against sickle cell anemia.

Eight separate research projects concerning sickle cell anemia are underway in VA hospitals and more will be started this year. All 166 VA hospitals will launch a broad screening, treatment and educational effort to combat this disease.

On any given day, about 17,000 black veterans are in VA hospitals and some 116,000 are treated annually.

All these expanded efforts will lead to a better and longer life for thousands of black Americans.

Family Planning Services

Nearly three years ago, I called for a program that would provide family planning services to all who wanted them but could not afford their cost. The timetable for achieving this goal was five years.

To meet that schedule, funding for services administered by the National Center for Family Planning for this program has been steadily increased from $39 million in fiscal year 1971 to $91 million in fiscal year 1972. I am requesting $139 million for this Center in fiscal year 1973.

Total Federal support for family planning services and research in fiscal 1973 will rise to $240 million, a threefold increase since fiscal year 1969.

Venereal Disease

Last year, more than 2.5 million venereal disease cases were detected in the United States. Two-thirds of the victims were under 25.

A concentrated program to find persons with infectious cases and treat them is needed to bring this disease under control. I am, therefore, recommending that $31 million be allocated for this purpose in fiscal year 1973, more than two and one-half times the level of support for VD programs in 1971.

Health Education

Aside from formal treatment programs, public and private, the general health of individuals depends very much on their own informed actions and practices.

Last year, I proposed that a National Health Education Foundation be established to coordinate a nationwide program to alert people on ways in which they could protect their own health. Since that time, a number of public meetings have been held by a committee I established then to gather views on all aspects of health education. The report of this committee will be sent to me this year.

The committee hopes to define more explicitly the Nation's need for health education programs and to determine ways of rallying all the resources of our society to meet this need.

Consumer Safety

More than a half century has passed since basic legislation was enacted to ensure the safety of the foods and drugs which Americans consume. Since then, industrial and agricultural revolutions have generated an endless variety of new products, food additives, industrial compounds, cosmetics, synthetic fabrics and other materials which are employed to feed, clothe, medicate and adorn the American consumer.

These revolutions created an entirely new man-made environment -- and we must make absolutely certain that this new environment does not bring harmful side-effects which outweigh its evident benefits.

The only way to ensure that goal is met is to give the agency charged with that responsibility the resources it needs to meet the challenge.

My budget request for the Food and Drug Administration for fiscal year 1973 represents the largest single-year expansion in the history of this agency -- 70 percent. I believe this expansion is amply justified by the magnitude of the task this agency faces.

In the past year, the foundations for a modern program of consumer protection have been laid. The FDA has begun a detailed review of the thousands of non-prescription drug products now marketed. The pharmaceutical industry has been asked to cooperate in compiling a complete inventory of every drug available to the consumer.

Meanwhile, I have proposed the following legislation to ensure more effective protection for consumers:

-- A wholesome fish and fish products bill which provides for the expansion of inspections of fish handlers and greater authority to assure the safety of fish products.

-- A Consumer Product Safety bill which would authorize the Federal Government to establish and enforce new standards for product safety.

-- Medical device legislation which would not only authorize the establishment of safety standards for these products, but would also provide for premarketing scientific review when warranted.

-- A drug identification bill now before the Congress would provide a method for quickly and accurately identifying any pill or tablet. This provision would reduce the risk of error in taking medicines and allow prompt treatment following accidental ingestion.

-- The Toxic Substances Control Act that I proposed last year also awaits action by the Congress. This legislation would require any company developing a new chemical that may see widespread use to test it thoroughly beforehand for possible toxic effects.

Nursing Homes

If there is one place to begin upgrading the quality of health care, it is in the nursing homes that care for older Americans. Many homes provide excellent care and concern, but far too many others are callous, understaffed, unsanitary and downright dangerous.

Last August I announced an eight-point program to upgrade the quality of life and the standards of care in American nursing homes. The Federal interest and responsibility in this field is clear, since Federal programs including Medicare and Medicaid provide some 40 percent of total nursing home income nationally.

That HEW effort is well underway now:

Federal field teams have surveyed every State nursing home inspection program, and as a result 38 of 39 States found to have deficiencies have corrected them. The 39th is acting to meet Federal standards. To help States upgrade nursing homes, I have proposed legislation to pay 100 percent of the costs of inspecting these facilities.

Meanwhile, at my direction, a Federally-funded program to train 2,000 State nursing home inspectors and to train 41,000 nursing home employees is also underway. The Federal field force for assisting nursing homes is being augmented and fire, safety and health codes have been strengthened.

One way to measure the results of these efforts is to learn how patients in nursing homes feel about the care they are given. We have therefore also begun a program to monitor the complaints and suggestions of nursing home residents.

Applying Science and Technology

In my State of the Union message, I proposed a new Federal partnership with the private sector to stimulate civilian technological research and development. One of the most vital areas where we can focus this partnership -- perhaps utilizing engineers and scientists displaced from other jobs -- is in improving human health. Opportunities in this field include:

1. Emergency Medical Services: By using new technologies to improve emergency care systems and by using more and better trained people to run those systems, we can save the lives of many heart attack victims and many victims of auto accidents every year. The loss to the Nation represented by these unnecessary deaths cannot be calculated. I have already allocated $8 million in fiscal year 1972 to develop model systems and training programs and my budget proposes that $15 million be invested for additional demonstrations in fiscal year 1973.

2. Blood: Blood is a unique national resource. An adequate system for collecting and delivering blood at its time and place of need can save many lives. Yet we do not have a nationwide system to meet this need and we need to draw upon the skills of modern management and technology to develop one. I have therefore directed the Department of Health, Education, and Welfare to make an intensive study and to recommend to me as soon as possible a plan for developing a safe, fast and efficient nationwide blood collection and distribution system.

3. Health Information Systems: Each physician, hospital and clinic today is virtually an information island unto itself. Records and billings are not kept on the same basis everywhere, laboratory tests are often needlessly repeated and vital patient data can get lost. All of these problems have been accentuated because our population is so constantly on the move. The technology exists to end this chaos and improve the quality of care. I have therefore asked the Secretary of Health, Education, and Welfare to plan a series of projects to demonstrate the feasibility of developing integrated and uniform systems of health information.

4. Handicapping Conditions: In America today there are half a million blind, 850,000 deaf and 15 million suffering paralysis and loss of limbs. So far, the major responses to their need to gain self-sufficiency, have been vocational rehabilitation and welfare programs. Now the skills that took us to the moon and back need to be put to work developing devices to help the blind see, the deaf hear and the crippled move.

TOWARD A BETTER HEALTH CARE SYSTEM

Working together, this Administration and the Congress already have taken some significant strides in our mutual determination to provide the best, and the most widely available, health care system the world has ever known.

The time now has come to take the final steps to reorganize, to revitalize and to redirect American health care -- to build on its historic accomplishments, to close its gaps and to provide it with the incentives and sustenance to move toward a more perfect mission of human compassion.

I believe that the health care resources of America in 1972, if strengthened and expanded as I have proposed in this Message, will be more than sufficient to move us significantly toward that great goal.

If the Administration and the Congress continue to act together -- and act on the major proposals this year, as I strongly again urge -- then the 1970s will be remembered as an era in which the United States took the historic step of making the health of the entire population not only a great goal but a practical objective.

RICHARD NIXON

THE WHITE HOUSE,

March 2, 1972.

# # #

FOR IMMEDIATE RELEASE MARCH 2, 1972

Office of the White House Press Secretary
(Key Biscayne, Florida)

FACT SHEET

These are the major features of the Health Message which the President sent to the Congress today:

National Health Insurance Standards Act will require

-- All employers of one or more persons to provide minimim standard health insurance protection for their employees and dependendts of employees. Exceptions: State and local government; self-employed; household domestics; part-time and seasonal workers.

-- Standard benefit plan which includes inpatient hospital care (or equivalents in extended care facilities or home health services), surgical and medical care including physicians services, laboratory and X-ray-ancillary services on an inpatient and outpatient basis, maternity care, well-child care and vision care for children.

-- Deductible of $100 per person up to three (not applicable to well child and vision care), plus 2 days of hospital room and ward charges (average $54/day). Coinsurance of 25% of costs up to $5000 in medical bills per person; once $5000 in covered costs reached in a year, no further coinsurance for that person for that year and 2 succeeding years.

-- Catastrophic cost protection of at least $50,000 per person with an automatic restoration of $2000 in benefits a year.

-- Employer to pay at least 65% of the premium costs for the first two and one-half years and a minimum of 75% of the costs thereafter. Effective date, July 1, 1973.

-- Establishment of private insurance pools for risk sharing among small employers, the self-employed and people outside of the labor force. Permits purchase at group rates.

-- Employees to be given the option of obtaining services through traditional providers or prepaid HMO systems.

-- Cost control, utilization review, standards for providers.

Family Health Insurance Plan will provide:

-- Basic health insurance protection to all low income families with children not covered by employer plans.

-- Uniform nationwide definition of eligibility with the income cutoff at $5000 (for a family of four).

more (OVER)

-- Removal of the current inequities in Medicaid between male and female headed families, the working and non-working poor. Removes the eligibility inequities among States based on income and the wide variation in benefits. Removal of the Medicaid problem of sudden loss of all benefits.

-- Benefits that include 30 days of inpatient hospital care (or equivalents in extended care facilities or home health services), surgical and medical care including physicians services, maternity care and family planning, well-child care, vision care for children, emergency services and diagnostic laboratory and X-ray. Benefits are the same for all low income families nationwide; fully federally financed.

-- No cost sharing for families with incomes below $3000 (for a family of four). Premiums, deductibles and coinsurance rise as income rises up to the income cutoff where the families' share would be equivalent to cost sharing under the employer plan.

-- Option for the family to elect to receive services from HMO's on a prepaid capitation basis.

-- Similar requirements as in Medicare for standards for providers, cost controls, utilization and peer review. Effective July 1, 1973.

-- The current Medicaid program for the aged, blind and disabled will remain in effect for those categories of persons.

Combining Parts A and B of Medicare

Part B of Medicare, which covers primarily physicians' fees, is now a voluntary program with one-half of the cost paid by older people at the current rate of $5.80 per month and with one-half paid from general revenues. Under the proposal, the premium payment required of older people would be prepaid by employer and employee contributions, just as is presently the case with Medicare hospital insurance, with coverage beginning automatically at age 65 for those insured under the social security and railroad retirement programs.

The Proposal would offer significant advantages to the aged.

-- The aged would no longer have to pay premiums out of their reduced incomes after retirement.

-- Elimination of the premium would be the equivalent, on the average, of about a 5 percent increase in social security benefits of those now paying premiums. In fiscal year 1973, savings to older people in premiums and reduced payments by States on their behalf would be $1.5 billion. (This, of course, would much more than offset the increase in co-payments under Medicare proposed in the budget as a measure to improve utilization -- estimated at a $400 million saving to the program.)

Of the 20 million persons 65 and over who are protected by hospital insurance, 19-1/2 million (about 96%) have signed up for Part B. (States are paying the premiums on behalf of about 2 million persons who receive assistance or are medically indigent, and would save $143 million under this proposal.)

The combined finances will result in administrative simplification and operating savings since it will eliminate such processes as enrollment and disenrollment and periodic premium changes for nearly all the aged. It will be necessary to retain only a small voluntary insurance roll for persons uninsured for social security benefits who wish to join Medicare.

Health Maintenance Organizations

A Health Maintenance Organization, or "HMO", is an organized system of health care providing comprehensive services (ambulatory and hospital care at a minimum) to a voluntarily enrolled population for a fixed prepaid fee. Consumers have convenient access to a system and do not have to find each piece separately.

Reasons for HMO development:

-- Organization into one system with strong linkages between general practitioners, specialists, hospitals, clinics, laboratory, ECFs.

-- Built-in incentives for controlling cost, efficient use of resources leading to self-regulation, not more direct Federal involvement.

-- Vehicle for responding to all health care problems; organization, financing, manpower, prevention.

# # # # # # #

FOR IMMEDIATE RELEASE MARCH 2, 1972

OFFICE OF THE WHITE HOUSE PRESS SECRETARY
(Key Biscayne, Florida)

THE WHITE HOUSE

PRESS CONFERENCE
OF
DR. MERLIN DUVAL, ASSISTANT SECRETARY OF HEW
FOR HEALTH AND SCIENTIFIC AFFAIRS

12:20 P.M. EST

MR. BALL: You have the President's message on health which was delivered to the Congress at noon, and you also have a Fact Sheet covering some of the legislation.

Here to brief you on the message is Dr. Merlin DuVal, Assistant Secretary of HEW on Health and Scientific Affairs.

DR. DuVAL: The President, as you know, is sending to Congress today a Health Message. The President remains concerned about the fact that there is not equal access to quality health care in the United States. He does concede again that there remains an imbalance in the supply and demand of health personnel and that there are gross inefficiencies in this system.

Because you have not had the message for very long, I am going to attempt to highlight some of the things in it for you and then respond to some of your questions.

The President, as you know, in February of 1971, did send forward a message to the Congress on health. It consisted of a number of very specific pieces of legislation which together fit into a very comprehensive and articulat package.

It included certain selective investments. It focused very heavily on institutional reform, but at the same time was structured in such a way that it would permit a reform of the American medical distribution system and yet build on its existing strengths.

I believe the history will show this is the first president who has ever put together a single total strategy, certainly in health. That constituted the substance of his message at that time one year ago.

The Congress, of course, has already responded in part to that message, and it has passed. He, in turn, has filed the Health Manpower Act, the Nurse Training Act, the Cancer Authority, the Special Action Office for Drug Abuse. But, as you also know, we have submitted legislation as a part of that package including the National Health Insurance Partnership Act and the Health Maintenance Organization Assistance Act which is to encourage institutional reform and welfare reform because it includes certain provisions related to Medicare and Medicaid.

You have, as Mr. Ball has already said, a three-page fact sheet that discusses the outstanding legislation, and I will not dwell on those.

MORE OVER

The message today is a reminder to Congress that the work on this very comprehensive package remains incomplete, but the message highlights certain matters about which the President wanted to express particular concern and to which he wanted to draw paraticular attention. I will cite those for you quickly, so that they can serve as a stimulus for such questions as you choose.

First -- and not in any priority; I am taking them alphabetically -- was his concern about alcoholism. He has, as you know, directed our National Institute on Alcohol Abuse and Alcoholism to undertake a very massive education program, and we have already engaged and recently started a joint effort with the Department of Transportation now in 30 States in a large program on highway safety, education about alcohol and driving, and enforcement.

With regard to cancer, as you know, the new cancer authority machinery is already in place. The director of a three-man cancer panel has been identified, as have now the other two members of the cancer panel. The President will shortly be announcing the membership of the cancer authority, along with the names of the persons who will serve on the advisory board.

He is eager to point out that since the investment of $185 million in 1969, this has been rapidly expanded to the point in 1973 where he is recommending $430 million be spent on cancer research.

He has focused on consumer safety in a most interesting way. In fact, the Food and Drug Administration has never in its history been accorded the treatment it is receiving this year at the suggestion of the President, who is deeply conscious of the concern of the American people about safety.

We have recommended an increase of 70 percent in his budget up to a total of approximately $188 million. They have already started an enormous review of over-the-counter prescription drugs. We have had wonderful cooperation on this point by the drug industry in establishing a complete inventory of the drugs available on the American scene, and we are moving heavily into the area of food plant inspection and enforcement.

In the field of drug abuse, as you know, the President had established a Special Action Office on Drug Abuse in June 1971. He has since had confirming legislation from the Congress setting up the Special Action Office with appropriate authority.

This Administration is very pleased to point out that since it came in, it has increased by a factor of eight the total investment of the Government in drug abuse and the problems allied therewith, and in 1973 will be up to an investment of $365 million.

In family planning, which the President has paid particular attention to, he points out that even as recently as 1971 we were only investing $39 million. We have pushed that in 1972 to $91 million, and next year to $139 million in HEW alone.

In addition, we are recommending that $44 million be expended on research on birth control and on population growth.

MORE

Along with the investment, incidentally, from Medicaid and certain other programs, together with those in the office of Economic Opportunity and the AID, our total investment in family planning has now reached $360 million.

The President has felt for some time that the system can be no better than the capacity of the individual citizens to use it, and he has recommended the stablishment, since created, of a national commission, an advisory committee at this moment to him, on health education.

That committee is now functioning and undertaking the assignment on his behalf of coming in with techniques for tapping the private sector and all of the media for conducting a massive campaign on the significance of personal health and the environment.

In the area of heart disease, the President is recommending an additional boost this year of $22 million, has invited, and will be announcing shortly, the names of a panel to sit in judgment of the real significance of heart disease to the American people and precisely what the role should be in solving this problem.

This year we will attempt to increase our enthusiasm and emphasis on the establishment of new devices to be of assist to people with cardiac problems. As you have probably heard from other sources, an announcement to this having to do with the first fabrication of a completely atomic-powered implantable heart was released this morning.

MORE

We are also going to focus on the prevention of heart disease, screening clinics and the epidemiology of heart disease, because, as you know, we have a very firm clue now that the three basic flaws, so to speak, that may lead to higher incidence of coronary heart disease is smoking, obesity and high blood fat levels. When those three occur simultaneously, the incidence of coronary heart disease begins to skyrocket.

The President has begun to focus again on health maintenance organizations. This is part of the legislation that remains unpassed at this time in Congress, and he has asked that the expenditure on their behalf be increased from $27 million to $60 million in 1973, and the President has asked us to continue actively his program announced in New Hampshire last August to upgrade the nursing homes in the United States through an 8-point program involving the education and training of 2,000 nursing home inspectors and 41,000 nursing home employees.

In the meantime, we have also further strengthened the fire and safety codes, and we have evidence that all but one State are now in compliance.

In the field of science and technology, the President has felt that the extraordinary advances made particularly through the space industry are applicable in the field of health, and he has asked us to focus on the creation of emergency medical service systems in the United States. He has asked the Department of Health, Education, and Welfare to do an intensive study on how we can better utilize and distribute human blood, which, as you know, is a natural resource and not otherwise manufacturable, and to put in place health information systems which will make it possible for us to nationalize and do a better job with what we do in the health field.

The President has also again singled out for attention sickle cell disease, and he has asked that we increase the budget another 50 percent, up $15 million, and has asked all Veterans Administration hospitals to get on with a screening of all patients who are black and who come into the jurisdiction of the Veterans Administration hospitals. At any day there are about 1500 or 1700 such patients within the Veterans Administration hospitals.

He has, as you know, set in place a very special Advisory Committee on Sickle Cell Disease which is active and working at this time.

In vener al disease, which, as most of you know, has shown evidence of a breakthrough in very recent years, we have pushed our Federal concern through investment in 1971 from $12.1 million up to $31 million this year in order to getin palce the capacity within the system to get at particularly the young people who are afflicted with venereal disease. Public education will be a large part of this program.

Then, with regard to the Food and Drug Administration, again I would mention one other thing which remains from past references: that the President has expressed a

deep interest in moving into the area of consumer product safety, and has asked us, through legislation, to establish and enforce standards in this area to begin to describe and set up standards for medical devices, to proceed further with drug identification so that it will make it possible in cases of poisoning to act more quickly and more responsively, and to require the pre-testing of toxic substances so they can be better controlled.

This does represent, in effect, a brief summary of a health message which I have taken you through because you have not had the benefit of a long exposure to it this morning.

Q Dr. DuVal, can you tell me the legislative status at the end of last year of the principal recommendations on insurance? The one the House passed?

DR. DuVAL: In the instance of insurance, we have a situation in which the President's bill has been through the phase of public hearings before Ways and Means on the House side. That is now in Executive Session. It is my understanding that by approximately March we may see a bill. In the meantime, the Senate Finance Committee will be taking it up after it finishes its work on welfare reform.

Q What is the status of Jesse Steinfeld? Is he on his way out?

DR. DuVAL: Not at all, as far as I know.

Q There are persistent reports to the effect that Steinfeld refuses to discuss it now.

DR. DuVAL: If you wish, I will clarify that this way and if, afterwards, you want additional information, I will give you everything you need: The issue specifically here is this: that the U.S. Public Health Service, until approximately the second world war, was, in effect, the Public Health Service commissioned corps. They were one and the same. In the last roughly 20 to 25 years the U.S. Public Health Service has become a very large operation of approximately 45,000 employees, of which only about 5,000 are commissioned corps. That is because of the NIH, the FDA and HISMA.

As a consequence of this change, the senior operating officer of the Public Health Service, in years past having been the Surgeon General, was, in fact, replaced by an Assistant Secretary for Health and Scientific Affairs as a consequence of the Executive Reorganization in 1969. The anomaly that persists after that is that you have, in effect, two potential voices within Government that can speak for health.

As a consequence of the Perkins Committee study this year which recommended to the Secretary that we move away from a dual personnel system -- that is, a commissioned corps and a civil service -- and more, instead, toward a situation where there was a single personnal service, the issue of the future of the Surgeon General must obviously then be treated, and I have been assigned the function of determining what should be the future role of the Surgeon General.

The issue is this: At this time the Surgeon General, by virtue of heritage, serves as the principal Deputy Assistant Secretary or the Assistant Secretary for Health and Scientific Affairs, and also as Surgeon General. Inasmuch as all three agencies now have as their directors or administrators Presidential appointees, we believe that it would be wiser to have political appointees or Presidential appointees reporting to a Presidential appointee rather than to a career officer.

So our suggestion has been that we disengage the two titles of Surgeon General and Deputy Assistant Secretary, and that is all. Following that maneuver -- if we proceed through it -- and that is the recommendation as of today -- the Surgeon General will remain as the principal health adviser to the Office of the Assistant Secretary.

It is a long answer. I am sorry, but it is very complicated.

MORE

Q He would no longer have authority over FDA?

DR. DuVAL: He doesn't now, only to the extent he may serve as my principal deputy if I am out of town. Obviously, he can operate as a principal deputy in the line chart. He has, obviously, never functioned, however, in that role, so there is no change.

Q Can you tell us what the major changes are in this year's health program over last year?

DR. DuVAL: I think, to the extent that one defines "changes" ordinarily, I would not single out any changes. To me, the special point of the message especially, I might add, to someone like myself who has a deep and abiding concern on health matters on behalf of the American people--and came to Washington, incidentally, to see to what extent I might represent those interests--I find great reassurance in this, for two reasons: As I have already indicated, this is the first president in the history of the United States who has ever assembled a completely comprehensive and articulated package to treat the entire issue of the health problem of the American people.

This message, secondly, reaffirms his continued pressure on Congress that all of those pieces must come into place. If they do not, it will be complete and we will not be able to get the job done.

Q Is he asking for anything now that he did ask for last year and failed to get then?

DR. DuVAL: Beyond the individual items that I singled out, which represent different budgetary emphases with regard to individual programs, there is nothing different in the overall strategy.

Q To refresh my memory, did he last year propose the elimination of the $5.80 premium on Medicare?

DR. DuVAL: Yes.

Q Do you expect this to come out of the House Ways and Means Committee essentially as you have outlined here in your fact sheet?

DR. DuVAL: There is no way I--and I presume most of my fellow Americans, if I can use that expression--can anticipate what Mr. Mills expects to do to that bill.

I would say this, though: To the extent one can reasonably guess, it seems logical if an insurance bill comes out of the Ways and Means Committee it will probably be a bill that will be based on the existing combination of private and Federal investment in the health financial structure. To that extent, the President's basic posture will have been protected. As you know, the alternative discussions to this are not attractive.

Q In other words, you do expect to get essentially what you have outlined in the message?

DR. DuVAL: I would not wish to speak to the specifics, but the core system for financing health care, I expect, will be in the bill.

Q Can you give us a budgetary figure showing the increase totally in additional funds requested for 1973 versus 1972?

DR. DuVAL: Yes. In terms of grant totals?

Q You said the major emphasis was on budgetary differences. I wonder if you could give us a sum total.

DR. DuVAL: The figure I have in front of me--but I might have to correct this by looking at the budget--is a total increase of $485 million. **

Q That is compared to last year?

DR. DuVAL: Yes.

Q Fiscal 1973?

DR. DuVAL: That is correct, fiscal 1973 was my response.

Q An increase from what to what, sir?

DR. DuVAL: Again, I may have to get the actual figure, but it is approximately $4.5 billion.

Q In 1973?

DR. DuVAL: 1973.

Q Is that the whole thing? Is that the whole package?

DR. DuVAL: "Whole" is a relative word. There is an enormous amount of health expenditure in Title 18 and Title 19. In other words, in Medicare and Medicaid. I was not including such figures in that. I was only referring specifically to the three health agencies of the Public Health Service: FDA, the National Institutes of Health, and the Health Services and Mental Health Administration.

THE PRESS: Thank you, Dr. DuVal.

END (12:53 p.m. EST)

** NOTE: HEW health budget for FY '73 is $1.514 billion over FY '72 budget.

EMBARGOED FOR RELEASE
UNTIL 12:00 NOON TUESDAY
FEBRUARY 8, 1972

FEBRUARY 7, 1972

OFFICE OF THE WHITE HOUSE PRESS SECRETARY

THE WHITE HOUSE

REMARKS OF THE PRESIDENT
ON THE ENVIRONMENTAL MESSAGE FOR RADIO AND TELEVISION

Each of us, all across this great land, has a stake in maintaining and improving environmental quality: clean air and clean water, the wise use of our land, the protection of wildlife and natural beauty, parks for all to enjoy.

These are part of the birthright of every American. To guarantee that birthright, we must act, and act decisively. It is literally now or never.

During the past three years, we have made a good start. We have passed new laws to protect the environment, and we have mobilized the power of public concern. But there is much yet to be done.

Eighteen of the major environmental proposals which I put forward a year ago have still not received final action by the Congress. I repeat today my urgent request for Congressional action on this much needed legislation, and I am also presenting a number of new proposals.

The environmental agenda now before the Congress includes laws to deal with water pollution, pesticide hazards, ocean dumping, excessive noise, careless land development, and many other environmental problems. These problems will not stand still for politics or for partisanship. They demand to be met now. By meeting them now, we can make 1972 the best year ever for environmental progress.

The time has come for man to make his peace with nature. Let us renew our commitment. Let us redouble our effort. The quality of our life on this good land is a cause to unite all Americans.

# # # # # # # #

FOR RELEASE AT 12:00 NOON (EST) February 8, 1972

Office of the White House Press Secretary

THE WHITE HOUSE

LETTER FROM THE PRESIDENT TO THE
PRESIDENT OF THE SENATE AND THE SPEAKER OF
THE HOUSE OF REPRESENTATIVES

Dear Mr. President: (Dear Mr. Speaker:)

Pursuant to the Wilderness Act of September 3, 1964, I am pleased today to transmit proposals for 18 additions to the National Wilderness Preservation System.

The proposed new wilderness areas, which cover 1.3 million acres in all, are enumerated in my Special Message on the Environment of today's date. Two other possibilities considered by the Secretary of the Interior in his review of roadless areas of 5,000 acres or more -- Martin National Wildlife Refuge, Maryland, and Wupatki National Monument, Arizona -- were found to be unsuitable for inclusion in the Wilderness System. I concur in this finding and in the 18 favorable recommendations of the Secretaries of the Interior and of Agriculture, all of which are transmitted herewith.

Timely and farsighted action is imperative if we are to preserve America's irreplaceable heritage of wildness as part of our legacy to the future. I urge that protected status be promptly extended to the lands covered by these proposals and by the 31 previous wilderness recommendations already pending before the Congress.

Sincerely,

RICHARD NIXON

Honorable Spiro T. Agnew
President of the Senate
Washington, D.C.

Honorable Carl Albert
Speaker of the
House of Representatives
Washington, D.C.

#####

FOR RELEASE AT 12 NOON, EST February 8, 1972

Office of the White House Press Secretary

THE WHITE HOUSE

TO THE CONGRESS OF THE UNITED STATES:

From the very first, the American spirit has been one of self-reliance and confident action. Always we have been a people to say with Henley "I am the master of my fate . . . the captain of my soul" -- a people sure that man commands his own destiny. What has dawned dramatically upon us in recent years, though, is a new recognition that to a significant extent man commands as well the very destiny of this planet where he lives, and the destiny of all life upon it. We have even begun to see that these destinies are not many and separate at all -- that in fact they are indivisibly one.

This is the environmental awakening. It marks a new sensitivity of the American spirit and a new maturity of American public life. It is working a revolution in values, as commitment to responsible partnership with nature replaces cavalier assumptions that we can play God with our surroundings and survive. It is leading to broad reforms in action, as individuals, corporations, government, and civic groups mobilize to conserve resources, to control pollution, to anticipate and prevent emerging environmental problems, to manage the land more wisely, and to preserve wildness.

In messages to the Congress during 1970 and 1971 I proposed comprehensive initiatives reflecting the earliest and most visible concerns of the environmental awakening. The new cast of the public mind had to be translated into new legislation. New insights had to have new governmental forms and processes through which to operate. Broadly-based problems -- such as air pollution, water pollution and pesticide hazards -- had to be dealt with first.

The necessary first steps in each of these areas have now been taken, though in all of them the work is far from completed. Now, as we press on with that work in 1972, we must also come to grips with the basic factors which underlie our more obvious environmental problems -- factors like the use of land and the impact of incentives or disincentives built into our economic system. We are gaining an increasingly sophisticated understanding of the way economic, institutional, and legal forces shape our surroundings for good or ill; the next step is learning how to turn such forces to environmental benefit.

more (OVER)

Primary responsibility for the actions that are needed to protect and enhance our environment rests with State and local government, consumers, industry, and private organizations of various kinds -- but the Federal Government must provide leadership. On the first day of this decade I stated that "it is literally now or never" for true quality of life in America. Amid much encouraging evidence that it can and will be "now," we must not slacken our pace but accelerate it. Environmental concern must crystallize into permanent patterns of thought and action. What began as environmental awakening must mature finally into a new and higher environmental way of life. If we flag in our dedication and will, the problems themselves will not go away. Toward keeping the momentum of awareness and action, I pledge my full support and that of this Administration, and I urgently solicit the continuing cooperation of the Congress and the American people.

TWO YEARS' AGENDA

From Consideration to Action

In my 1971 environmental message, just one year ago today, I sent to the Congress a comprehensive program designed to clean up the problems of the past, and to deal with emerging problems before they become critical. These proposals included:

Regulation of toxic substances

Comprehensive improvement in pesticide control authority

Noise control

Preservation of historic buildings

Power plant siting

Regulation of environmental effects of surface and underground mining

Ocean dumping regulation

More effective control of water pollution through a greatly expanded waste treatment grant program and strengthened standard-setting and enforcement authorities

A National Land Use Policy Act

Substantial expansion of the wilderness system

Expanded international cooperation

To date, most of the legislation on this list has been the subject of congressional hearings; most of it has attracted heartening interest and support; but none of it has yet received final congressional action. Last year was, quite properly, a year of consideration of these measures by the Congress. I urge, however, that this be a year of action on all of them, so that we can move on from intention to accomplishment in the important needs they address. Passage of these measures and creation of the unified Department of Natural Resources which I also proposed in 1971 -- by this 92nd Congress -- will be essential if we are to have an adequate base for improving environmental quality.

Building on the Base

As that base is being established, we must move ahead to build wisely and rapidly upon it. I shall outline today a plan for doing that, with initiatives and actions in the following areas:

-- Tightening pollution control

A Toxic Wastes Disposal Control Act

Legislation to control sediment from construction activities

An emissions charge to reduce sulfur oxide air pollution

Clean energy research and energy conservation measures

-- Making technology an environmental ally

Integrated pest management

Stepped-up research on noise control

Stepped-up research on air pollution effects and measurement

-- Improving land use

Expansion and strengthening of the National Land Use Policy Act

Protection of wetlands

-- Protecting our natural heritage

A ban on use of poisons for predator control on public lands

A stronger law to protect endangered species of wildlife

Big Cypress National Fresh Water Reserve

National Recreation Areas around New York Harbor and the Golden Gate

Conversion of 20 additional Federal properties to recreational use

18 new Wilderness Areas

Regulation of off-road vehicles on Federal lands

-- Expanding international cooperation on the environment

Establishment of a United Nations Fund for the Environment

Further measures to control marine pollution

-- Protecting children from lead-based paint

-- Enlisting the young

President's Environmental Merit Awards Program for high schools

Youth opportunities in the Department of Agriculture Field Scout program.

TIGHTENING POLLUTION CONTROL

The legislative framework for dealing with our major air pollution problems has become law, and I have made comprehensive recommendations regarding water pollution control. But several problems remain to be addressed which are difficult to deal with under the general pollution control authorities.

Disposal of Toxic Wastes

Increasingly strict air and water pollution control laws and their more effective enforcement have led to greater reliance on land -- both surface and underground -- for disposal of waste products from the toxic substances being used in ever greater volume and variety in our society. Without adequate controls, such waste disposal may cause contamination of underground and surface waters leading to direct health hazards.

-- I propose a Toxic Wastes Disposal Control Act, under which the Environmental Protection Agency would establish Federal guidelines and requirements for State programs to regulate disposal on or under the land of those toxic wastes which pose a hazard to health. The act would provide for Federal enforcement action if a State should fail to establish its own program.

Sediment Control

Sediment, small particles of soil which enter the water, is the most pervasive water pollution problem which does not come primarily from municipal or industrial sources. Heavy loads of sediment interfere with many beneficial uses of water, such as swimming and water supply, and can change the entire character of an aquatic environment. Many of our great waterways are afflicted with this problem. In our urban areas, a significant amount of sediment comes from construction. However, if proper construction practices are followed, sediment runoff from this source can be greatly reduced.

-- I propose legislation calling upon the States to establish, through appropriate local and regional agencies, regulatory programs to control sediment affecting water quality from earth-moving activities such as building and road construction.

The Environmental Protection Agency, together with other Federal agencies, would develop Federal guidelines for appropriate control measures. Federal enforcement would take place in situations where a State failed to implement such a program.

Sulfur Oxides Emissions Charge

In my 1971 Environmental Message, I announced plans to ask for imposition of a charge on sulfur oxides emissions, one of the air pollutants most damaging to human health and property, and vegetation. The Council on Environmental Quality, the Treasury Department and the Environmental Protection Agency have now completed their studies on this measure and have developed the details of an emission charge proposal.

-- I propose a charge on sulfur emitted into the atmosphere from combustion, refining, smelting, and other processes.

This charge would begin in 1976 and apply in all regions where the air quality does not meet national standards for sulfur oxides during 1975. The charge would be 15¢ per pound on sulfur emitted in regions where the primary standards -- which are designed to be protective of public health -- have not been met within the deadline for achievement prescribed in the Clean Air Act. In regions where air quality met the primary standard but exceeded the secondary national standard -- designed to protect property, vegetation, and aesthetic values -- a charge of $.10 per pound of sulfur emitted would apply. Areas which reduce emissions sufficiently to meet both primary and secondary air quality standards would be exempt from the emission charge.

This charge is an application of the principle that the costs of pollution should be included in the price of the product. Combined with our existing regulatory authority, it would constitute a strong economic incentive to achieve the sulfur oxides standards necessary to protect health, and then further to reduce emissions to levels which protect welfare and aesthetics.

Clean Energy Generation and Conservation

Ours is an energy-based economy, and energy resources are the basis for future economic progress. Yet the consumption of energy-producing fuels contributes to many of our most serious pollution problems. In order to have both environmental quality and an improving standard of living, we will need to develop new clean energy sources and to learn to use energy more efficiently.

Our success in meeting energy needs while preventing adverse environmental effects from energy generation and transmission will depend heavily on the state of available technology. In my message to the Congress on energy of last June, I announced a series of steps to increase research on clean and efficient energy production. But further action is needed.

-- As part of my new commitment to augment Federal Research and development and target it more effectively on solving domestic problems, I have requested in the 1973 budget an additional $88 million for development of a broad spectrum of new technologies for producing clean energy.

In addition to carrying forward the priority efforts I have already announced -- the liquid metal fast breeder reactor, pipeline quality gas from coal, and sulfur oxide control technology -- the budget provides funds for new or increased efforts on fusion power, solar energy, magnetohydrodynamics, industrial gas from coal, dry cooling towers for power plant waste heat, large energy storage batteries and advanced underground electric transmission lines. These new efforts relate to both our immediate and our future energy problems, and are needed to assure adequate supplies of clean energy.

My message on energy also announced several steps that would be taken by the Federal Government to use energy more efficiently and with less environmental harm. One of these steps was issuance by the Secretary of Housing and Urban Development of revised standards for insulation in new federally insured houses. The new standards for single-family structures, which have now been issued through the Federal Housing Administration, reduce the maximum permissible heat loss by about one-third for a typical home. The fuel savings which will result from the application of these new standards will, in an average climate, exceed in one year the cost of the additional insulation required.

-- I am now directing the Secretary of Housing and Urban Development to issue revised insulation standards for apartments and other multifamily structures not covered by the earlier revision. The new rules will cut maximum permissible heat loss by 40%.

The savings in fuel costs after a 5-year period will on the average more than offset the additional construction costs occasioned by these revised standards.

These stricter insulation standards are only one example of administrative actions which can be taken by the Federal Government to eliminate wasteful use of energy. The Federal Government can and must provide leadership by finding and implementing additional ways of reducing such waste.

-- I have therefore instructed the Council on Environmental Quality and the Office of Science and Technology, working with other Federal agencies, to conduct a survey to determine what additional actions might be taken to conserve energy in Federal activities.

This survey will look at innovative ways to reduce wasteful consumption of energy while also reducing total costs and undesirable environmental impact.

Recycling

Recycling -- the technique which treats many types of solid wastes not as pollutants but as recoverable and reusable "resources out of place" -- is an important part of the answer to the Nation's solid waste burden. Last year, at my direction, the General Services Administration began reorienting government procurement policies to set a strong Federal example in the use of recycled products.

-- Because Federal tax policy should also offer recycling incentives, the Treasury Department is clarifying the availability of tax exempt treatment industrial revenue bond financing for the construction of recycling facilities built by private concerns to recycle their own wastes.

The Environmental Transition

Many environmental problems are influenced by the way our economy operates. Conversely, efforts to improve environmental quality have an impact on the economy. Our national income accounting does not explicitly recognize the cost of pollution damages to health, materials, and aesthetics in the computation of our economic well-being. Many goods and services fail to bear the full costs of the damages they cause from pollution, and hence are underpriced.

Environmental quality requirements will affect many of our industries by imposing new costs on production. We know that these impacts fall unevenly on industries, new and old firms, and on communities, but little concrete data has been available. Contract studies have recently been performed for the Council on Environmental Quality, the Environmental Protection Agency, and the Department of Commerce, under the policy guidance of the Council of Economic Advisers. These initial studies suggest that pollution control costs will result in some price increases, competitive trade disadvantages, and employment shifts. The major impact of these costs will be on older, and usually smaller plants.

As long as we carefully set our environmental goals to assure that the benefits we achieve are greater than the social and economic costs, the changes which will occur in our economy are desirable, and we as a Nation will benefit from them.

2. MAKING TECHNOLOGY AN ENVIRONMENTAL ALLY

The time has come to increase the technological resources allocated to the challenges of meeting high-priority domestic needs. In my State of the Union Message last month, I announced an expanded Federal research and development commitment for this purpose. There is great potential for achievement through technology in the fight against pollution and the larger drive for quality in our environment.

The temptation to cast technology in the role of ecological villain must be resisted -- for to do so is to deprive ourselves of a vital tool available for enhancing environmental quality. As Peter Drucker has said, "the environment is a problem of [the] success" of technological society, by no means a proof of its failure. The difficulties which some applications of technology have engendered might indeed be rectified by turning our backs on the 20th century, but only at a price in privation which we do not want to pay and do not have to pay. There is no need to throw out the baby with the bath water. Technology can and must be wisely applied so that it becomes environmentally self-corrective. This is the standard for which we must aim.

Integrated Pest Management

Chemical pesticides are a familiar example of a technological innovation which has provided important benefits to man but which has also produced unintended and unanticipated harm. New technologies of integrated pest management must be developed so that agricultural and forest productivity can be maintained together with, rather than at the expense of, environmental quality. Integrated pest management means judicious use of selective chemical pesticides in combination with nonchemical agents and methods. It seeks to maximize reliance on such natural pest population controls as predators, sterilization, and pest diseases. The following actions are being taken:

-- I have directed the Department of Agriculture, the National Science Foundation, and the Environmental Protection Agency to launch a large-scale integrated pest management research and development program. This program will be conducted by a number of our leading universities.

-- I have directed the Department of Agriculture to increase field testing of promising new methods of pest detection and control. Also, other existing Federal pesticide application programs will be examined for the purpose of incorporating new pest management techniques.

-- I have directed the Departments of Agriculture and of Health, Education, and Welfare to encourage the development of training and certification programs at appropriate academic institutions in order to provide the large number of crop protection specialists that will be needed as integrated pest management becomes more fully utilized.

-- I have authorized the Department of Agriculture to expand its crop field scout demonstration program to cover nearly four million acres under agricultural production by the upcoming growing season.

Through this program many unnecessary pesticide applications can be eliminated, since the scouts will be used to determine when pesticide applications are actually needed.

In my message on the environment last February, I proposed a comprehensive revision of our pesticide control laws -- a revision which still awaits final congressional action. Also essential to a sound national pesticide policy are measures to ensure that agricultural workers are protected from adverse exposures to these chemicals.

-- I am directing the Departments of Labor and Health, Education, and Welfare to develop standards under the Occupational Safety and Health Act to protect such workers from pesticide poisoning.

more

Noise Control Research

Scientific findings increasingly confirm what few urban dwellers or industrial workers need to be told -- that excessive noise can constitute a significant threat to human well-being. The Congress already has before it a comprehensive noise control bill, which I proposed a year ago. A quieter environment cannot simply be legislated into being. We shall also need to develop better methods to achieve our goal.

-- I have requested in my 1973 budget a $23 million increase in research and development funds for reducing noise from airplanes. I have also requested new funds for research and development for reducing street traffic noise.

Research on Air Pollution Effects and Measurement

Our pollution control efforts are based largely on the establishment of enforceable standards of environmental quality. Initial standards have often been based on incomplete knowledge because the necessary information has not been available. Also, the lack of adequate instruments to measure pollution and of models of how pollutants are dispersed has made it difficult to know exactly how much pollution must be controlled in a particular area. We need added research and development to make more precise judgments of what standards should be set and how we can most practically achieve our goals.

-- I have requested in my 1973 budget an additional $12 million to increase research on the health effects of air pollution, on regional air pollution modeling, and on improved pollution instrumentation and measurement.

IMPROVING LAND USE

In recent years we have come to view our land as a limited and irreplaceable resource. No longer do we imagine that there will always be more of it over the horizon -- more woodlands and shorelands and wetlands -- if we neglect or overdevelop the land in view. A new maturity is giving rise to a land ethic which recognizes that improper land use affects the public interest and limits the choices that we and our descendants will have.

Now we must equip our institutions to carry out the responsibility implicit in this new outlook. We must create the administrative and regulatory mechanisms necessary to assure wise land use and to stop haphazard, wasteful, or environmentally damaging development. Some States are moving ahead on their own to develop stronger land-use institutions and controls. Federal programs can and should reinforce this encouraging trend.

National Land Use Policy Act

The National Land Use Policy Act, which I proposed to the Congress last year, would provide Federal assistance to encourage the States, in cooperation with local governments, to protect lands which are of critical environmental concern and to control major development. While not yet enacted, this measure has been the subject of much useful debate.

-- I propose amendments to this pending National Land Use Policy legislation which would require States to control the siting of major transportation facilities, and impose sanctions on any State which does not establish an adequate land use program.

Under these amendments, the State programs established pursuant to the act would not only have to embody methods for controlling land use around key growth-inducing developments such as highways, airports, and recreational facilities; the States would also have to provide controls over the actual siting of the major highways and airports themselves. The change recognizes the fact that these initial siting decisions, once made, can often trigger runaway growth and adverse environmental effects.

The amendments would further provide that any State that had not established an acceptable land use program by 1975 would be subject to annual reductions of certain Federal funds. Seven percent of the funds allocated under sections of the Airport and Airways Development Act, the Federal-Aid Highway Acts including the Highway Trust Fund, and the Land and Water Conservation Fund, would be withheld in the first year. An additional 7 percent would be withheld for each additional year that a State was without an approved land use program. Money thus withheld from noncomplying States would be allocated among States which did have acceptable programs.

These strong new amendments are necessary in view of the significant effect that Federal programs, particularly transportation programs, have upon land use decisions.

Protection of Wetlands

The Nation's coastal and estuarine wetlands are vital to the survival of a wide variety of fish and wildlife; they have an important function in controlling floods and tidal forces; and they contain some of the most beautiful areas left on this continent. These same lands, however, are often some of the most sought-after for development. As a consequence, wetland acreage has been declining as more and more areas are drained and filled for residential, commercial, and industrial projects.

My National Land Use Policy Act would direct State attention to these important areas by defining wetlands among the "environmentally critical areas" which it singles out for special protection, and by giving priority attention to the coastal zones. I propose to supplement these safeguards with new economic disincentives to further discourage unnecessary wetlands development.

-- I propose legislation to limit applicability of certain Federal tax benefits when development occurs in coastal wetlands.

Management of Public Lands

During 1971, I acted to strengthen the environmental requirements relating to management and use of the Nation's vast acreage of federally-owned public lands administered by the Department of the Interior. I proposed new legislation to establish an overall

management policy for these public lands, something which we have been without for far too long. This legislation, still pending before the Congress, would direct the Secretary of the Interior to manage our public lands in a manner that would protect their environmental quality for present and future generations. The policy which it would establish declares the retention to the public lands to be in the national interest except where disposal of particular tracts would lead to a significant improvement in their management, or where the disposal would serve important public objectives which cannot be achieved on non-public lands.

PROTECTING OUR NATURAL HERITAGE

Wild places and wild things constitute a treasure to be cherished and protected for all time. The pleasure and refreshment which they give man confirm their value to society. More importantly perhaps, the wonder, beauty, and elemental force in which the least of them share suggest a higher right to exist -- not granted them by man and not his to take away. In environmental policy as anywhere else we cannot deal in absolutes. Yet we can at least give considerations like these more relative weight in the seventies, and become a more civilized people in a healthier land because of it.

Predator Control

Americans today set high value on the preservation of wildlife. The old notion that "the only good predator is a dead one" is no longer acceptable as we understand that even the animals and birds which sometimes prey on domesticated animals have their own value in maintaining the balance of nature.

The widespread use of highly toxic poisons to kill coyotes and other predatory animals and birds is a practice which has been a source of increasing concern to the American public and to the Federal officials responsible for the public lands.

Last year the Council on Environmental Quality and the Department of the Interior appointed an Advisory Committee on Predator Control to study the entire question of predator and related animal control activities. The Committee found that persistent poisons have been applied to range and forest lands without adequate knowledge of their effects on the ecology or their utility in preventing losses to livestock. The large-scale use of poisons for control of predators and field rodents has resulted in unintended losses of other animals and in other harmful effects on natural ecosystems. The Committee concluded that necessary control of coyotes and other predators can be accomplished by methods other than poisons.

Certainly, predators can represent a threat to sheep and some other domesticated animals. But we must use more selective methods of control that will preserve ecological values while continuing to protect livestock.

-- I am today issuing an Executive Order barring the use of poisons for predator control on all public lands. (Exceptions will be made only for emergency situations.) I also propose legislation to shift the emphasis of the current direct Federal predator control program to one of research and technical and financial assistance to the States to help them control predator populations by means other than poisons.

Endangered Species

It has only been in recent years that efforts have been undertaken to list and protect those species of animals whose continued existence is in jeopardy. Starting with our national symbol, the bald eagle, we have expanded our concern over the extinction of these animals to include the present list of over 100. We have already found, however, that even the most recent act to protect endangered species, which dates only from 1969, simply does not provide the kind of management tools needed to act early enough to save a vanishing species. In particular, existing laws do not generally allow the Federal Government to control shooting, trapping, or other taking of endangered species.

-- I propose legislation to provide for early identification and protection of endangered species. My new proposal would make the taking of endangered species a Federal offense for the first time, and would permit protective measures to be undertaken before a species is so depleted that regeneration is difficult or impossible.

Migratory Species

The protection of migratory species, besides preserving wildlife values, exemplifies cooperative environmental effort among the United States, Canada, and Mexico. By treaties entered into among these three countries, migratory species are protected. New species may be added by common agreement between the United States and Mexico.

-- I have authorized the Secretary of State, in conjunction with the Secretary of the Interior, to seek the agreement of the Mexican Government to add 33 new families of birds to the protected list.

Included in the proposal are eagles, hawks, falcons, owls, and many of the most attractive species of wading birds. I am hopeful that treaty protection can be accorded them in the near future.

Big Cypress National Fresh Water Reserve

After careful review of the environmental significance of the Big Cypress Swamp in Florida, particularly of the need for water from this source to maintain the unique ecology of Everglades National Park, I directed the Secretary of the Interior to prepare legislation to create the Big Cypress National Fresh Water Reserve. This legislation, which has now been submitted to the Congress, will empower the Federal Government to acquire the requisite legal interest in 547,000 acres of Big Cypress.

New Parklands at the Gateways

The need to provide breathing space and recreational opportunities in our major urban centers is a major concern of this Administration. Two of the Nation's major gateways to the world -- New York City and San Francisco -- have land nearby with exceptional scenic and recreational potential, and we are moving to make that land available for people to enjoy. In May of 1971, I proposed legislation to authorize a Gateway National Recreation Area in New York and New Jersey. This proposal would open to a metropolitan region of more than 14 million people a National Recreation Area offering more than 23,000 acres of prime beaches, wildlife preserves, and historical attractions including the nation's oldest operating lighthouse.

On our western shore lies another area uniquely appropriate for making recreational and scenic values more accessible to a metropolitan community.

-- I propose legislation to establish a Golden Gate National Recreation Area in and around San Francisco Bay.

This proposal would encompass a number of existing parks, military reservations, and private lands to provide a full range of recreation experiences. Altogether, the area would encompass some 24,000 acres of fine beaches, rugged coasts, and readily accessible urban parklands, extending approximately 30 miles along some of America's most beautiful coastline north and south of Golden Gate Bridge. Angel and Alcatraz Islands in the bay would be within the boundaries of the National Recreation Area, as would a number of properties on the mainland which afford magnificent views of the city, the bay and the ocean. As part of this plan, I am directing that the Presidio at San Francisco be opened for dual military and civilian recreational uses.

Converting Federal Properties to Parks

Among the most important legacies that we can pass on to future generations is an endowment of parklands and recreational areas that will enrich leisure opportunities and make the beauties of the earth and sea accessible to all Americans. This is the object of our Legacy of Parks program, initiated early in 1971. As part of this program, I directed the Property Review Board to give priority to potential park and recreation areas in its search for alternative uses of federally held real property. The results of this search so far have been most encouraging. To the original 40 properties which I announced in my Environmental Message of 1971 as being well suited for park use, another 111 prospects have been added. And from this total of 151 prospective parklands, 63 have already been made available.

-- Today I am pleased to announce that 20 more parcels of Federal land are being made available for park and recreation use.

These newest parcels, combined with those which have been announced over the past year, provide a legacy of 83 parklands for America which comprise 14,585 acres in 31 States and Puerto Rico. The estimated fair market value of these properties is over $56 million. In the months to come, every effort will be made to extend this legacy to all 50 States. The green spaces and natural retreats that we tend to take for granted will not be available for future enjoyment unless we act now to develop and protect them.

Wilderness Areas

One of the first environmental goals I set when I took office was to stimulate the program to identify and recommend to the Congress new wilderness areas. Although this program was behind schedule at that time, I am now able to report that the September, 1974 statutory deadline for reviews can and will be met.

The Wilderness Act of 1964 set aside 54 areas, consisting of about 9.1 million acres, as the nucleus of our wilderness system. Since then, 33 new areas totalling almost 1.2 million acres within National Forests, National Parks, and National Wildlife Refuges have been added to the system. Thirty-one areas totalling about 3.6 million acres, including 18 areas submitted by this Administration, have been proposed to the Congress but have yet to be acted upon. One of the most significant elements of this process has been the active participation by the public in all of its phases. At public wilderness hearings held all across the country, fair consideration has been given to all interests and points of view, with constructive citizen involvement in the decision-making process.

-- I am today proposing 18 new wilderness areas which, when approved, will add another 1.3 million acres to the wilderness system.

Eight of these proposals are within the National Forests, four are within National Park areas, and six are in National Wildlife Refuges.

Of these areas, 1.2 million acres would be in the following National Forests: Blue Range National Forest, Arizona and New Mexico; Agua Tibia and Emigrant National Forests, California; Eagles Nest and Weminuche National Forests, Colorado; Mission Mountains National Forest, Montana; Aldo Leopold National Forest, New Mexico; and Glacier National Forest, Wyoming.

A total of 40,000 acres would be in our National Park system in the following locations: Black Canyon of the Gunnison National Monument, Colorado; Bryce Canyon National Park, Utah; Chiricahua National Monument, Arizona; Colorado National Monument, Colorado.

Finally, a total of 87,000 acres would be in areas administered by the Fish and Wildlife Services of the Department of the Interior in the following locations: St. Marks, National Wildlife Refuge, Florida; Wolf Island, National Wildlife Refuge, Georgia; Moosehorn National Wildlife Refuge, Maine; San Juan Islands, National Wildlife Refuge, Washington; Cape Romain, National Wildlife Refuge, South Carolina; and Bosque del Apache, National Wildlife Refuge, New Mexico.

The year 1972 can bring some of the greatest accomplishment in wilderness preservation since passage of the Wilderness Act in 1964. I urge prompt and systematic consideration by the Congress of these 18 new proposals and of the 31 currently pending before it. Approval of all 49 additions would bring the system up to a total of over 15 million acres.

Unfortunately, few of these wilderness areas are within easy access of the most populous areas of the United States. The major purpose of my Legacy of Parks program is to bring recreation opportunities closer to the people, and while wilderness is only one such opportunity, it is a very important one. A few of the areas proposed today or previously are in the eastern sections of the country, but the great majority of wilderness areas are found in the West. This of course is where most of our pristine wild areas are. But a greater effort can still be made to see that wilderness recreation values are preserved to the maximum extent possible, in the regions where most of our people live.

-- I am therefore directing the Secretaries of Agriculture and the Interior to accelerate the indentification of areas in the Eastern United States having wilderness potential.

Off-road Vehicles

A recent study by the Department of the Interior estimated that Americans own more than 5 million off-road recreational vehicles -- motorcycles, minibikes, trail bikes, snowmobiles, dune-buggies, all-terrain vehicles, and others. The use of these vehicles is dramatically on the increase: data show a three-fold growth between 1967 and 1971 alone.

As the number of off-road vehicles has increased, so has their use on public lands. Too often the land has suffered as a result. Increasingly, Federal recreational lands have become the focus of conflict between the newer motorized recreationist and the traditional hiker, camper, and horseback rider. In the past, Federal land-management agencies have used widely varying approaches to dealing with this conflict. The time has come for a unified Federal policy toward use of off-road vehicles on Federal lands.

-- I have today signed an Executive Order directing the Secretaries of Agriculture, Interior, Army and the Board of Directors of the Tennessee Valley Authority to develop regulations providing for control over the use of off-road vehicles on Federal lands.

They will designate areas of use and non-use, specify operating conditions that will be necessary to minimize damage to the natural resources of the Federal lands, and ensure compatibility with other recreational uses, taking into account noise and other factors.

EXPANDING INTERNATIONAL COOPERATION ON THE ENVIRONMENT

We are now growing accustomed to the view of our planet as seen from space -- a blue and brown disk shrouded in white patches of clouds. But we do not ponder often enough the striking lesson it teaches about the global reach of environmental imperatives. No matter what else divides men and nations, this perspective should unite them. We must work harder to foster such world environmental consciousness and shared purpose.

United Nations Conference on the Human Environment

To cope with environmental questions that are truly international, we and other nations look to the first world conference of governments ever convened on this subject: the United Nations Conference on the Human Environment, to be held in Stockholm, Sweden, in June of this year. This should be a seminal event of the international community's attempt to cope with these serious, shared problems of global concern that transcend political differences.

But efforts to improve the global environment cannot go forward without the means to act.

-- To help provide such means, I propose that a voluntary United Nations Fund for the Environment be established, with an initial funding goal of $100 million for the first 5 years.

This Fund would help to stimulate international cooperation on environmental problems by supporting a centralized coordination point for United Nations activities in this field. It would also help to bring new resources to bear on the increasing number of worldwide problems through activities such as monitoring and cleanup of the oceans and atmosphere.

-- If such a Fund is established, I will recommend to the Congress that the United States commit itself to provide its fair share of the Fund on a matching basis over the first 5 years.

This level of support would provide startup assistance under mutually agreed-upon terms. As these programs get underway, it may well be that the member nations will decide that additional resources are required. I invite other nations to join with us in this commitment to meaningful action.

Control of Marine Pollution

Ocean pollution is clearly one of our major international environmental problems. I am gratified that in the past year the Congress has taken several steps to reduce the risks of oil spills on the high seas. However, further congressional action is needed to ratify several pending international conventions and to adopt implementing legislation for the various oil-spill conventions which have been ratified or which are awaiting approval.

Action on these recommendations will complete the first round of international conventions to deal with marine pollution. We have taken initiatives in three international forums to develop a second and more sophisticated round of agreements in this area. We are preparing for a 1973 Intergovernmental Maritime Consultative Organization (IMCO) Conference to draft a convention barring intentional discharges to the sea of oil and hazardous substances from ships. In conjunction with the Law of the Sea Conference scheduled for 1973, we are examining measures to control the effects of developing undersea resources. And, in the preparatory work for the 1972 U.N. Conference on the Human Environment, progress has been made on an agreement to regulate the ocean dumping of shore-generated wastes, and further work in this area has been scheduled by IMCO. We hope to conclude conventions in each of these areas by 1973.

PROTECTING CHILDREN FROM LEAD-BASED PAINT

To many Americans, "environment" means the city streets where they live and work. It is here that a localized but acutely dangerous type of "pollution" has appeared and stirred mounting public concern.

The victims are children: the hazard is lead-based paint. Such paint was applied to the walls of most dwellings prior to the 1950's. When the paint chips and peels from the walls in dilapidated housing, it is frequently eaten by small children. This sometimes results in lead poisoning which can cause permanent mental retardation and occasionally death. We can and must prevent unnecessary loss of life and health from this hazard, which particularly afflicts the poorest segments of our population.

To help meet the lead-paint threat, the Department of Health, Education, and Welfare will administer grants and technical assistance to initiate programs in over 50 communities to test children in high-risk areas for lead concentrations. In addition, these programs will support the development of community organization and public education to increase public awareness of this hazard. Other Federal agencies are also active in the effort to combat lead-based paint poisoning. ACTION and other volunteers will assist city governments to help alleviate lead paint hazards. The Department of Housing and Urban Development is engaged in research and other actions to detect and eliminate this hazard.

The resources of the private sector should also be utilized through local laws requiring owners of housing wherever possible to control lead paint hazards.

ENLISTING THE YOUNG

The starting point of environmental quality is in the hearts and minds of the people. Unless the people have a deep commitment to the new values and a clear understanding of the new problems, all our laws and programs and spending will avail little. The young, quick to commit and used to learning, are gaining the changed outlook fastest of all. Their enthusiasm about the environment spreads with a healthy contagion: their energy in its behalf can be an impressive force for good.

more

Four youth participation programs of mutual benefit to the young and the Nation are now planned or underway:

Last October, I initiated the Environmental Merit Awards Program. This program, directed by the Environmental Protection Agency in cooperation with the U. S. Office of Education, awards national recognition to successful student projects leading to environmental understanding or improvement. Qualifications for the awards are determined by a local board consisting of secondary school students, faculty, and representatives of the local community. Already more than 2,000 high schools, representing all fifty States, have registered in the program.

The Department of Agriculture's expanded field scout demonstration program, designed to permit more effective pest control with less reliance on chemical pesticides, will employ thousands of high school and college students. These young people will be scouting cotton and tobacco pests in the coming growing season, and the program will be expanded to other crops in future years.

The Environmental Protection Agency has recently initiated in its Seattle regional office a pilot program using young people to assist the agency in many of its important tasks, including monitoring. EPA is working with State and local pollution control agencies to identify monitoring needs. ACTION and the youth training programs are providing the manpower. If this initial program proves successful, the concept will be expanded.

ACTION volunteers and young people employed through the Neighborhood Youth Corps, Job Corps, and college work-study programs will work with city governments to help alleviate lead paint hazards, gaining experience in community health work as they give urgently needed aid to inner-city families.

Young people working on environmental projects, learning the skills necessary for a particular job, must also understand how their work relates to the environmental process as a whole. Thus, all of these activities must be supplemented by continued improvement in many aspects of environmental education to help all of our citizens, both young and old, develop a better awareness of man's relation to his environment. In my first Environmental Quality Report, I stressed the importance of improving the Nation's "environmental literacy." This goal remains as important as ever, and our progress toward it must continue.

ONE DESTINY

Our destiny is one: this the environmental awakening has taught America in these first years of the seventies. Let us never forget, though, that it is not a destiny of fear, but of promise. As I stated last August in transmitting the Second Annual Report of the Council on Environmental Quality: "The work of environmental improvement is a task for all our people... The achievement of that goal will challenge the creativity of our science and technology, the enterprise and adaptability of our industry, the responsiveness and sense of balance of our political and legal institutions, and the resourcefulness and the capacity of this country to honor those human values upon which the quality of our national life must ultimately depend." We shall rise to the challenge of solving our environmental problems by enlisting the creative energy of all of our citizens in a cause truly worthy of the best that each can bring to it.

While we share our environmental problems with all the people of the world, our industrial might, which has made us the leader among nations in terms of material well-being, also gives us the responsibility of dealing with environmental problems first among the nations. We can be proud that our solutions and our performance will become the measure for others climbing the ladder of aspirations and difficulties; we can set our sights on a standard that will lift their expectations of what man can do.

The pursuit of environmental quality will require courage and patience. Problems that have been building over many years will not yield to facile solutions. But I do not doubt that Americans have the wit and the will to win -- to fulfill our brightest vision of what the future can be.

RICHARD NIXON

THE WHITE HOUSE,

February 8, 1972.

# # # # #

Report to Dr. Edward E. David, Jr.
Science Adviser to the President

An ad hoc Panel to Advise on National Water Quality Problems

Summary Report

On December 6, 1971, a panel of water quality specialists met at the invitation of Dr. Edward E. David, Jr., to consider national water quality problems with particular reference to the water quality legislation presently before the Congress. The panel believes that at this time there is a need to reaffirm rational water quality planning and management based on stream quality as the measure of the program, with economic justification for the actions necessary to achieve and maintain a high standard of water quality. Accordingly, the panel is firmly of the view that water quality standards and not effluent standards should be the guiding principle for water quality management. In calculating the costs and benefits of water quality management, all economic, social and environmental costs and benefits from both the short-term and long-term points of view must be recognized.

The legislation now before Congress contains a number of important and fundamental policy changes, some of which are—

1. The national goal that "the discharge of pollutants into the navigable waters be eliminated". The panel is firmly of the opinion that such a goal may be unrealistic as well as being undesirable from both the economic and environmental points of view. The panel recommends the abandonment of this goal. Instead, it suggests that water pollution should properly be defined as a man-made alteration of the physical, biological, chemical or radiological characteristics of a body of water so as to inhibit or otherwise affect the suitability of that water for a specified purpose. Thus pollution represents inappropriate use of our waters and it is this kind of use that should be prohibited.

2. The use of a national uniform water quality standard. Part of the strength of the United States is in its diversity. An appropriate water quality strategy will recognize this and reinforce it rather than impose a uniform treatment standard which in some cases is uneconomical and in limited circumstances even counterproductive. Both the standard of uniform secondary waste treatment for communities and technology based standards are examples of arbitrary decisions that can impede an optimal strategy of water quality management.

3. Increased Federal role in cost-sharing for treatment plant construction. The panel believes it is unwise to modify the current federal formula of supporting 30 to 55 percent of capital costs. The reasons for this include the unsettling effect changes have on the states and local governments, and as it encourages procrastination while awaiting more favorable future support.

4. Erosion of the states' role in water quality management. The panel views with concern the fact that the role of the states in the regulation of water quality control is further attenuated by the proposed legislation. It believes there are appropriate organizational roles in water quality management for the states and other levels of government, as well as for effective multipurpose regional institutions with responsibility for water quality management.

The panel is firmly of the opinion that the water quality legislation presently before the Congress, S. 2770 and H. R. 11895, is unsatisfactory as it stands and recommends that it be modified substantially.

The full report of the panel is attached.

Report to Dr. Edward E. David, Jr.
Science Adviser to the President

An ad hoc Panel to Advise on National Water Quality Problems

On December 6, 1971, a panel of water quality specialists as listed on the attachment, met at your invitation to consider national water quality problems with particular reference to the legislation presently before the Congress, namely S. 2770 and H. R. 11895, the "Federal Water Pollution Control Act Amendments of 1971."

This panel shares the concern expressed by the Senate in not being satisfied with the progress that has been made to date in keeping pace with the water quality problems of this Nation. It believes that the progress up to now has been less than what it might have been, partly on account of insufficient funds having been allocated for this purpose and partly because the money spent has been poorly allocated. In addition, the institutions responsible for water quality control have often been inappropriately empowered and hence have not commonly considered the broad range of alternatives possible in water quality management but rather have emphasized the construction of waste treatment plants.

At this time there is a need to reaffirm rational water quality planning and management based on stream quality as the measure

of the program, with economic justification for the actions necessary to achieve and maintain a high standard of water quality.

The valid objective of a water quality program is high quality for the Nation's waters. Accordingly, the panel is firmly of the view that water quality standards and not effluent standards should be the guiding principle for water quality management. The panel rejects the contention that stream quality and effluent characteristics cannot be satisfactory related. Effluent standards will follow from appropriate water quality standards and their derivation from suitable water quality standards can be accomplished with sufficient accuracy for these purposes.

The Nation's water quality standards should recognize all appropriate purposes for which waters are used or could be used. These uses must include due recognition of ecological and environmental concerns. Rational moves toward the attainment of these stream water quality standards must be dictated by a comprehensive examination of the costs and benefits of achieving them. Any calculation of costs and benefits must recognize all economic, social and environmental aspects of the costs and benefits from both the short-term and long-term points of view.

Management of water quality in this Nation with its diverse problems and conditions has an essential need for basic data plus

a continuing, multi-faceted research effort to refine and extend our ability to deal with our problems. It is gratifying to note that the Congress is aware of the need for more information and research to strengthen our water quality management.

The legislation now before Congress raises a number of important and fundamental policy issues, some of which are discussed below:

1. The national goal that "the discharge of pollutants into the navigable waters be eliminated"

The panel is firmly of the opinion that such a goal may be unrealistic as well as being undesirable. The economical costs in achieving or even approaching such a goal would be very great and would almost certainly in every instance constitute a misallocation of the Nation's resources. Removing the last few percent of the common pollutants from water is usually extremely costly, yet the added benefits due to the extra treatment to bring waste waters to high purity in that regard are extremely questionable in all cases. This is especially true when nonpoint sources of pollution make such extreme measures ineffective in the overall control of stream quality.

The panel recommends the abandonment of this goal. Instead, it is suggested that water pollution should properly be defined as a man-made alteration of the physical, biological, chemical or radiological characteristics of a body of water

so as to inhibit or otherwise affect the suitability of that water for a specified purpose. Another way of expressing this concept is that pollution is a result of "too much" of something. What is too much can be scientifically assessed with respect to the various uses and stated in the form of water quality criteria.

Whether or not a particular criterion should be applied to a waterway is dependent on a choice of what uses are to be protected. When this choice is made, the criterion becomes a standard and the standard represents the ability of the water to be used for the specified purposes. Thus pollution represents inappropriate use of our waters and it is this kind of use that should be prohibited.

Our society produces wastes, and rational management of them requires that we dispose of them in the most acceptable manner. Prohibiting all waste products from going into our Nation's waters means that these wastes unless they can be used constructively must inevitably be placed on the land or in the air. If in fact we stop all our wastes from going into the water, then the cost in both money and energy as well as in land and air pollution will be considerable. Raising water quality standards will increase sludge

disposal problems. Thus our water quality goals should not be set arbitrarly but so that we always make a net gain in environmental quality.

Legislating a goal of having no discharge of pollutants into our waters is an uneconomical, undesirable and possibly unattainable objective. A more appropriate goal is to legislate against polluting discharges as defined herein.

2. The Use of a national uniform water quality standard

Present legislative proposals impose a minimum standard for all communities of secondary waste treatment by 1976. While such a level of waste treatment may well be the desirable standard for most communities, a blanket uniform standard is inconsistent with the principle that our water quality management strategy should be tailored to individual water quality conditions and goals throughout the country. Part of the strength of the United States is in its diversity. An appropriate water quality strategy will recognize this and reinforce it rather than impose a uniform treatment standard which in some cases is uneconomical and in limited circumstances even counter-productive. By the same token, the principle of diversity and flexibility will commend a broad range of techniques for achieving particular water quality standards. These

techniques may include effluent controls, effluent taxes, permit systems, regional collection and treatment facilities and a variety of technical, economical and social devices, combinations of which may be best for particular situations.

While uniform secondary treatment for all communities may be a desirable target, it must be recognized that this level of treatment may not always be needed when it will cause unnecessary expenditure, when, for instance, suitable ocean disposal is available. In those cases where secondary treatment would deny potentially useful nutrients to the receiving waters, sewage should be treated to the extent that it has no deleterious effect on aquatic life. Whether or not secondary treatment is indicated in such circumstances must be determined on a case-by-case basis.

Attempting to attain uniform secondary treatment of municipal effluents in the next five years could also have other undesirable effects. It will seriously strain the ability of the construction industry to build the necessary facilities in the requisite time which could lead to inflation

of costs and probably delays in the completion of works--some of which may be badly needed. Such a crash program would likewise further extend the present shortage of waste treatment plant operators who are essential to the satisfactory performance of treatment works.

A strategy of water quality management based on stream standards will commonly but not always involve secondary treatment or better for municipal wastes. Arbitrary standards, which the requirement for secondary waste treatment is one, are no longer necessary. Today planning methods can determine economical solutions for regulating the quality of our streams tailored to the water quality goals and local conditions that prevail.

Similarly imposing treatment standards related to the state of technology is laudable in intent but is rigid and arbitrary. Pursuit of properly defined water quality goals using economical methods will of necessity use the best practical technology, as appropriate. To legislate an arbitrary but moving standard based on technology

imposes an unnecessary and possibly detrimental constraint on an optimal management strategy for our water quality.

3. Increased Federal role in cost-sharing for treatment plant construction

The panel is agreed that to date generally unsatisfactory progress has been made in improving the quality of our streams, lakes and estuaries. The question is what changes, if any, in laws and regulations will improve the rate of progress.

First, the panel believes there is undue impatience with progress to date through lack of appreciation for the complexity of the problems and the time and the money required to reverse the polluting policies of the past.

Secondly, by frequent changes of the rules, by promising goals which cannot be met or by demanding compliance which is unreasonable or impossible, there is a grave danger of losing credibility of the entire effort.

The panel believes it is unwise to modify the current federal formula of supporting 30 to 55 percent of capital costs, particularly because of the unsettling effect changes have

on the states and local governments, and as it encourages procrastination while awaiting more favorable future support.

The federal program of fiscal support for treatment plant construction is heavily capital-oriented and has added to local government budgets considerable capital and operating burdens which compete with other programs dependent on local support, such as education. In addition, it has been shown that for lower income groups, the added local tax impact of water quality programs is disproportionate to the benefits derived. To avoid compounding this problem, some form of continuing federal aid to local governments should be examined as a means of ensuring that inequities are minimized in paying for better water quality.

To encourage the best operation of treatment facilities, the panel would like to see innovation in the area of incentives with reward for superior performance of treatment plants.

The panel explicitly opposes a program of widespread support for construction to deal with the problem of combined sewers. Due to present lack of precise

knowledge of the importance of this problem and the alternative strategies for its solution, more research and demonstration is needed to define the problem and its optimum solutions.

4. Erosion of the states' role in water quality management

If there were lingering doubts about the primacy of the states in the regulation of water quality control, these doubts are effectively erased by the current proposed federal legislation. The states are told what they must do and when it is to be accomplished, and within a framework of constraints that are ill-defined. In brief, the states have been relegated to the role of regulatory puppets.

The Congress should now recognize the fact that the federal attenuation of states' prerogatives in the development of water quality control programs calls for a redefinition of states' roles and duties in advancing national aspirations. Precisely what these duties should be is a topic deserving of more consideration than this panel has been able to devote. However, one thing is clear under the proposed

legislation, namely that the states would no longer be permitted to exercise primary responsibility in water quality management. That responsibility even in such details as determining the appropriateness of user-charges is reserved to the Federal Administrator.

In any definition of appropriate organizational roles in water quality management, the panel believes there is a need to develop effective regional approaches including multipurpose institutions with responsibilities for functions including water quality management (planning and implementation.)

Recommendations

The panel is firmly of the opinion that the legislation before the Congress, S. 2770 and H. R. 11895, the "Federal Water Pollution Control Act Amendments of 1971," should be modified to embody substantive changes. The changes the panel considers essential in any revised legislation would recognize--

(1) That management of the quality of the Nation's waters should proceed from water quality standards based on

environmental criteria or potential use and a broad, flexible strategy of controlling effluents based on those water quality standards.

(2) That our water quality management program needs to maintain credibility of effort. It should embody a consistency of approach for instance in the federal participation in treatment works financing and not be changed for the sake of change. It should not embody an unattainable goal such as no discharge of pollutants nor should it impose undue burdens on the various levels of government or on other parts of our total environment.

(3) That our water quality management should be based on standards which are logically related to our water quality goals rather than on arbitrary standards. Arbitrary standards are unnecessary, may be undesirable and will lead to a less than optimal allocation of this Nation's resources.

(4) That there is an appropriate role to be played by local and state governments as well as by effective regional institutions with functions including water quality management. Federal actions should be supportive of these roles rather than preempting decisions which rightfully belong at other levels.

William C. Ackermann
Chairman of the ad hoc Panel

Attachment:
list of panel members

Ad hoc Panel on Water Quality

CHAIRMAN: Dr. William C. Ackermann
Chief, Illinois State Water Survey
Box 232
Urbana, Illinois 61802

MEMBERS

Dr. Rolf Eliasson
Professor of Environmental Engineering
Stanford University
Stanford, California 94305

Dr. Edward J. Cleary, Consultant
Ohio River Valley Water Sanitation Commission
Cincinnati, Ohio 45202

Dr. Marc J. Roberts
Associate Professor
Harvard University
Cambridge, Massachusetts 02140

Dr. Ruth Patrick
Academy of Natural Sciences
Philadelphia, Pennsylvania 19118

Dr. Joseph A. Mihursky
Natural Resources Institute
University of Maryland
Prince Frederick, Maryland 20678

Dr. Robert K. Davis
Research Professor
Natural Resources Policy Center
George Washington University
Washington, D. C.

12-21-71

President's Science Advisory Committee

Statement on Water Pollution Control

The President's Science Advisory Committee applauds the fact that Congress is presently striving to improve the nation's water pollution control strategy. This Committee also is concerned that to date too little has been achieved in dealing with this ever-mounting problem.

Present federal water quality policy is based on several principles that appear to us sound. These principles should be strengthened and pursued vigorously, not abandoned. We must maintain and raise the capacity of our streams to support a desirable, balanced pattern of uses. This requires reducing in many places the discharge of pollutants into navigable streams, but with a proper sense of specific quality goals for specific streams. The present framework for setting stream quality standards and supporting the construction of improved treatment facilities for discharges are consonant with those national goals.

In its frustration with past performance, the nation should be wary of discarding present approaches in favor of an impractical alternative at the expense of sounder approaches. Living inevitably generates wastes, part of which must ultimately be discharged into the water, the land, or the air. Therefore, our water quality problem must be dealt with as part of an over-all waste management problem involving air pollution and solid waste management as well. This calls for a systems approach in developing a national strategy.

Many experts in the water pollution control field have expressed doubts about the wisdom of proceeding as outlined in S. 2770. Therefore, PSAC strongly urges that the Congress give consideration to asking an independent group of scientists and engineers such as the National Academy of Sciences to examine the social, economic, and environmental implications of setting a 1985 goal of no discharge of pollutants to our waters, in relation to alternative approaches. With the benefit of this study, Congress will be in a stronger position to set our national course for an optimum water quality management strategy for the years ahead.

12-20-71

PRESIDENT'S SCIENCE ADVISORY COMMITTEE

Statement on the Nation's Water Pollution Control Strategy

Water is a resource, a resource used for recreation, for domestic purposes, to support natural ecological systems, for irrigation, in producing goods and services, and to absorb and recondition wastes. As with other resources, the central problem of social policy is to allocate water among its many competing potential uses in a balanced and rational way. Managing water in the interests of a single use, and discounting the problems that would arise from dispensing with its other uses, is not a balanced and rational policy. Several of the provisions of the proposed legislation appear to us to reflect such an imbalance.

Present federal water quality policy is based on several principles that appear to us sound. These principles should be strengthened and pursued vigorously, not abandoned.

The national goal must be to achieve a better human use of all our resources -- water, air, land and minerals, without managing one in such a way as to impose undesirable burdens on others. As far as water is concerned, we must maintain and raise the capacity of our streams to support a desirable, balanced pattern of uses. This requires reducing in many places the discharge of pollutants into navigable streams, but with a proper sense of specific quality goals for specific streams. The present framework for setting stream quality standards and supporting the construction of improved treatment facilities for discharge are

consonant with those national goals; a statement that "the discharge of pollutants into the navigable waters be eliminated" is not.

To achieve a desirable water quality policy, we need to maintain and strengthen our system for moving toward regional water quality standards, based on regional patterns of water use [needs] and regional priorities. A national uniform water quality standard would impede, not accelerate, this progress.

Setting unrealistic standards for the nation's streams -- standards that focus on an abstraction called "pure water" without careful consideration of the uses to which water is put and the desirable quality standards that are consistent with these uses -- impose unnecessary burdens on our nation's resources and will not provide an effective route toward improved water quality.

We recommend that the proposed legislation be modified substantially so as to reflect the goals of balanced resource use outlined here and to eliminate provisions, like those mentioned specifically here, that ignore the problems of balance.

ICAS Report No. 15a
June 1971

A National Program for Accelerating Progress in Weather Modification

Interdepartmental Committee
for
Atmospheric Sciences

FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY
Executive Office of the President

FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY

EDWARD E. DAVID, Jr., Chairman
Science Adviser to the President

NED D. BAYLEY
Department of Agriculture

JAMES H. WAKELIN, Jr.
Department of Commerce

ROGER O. EGEBERG
Department of Health, Education, and Welfare

WILLIAM T. PECORA
Department of the Interior

WILLIAM D. McELROY
National Science Foundation

ROBERT H. CANNON, Jr.
Department of Transportation

JOHN D. DARROCH (Observer)
Council of Economic Advisers

STANLEY M. GREENFIELD (Observer)
Environmental Protection Agency

WILLIAM A. ANDERS (Observer)
National Aeronautics and Space Council

DONALD B. RICE (Observer)
Office of Management and Budget

LYNDON E. LEE (Observer)
Veterans Administration

GLENN T. SEABORG
Atomic Energy Commission

JOHN S. FOSTER, Jr.
Department of Defense

HAROLD B. FINGER
Department of Housing and Urban Development

Dr. George M. Low
National Aeronautics and Space Administration

HERMAN POLLACK
Department of State

SPURGEON M. KEENY, Jr. (Observer)
Arms Control and Disarmament Agency

RUSSELL E. TRAIN (Observer)
Council of Environmental Quality

IRVING SLOTT (Acting) (Observer)
Department of Justice

JOHN OLIVER WILSON (Observer)
Office of Economic Opportunity

S. DILLON RIPLEY
Smithsonian Institution

LAWRENCE A. GOLDMUNTZ
Executive Secretary

INTERDEPARTMENTAL COMMITTEE FOR ATMOSPHERIC SCIENCES

CARL H. SAVIT, Chairman
Office of Science and Technology

EDWARD P. TODD
National Science Foundation

ROBERT M. WHITE
Department of Commerce

STANLEY M. GREENFIELD
Environmental Protection Agency

RUDOLF ENGELMANN
Atomic Energy Commission

HERMAN POLLACK
Department of State

ARNOLD G. SKRIVSETH (Observer)
Federal Communications Commission

DAVID LAWHEAD (Observer)
Office of Management and Budget

CLAYTON E. JENSEN (Observer)
Interdepartmental Committee for Applied Meteorological Research

THEODORE C. BYERLY
Department of Agriculture

GUS D. DOROUGH
Department of Defense

HOMER E. NEWELL
National Aeronautics and Space Administration

JAMES KERR (Acting)
Department of the Interior

JOSEPH F. SOWAR
Department of Transportation

HAROLD B. FINGER
Department of Housing and Urban Development

JOHN R. SIEVERS (Observer)
National Academy of Sciences

SIDNEY N. GRAYBEAL (Acting) (Observer)
Arms Control and Disarmament Agency

SHERMAN W. BETTS
Executive Secretary

This Program was approved by the Federal Council

for Science and Technology on July 27, 1971

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY
Washington, D. C. 20506

Release: For release Sunday AMs
October 10, 1971

For further information contact:
Capt. W. S. Betts
Interdepartmental Committee for
Atmospheric Sciences, Wash., D. C.
(202) 967-2310

WASHINGTON -- The Federal Council for Science and Technology today consolidated a number of prime government weather modification efforts into seven key projects as a prelude to actual operational weather control.

One now underway actually involves weather manipulation. It is a pilot project of controlled cloud seeding by which the Bureau of Reclamation of the Department of Interior is attempting to increase the snowpack in the Colorado River Basin for five consecutive winters.

According to Dr. Edward E. David, Jr., Chairman of FCST and the Science Adviser to the President, the seven projects should remove most of the remaining technical barriers to operational snow diversion, rain-making, fog dispersion, hurricane modification and lightning and hail modification.

The Colorado River pilot project's aim is to store water in the form of snow. As the snow melts, towards the spring runoff, it then recharges the reservoirs from which water is distributed for use throughout the Southwest and Mexico during dry seasons.

Colorado River snowpack is concentrated at altitudes of 9,500 feet or more in a 14,000 square mile area. This represents some 10 per cent of the entire river basin. The pilot project involves only 2,200 miles of that total, part of the San Juan Mountains of Colorado.

Planners anticipate a 15- to-20 per cent increase in water runoff in the test section.

If the same augmentation were achieved operationally over the entire snowpack area, some 400,000 acre/feet of water (the amount required to cover an acre to a depth of one foot) in an area where water costs up to $50 per acre/foot, it would not only add to the water available but might even bring the price down.

The estimated cost for producing each additional acre foot is only $1.50. If the entire 14,000 mile area of the upper Colorado were seeded, as much as two million acre/feet worth $100 million could be produced.

- MORE -

The FCST report also called for a national repository of weather modification data and additional support of basic research in the chemistry and physics of weather modification which are not part of the seven key projects. Both, it felt, would "insure the earliest practical availability of operational technology."

Weather modification is now being widely used abroad, particularly in the Soviet Union for hail suppression. The FCST report contains a section on the state of weather modification both here and abroad.

All seven projects are keyed to the fact that silver iodide crystals introduced into clouds form nuclei around which ice crystals form. How and where they form has important implications for cloud dynamics and the release of both heat and moisture, the controlling factors in weather systems.

The six remaining projects are more research-oriented. Three of them are being conducted with the National Oceanic and Atmospheric Administration as lead agency. They are:

A hurricane modification project designed to work out seeding techniques which will reduce the maximum wind velocities of these storms and development of mathematical (computer) models of hurricanes;

A snow redistribution experiment designed to test the feasibility of directing snowfall inland from -- rather than on -- the shores of Lake Erie, and;

A cumulus cloud modification project to increase rainfall in specific areas.

The U. S. Forest Service of the Department of Agriculture will try to modify the lightning potential of summer storms as a means of preventing forest fires.

The Federal Aviation Agency of the Department of Transportation will try to develop a low cost fog dispersion system involving mathematical modeling and work out a basic understanding of how and why fog forms. The National Science Foundation will attempt to work out seeding technology and mathematical models aimed at reducing hail damage without interfering with rainfall.

- - 30 - -

\# \# \#

(The report is available from Capt. W. S. Betts, Interdepartmental Committee for Atmospheric Sciences, Department of Commerce, Washington, D. C. 20230.)

CONTENTS

SUMMARY

This report proposes a program for accelerating national progress in the management of our national resources through a structured attack on certain defined objectives in the area of weather modification. National needs have been identified. Research efforts which have clear near term potential for meeting these needs have been identified as National Projects. A special designation of National Pilot Project has been assigned for one activity designed to gain experience with operational problems. Lead agencies have been recommended and pertinent multiagency assistance has been proposed to accelerate progress in each Project.

National Projects represent an increased emphasis on about one-half of the existing weather modification research and development programs; some $9 million of a FY 1972 $20 million program. The fact that socioeconomic, legal and ecological considerations must play the dominant role in determing the operational readiness of any technological system which may affect the environment of large segments of the population is recognized.

The proposed National Projects and Lead Agencies are:

National Colorado River Basin Pilot Project - Bureau of Reclamation
To test the feasibility of applying a cloud seeding technology, proven effective under certain conditions, to a river basin for a winter season to augment the seasonal snowpack.

National Hurricane Modification Project - National Oceanic and Atmospheric Administration
To develop a seeding technology and associated mathematical models to reduce the maximum surface winds associated with hurricanes.

National Lightning Suppression Project - Forest Service
To develop a seeding technology and associated physical and mathematical models to reduce the frequency of forest fire-starting lightning strokes from cumulonimbus clouds.

National Cumulus Modification Project - National Oceanic and Atmospheric Administration
To develop a seeding technology and associated mathematical models to promote the growth of cumulus clouds in order to increase the resulting natural rainfall in areas where needed.

National Hail Research Experiment - National Science Foundation
To develop a seeding technology and associated mathematical models to reduce the incidence of damaging hailfall from cumulonimbus clouds without adversely affecting the associated rainfall.

National Great Lakes Snow Redistribution Project - National Oceanic and Atmospheric Administration
To develop a seeding technology and associated mathematical models to spread the heavy snowfall of the Great Lakes coastal region farther inland.

National Fog Modification Project - Federal Aviation Administration
To develop seeding or other technology and associated physical and mathematical models to improve the visibility in warm and cold fogs where and to the extent needed.

Each of the National Projects has a background of years of research. That research has, within the last few years, developed a combination of theoretical knowledge and associated mathematical models, supported in varying degrees by field experimental data, which indicates that technology now available is nearly ready for regular application. Organization of these activities into National Projects has been recommended, with specific multi-agency participation, to insure the earliest practicable availability of operational technology.

In addition to the special support for these National Projects a significant increase in relevant broad background research and development support is also needed. This is particularly needed in the areas of nuclei counting and efficiency assessment, the physical chemistry of nucleating agents, the microphysics and dynamics of mesoscale systems, mesoscale mathematical models, and cloud physics instrumentation, such as doppler radars and microwave sensors.

Specific recommendations are also made to establish a national depository for weather modification data, for the study of and effective handling of the socioeconomic legal aspects for the future, and for certain ecological and hydrological studies to be performed.

Chapter I.

INTRODUCTION

Bjerknes said, "Man is born, lives, and dies in an ocean of air called the atmosphere."

The extent and capricious behavior of this atmosphere has amazed and terrified man throughout the ages. Over the same period, it has sustained him with water for his crops and with power to drive his mills. Today, under the pressure of the social needs of a burgeoning population man can no longer be content to bear stoically the extremes of nature's favors.

In the recent past, many individuals, groups, and organizations have conducted weather modification studies and carried out field experiments, cooperatively and otherwise, on behalf of their individual and often mutual interests. This storehouse of scientific knowledge, and the extensive field experience, derived over the past 25 years by the Federal, academic, and industrial community combined with newly developed instrumentation and computer technology, must now be applied to the problem of managing effectively one significant segment of our environment for the benefit of mankind.

Specifically, the areas considered for a coordinated national effort to meet identified national needs are precipitation management for water resources, reduction of damage from hail, lightning, and violent storms, and improvement of visibility in fogs. Our state of knowledge and operational readiness is greater in some areas than in others. However, some beneficial results can now be achieved for our economy and ecology. Attainment of these goals will provide man with more food, more power, and better environment and, above all, more peace of mind. The estimated cost of such a program is small compared to the cost of inaction.

The potential benefits to various segments of the national economy are reasonably clear, although not quantitatively precise. It appears, however, that the ultimate application of the technologies under development to the pertinent problems involved, could result in benefit-cost ratios of from 2 to 1 up to 20 to 1.

In areas served by the Colorado River Basin, where, for just the irrigation benefits, increased water is worth up to $50 per acre-foot per year, conservative indications are that the increase in runoff resulting from the planned snowpack augmentation program will amount to over 2,000,000 acre-feet at a cost of about $1.50 per acre-foot. The increased capability for power generation, alleviation of critical shortages, and salinity control are bonuses which would insure the maintenance of very favorable benefit-cost ratios.

Hurricane damage in the United States averages about $500 million per year. Recent results of the joint hurricane modification Project Stormfury indicate a potential for reducing maximum surface winds by 10 to 20%. Possible reductions in damage of considerably more than 10%, coupled with the possibility of saving even a few lives, indicate a favorable return on funds supporting Stormfury.

Over two million acres of forests in the western United States are burned annually by lightning-caused fires. To the terrible although indeterminate cost of such forest fires must be added the cost of about $100 million and some human lives each year fighting the fires. Experiments conducted over a limited area of the Northern Rocky Mountains by the Forest Service Project Skyfire indicate a reduction of over 50 percent in fire-starting lightning activity. These results promise a very favorable benefit-cost ratio for a lightning suppression program.

In certain areas, such as the Florida peninsula, traversed by moisture-laden but sometimes nonprecipitating or very lightly precipitating cumulus clouds, increases in precipitation can be accomplished by cloud seeding. In some areas during periods of local need, such augmentation of rain can be worth $50 per acre-foot and recent experiments indicate that in limited areas, rainfall augmentation can be accomplished for less than $1 per acre-foot.

Annual hail damage in the United States amounts to over $300 million. Where limited areas of certain crops have been "protected" by commercial seeding operations, reported benefit-cost ratios have been generally better than 2 to 1. The development of adequate models of hail producing clouds and consistently effective seeding techniques should insure effective protection of high priority areas at very favorable benefit-cost ratios.

Annual snow removal costs for the City of Buffalo amount to about $2 million. Potential amelioration of associated social and economic problems in a high population density area added to the reduction of excessive snow removal costs calls for continuing experimental efforts to delineate the capability and to develop an economically effective technology for reducing the intensity of major lake-effect snowstorms.

Annual costs to the U. S. airlines of delays caused by warm fogs at airports are over $75 million. Highway and harbor fogs add considerably to this figure in terms of transportation delays, damages, injuries and deaths. Thus warm fog modification possibilities under investigation warrant intense efforts to develop effective techniques which can approach the better than 5 to 1 benefit-cost ratio for current cold fog modification activities at frequently affected airports.

If a program for accelerating progress in weather modification is to be successful, it must include careful consideration of the role that public perception of weather modification will play. In the past, public acceptance

of weather modification has varied widely across the nation. Indifference, amused tolerance, ardent advocacy, and violent opposition have all been evidenced. In the same year that citizens of South Dakota asked for Federal help in the institution of a statewide precipitation augmentation and hail suppression program, citizens of some eastern states were reported to be shooting at transient aircraft assumed to be conducting cloud seeding as part of a suspected Federal "plot" to cause widespread drought.

Experience has shown that adverse public reaction can easily force changes in the design or outright termination of weather modification projects. Acceptance of weather modification has been greatest where it has resulted from the initiative of local interests with local benefits in mind. Weather modification imposed from afar with no obvious local benefits, and perhaps even likely disbenefits in the experimental area, can be expected to generate intense public opposition.

Inclusion at an early time of respected local citizens in the planning and monitoring of weather modification activities has proven effective both in improving scheduling and design and in forestalling development of uninformed opposition.

Workable systems for weather modification must include three considerations. These are:

1. Scientific and engineering variables
2. Human variables
3. Resource variables

The program described in the following pages aims at accelerating progress in weather modification with due regard for all three.

Chapter II.

WHERE WE ARE NOW IN WEATHER MODIFICATION

Many people consider the terms weather modification and rainmaking to be synonymous because of the publicity given to the discovery of cold cloud modification to produce precipitation in the mid-1940's. In the mid-1930's, however, Massachusetts Institute of Technology scientists demonstrated a capability to dissipate warm fog by the application of calcium chloride solution distributed into a fog bank by spray nozzles. The uses of both freezing and hygroscopic nuclei to modify weather are still the primary tools of weather management to augment our atmospheric water resources and to reduce the hazards produced by weather.

Atmospheric Water Resources Management

Much of the present effort in weather modification today is being devoted to the objectives of clean water augmentation. Years of experience of private and public groups in efforts aimed at increasing the winter snowpack over mountain ranges for water and recreational use have now been acquired. In the spring the snowpack melts and provides the runoff for the river basin areas which produce water for urban use, electrical power generation, and irrigation. The meteorological circumstances under which cloud seeding will effect snowpack increases over the mountains have now been reasonably well identified, and in several locations this knowledge is well enough established to justify the initiation of pilot or preoperational tests directed toward obtaining answers to the economic aspects of water increases, operational procedures, and ecological consequences of such augmentation. At Climax, Colorado, where research on snowpack augmentation over the mountains has been conducted for a period of 6 years, it has been found that increases of over 100 percent in individual storm snowfalls can be expected if the temperature at the 500 millibar level, which is usually also the level of cloud tops, is between minus 12°C and minus 23°C when seeding is conducted. If the 500mb temperature is colder than minus 25°C, the effect of seeding is to reduce the amount of snow which would normally fall on the windward slopes. In some of the colder cases, snow reduction of up to 50 percent was observed. This is consistent with the physical behavior of natural and artificial ice nuclei. More important, it explains the sometimes erratic results of earlier tests in which seeding was done indiscriminately. Stratification of seeding criteria has also been made for various conditions of wind velocity, wind direction, lapse rate and other meteorological parameters, and optimum seeding limits have been established. If these criteria are carefully observed, positive augmentation due to seeding is almost assured in this locality.

Much remains to be learned of the basic meteorological processes which take place in the atmosphere before these successful techniques can be applied directly to other geographical areas having somewhat different meteorological environments. The establishment of adequate mathematical models to describe

and forecast the reaction of orographic clouds to seeding are now under development and show considerable promise of providing this universal capability in the near future. Improved methods of evaluating the results of modification are expected to also emerge from these basic model studies.

The augmentation of water from summer convective cloud systems has been tested in areas such as Florida, Arizona, and the midwestern Great Plains with mixed but lately encouraging results. Due to the fact that precipitation from these cloud systems is not confined to any particular groundwater system and normal precipitation patterns are so variable on an areal and temporal basis, it is difficult to evaluate either the economic or ecological impact of potential artificial augmentation attempts. In experiments conducted in Florida, observations of selected tropical clouds which have been seeded with silver iodide according to mathematical model prediction have indicated a growth in height averaging more than 10,000 feet over the unseeded systems and an increase of precipitation as deduced from radar measurements of approximately 100 acre-feet of water per cloud. This is a statistically significant increase in normal precipitation expectations of approximately 100 percent. With the improved capability to measure cloud parameters directly from instrumented aircraft or indirectly from the ground and the further development of forecasting capabilities using mathematical models, it would appear reasonable to expect that the stimulation of convective clouds in general will be advanced to operational usefulness if a national effort is focused on this problem.

In addition to stimulating increased quantities of precipitation from existing cloud systems, there is also the possibility of diverting precipitation from areas already receiving more than an adequate water supply to those in need of additional precipitation. In many cases, this could take the form of suppressing the formation of precipitation on the upslope of a mountain chain and the stimulation of rainfall on the downslope, thus reducing the effects of the natural rain shadow. By diverting the precipitation from one side of the mountain to the other, an entirely different watershed distribution could be obtained.

Over the Great Lakes, seeding experiments are being conducted to redistribute snowfall from large accumulations on the shoreline to a more even distribution over many thousands of square miles inland. This is being accomplished by supplying freezing nuclei to the cloud system over the Great Lakes in accordance with a three-dimensional mathematical model. The seeding is designed to convert supercooled water droplets in the cloud into ice crystals which drift miles inland instead of forming rimed snow pellets which fall out on the shoreline and create highway hazards and power distribution failures.

Although research is still in the exploratory stages in this field of precipitation mangement, there is reason to believe that it will eventually result in a practicable form of water resource management.

It should be noted that the emphasis of the present program of atmospheric water management is directed toward increasing or diverting precipitation from existing cloud systems which nature provides. The alleviation of long-term drought is, unfortunately, beyond the reasonable expectation of these techniques because they require the presence of cloud systems containing adequate water budgets. In many long-term drought situations, the lack of precipitation is caused by the persistence of dry air masses over the distressed area, and the means to divert moisture-laden air masses over these arid regions contrary to the naturally established global circulation patterns have not yet been developed. Studies of these large-scale circulations and their modification potential at present are being performed largely through computer simulation based upon worldwide data supplied by satellite, aircraft, ship, and ground network observations. Projects such as the Barbados Oceanographic and Meteorological Experiment (BOMEX) and Global Atmospheric Research Program (GARP) will add to our knowledge of these energy exchange processes. The development of a new generation of computers starting with ILIAC IV will greatly accelerate our understanding.

The increasing capability to manage our atmospheric water resources is being developed largely by the Department of the Interior's Bureau of Reclamation, and is based upon the research information in basic atmospheric mechanisms provided by programs of the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), and the Department of Defense (DOD). A close working relationship among these Federal agencies, coupled with the experience and expertise developed over the years by the academic and industrial sector of the atmospheric science community, has brought us today to the threshold of application of weather modification technology for the benefit of mankind.

Weather Hazards

Since the beginning of time, man has learned to respect and fear the destructive powers of the weather. The loss of property and lives due to floods, winds, lightning, and hail has been reduced by the increased accuracy and lead time of forecasting, but the basic problem of alleviating the forces of severe storms remains one of the primary objectives of weather modification research. In these times of high speed travel in the air, on the land, and on the sea, the reduction of visibility due to fog has also become a hazard which must be lessened.

In the past decade, the loss of life due to hurricanes has decreased because of improved warning capabilities, but the loss of property has continued to soar, reaching 1.5 billion dollars in 1969. Airborne, ship, and shore based instrumentation, including powerful radar installations, have provided sufficient information on the structure of hurricanes to develop

mathematical models of their behavior. These lead to the expectation that the maximum wind speeds, which sometimes exceed 200 miles per hour in the central eyewall, could be significantly reduced if the diameter of the eye could be enlarged. Computations indicate that massive seeding of the cloud region just outside of the eyewall of the storm with silver iodide should produce this effect.

On August 18, 1969, research aircraft and scientists of the National Oceanic and Atmospheric Administration and the Department of Defense seeded hurricane "Debbie" with massive quantities of silver iodide with five seeding flights over an 8-hour period. The treatment was applied to the storm in accordance with the computer model recommendations. Aircraft penetrations of the storm before, during, and after treatment showed an overall reduction of 30 percent in maximum wind speed several hours after the last seeding.

Forty-eight hours after the first seeding, reconnaissance flights through Debbie showed the existence of a concentric double eyewall near the center of the storm which had by then reintensified in wind velocity. A series of five additional seeding flights at 2-hour intervals were followed by a reduction of 15 percent in maximum wind velocity. Tests in earlier years showed qualitatively similar results. This provides hope that the reduction in the destructive power of the hurricane, without affecting its overall beneficial rainfall aspects, may become an operational reality in the near future. Modeling efforts and open sea seeding tests on hurricanes are being accelerated.

Damage to property and agricultural crops by severe hail in the contiguous United States amounts to over $300,000,000 each year. A cooperative program of research on the formation of hail in severe thunderstorms has been established in Colorado under leadership of the National Science Foundation and in cooperation with the National Oceanic and Atmospheric Administration, the Department of Agriculture, the Department of Interior, Atomic Energy Commission, the National Aeronautics and Space Administration, the Department of Transportation, and the Department of Defense.

The objective of the field experiments, which are being coordinated through the National Center for Atmospheric Research, is to understand the natural mechanism of hail formation in severe storms sufficiently well to recommend, develop, and test techniques for suppressing the formation of hail. With the assistance of the academic and industrial sectors of the scientific community, mathematical models of the various types of hailstorms encountered in South Dakota, Nebraska, Illinois, and Colorado are being constructed and the prediction of the results of ice nuclei injection upon the dynamics and hail-forming mechanism of the storm is being tested.

Preliminary evidence of hailstorms investigated to date indicate that the two distinct types, namely airmass and squall line storms, will require different treatments.

Impressive success has been reported by the Soviet antihail field program which operates in nine different areas protecting millions of acres by radar-targeted projectiles carrying nucleating agents.

Some success in suppressing hail on an operational basis has also been reported by commercial operators in North Dakota, Texas, Canada, Kenya, and other areas, but the basic system for the evaluation of results still remains one of the problems yet to be resolved. While the suppression of hail may now appear to be possible by massive over-seeding of growing convective cloud cells to destroy their growth, this is not considered an acceptable solution if the end result is a deficiency in regional rainfall. More sophisticated techniques must be developed, based upon mathematical modeling, which will stimulate or not affect rain production at the same time that hail is suppressed.

The large losses in forest resources each year caused by lightning-induced forest fires has prompted the U. S. Forest Service of the Department of Agriculture to conduct a series of experiments in Montana which are directed toward the reduction of ignition-causing lightning strokes by massively seeding "dry" thunderstorms over the national forests.

These tests have produced statistical evidence which has suggested a substantial reduction in the number of cloud-to-ground lightning strokes. Moreover, this treatment modifies the long duration cloud-to-ground lightning strokes believed to be responsible for the ignition of lightning fires. Basic research to shed further light on the mechanisms of lightning suppression is being conducted by both the National Science Foundation and the National Oceanic and Atmospheric Administration. In addition, the Bureau of Land Management, and the Bureau of Reclamation of the Department of the Interior, the Forest Service of the Department of Agriculture, the National Oceanic and Atmospheric Administration of the Department of Commerce and the Air Force are collaborating on a study of means to stimulate precipitation for controlling forest fires through cloud seeding. A test program is now being carried on in the the forests of Alaska. In addition, during the 1970 forest fire emergency in the Pacific Northwest, the Forest Service performed pioneering operational trials of seeding technology for both lightning suppression and reduction of fire danger.

The reduction of visibility over airport runways due to fog is responsible for many lost hours in aircraft traffic. The dissipation of fogs containing supercooled water droplets is reasonably well understood. Such cold fog dissipation programs particularly those utilizing airborne techniques to seed the fog with dry ice are operational at several commercial and military airports.

The more difficult dissipation of warm fog is receiving increasing attention. There are many studies being made, largely in the Department of Defense, with significant contributions by the National Aeronautics and Space Administration, on techniques for dissipating warm fog which involve the use of heat along the runway or the use of hygroscopic nuclei to precipitate the water vapor in the fog and produce fog droplet evaporation. Several of these methods have been successfully demonstrated from time to time, but economic considerations or the possibility of corrosive contamination have restricted their operational use. The use of helicopter downwash to clear ground fog has been tested by cooperating agencies in the Department of Defense and has been given limited operational tests in areas of military operations with some success. The U. S. airline operators have tested various warm fog dissipation techniques using hygroscopic nuclei, polyelectrolytes, and surfactants on an experimental or semioperational basis. The lack of adequate scientific measurement techniques for fog and the need of a more adequate evaluation system has retarded the consideration of warm fog dissipation techniques for operational use in the immediate future. The Federal Aviation Administration (FAA) of the Department of Transportation is developing a systematic approach to the problem considering all aspects of fog dissipation, including fog inhibitors, measurement techniques, mathematical modeling, laboratory experiments, ecological impact, and particularly test and evaluation techniques.

The most violent of all severe storms are those which give rise to tornadoes. These funnels, however, are of such transient nature that new techniques involving remote sensing from the air or the ground must be developed before experiments to investigate them and explore possible modification procedures can be accomplished. Most of the tornado suppression research today is confined to theoretical study, computer simulation, and to laboratory experiments in rotating water tanks or wind tunnels. The probability of devising a field procedure for testing tornado suppression is small for the next 3 to 5 years, since the nature of tornadoes is not sufficiently understood and no convincing suppression concept exists at this time. The future outlook will be influenced strongly by studies of severe storm mechanisms. Efforts are also under way to track tornadoes and to investigate the circumstances under which a milder form, the waterspout, is generated over the warm waters of the Florida Keys.

Techniques to modify the microclimate from treetop level to the ground have been used to provide field crops and orchards with a protected environment. It has long been the practice to use rows of sturdy trees to break the force of winds that can damage crops. Heaters and large fans have long and widespread use in frost protection. More recently, artificial fogs, stabilized against evaporation with small amounts of chemicals such as hexadecanol, have been used to reduce radiant heat loss as a means of fighting frost. Sprays of plain water are used to provide evaporative cooling to protect crops from extreme heat. These practices will continue to be improved as our knowledge of the surface boundary layers of the atmosphere increases and our engineering and agricultural knowledge continues to grow.

Pollution and Weather Relationships

Atmospheric scientists have long recognized the important role of solar radiation in providing the source of energy to drive our global atmospheric circulation system. Recently it has become evident that there is a strong interaction between the composition of the atmosphere and solar-induced weather behavior. Observations made by the Mauna Loa Observatory at Hawaii have shown an increase in carbon dioxide content of the atmosphere of approximately 0.2 percent per year apparently due to the combustion of fossil fuels by man. Calculations show that an eventual doubling of the amount of carbon dioxide in the atmosphere could result in a $2^{\circ}C$ rise in average temperature of the earth's surface and a drop in temperature at the 40,000-foot level of approximately $15^{\circ}C$.

Increased quantities of particulates in the atmosphere could produce the opposite effect at the earth's surface. Over the past 10 years, a decline in temperature has replaced decades of gradual warming. This has been interpreted by some scientists as evidence that the particulate increases due to pollution are now sufficiently high to have reversed the long-term warming trend. Atmospheric scientists have reported over the past 5 to 10 years visual changes in the appearance of clouds over the heavily populated northeastern portion of the United States which they believe are caused by the increased glaciation of supercooled clouds by surface released pollution. There has been considerable speculation that the source of these increased ice-forming nuclei can be traced to lead released by the combustion of fuels in automotive and aviation engines. There are special efforts under way to evaluate the potential long-term effects of future Super-Sonic Transport operations on the world's weather through the concentration of added particulates in the lower stratosphere.

Studies of freezing nuclei over the Great Lakes in 1969 have shown concentrations of approximately 10 times normal background in the downwind plumes of cities such as Cleveland and Toronto, and in some instances it was possible to observe snow showers which may have been triggered by these pollution plumes. Climatological studies of anomalous rainfall associated with industrial complexes, have been reported in the scientific literature, and correlations between rainfall and steel mill operations are impressive. The burning of sugarcane slash in Tasmania has been correlated with the reduction in rainfall in that area, and a similar phenomenon was noted by research workers in the Philippines. Although more information is required to confirm these observations, it does appear that a delicate balance exists between the composition of the atmosphere and the weather patters which occur.

It is evident that we must intensify our efforts to minitor globally the ever-increasing burden of atmospheric pollution. At present, a number of atmospheric constituents are being monitored in Hawaii, at the South Pole,

and in Boulder, Colorado. Additional stations are planned for the eastern United States and Canada. Further ground-based, airborne, and satellite atmospheric observations must be initiated at the earliest possible date over the entire surface of the earth and oceans in order that we may properly evaluate the extent of the interaction between pollutants and the weather and find ways to combat their deleterious effects by more effective atmospheric management procedures.

Technology and Tools

A great deal of the technology of weather modification is based upon the understanding of smaller scale physical processes than those of concern to the weather forecaster.

In the identification and measurement of parameters, the chemist, the physicist, and the engineer have all made important contributions to our understanding of atmospheric mechanisms. The mathematicians and statisticians have assisted in the design and interpretation of experiments and are now developing a capability to construct mathematical models from which a quantitative approach to weather modification is emerging.

Instrumentation - Aircraft instruments are now in existence to measure in situ: water vapor, liquid water, rate of riming, cloud drop size and number density, ice crystal type and size and number density, ice nuclei concentration as a function of activation temperature, condensation nuclei as a function of activation supersaturation, temperature in cloud, vertical and horizontal wind, turbulence, cloud particle charge, strength and direction of the electrical field, etc. There is difficulty in making the instruments work reliably in the severe environment in which they must perform, and the data collection and analysis are tedious and difficult. Unfortunately, the accuracy to be achieved with many of these instruments is open to question and much further research is required.

Remote sensing is an ideal way to collect information for real-time decision making. Weather modifiers have in general adapted surplus military radars for mapping precipitation in space-time and found them to be invaluable though not ideal for their purposes. Doppler radars which use precipitation particles as targets and which measure the flow field inside large convective clouds have been successfully developed and will soon come into use.

Increasing use is being made of telemetered information from remote weather stations in the nearly inaccessible mountain snowshed regions. These measure: snow accumulation, wind direction and speed, air temperature, rime accumulation, etc. The Forest Service's Project Skyfire has developed systems to sense information about the electrical characteristics of lightning strokes simultaneously from a number of observation stations and from aircraft. In some projects, cloud physics information is telemetered from aircraft back to the project command and control center.

Seeding Materials - Most cloud modification practiced at present uses ice-phase seeding, but warm cloud seeding is potentially very important. For ice forming nuclei, such substances as silver iodide, complexes of silver iodide and alkali iodides, lead iodide and its degradation products and complexes have been used. A study of cupric sulfide has been made by Soviet Scientists, and this material has been proposed for more extensive evaluation, but no practical means of dissemination is apparent. Organic nucleating materials cometimes show excellent promise in laboratory experiments but so far have yielded less attractive results in field experimentation. Attention is also being directed toward the assessment of the ecological impact upon the environment which might result from the widespread release of these materials into the atmosphere in future operational programs. Materials which provide minimal impact upon the environment when used in the usual dilute concentrations will be favored for large seeding projects, and work will continue on the development of suitable nucleants with biodegradable properties.

Much confusion in the field has resulted from a lack of appreciation of the role of nuclei chemistry. For instance, it has been generally considered that the ice nuclei activity of silver iodide-sodium iodide-acetone burner products is attributable to the silver iodide alone and that the sodium iodide played no role, other than perhaps a simple hygroscopic enhancement. Recent laboratory experiments have shown that silver iodide from the silver iodide-ammonium iodide system is markedly superiod to the much used silver iodide-sodium iodide system at temperatures above minus $10^{o}C$.

In warm cloud and warm fog seeding, sodium chloride is effective, but other substances that are beneficial to agriculture, noncorrosive to metals, and harmless to humans must be employed. Here it is important to achieve the optimum placement, size, and number density of the dust or spray if the treatment is to be effective and the costs of materials are to be kept in line with benefits.

Delivery Systems - Delivery systems of ice nuclei generation have evolved over 25 years, from techniques for crushing and dispensing "dry ice" through techniques of igniting and dispensing charcoal pellets impregnated with silver iodide-sodium iodide mixtures to ground and aerial burners and systems for dropping pyrotechnic generators of silver iodide into the cloud from aircraft.

Aerial pyrotechnic generators are being used to produce a horizontal line source of nuclei. Free-falling flares and cartridges are being used to produce a vertical line source. Development of rocket and gun systems and related aircraft hardware, such as wing racks, dispensing pods, and associated electrical circuitry is also under way. Versatility is the outstanding feature of the pyrotechnic system: dispensing hardware, nuclei types, generation rates, and total quantities of nucleants can be tailored to suit the experiment.

Ecological and Hydrological Aspects

Weather is a dominant element in ecology. Soil-plant-animal interrelationships are influenced by a wide variety of atmospheric factors including long period climatic patterns and short period variations in weather parameters. More recently, accelerated efforts have been made to enlarge understanding of the impact of man, his industries, machines, materials and mode of living on the total ecology of the earth.

Development of an understanding of ecological systems has been a long-standing activity of many research groups. For example the Department of Agriculture has ongoing programs to study ecological aspects of agricultural, forest, range and wild land environments. The Department of the Interior has research programs focused on fish and wildlife ecology, water, and public lands. The Department of Commerce is concerned with the ecological aspects of marine fisheries. The Environmental Protection Agency and the Department of Commerce have programs to study air pollution-atmospheric-human relationships. Many universities have efforts in ecological research, which are pertinent to weather modification programs.

These efforts provide a foundation of knowledge for specific aspects of a national weather modification program which must now include indepth examination of ecological impacts. The following are a few examples of the status of weather modification-related knowledge of ecology.

Insect Populations - Biologists have developed some initial understanding of the effects of weather upon the incidence of insect epidemics. Alteration of weather patterns by weather modification activities might tend to exert an influence on the development of the insect population. For example, it is possible that local augmentation of June rainfall could aid in control of the spruce budworm, a forest insect that periodically causes severe damage. For this insect, knowledge has been developed on the importance to population growth of the timing of early winter snow, continuing snow and cold temperatures during the winter, spring rainfall and temperature, and dry summer weather during the period of establishment of larvae.

Many insects causing impacts on agriculture could possibly be affected by weather modification. Generally, most insects are influenced more by temperature than by precipitation, although interactions of precipitation and temperature are important. For example, grasshoppers are strongly affected by warm, dry, sunny weather that favors egg production, high survival and rapid development. Cool, moist conditions, especially in the spring will aid in retarding their populations. For a large variety of insects, it is known that rainfall frequency is a critical factor. This knowledge can provide an important guide for planning and managing weather modification operations with the objective of providing net benefits and reducing possible adverse effects.

Plant Diseases - Pathologists have identified the great importance of weather factors to the spread and intensification of a variety of plant diseases. From the results of research in plant pathology, it is possible that weather modification might have different effects on diseases of annual agricultural crops and on diseases of perennial shrubs and trees. Timing of precipitation is critical to the severe outbreak of diseases in grain. High humidity, rather than amount of rainfall is known to be a major factor in the development of potato blight. Some seedborne diseases in cabbage such as black leg and black rot develop to epidemic stages only when there is summer rain. Weather conditions needed for heavy infestations of most forest diseases are so highly variable that generalizations are meaningless. However, for some forest disease situations, weather factors have been identified and these indicate some of the decisions factors in weather modification. For example, molds favored by deep snow remaining on the ground well into spring may damage spruce in the Rocky Mountains. On the other hand, the type of herbaceous ground vegetation might be shifted to species more resistant to snow-mold attack.

From the body of knowledge now available on plant disease and weather relationships, several critical areas for special ecological studies can be identified.

Watershed Hydrology - Many years of research have advanced the needed understanding of some of the complex soil-vegetation-weather relationships in the storage, use, and runoff of precipitation. We know that the amount and type of forest cover, the balance between open ground and dense forests, and soil-geographic characteristics all influence the amount, quality, timing, and duration of flow of water from mountain watersheds. Although this knowledge is far from complete, it provides a rational basis to assist in planning weather modification programs. Moreover, the strength already developed in watershed research provides a background for enhancing and beneficially applying the results of weather modification programs.

Ecosystems - During the last 60 years, considerable information has been assembled on the relationship between organisms and environment. A general understanding has been developed of baseline ecology in several major plant-animal-climatic communities. The International Biological Program is attempting to refine understanding of the function of ecosystems. This research is now on the threshold of development of predictive models for evaluating effects of environmental change on whole ecosystems. These models can become important elements in weather modification decision making.

Although the foregoing are only examples of available knowledge on ecological and hydrological aspects of weather factors, it is evident that a basic understanding is being developed of these interrelationships. Within the near future, man should have sufficient understanding of how major ecosystems work to permit weather modification to proceed with the necessary safeguards against

possible adverse effects. Moreover, a nucleus of basic knowledge is available to aid in selecting the times and situations where weather modification can contribute to environmental protection and can yield substantial economic benefits. Man knows that ecological and hydrological factors must have major emphases in weather modification. The important thing now is to enlarge our understanding of these factors through indepth studies on specific weather modification projects.

Socioeconomic and Legal Considerations

Now that man has arrived at the threshold of a potential capability to influence the vagaries of his environment, he is faced with the necessity of making decisions on how to use this newly developed management capability. It is in this area of decision making where much study remains to be done. In December 1967, a 2-day workshop was supported under a National Science Foundation grant at the Southern Methodist University to explore the state of law in the field of weather modification and the implications for society of the interplay of science, technology, and law. The conferees concluded that there was a need to establish a new legal framework to cover the practice of weather modification, as the application of existing water right laws could not be applied with any degree of consistency from state to state.

A study on the legal guidelines for atmospheric water management which was made at the University of Arizona for the Bureau of Reclamation further emphasizes the inadequacies of our legal system to cope with problems of weather modification. This applies primarily to liability and indemnification for damages believed to have been caused by cloud seeding activities.

A Task Group on the Legal Problems of Weather Modification was recently sponsored by the National Science Foundation at the Law School of the Southern Methodist University. The purpose of the task group was to build upon these past studies and to make creative suggestions as to how the promising field of weather modification might be regulated by society to advance the public interest. The work has now been completed and the report has been published in a book, "Controlling the Weather," Dunnellen Publishing Co.

The human aspect of weather modification has not been neglected. Under the support of the National Science Foundation's Special Commission on Weather Modification, a Symposium on the Economic and Social Aspects of Weather Modification was held in Boulder, Colorado, in July 1965 at the National Center for Atmospheric Research. This conference pointed out the necessity for the social scientist to become aware of the social problems inherent in weather modification and to take part in the planning for the future.

As a follow-up to this conference, the National Science Foundation requested the National Center for Atmospheric Research to establish a Task Group on the Human Dimensions of the Atmosphere to follow up on the original study and to identify specific areas for research in human uses of the atmosphere and to

foster and stimulate interest in these problems among both social and physical scientists. The conclusions and recommendations of this 13-man task group of experts from the field of economics, geography, sociology, political science, law, ecology, and meteorology has been published by the National Science Foundation as NSF Report 68-18 entitled "Human Dimensions of the Atmosphere." Research projects have been, and are now being sponsored by Federal agencies such as the National Science Foundation. Bureau of Reclamation, and the National Oceanic and Atmospheric Administration to proceed with the studies recommended by this report at various universities such as the University of Colorado, University of Michigan, University of Missouri, Montana State University, and many other academic institutions.

The economic potential of weather modification is impressive. Where rainfall is marginal, an increase of only 5 percent rainfall at the right time of the year may mean the difference between crop failure and a bountiful harvest. In Florida in a summer month, for instance, mathematical model computations indicate that the seeding of convective clouds in the vicinity of Miami and Tampa could increase the rainfall by 0.7 inches which would result in an additional 64,000 acre-feet of water in each location. This would mean an increase in rainfall for Tampa of 18 percent and for Miami 11 percent during this 1-month period.

Snow augmentation in the Colorado River Basin is estimated to produce an increase runoff of 1,870,000 acre-feet of water. In addition to the gain of approximately $100 million in water for irrigation purposes, a small incremental income from existing Federal hydroelectric plants at established power rates of about $7.5 million would also be produced. If all this water were diverted for use in either California or Arizona, an additional annual income of $6.9 million from power production could be obtained. Estimates of 15 percent precipitation augmentation from a managed atmospheric water resource system in the Connecticut River Basin have indicated an incremental runoff of 2,000,000 acre-feet of water.

In one area of the North Caucasus of the Soviet Union where hail suppression has been in operational use for more than 5 years, several millions of acres of farmland are being protected by the use of silver iodide injected into critical parts of storm systems by means of rockets or artillery shells. It has been reported that the value of crops being saved by this technique exceeds the cost of the seeding operation by a factor of 10 or greater.

Airlines in the United States have been conducting cold fog dissipation programs at several airports with a benefit-cost ratio of better than 5 to 1 in savings on delayed or diverted traffic. Most fogs which impede air travel, however, are warm fogs, and the Airline Transport Association estimates that the elimination of delays due to warm fogs at airports would result in an annual savings of over $75 million. The cost of cancellation of a single transcontinental jet flight is in excess of $3,000.

In the Rocky Mountain and Pacific Coast States an average of 1,300,000 acres of forests including 262,000 acres of valuable commercial timber lands are burned annually by lightning-caused fires. Weather modification technology for lightning suppression has the potential of saving up to 50 percent of the lightning fire losses and could add more than 1 billion board feet annually to timber supplies and reduce fire control costs by as much as $50 million.

Finally, the losses in property sustained by major hurricanes when they strike land may exceed $1 billion for each major event. A reduction of 30 percent in wind velocity could possibly reduce property losses by 50 percent and save many lives. Even a reduction by only 10 percent in losses, would offer benefit-cost ratios far in excess of 10 to 1.

Chapter III.

HOW WE CAN ACCELERATE PROGRESS

Weather modification has progressed along many avenues as a result of the efforts of groups that have often been small and occasionally independent of each other. Progress can be accelerated by making it easier for these groups to bring together their skills, resources, and mutual interests. Early focusing of combined efforts on the most promising areas can strengthen and speed up the advancement of the entire field of weather modification.

There is little doubt that our understanding of certain types of weather modification has reached the point where practicable application can become a reality in the very near future, provided that systematic progress is made, where possible, from research to operational status through a concerted national effort. An interdisciplinary multiagency approach will ensure that not only are the techniques perfected, but that all consequences, beneficial and detrimental, local, national and international, are fully assessed.

The suggested mechanism for accomplishing this is the establishment of National Projects.

National Projects are multiagency efforts of major national significance which have clear near term potential for meeting identified national needs. Each has as a base an on-going weather modification program with a potential for making a vital contribution to the solution of a national problem.

The National Projects are designed to learn about physical mechanisms and to test scientific concepts, except for one with the special designation Pilot Project. The Pilot Project is primarily concerned with the development of efficient, operational techniques and the process of decision making. National Projects have the characteristic that the different departments, with differing missions, see a chance to advance their own, as well as national interests by formal collaboration with one another. Designation as National Projects should improve or accelerate their chances of success.

It is emphasized that this report does not address those aspects of weather modification which do <u>not</u> require formal collaboration between departments. The different aspects of weather modification research, ranging from stream flow augmentation to forest fire fighting to hurricane modification are <u>not</u> all best managed by a single central agency and each application has peculiar features justifying its own research efforts. There are also problem areas beyond these which, although important, are not expected to yield to formal management efforts. For example, the development of computer models requires a multiplicity of approaches and work on them proceeds in almost all projects. The nation benefits more from competition in this effort.

Recent successes reported by several researchers, particularly in the fields of mountain snowpack augmentation, rain augmentation from cumulus clouds and hurricane modification, give added significance to the work at this time. ICAS believes we are on the threshold of important results and offers these Projects at this time as representing the best way to further the national interests.

The proposed National Projects and Lead Agencies are:

National Colorado River Basin Pilot Project - Bureau of Reclamation
To test the feasibility of applying a cloud seeding technology, proven effective under certain conditions, to a river basin for a winter season to augment the seasonal snowpack.

National Hurricane Modification Project - National Oceanic and Atmospheric Administration
To develop a seeding technology and associated mathematical models to reduce the maximum surface winds associated with hurricanes.

National Lightning Suppression Project - Forest Service
To develop a seeding technology and associated physical and mathematical models to reduce the frequency of forest fire-starting lightning strokes from cumulonimbus clouds.

National Cumulus Modification Project - National Oceanic and Atmospheric Administration
To develop a seeding technology and associated mathematical models to promote the growth of cumulus clouds in order to increase the resulting natural rainfall in areas where needed.

National Hail Research Experiment - National Science Foundation
To develop a seeding technology and associated mathematical models to reduce the incidence of damaging hailfall from cumulonimbus clouds without adversely affecting the associated rainfall.

National Great Lakes Snow Redistribution Project - National Oceanic and Atmospheric Administration
To develop a seeding technology and associated mathematical models to spread the heavy snowfall of the Great Lakes coastal region farther inland.

National Fog Modification Project - Federal Aviation Administration
To develop seeding or other technology and associated physical and mathematical models to improve the visibility in warm and cold fogs where and to the extent needed.

In addition to special support for these National Projects a significant increase in relevant broad background research and development support is also recommended. This is particularly needed in the areas of nuclei counting and efficiency assessment, the physical chemistry of nucleating agents, the microphysics and dynamics of mesoscale systems, mesoscale mathematical models, and cloud physics instrumentation, such as doppler radars and microwave sensors.

National Colorado River Basin Pilot Project for the Augmentation of the Rocky Mountain Snowpack

The proposed project builds on the existing operationally oriented effort by the Bureau of Reclamation of the Department of the Interior to augment the snowpack in the Upper Colorado River Basin. By overlaying concentrated research on an ongoing project, time losses and costs will be minimized. The initial seeding, communication, and observation systems and the project forecasting headquarters are already established. The seeding and research techniques to be used are based on well-understood physical principles, and there is promise that the results will be highly beneficial to the social, economical, and ecological needs of an important part of our country.

The critical water shortage in the Colorado River Basin is well known. This basin serves the States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming, in addition to the neighboring Republic of Mexico; among others it supplies 80 percent of the water needs of metropolitan Los Angeles. The primary source of this water is the snowpack accumulation during the winter on the crests of the Rocky Mountains. In the Upper Colorado River Basin, which has an annual runoff of approximately 15 million acre-feet, the snowpack is concentrated at levels above 9,500 feet in an area representing only about 10 percent of the total river basin. It is on this area that the snow augmentation effort can be most efficiently concentrated.

The planned pilot project operations will initially take place over some 2,200 square miles of the San Juan Mountains. There, it is estimated that randomized seeding will cause a 15 to 20 percent increase in local runoff. An expected additional 400,000 acre-feet of water will thus be produced by the pilot project and will help relieve existing shortages.

Present total cost of water is up to $50 per acre-foot in the Colorado River Basin. The estimated cost of water increase through orographic seeding in this area is about $1.50 per acre-foot. The resulting economic gains and cost-benefit ratios are impressive. If, at a later time, full-scale operations are extended to the total 14,000 square mile area of snowpack in the Upper Colorado River Basin, an annual water increase of almost 2 million acre-feet valued as high as $100 million may be expected.

It should be recognized that the cost figure of $1.50 per acre-foot and the value estimate of $100 million do not result from sophisticated economic analyses. Scholarly dissertations have been written on the complexity of performing valid economic evaluation of weather modification; such actual evaluations are not presently available. Careful economic studies have been undertaken in connection with the Upper Colorado River Pilot Project but no results are as yet available. Many more such studies are needed and should be undertaken as rapidly as qualified economists can be attracted to the task.

The techniques to be applied in the San Juan Mountains will take advantage of the temperature activation spectrum of natural ice nuclei. At cloud top temperatures, warmer than minus 23°C, the supercooled cloud systems forming over the windward slopes cannot precipitate efficiently due to a lack in effective ice nuclei. Seeding in proper quantities on days with cloud top temperature between minus 12°C and minus 23°C is expected to cause most of the available condensate to fall out and to double the natural snowfall rate. Seeding during all suitable days should add about 30 percent to the total San Juan snowpack. Indiscriminate seeding including days with could top temperatures colder than minus 25°C would reduce or neutralize this effect by adding artificial ice nuclei under conditions where natural ice nuclei are already abundant. Such overseeding would reduce snowfall by keeping the smaller ice crystals from reaching the ground before evaporation on the downwind side. Therefore, careful assessment of the given atmospheric conditions prior to a seeding operation will be an important ingredient of the project plans.

The Upper Colorado River Basin Project of the Department of the Interior is well planned and ideally suited to make it the focal point of a National Pilot Project. As such, it should be augmented to take full advantage of the opportunity for accumulating an unprecedented amount of information and experience for future operational programs.

A 3- to 5-year effort will be required to:

Develop optimum diagnostic methods
Perfect prognostic capabilities
Develop the most efficient operational techniques
Devise a clear picture of the full sequence of physical events and consequences
Assess the quantitative results in terms of water augmentation capability
Derive upwind conditions and downwind effects
Assess the total economic impact
Develop sociological relations and procedures
Devise the full spectrum of social and legal effects
Assess short- and long-range ecological consequences

To accomplish this expansion in scope, it is desirable to increase the presently planned density and areal extent of measurements; to bring in advanced meteorological field instrumentation and measuring platforms; to increase the project scientific staff; to enhance the real-time data acquisition and processing capabilities; to provide for a comprehensive meteorological mountain mesoscale analysis; to accelerate the development of advanced mathematical and cloud physics models; and to inject additional related research efforts, including snow hydrology and avalanche studies.

The National Pilot Project provides a meaningful, pertinent situation to investigate the sociological and environmental considerations of a large-scale weather modification effort. These vital considerations need to be studied to provide a sound basis on which public and legal policies of operational seeding can be formulated.

The pilot project area also offers an excellent opportunity for testing remote sensing equipment and application under the Earth Resources Technology Satellite (ERTS) Program. The project measurements provide ground-truth data from a rugged, mountainous area under severe winter conditions. The remote sensing of environmental parameters would be used in connection with the ecological investigations being made as part of the project.

The basic program currently involves Colorado State University, Colorado University and Ft. Louis College as well as the Soil Conservation Service, the Forest Service and the Geological Survey.

It is clear that the National Pilot Project will require a concerted effort by other government agencies, such as the Departments of Commerce, Defense, Transportation, the National Science Foundation, and additional segments of the Departments of Agriculture and the Interior as well as state agencies. Desirable supportive efforts from major components of the Federal Government are listed in Tables 1 and 1.a.

Table 1

Desirable Supportive Efforts for the National
Colorado River Basin Pilot Project
Lead Agency - Bureau of Reclamation, Department of the Interior

Type of Effort	Possible Sources					
	Department of Agriculture	Department of Commerce	Department of Defense	National Science Foundation	Department of the Interior	Department of Transportation
Monitor cloud top heights and temperatures (airborne IR measurements)		X		X		
Precipitation and wind field in clouds						
Radar			X			
Doppler radar		X				
Nuclei characteristics up and down-wind (airborne counters)		X		X		
Additional upper air soundings		X	X			
Additional ground stations						
Snow depth	X					
Snow characteristics	X					
Precipitation		X				
Wind		X				
Advanced instrumentation						
Weather proof anemometers		X	X			
Mobile weather stations		X	X			
Soil moisture sensing devices	X					
Nuclei - activation measurements				X		
Real time satellite information		X				
Specialized local forecast		X				
Climatological and hydrological analysis	X	X				
Advanced mathematical models	X		X			
Special studies on the effects of:						
Water quality					X	
Stream morphology					X	
Forest fire probability	X					
Surface transportation						**
Sociology				X		
Legal aspects				X		
Multiple use forest management	X					
Flight space and control						X

** State Highway Department.

Table I-a

Required Research for National Colorado River Basin Pilot Project

Needed Cooperative Efforts	Additional Support Required	Redirection of Existing Efforts	Total Required Effort
	Thousands of Dollars Annually		
Expanded atmospheric research: Additional observation and research to provide increased understanding of physical and dynamic atmospheric processes important to winter orographic cloud seeding operations	130	95	225
Monitor cloud-top heights and temperatures with aircraft and satellite infrared sensor measurements	40 Commerce-NOAA	15 NSF-NCAR	55
Measure airborne nuclei concentrations and physical characteristics under natural and seeded conditions upwind and downwind of target areas and increased studies of nuclei activation	30 Commerce-NOAA	5 NSF-NCAR	35
Additional upper air soundings for determining vertical dynamic and water balance changes across the mountain profiles	20 Commerce-NOAA	20 DOD-AF	40
Additional local forecasts and verification using specialized information and techniques including real-time evaluation of advanced mathematical models	20 Commerce-NOAA	15 Commerce-NOAA	35
Detailed climatology and synoptic/hydro-meteorology of winter storms in San Juan Mountains	20 Comm-NOAA	40 Commerce-NOAA	60
Expanded snow and watershed studies: Determine effects of increased snow on watershed hydrology for evaluating efficiency of seeding in producing a usable augmentation of streamflow	125	90	215
Distribution of snowfall, drifting, and aerial extent of increased snowpack over selected mountain watersheds	70 Agri-For. Serv.	20 Agri-For. Serv.	90
Change in snowflake and snowpack structure and the resultant effects on avalanche potential and melt characteristics	30 Agri-For. Serv.		30
Soil moisture, water quality, and stream morphology investigations to assist watershed-hydrologic modeling of effects under natural and seeded conditions	25 Agri-SCS Interior-GS	10 Interior-GS	35
Comprehensive watershed-hydrological modeling studies of the project and downwind areas		60 Agri-For. Serv. Universities	60

Needed Cooperative Efforts	Additional Support Required	Redirection of Existing Efforts	Total Required Effort
	Thousands of Dollars Annually		
Specialized data acquisition and processing: Concentrate newly developed equipment and techniques to aid project operations, research and evaluations, and to test new developments where extensive verification data and severe operating conditions exist	130	25	155
Mapping precipitation and wind fields in orographic clouds by Doppler radar	50 Commerce-NOAA		50
Weatherproof anemometers and other instrumentation to provide reliable operational data from remote locations	20 Comm-NOAA	5 Interior-BuRec	25
Mobile weather stations for economically providing concentrations of measurements in different areas according to forecast storm intensity	20 Comm-NOAA	20 DOD-AF	40
Use of satellite weather information, including furnishing special data receivers in project forecast and control center	25 Commerce-NOAA		25
Improved real-time data processing and establishment of an expanded project data storage and retrieval for enhancing early research on seeding effects	15 Interior-BuRec		15
Sociological and environmental investigations: To define problems and interrelated effects of increased snowfall in mountain areas and study means of resolving nontechnical questions of large-scale applications	95	70	165
An in-depth sociological case study of attitudes and effects on people in and near the San Juan Mountains and any changes during the project	40 NSF		40
Multi-use forest management studies on interrelated and possible synergistic efficiencies with additional snowpack on timber management, recreation, grazing, and forest fire prevention	35 Agri-For. Serv.	70 Agri-For. Serv.	105
Evaluation of surface transportation effects and costs, particularly snow removal, of additional snowfall	20 Interior-BuRec Colo. Highway Dept.		20
TOTAL EFFORT - National Pilot Project	480	280	760

National Hurricane Modification Project

The advances made in 1969 in the modification of hurricanes were described in the foregoing chapter. There is an urgent need to confirm these findings and to advance the physical concepts and mathematical models developed in Project STORMFURY. Because of the infrequency of hurricanes within reach of available test bases, a large statistical sample cannot be expected and emphasis has to shift to the testing of physical chains of events in concurrence with the prediction by refined computer models. Any opportunity, within safe limitations, must be used to test these concepts and every effort must be made to advance the existing mathematical models and technological tools at hand. This includes a better understanding and prediction of hurricane tracks and their inadvertent or deliberate alteration by artificial means.

If the evidence available at this time is substantiated in future tests and reductions in the kinetic energy of maximum winds as high as 30 percent can indeed be achieved, it may be expected that the pressure from the public sector will increase to apply hurricane modification techniques on an operational basis and to reduce the huge losses in property and life from catastrophes such as Hurricane "Camille" in 1969. It is in the national interest that preparations for the transition from research to operations are vigorously pursued and carefully planned taking all technical needs as well as the potential economic and legal implications into account. The additional support indicated in Table 2 will be instrumental in accelerating our progress towards hurricane control.

Table 2

Desirable Supportive Efforts for the National Hurricane Modification Project

Lead Agency - National Oceanic and Atmospheric Administration
Department of Commerce

Type of Effort	Possible Sources						
	Department of Housing and Urban Development	Department of Defense	NASA	National Science Foundation	Atomic Energy Commission	Department of the Interior	Department of Transportation
Increased aircraft support for monitoring hurricane parameters							
Two fully instrumented turbo prop research aircraft		X					
High altitude cloud physics probing		X		X			
Intensified high altitude cloud photography (60,000 feet)		X					
Airborne tracer studies		X			X		
Improved airborne radar		X					
Satellite monitoring of hurricane characteristics including cloud top temperature			X				
Ground monitoring							
Increased utilization of existing radar networks		X					
Flight space and control							X
Damage survey and analysis of wind velocity relationship	X			X			
Expanded Research studies and experiments							
Evaporation suppression studies and experiments		X		X		X	
Special economic and legal impact studies				X			

National Lightning Suppression Project

The efforts by Forest Service Project Skyfire of the Department of Agriculture are focused on lightning-caused forest fires. Lightning is the greatest single cause of forest fires in the western states and accounts for more than 60 percent of the fires on Federally protected forests and 50 percent of the fire loss to commercial timber. In addition, these fires generate air and water pollution, damage outdoor recreation and areas of scenic beauty, and often take a toll of homes, industries, and human lives. Continued advances in special weather modification technology now indicate that this may be the most fruitful approach to reduce the annual lightning fire control costs of some $100 million and the much greater costs of natural resource losses.

As described in Chapter II, carefully designed experiments performed over a long period of time indicate that cloud-to-ground lightning from individual thunderstorms can be reduced through application of massive seeding techniques. More important, the special type of lightning which now has been found to be almost exclusively responsible for forest fires was strongly affected. This so-called "hybrid" cloud-to-ground discharge combines the unfavorable characteristics of multiple return strokes and long continuous currents. In one experiment involving massively seeded lightning storms, the number of return strokes per hybrid discharge as well as the duration of the continuous currents were significantly reduced.

Although the physical mechanism by which massive seeding modifies lightning activity is not fully understood, the probability is high that the basic mechanism of charge generation in thunderstorms is affected. Extrapolation of the results of lightning modification to fire ignition probability in the relatively small Project Skyfire field experimental area suggests an appreciable reduction in forest fire starts from lightning.

The results now available and the potential economic gains are sufficent to justify a national project designed to establish operational feasibility and to fully ascertain the physical mechanisms involved.

The National Lightning Suppression Project will fulfill these aims. This project will extend the developed cloud seeding techniques over a much larger forest area in the northern Rocky Mountains having a known high incidence of fires. (Continued development of airborne instrumentation for seeding evaluation and numerical modeling techniques for determining where and when to seed are projected as a part of this program.) The project will be designed to continue investigation of lightning mechanisms and to evaluate operational application of weather modification techniques most likely to prevent fires and reduce forest fire danger under specific meteorological conditions.

Although the Forest Service plans to strengthen its resources for support of the National Lightning Suppression Project it has several sub-critical aspects. They need to be removed by the cooperation of other government agencies, universities, and private industries. Specifically, we recommend interagency participation in the areas listed in Table 3.

In addition to the efforts of the National project the Forest Service will continue its lightning research program including studies for the extension of lightning suppression systems to other forest regions.

Table 3

Desirable Supportive Efforts for the National Project on Lightning Suppression (Project Skyfire)

Lead Agency - Forest Service, Department of Agriculture

Type of Effort	Possible Sources					
	Department of Commerce	Department of the Interior	Department of Defense	Department of Transportation	NASA	National Science Foundation
Research and Development Support						
Lightning Storm Models	X	X	X			X
Predicting Amount and Type of Lightning from Thunderstorms	X					
Development of Radar Techniques	X					
Aircraft and Spacecraft Observations						
Joint Use of Aircraft for in-cloud measurements	X	X				X
High altitude aircraft for lightning sensing			X		X	
Spacecraft monitoring of lightning storms	X				X	
Services						
Special Fire-Weather Forecasting	X					
Point Six Radar Operation	X					
Rawinsonde operations	X					
Analysis of Seeding Devices and materials			X			X
Aircraft monitoring and control				X		
Micro and meso-scale weather analysis	X					

National Cumulus Modification Project

As pointed out in the previous chapter, rain augmentation from convective cloud systems in general requires a better scientific understanding of the complex convective processes. However, remarkable progress has been made during the last few years in the modification of certain types of cumulus clouds. This specific approach shows significant economical promise and appears nearly ready for operational application.

In tropical latitudes, as well as in certain regions of the temperate latitudes, the seedability of cumulus clouds can now be predicted by computer models, using as inputs the day-to-day atmospheric soundings and local observations. NOAA's present and planned efforts in Florida to augment precipitation from tropical cumulus clouds are based on mathematical models which take into account the effects of entrainment and waterload and are able to predict vertical cloud development, precipitation growth and fallout for seeded and unseeded clouds.

Seeding operations are guided by these objective predictions. It is now well established by physical and statistical tests that precipitation increases of more than 100 percent can be achieved in individual seedable clouds which grow explosively after massive seeding due to the liberation of large amounts of latent heat of freezing ("dynamic seeding"). Since seedability varies from day to day and from month to month, the monthly or seasonal increases in total precipitation are smaller. Systematic "area-seeding," however, promises to result in economically significant increases approaching the 20 percent level in certain months.

Also, tests in temperate latitudes, for example those in South Dakota sponsored by the Department of the Interior's Bureau of Reclamation, indicate that modifiers know how to produce substantial increases from a frequently recurring set of cloud types. Clearest demonstrations of this are when important amounts of rain are produced from cumulus that would not rain at all in the natural state. In these regions, this may or may not be associated with important induced changes in the dynamics of the cloud. The more advanced mathematical models used in these tests incorporate the effects of terrain, evaporation, and cloud shadows.

While the treatment of individual cumulus clouds has been strikingly effective, parallel attempts to treat systems of convective clouds are still in the early stages. Much more research is needed to develop adequate correlation during theoretical analyses, mathematical models and field experiments.

The dynamics of convective cloud systems are extraordinarily complicated and no satisfactory, three-dimensional model exists at this time. System seedability criteria readily available based on atmospheric parameters need to be established. Possible downwind effects must be investigated.

This project will make major strides in the clarification of many long-standing scientific problems such as the mechanism of entrainment and its dependence on cloud characteristics and environment, the mesoscale organization control of convective cloud systems, the action of hydrometeoric drag, nucleating mechanisms, efficiency of natural and artificial nuclei in warm and cold clouds and different climates, and artificial modification of buoyancy.

A number of criteria enter into the selection of optimum locations for field tests. Among these are:

Favorable and representative meteorological conditions offering a sufficient variety of typical convective phenomena and related atmospheric structures
Minimum interference with human activities
Favorable attitude of state and local authorities
Need for rain augmentation in the general area of field testing

Certain parts of Texas offer these conditions. Winds from the Gulf of Mexico or from Mexico itself produce a great variety of convective situations from arid to tropical (Florida type) regimes, with warm and cold cloud tops, shallow and large developments, organized and unorganized systems. Also, the remaining criteria seem to apply here. Other areas to be considered are Florida, Utah, Illinois, Oklahoma, and Soutn Dakota, where surveillance networks already exist.

The expanded project should be centered around NOAA's Tropical Cumulus Project in Florida. The Florida Project should be systematically expanded towards operational readiness. Areawide seeding techniques and ground control should be advanced to a fully operational stage, to be applied in regions and at times of strong economical or environmental needs. In this connection, the available techniques for suppression of precipitation during periods of flooding should also be developed.

Optimum methods to cooperate with local users and authorities and to deal with legal problems are expected to evolve from this important project.

The additional support listed in Table 4 is considered desirable to achieve these goals. Of special importance is the addition of reliably calibrated weather radar.

Table 4

Desirable Supportive Efforts for the National Project on Precipitation Augmentation from Cumulus Clouds

Lead Agency - National Oceanic and Atmospheric Administration
Department of Commerce

Type of Effort	Possible Sources				
	Department of Agriculture	Department of Defense	Department of the Interior	National Science Foundation	Atomic Energy Commission
Increased ground support					
Expanded precipitation network	X		X		
Increased aircraft support					
High altitude panoramic cloud photography		X			
Special studies					
Socioeconomic, legal studies				X	
Ecological studies	X				
Advanced mathematical models/ computer time			X		
Pyrotechnic Development			X		
Plume research and tracking					X
Standard Laboratory for nuclei tests/ nuclei counters				X	

National Hail Research Experiment (NHRE)

Damage to crops and property in the United States each year due to hail exceeds $300,000,000 per year. There is reason to believe that a significant reduction in the growth of this damaging hail in severe storms can be accomplished by suitable modification techniques. The injection of silver iodide into the liquid water accumulation zone of the storm using explosive artillery shells or rockets targeted by radar has been reported to be highly successful in the Soviet Union in reducing losses due to hail. Cloud base seeding from aircraft released into selected portions of the updraft of the storm by pyrotechnic silver iodide generators has been reported to be successful in reducing hail crop damage in Kenya, Africa, North and South Dakota, in Texas and elsewhere.

Although hail suppression has been believed to be successful in many instances, there is still a wide divergence in scientific opinion as to the mechanisms which are responsible in severe storms for the formation of hail and how they might be modified to suppress hail. Most evidence of successful hail suppression offered to date has been keyed to insurance statistics which compare crop losses in treated and untreated areas. Due to the sporadic nature of hail formation, such data have contributed very little scientific insight into understanding the actual hail suppression mechanisms in a storm.

The National Hail Research Experiment (NHRE) involves the intensive study of hailstorms over a target area using ground meteorological networks, instrumented aircraft, ground and airborne radar and infrared sensors, lidar, and synchronous satellite observations. From these observations, mathematical models of representative Great Plains hailstorms will be developed and a number of hail suppression techniques will be tested by simulation techniques. The most promising of these suppression techniques will then be applied to actual hailstorms over the test area and the results observed and compared to the model simulation. Penetrations will be made into the storm by specially instrumented aircraft including a T-28 aircraft which has been armored to withstand the direct impact of 3-inch hailstones in flight. Rockets containing silver iodide impregnated explosive nose cones will be launched into selected areas of the storm from jet aircraft to test the effect of glaciation upon the dynamics and hail-forming mechanism of the storm.

The areas chosen for selective glaciation will be determined from the computer model and the reaction of the storm will be observed by special dual wavelength radar, doppler radar, tracer materials and chaff injected into the storm, and the armored aircraft penetrating into the active storm center.

A major portion of the field effort will be conducted by the National Center for Atmospheric Research, academic and private institutions, under NSF support. Currently major contributions are planned from Colorado State

University, University of Wyoming, South Dakota School of Mines and Technology, the University of Chicago, and the University of Illinois. Many aspects of the field program, however, require the support, facilities, and expertise available only at other agencies of the Federal Government.

The NCAR basic program will be designed as a minimum adequate core program to which other agency participation will add effectiveness toward attaining the overall program goal as well as fulfilling other agency research requirements most efficiently. Desirable supportive efforts from major components of the Federal Government are listed in Table 5.

Table 5

Desirable Supportive Efforts for the
National Hail Research Experiment

Lead Agency - National Science Foundation

Type of Effort	Possible Sources							
	Department of Commerce	Department of the Interior	Department of Agriculture	Department of Defense	NASA	Department of Transportation	Atomic Energy Commission	National Science Foundation
Personnel loan								
Scientific or engineering		X	X	X				
Technical supporting		X		X				
Equipment loan	X	X		X				
Aircraft observations	X			X		X		
Air trajectory studies							X	
Services								
Forecasting	X							
Assessment and evaluation	X		X					
Satellite observations	X				X			
Traffic control						X		
Doppler radar observations	X							
Seeding devices	X		X	X				
Ground monitoring network	X							
Electrical measurements			X					
University Instrumentation Support								X

National Great Lakes Snow Redistribution Project

As mentioned in Chapter II, experiments have been conducted over a number of years by NOAA to reduce the heavy snowfalls on the shores of Lake Erie and to redistribute them over a larger area further inland. The concept can be applied to other parts of the world where polar air with subfreezing temperature moves over open warm waters causing heavy snowstorms at the downwind shorelines.

Progress achieved to date is so encouraging that the efforts, presently subcritical, should be intensified. Airborne measurements have borne out the predictions of a mathematical model with surprising accuracy. This three-dimensional model takes into account the effects of terrain and water (sometimes 20°C warmer than the air) and the resulting changes in friction and vertical flux of water vapor. It indicates that the top of the cold air is lifted near the downwind shore to such an extent that deep snow-bearing clouds form. In theory, injection of the proper amount of artificial freezing nuclei changes the type of precipitation from fast-falling rimed particles to slowly drifting small ice crystals thereby lessening the rate of snowfall near the shoreline.

What is needed now is refinement of theory and computer models, as well as real-time application of the mathematical model in guiding the seeding operations; improved cloud physics measurements inside the "lake effect clouds;" expanded precipitation monitoring by radar and ground networks; systematic counts of freezing nuclei; and intensified studies of the economic impact, the conflicting interests, the legal aspects, and the ecological consequences.

Table 6 summarizes the additional support considered desirable to ensure vigorous progress of this important research project toward eventual operational application.

Table 6

Desirable Supportive Effort for the National Great Lakes Project

Lead Agency - National Oceanic and Atmospheric Administration
Department of Commerce

Type of Effort	Possible Sources			
	Department of Agriculture	Department of Defense	Department of the Interior	National Science Foundation
Increased Aircraft Support				
High altitude panoramic cloud photography		X		
Improved liquid water content recorder		X		
Seeding support		X		
Additional Ground Support				
Snowgages for surface network	X			
Mobile 3 cm radar		X		
Additional rawinsonde stations		X		
Special Studies				
Technological Assessment:				
Socio-economic-legal studies			X	X
Ecological Studies	X			
Great Lakes Watershed Management Study			X	
AgI scavenging study (Univ. Grant)				X
Heat and momentum transfer study - NCAR a/c				X

Table 6 Notes

Desirable Supportive Effort for the National Great Lakes Project

A. INCREASED AIRCRAFT SUPPORT:

(1) High altitude panoramic cloud photography to provide a high quality, detailed over view of entire winter lake storm systems before and during seeding operations.

(2) A liquid water content recording to provide important information pertaining to potential seeding efficiency and potential benefit in terms of snow out.

(3) Recommended use of droppable cannister-type pyrotechnic flare seeding with technical and field assistance provided by Naval Weapons Center scientific personal and equipments.

B. ADDITIONAL GROUND SUPPORT:

(1) Assistance in measurement and analysis of snow rate and total snow measurements.

(2) Mobile 3 cm radar stationed as needed to provide measurements within the target area where severe operational difficulties arise as the result of ground clutter return on present WSR 57 radar.

(3) Upwind meteorological data are required as input to the predictive model. Mobile rawinsonde measurements obtained in the target area and upstream will provide this basic meteorological data needed.

C. SPECIAL STUDIES:

(1) and (2) Socio-economic-legal, ecological, and watershed management studies need be conducted to determine the impact of possi- applied weather modification in this area.

(3) Crystal analysis for a determination of the magnitude of AgI scavenging by crystals for the evaluation of seeding efficiency and seeding requirements.

(4) Heat and momentum transfer study using the NCAR Buffalo aircraft.

National Fog Modification Project

Throughout history fog has been responsible for economic and human losses in aviation, on highways and at sea.

Detrimental effects of fog on surface and air transportation are problems of major proportions. Commercial air carriers alone now lose over 80 million dollars annually in aircraft diversions, delays and cancellations. Costs in excess of 300 million dollars per year are incurred by fog-associated vehicle accidents on the nation's highways. Fog is a serious factor to the military in the movement of personnel, cargo and combat material at airfields and staging areas in the United States as well as overseas. Successful airborne cold fog dispersal operations have been conducted for a number of years, and large dollar savings were recently realized and documented for a military ground-based cold fog dispersal pilot installation (Fairchild AFB near Spokane, Washington) to the amount of approximately $200,000. The national fog modification project will accelerate technological breakthroughs in the dispersal of warm fogs (temperature above $0^{o}C$) and provide for greater efficiency in cold fog (temperature below $0^{o}C$) dispersal techniques.

Means of overcoming the adverse effects of fog include, among others, modern electronic navigation aids, improved lighting, acoustic methods, such as bell buoys and fog horns at sea, and recently fog dispersal systems.

The above techniques, while permitting some flow of traffic through fog-bound areas on land, air, and sea require considerable improvement and refinement in order to make them operationally reliable and economically beneficial.

The current state-of-art technology indicates that fog dispersal systems can be developed which meet user requirements. The dispersal of cold fog by airborne and ground-based systems which use dry ice or propane as the nucleating agent has already been successfully demonstrated. Ground-based cold fog dispersal systems are already operational at Orly Field, Paris, France and at some U. S. Air Force installations. In the U. S., seeding aircraft, under contract to diverse segments of the aviation industry, currently use dry ice to dissipate cold fog utilizing various airborne seeding techniques. Measurement and evaluation of fog dispersal techniques will be made to determine the system efficiency and its impact on the National Airspace Air Traffic Control System.

Efficient warm fog dispersal techniques have seriously lagged behind cold fog modification work, mainly because of the expenditures required to produce even minimal dispersal results. The main efforts in warm fog dispersal in the past few years have been in computer simulation, fog modeling and limited field testing of a variety of dispersal techniques, devices and

theories. A reliable, operational, cost-effective warm fog modification technique, either ground-based or airborne, does not yet exist. Several techniques, however, have shown some promise, i.e., heating devices to evaporate fog, airborne seeding of fog with sized chemicals and the removal of fog droplets by mechanical means have shown diverse levels of effectiveness.

The current trend in the U. S. is to disperse warm fog by seeding with chemicals from aircraft. To date, limited documentation exists on just exactly what effect such chemicals as urea, ammonium chloride, silver iodide, and polyelectrolytes, among others, have on warm fog droplet coalescence and fog dispersal. A scientific objective analysis of the dissipation capability of fog dispersal agents is urgently needed in order to eliminate those which are ineffective or may be potentially harmful to the environment and confirm those substances which can be successfully and safely used in fog dispersal. This is an area which will be investigated.

Numerous diverse techniques have been proposed for fog dispersal. To date, no suitable field test bed exists to measure and evaluate the capability of a proposed technique to dissipate fog.

An instrumented test bed will be developed on land at an area which has a high incidence of natural fog in order to field test proposed fog dispersal systems. An additional test bed will be developed in a high incidence of sea fog region to test and evaluate proposed fog dispersal systems for harbors, rivers, and sea approaches. Both of the above test beds will be used for research and development of fog dispersal systems.

Considerable basic research remains to be done on the history of fog formation, development, maturation and dissipation. Through the use of experimental data obtained from fog chambers, through computer modeling of fogs, and both theoretical and practical considerations, it is hoped to provide a deeper understanding into the basic physical, chemical, and electrical structure of fog and its geophysical interrelationships. This new knowledge will provide a base for improved second generation fog dispersal systems.

The operational techniques of fog dispersal which will be evaluated objectively will include, among others, airborne seeding, helicopter downwash, heat, electrical methods, ground-based seeding, mechanical techniques, and the use of jet engine blast. User requirements will be determined for specific cases and fog dispersal systems will be developed to satisfy those requirements. Both ground-based and airborne instrumentation will be employed as well as aerial photography to document fog dispersal efforts. Anomalies will be carefully analyzed to determine alternative methods of achieving maximum reliability for a fog dispersal system.

The use of tracer materials to determine airflow within a fog will provide additional information on fog droplet movement. The use of specially-designed Doppler radar may also provide an insight into the inner circulation of fogs.

A suitably equipped fog laboratory will include a fog chamber and supporting equipment. The effect of changes on the environment and ecology of an area subjected to fog dispersal operations will be investigated. Research will also be done on the micrometeorological effect of fog dispersal on plants, insects, etc.

An economic analysis of fog dispersal will be made for airports, highways, harbors, waterways and sea approaches. The economic losses due to fog projected over a ten-year period will be analyzed and cost-benefit ratios determined for developmental/installation costs of fog dispersal systems.

Fog dispersal at airports will affect current air traffic control procedures which may require revision when fog dispersal systems become fully operational. These relationships will be analyzed and, if needed, new FAA air traffic procedures will be proposed for the National Airspace System. A ground-based propane cold fog dispersal prototype system will be installed at a U. S. airport which has a high incidence of cold fog. The test, evaluation, and operation of the prototype system will provide specifications and advisory information for other airports qualifying for the installation of cold fog dispersal systems.

A systems engineering plan for a warm fog dispersal system will be developed from requirements for the fog dispersal system, terrain effects at airports, cost-benefit analysis, physical parameters of warm fog modification, and the measurement and evaluation of fog dispersal techniques. The systems engineering plan will be the basis for development and test of a prototype warm fog dispersal system installed at an airport which has a high incidence of warm fog. The test, evaluation and operation of the prototype warm fog dispersal system will provide specifications and advisory information for airports qualifying for the installation of warm fog dispersal systems.

This national project is designed to utilize the total thrust of the research and development communities to achieve a concentrated, coordinated attack on the modification of warm fogs and to develop more efficient cold fog dispersal systems.

Modification of the above systems to meet the requirements of other users on land and water will be accomplished.

Fog prevention techniques will be developed to reduce evaporation in harbors and other water bodies. The alteration of terrain by such techniques as tree planting, establishment of barriers etc. in order to develop operationally reliable fog preventive systems will also be investigated.

Thus, in terms of long-range planning the basic techniques developed for military and civil aviation use will provide a basis for total transportation fog dispersal systems development.

TABLE 7

Desirable Supportive Effort for the National Fog Modification Project

Lead Agency - Federal Aviation Administration
Department of Transportation

TYPE OF EFFORT	POSSIBLE SOURCES						
	Department of Commerce	Department of Agriculture	Department of Defense	NASA	Department of Transportation	Atomic Energy Commission	National Science Foundation
Research and Development Support							
1. Fog models			X	X			X
2. Fog prediction	X						
3. Cold/warm Fog Dispersal System Development			X		X		
4. Basic fog research				X			X
5. Development fog prevention techniques		X		X	X		
6. Climatology	X		X		X		
Increased Aircraft Support							
1. Measurement of fog parameters by aircraft	X		X				
2. Aerial photography	X		X				
3. Seeding support			X				
Ground Monitoring							
1. Instrumented fog test bed			X		X		
Services							
1. Analysis for dispersal techniques			X		X		
2. Fog measurements in harbors, waterways and at sea	X		X		X		
Special Studies							
1. Socio-economic, legal and ecological studies		X			X		X
2. Tracer materials in fog analysis				X		X	
3. Micro-meteorological effects of fog dispersal		X					
4. Economic analysis of fog dispersal at airports, highways, harbors and waterways					X		X
5. Interface of fog dispersal with Air Traffic Control, highway traffice, and harbor/river/ocean traffic procedures			X		X		

Background Research and Development Support

It is a matter of prime importance that basic research of the many natural weather processes be supported on a continuing basis. The emphasis in this report on activities for accelerating progress toward application should be viewed as advocacy of efforts which supplement rather than substitute for basic research. It is clearly not in the national interest to freeze weather modification technology at present levels. Future improvements in this technology can be expected only if improving foundations of understanding are constantly being sought.

Research and development are needed particularly in the following areas to insure the success of all of the foregoing projects:

Nuclei counting and assessment
Physical chemistry of nucleating agents
Microphysics and dynamics of mesoscale systems
Mathematical modeling
Tools and technology

The need to measure condensation and ice nuclei more accurately in the field and in the laboratory is most pressing. Recent comparative measurements by existing techniques show discrepancies in nucleating efficiencies of many orders of magnitude. It is obvious that an understanding of condensation and ice forming mechanisms cannot be achieved until a standardized method of nuclei measurements can be developed which provides some degree of confidence that the true nuclei concentrations are more accurately and consistently known.

The inherent difficulty of assessing the extent of efficiency of ice nucleation in field experiments has led to extensive laboratory investigations of nuclei generators. Such characterizations have been based on the assumption that a one-to-one relationship exists between active ice nuclei and ice crystals produced. It has become clear more recently that changes in liquid water content and nuclei concentrations cause marked change in both nuclei counts (ice crystal counts) and in the mechanisms of nucleation.

This problem can be solved only by understanding the relative effects of different agents as a function of temperature, moisture level, physical state, duration of action, and other operative variables. Inasmuch as the results of such research will have a considerable influence on field experimentation, a high priority should be attached to this area to improve the efficiency of future operation.

Although there has been a sustained systematic effort to develop cloud physics instrumentation needed for weather modification, the present instruments fall short of what is required.

An increased effort is required to develop Doppler radars that can map the wind field in space-time wherever there is precipitation reflecting the radar signal. Three Doppler radars synchronized through a computer are able to give the three-dimensional wind vector. This system will also give the precipitation size distribution throughout the space. Microwave radiometer sensors giving cloud temperatures and water vapor content as well as liquid water and ice content of clouds, remotely, need to be perfected.

The use of high resolution real-time satellite information in the field provides the possibility of continously surveying the side and observing the effects of weather modification operations.

In the future, it will be very important for the weather modifier to have computerized display systems to take advantage of the information that will be available to him for making real-time decisions.

Depository for Weather Modification Data

In the past, the statistical and physical assessment of weather modification results has been handicapped by the fact that many of the original data obtained during countless weather modification attempts in this country are practically unavailable.

A desirable addition to the national program for weather modification is the establishment of a depository for such weather modification data. It should be staffed by cooperating meteorologists, statisticians, and specialists in information retrieval. The depository would serve to collect, to organize, and to store all the observations (either originals or photo copies) made in the course of all experiments on weather modification conducted from public funds and such others as may be deemed appropriate and possible. A special regulation should be authorized, perhaps by Congress, requiring that experiments operating with the support of the Government provide the depository with copies of all the observations made, whether they are considered of permanent or only of transitory significance. Certain physical data, such as ice crystal replicas may have to be stored as stereoscopic photo pairs instead of the originals or as normal photos. The delivery of data to the depository should be effected at some reasonable intervals during the progress of an experiment and perhaps within 2 months after the close of each experimental season. Wherever possible, the data should be provided in a standardized format for computer processing.

After a reasonable period of time, during which each experimenter would have priority in using the data he collected, the observations in the depository should be considered public property, available at cost to all research workers. In a way, the proposed depository would be similar to the National Climatic Center in Ashville, North Carolina, which is used extensively by the scientific community. However, the collection of data by the depository

would include many items specifically collected in the course of experiments that are presently unavailable at Ashville. It is recommended that the Weather Modification Depository be attached as a special unit to the National Weather Records Center.

Socioeconomic Legal Aspects for the Future

What the public thinks about weather modification, rather than what scientists know about it, will play the dominant role in the future of this science. The most expertly developed technology, whether it be for augmenting the water supply or for suppressing damaging weather phenomena, will find only limited future application in the absence of a strong public demand.

Prerequisites for the development of widespread public understanding are:

Convincing evidence that the benefits promised can be gained without risk of catastrophe and at true costs more attractive than those of other options.

Clear demonstration to Peter that he is not to be robbed for the benefit of Paul. Easily used administrative means of processing claims for damages resulting from weather modification operations must be provided so that court action is not routinely required.

Effective mechanisms for public participation in scheduling and control of operations.

Reliable communications though public media about the scale of effects to be expected.

Much research and organizational effort are needed to analyze public demand.

As pointed out by Sewell in NSF Report 68-18 "Human Dimensions of the Atmosphere," the issue facing us now is to outline directions which future research on human adjustment to the atmosphere should take. He outlines four main lines of inquiry:

(1) Sensitivity of activities to weather and climate. - We must gain a much better appreciation of the sensitivity of our society to such factors as temperature, precipitation, and wind. Broad types of investigations are needed to cover studies of the impact of weather and climate on particular industries and upon the social patterns which have evolved within specific regions of the country. We must be able to anser specific question such as the economic or social significance of an extra degree of temperature for a particular activity, or the economic impact of hailstorms or hurricanes on a given region.

(2) Impact of weather and climate on locational decisions. - How strongly has the factor of weather and climate influenced the decesions of individuals or corporations to locate in a given region? Will the ability to modify the weather have a major impact upon such locational decisions, or are other factors such as available labor pools, natural resources, and transportation facilities more important in this determination?

(3) The role of weather and climate in decision making. - How do people decide which of several alternative means of assessing the impact of weather is the most appropriate? For example, what factors condition the manner in which people interpret and respond to information given in a weather forecast? Why do some people welcome weather modification activity but others oppose it?

(4) Effects of human activities on weather and climate: What effect does the thermal, particulate, and gaseous contribution of man's activities to the atmosphere have upon weather patterns?

It is apparent that if we are to make use of our growing capability to manage our environment, we must gain a much better understanding of these four critical problem areas which link man to the weather. Much of this understanding will require the talents and abilities of the social scientist. Unfortunately, the participation of the social sciences community in problems involving weather and climate has been minimal in the past. A concerted effort to attract these talents to environmental and atmospheric management problems can be made by providing equal partnership to the social scientist on the management teams and giving him the resources which he needs to do the job.

Many legal problems face the successful application of atmospheric management practices which are not covered by existing law. The application of water law or riparian rights to atmospheric water resources raises many controversial questions which fail to fit the circumstances involved. Who, indeed, owns the clouds which pass over a state, a city, or a property owner's boundaries? Are clouds to be considered in the same light as wild game in the forest which belongs to anyone who can capture and take possession of it? Are clouds and atmospheric moisture really national resources such as oil and minerals, and should they be subject to Federal or state regulation?

A new body of law for weather modification practices should be defined at this time rather than to submit to the present chaotic practice of building precedents through case records. Unfortunately, there are few court cases on record, and these have done little to point the way toward an equitable law structure.

Ecological and Hydrological Studies

A continuing program of basic and applied research in ecology and watershed hydrology is needed to provide the necessary background knowledge for weather modification programs. In addition, specific ecological and hydrological studies must be established at the sites of weather modification projects. They must become a significant part of the decisions on when, where, and how to perform cloud seeding and of the evaluations of the results.

Specific efforts are required to:

Improve technology for identifying, measuring, and monitoring biological and hydrological changes at sites specifically known to be influenced by weather modification operations.

Assess the impact of weather modification upon biological systems. Analyses should be made of ecosystem responses to specifically identifiable types and amounts of weather modification. Identifiable ecosystem responses within the zones of influence of weather modification need to be related to responses that occur elsewhere due to natural variations in weather.

Assess the impact of weather modification upon the physical landscape and hydrological cycles. Analyses should be made of the influence of artificial changes in precipitation (frequency, intensity, duration), radiation, and temperature upon the hydrology of large agricultural, forest, and other wild land watersheds. Changes in erosion, sedimentation and stream channel stability may occur as a result of weather modification. Studies should be made of the interrelated effects of forest or agricultural practices (size of timber openings, crop patterns, etc.) and weather changes on watershed behavior. In mountainous country, studies should be made of possible changes in snow avalanche characteristics that may occur as a result of modification of orographic storms.

Learn how micrometeorological processes in the soil-plant-air regime interact with specific changes in weather systems. These studies need to relate specific kinds and levels of weather modification to such things as radiation, sensible heat, water, carbon dioxide, and chemical processes within vegetative systems. A comprehensive model should be developed that predicts microclimate characteristics produced through weather modification. Techniques should be developed for applying knowledge gained from these studies to a variety of land management and environmental protection activities including enhancement of plant growth, reduction of rural duststorms, control of forest fires, and dissipation of heat and smog in cities.

Chapter IV.

RECOMMENDATIONS FOR ACTION

Implementation of the suggestions for acceleration of progress will require the preparation of detailed action plans. ICAS member agencies indicated as Lead Agencies for the designated national projects, should create a coordination committee for each project. The chairman of each committee should be drawn from the lead agency for the particular project and each participating agency should be represented.

The work of these coordination committees should include early development and submission to ICAS of action plans as well as periodic progress reports after the project is underway.

PROTECTION

FROM

NATURAL DISASTERS

October 15, 1971

PROTECTION FROM NATURAL DISASTERS

- Accelerate weather modification to reduce the economic and social burden of severe weather phenomena
  - Reduce by 30% the annual hurricane destruction of about $500 million
  - Make a significant reduction in annual hail damages of over $300 million
  - Reduce timber losses due to lightning-caused fires by 40% and fire control costs by 30% (total annual savings of $135 million)
  - Ameliorate paralyzing effects of severe shoreline snowstorms and reduce snow removal costs
  - Reduce annual fog-related transportation losses of $375 million by about 50%
  - Augment regional precipitation at times of strong economic or environmental need
- Assess impact of climatic change due to natural and manmade activities
  - Provide alerts to large-scale contaminant buildups
  - Provide basis for prevention of catastrophic climatic trends
  - Provide new insight and understanding into climatic change as basis for making valid decisions and planning wise strategies
- Improve effectiveness of weather warnings
  - Provide single authoritative source for warning information
  - Provide full spectrum of alerts and warning to at least 90% of the population
  - Improve detection, prediction, dissemination, and community preparedness
  - Eliminate unnecessary storm preparation costs

PROTECTION FROM NATURAL DISASTERS

- Reduce the impact of flood disasters on the nation
  - Improve forecasts to make life saving, evacuation and flood preventative actions more effective
  - Provide rapid collection of river and rainfall observations from remote areas using satellite technology
  - Extend flood warning service now furnished 2000 communities to an additional 500 localities
  - Reduce flood losses now at one billion dollars by estimated 50 million dollars annually
- Reduce significantly the threat from earthquakes, volcanoes and landslides
  - Protect the lives and property of the more than 40 million people who will be living in high risk areas by 1980 through adequate land use planning
  - Improve the damage resistant design of structures to reduce losses such as the more than $550 million cost of the 1971 San Fernando earthquake
  - Reduce the level of landslide damage which exceeds hundreds of millions of dollars annually
  - Predict earthquakes and volcanic events on a time scale ranging from decades to weeks or days
  - Demonstrate the feasibility of controlling the size of major earthquakes
  - Reduce the anticipated $20 billion destruction from a great earthquake in a major metropolitan area expected before the year 2000 by as much as 25%
- Improve effectiveness of forest fire prevention and control
  - Reduce the loss of lives and fire damage to communities such as occurred recently in southern California when 1,200 fires burned more than 600,000 acres, killed 14 people and destroyed 900 homes
  - Safeguard and enhance forest industrial production by reducing forest losses which in 1970 exceeded $700 million

PROTECTION FROM NATURAL DISASTERS

- Make forest fire control safer and more efficient to reduce annual costs of forest fire control of $350 million

- Reduce fire-related flood and erosion damage

- Safeguard the environmental quality in American forests

- Accelerate planning actions by state and local jurisdictions to reduce losses from all natural hazards

  - Provide technical and financial assistance to state and local jurisdictions in identifying areas subject to natural hazards

  - Provide criteria for land use planning and model zoning ordinances, regulations and building codes

  - Assist and encourage communities to adopt appropriate disaster protection measures with effective enforcement provisions

  - Apply Federal science and engineering through increased local governmental responsibility and capability

  - Reduce costs to the Federal government for disaster relief

PROTECTION FROM NATURAL DISASTERS

COST ($millions)			ITEM	PUBLIC IMPACT			JOBS			BALANCE OF TRADE		
72	73	74	WEATHER MODIFICATION	72	74	76	72	74	76	72	74	76
1.8	10.8	10.8	1. Expand Hurricane Modification project to other areas and increase computer modeling efforts	M	H	H	L	M	M	L	L	L
2.6	3.6	5.1	2. Accelerate experimentation with various hail suppression techniques	L	M	H	L	L	M	L	L	L
0.5	3.5	5.5	3. Develop storm model and lightning and fire-sensing system, and perform pilot lightning suppression experiment	L	M	H	L	L	M	L	L	L
0.5	1.0	2.0	4. Expand Great Lakes snow redistribution project to other areas and increase surface and aircraft support	L	M	H	L	L	L	L	L	L
3.0	10.8	15.8	5. Install additional cold fog dispersal systems and develop warm fog dispersal capability for ground and airborne transportation	L	M	H	L	M	M	L	M	M
0.7	1.7	3.7	6. Extend research on augmenting precipitation from cumulus clouds	L	M	H	L	L	L	L	L	L
-	54.6*	28.4*	7. Update national aircraft capability for weather modification support		n/a		L	M	M	L	L	L
-	25.0*	25.0*	8. Increase national computer capability		n/a		L	M	M	L	L	L
9.1	111.0	96.3										

* These are one-time costs.

PROTECTION FROM NATURAL DISASTERS

COST ($millions)			ITEM	PUBLIC IMPACT			JOBS			BALANCE OF TRADE		
72	73	74	CLIMATIC CHANGE	72	74	76	72	74	76	72	74	76
1.0	13.7	19.3	1. Establish 6 global and 10 regional baseline stations to measure gaseous and particulate composition	M	H	H	L	M	M	L	L	L
3.0	20.5	20.5	2. Conduct surface and upper air field investigations and perform modeling research	L	M	M	L	M	M	L	L	L
–	9.0	18.7	3. Apply promising measurement technology and develop new instrumentation and automated remote sensors	L	M	M	–	M	M	L	L	L
4.0	43.2	58.5										
			WEATHER WARNINGS									
13.7	20.9	40.9	1. Improve detection and prediction (radar, automatic stations, research and applications)	H	H	H	L	M	H	L	L	L
4.0	15.7	19.9	2. Improve dissemination (satellite systems, radio nets, weather wire multi-line telephone)	H	H	H	L	M	H	L	L	L
0.2	0.4	1.4	3. Improve community preparedness (education, evacuation plans)	H	H	H	H	H	H	n/a		
17.9	37.0	62.2										
			FLOODS									
3.0	7.2	9.8	1. Automation of observational reporting networks	L	M	M	L	M	M	L	L	L
0.7	1.4	1.9	2. Computer models for prediction and warning	L	M	M	L	L	L	L	L	L
3.7	8.6	11.7										

PROTECTION FROM NATURAL DISASTERS

COST ($millions)			ITEM	PUBLIC IMPACT			JOBS			BALANCE OF TRADE		
72	73	74	EARTHQUAKES, VOLCANOES AND LANDSLIDES	72	74	76	72	74	76	72	74	76
4.0	20.2	20.0	1. Locate hazardous areas	M	H	H	L	M	M		n/a	
3.6	16.2	32.6	2. Design damage resistant structures	L	M	H	L	M	M	L	L	L
4.8	18.8	33.8	3. Predict earthquakes and then effects on the works of man	L	M	H	L	M	M		n/a	
2.2	25.5	17.7	4. Control the maximum size of future earthquakes	L	L	M	L	M	M		n/a	
0.6	1.5	1.9	5. Reduce damage from volcanoes	L	L	L	L	L	L		n/a	
0.8	2.8	4.8	6. Reduce damage from landslides	L	M	H	L	L	L		n/a	
16.0	85.0	110.8										
			FOREST FIRE PREVENTION AND CONTROL									
1.5	5.5	11.6	1. Implement Project Aero-Fire (Develop fire attack systems, fire command and control systems, and hazard reduction methods and determine cost-benefit ratios for various alternatives.)	L	M	H	L	M	M	L	L	M
1.3	2.5	2.5	2. Expand the National Fire Weather Service (complete the planned Fire Weather Forecast Center Network, expand special data acquisition systems, and develop improved forecasting and applications techniques.)	L	M	M	L	L	L	L	L	L
2.8	8.0	14.1										

PROTECTION FROM NATURAL DISASTERS

COST ($millions)			ITEM	PUBLIC IMPACT			JOBS			BALANCE OF TRADE		
72	73	74	COMMUNITY DISASTER PROTECTION ACTIONS	72	74	76	72	74	76	72	74	76
0	10.0	25.0	1. Community assistance program	L	M	H	L	M	M	n/a		
0.5 0.5	1.5 11.5	2.5 27.5	2. Federal supporting research and demonstration	L	M	H	L	L	L	n/a		