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Prospects and Implications of Technological Advance

Henry Jarrett

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SCIENCE AND RESOURCES

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SCIENCE *and*

Prospects and Implications

ESSAYS BY

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Horace R. Byers
John A. S. Adams
Earl P. Stevenson
Willard F. Libby
Lee A. DuBridge
Henry A. Wallace
Oris V. Wells
Clinton P. Anderson
Edward A. Ackerman
James Boyd
Paul W. McGann
Frederick T. Moore
Richard L. Meier
Philip Mullenbach
E. Blythe Stason
Alan L. Dean
Philip C. Jessup

RESOURCES

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EDITED BY *Henry Jarrett*

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Resources for the Future is a nonprofit corporation for research and education to advance development, conservation, and use of natural resources. It was established in 1952 with the co-operation of The Ford Foundation and its activities have been financed by grants from that Foundation. The main research areas of the resident staff are Water Resources, Energy and Mineral Resources, Land Use and Management, Regional Studies, and Resources and National Growth. One of the major aims of Resources for the Future is to make available the results of research by its staff members and consultants. Unless otherwise stated, interpretations and conclusions in RFF publications are those of the authors. The responsibility of the organization as a whole is for selection of significant questions for study and for competence and freedom of inquiry.

This book is one of Resources for the Future's general publications. It is based on the papers prepared by authorities who participated in the 1959 RFF Forum.

Editor's Introduction

RECENT ADVANCES in science and technology already are strongly influencing the production and use of natural resources, and will have even larger effects in the future. Nearly everyone recognizes that this is so, but the exact nature of the new discoveries, the forces they are letting loose, and the directions in which they are leading, are not nearly so widely known or well understood. This book explores some of these difficult and critical questions.

There is nothing new in the close tie between technology and natural resources. People have been devising better ways of using resources ever since they climbed down from the trees; some of the greatest achievements, in fact, belong to prehistory —the wheel, the beginnings of organized agriculture and metallurgy, and other epoch-making discoveries. During the long interval the range of usable resources has been constantly broadened, though many particular methods and materials have been supplanted along the way. Neither is there anything unfamiliar about the way that resource technology is supported and propelled by modern science; that relationship in its modern form dates from the Seventeenth Century. The new elements are, rather, the continuing acceleration of the technological drive and the fundamental nature of some of the things science is discovering.

The world has not yet nearly assimilated the great technological gains of the Nineteenth Century whose many accomplishments included the widespread harnessing of steam power, mastery of electricity, and development of the internal combustion engine. Before the digestive process is finished there will be many further changes in farm and mine production, factory output, wage levels and work weeks, trade patterns, road-building, school systems, taxes, and almost everything else. Meanwhile new technological yeast is constantly being added to the ferment.

Consider just a few of the events of the past twenty years. Nuclear energy has been unlocked, changing uranium from a little-used resource into a prized raw material, promising to ease the strain on coal, oil, and gas as sources of energy, posing the riddle of disposal of radioactive wastes, and offering many other good or evil possibilities completely aside from its frightful military potential. New plastics and other products of what Earl Stevenson later in this book calls "molecular engineering" are challenging many uses of familiar materials like steel, copper, lead, wool, cotton, and wood, often enabling commonplace and plentiful raw materials to do work hitherto performed by relatively scarce ones. New knowledge of how clouds behave already appears to have given man some power to influence the pattern of rainfall in mountain areas; and although much work remains to be done a much more effective degree of weather control seems entirely possible. Continuing improvements in plant and animal genetics and other branches of agricultural science are bringing large increases in yield—so large in fact that for the present at least the United States is much embarrassed by farm surpluses. In the long run, however, the influence of modern genetics upon farm production may be small as compared with its influence upon man himself as the maker and user of resources. Then there are the beginnings of the exploration of outer space. Although, as Lee DuBridge points out, the direct effect upon resources during the next few years is likely to be consumption of vast amounts of raw materials in the effort to escape the pull of gravity, greater

knowledge and control of the terrestrial environment already are in sight even from the first tentative probes; moreover, even after a taste of the great adventure, man's concept of his future and material resources never again can be completely earthbound.

With such continual changes in the patterns and background of resources supplies and use, there is every reason for reviewing periodically, and more frequently than in the past, developments on the scattered fronts of science and technology and to appraise their meaning. The need is sharpened by another circumstance: the sudden and wide acceptance of forward planning, with its heavy dependence upon projections. Man's interest in his long destiny in the next world is an old preoccupation; individuals have planned ahead for immediate families, and rulers for dynasties; but the concern of whole nations over what things will be like 25 or 100 years hence is a truly new phenomenon. And this is not just a passive concern. Even in the United States and other countries that make the deepest bows to both democracy and *laissez faire,* people act in the present to avert calamities or induce benefits in a fairly distant future. Many public and private decisions are being made at least partly on the basis of projections and analysis of their meaning. The value of a projection rests largely on its underlying assumptions, and in dealing with natural resources one of the key assumptions is that of the future state of technology. There are infinite possibilities for error here, from too much imagination as well as from too little. At first glance it might seem that the safest course would be to assume no change from present technology, but with today's rate of technological gain this is just about the surest way of going wrong. From what was known in 1900, with only a few uncertain horseless carriages on the bad roads, the probable 1950 demand for buggy whips would have looked quite respectable.

These reasons led to the 1959 Resources for the Future Forum, held in Washington during January, February, and March. The papers in this book were first presented there. As

planned by Reuben G. Gustavson and Joseph L. Fisher, executive director and associate director of Resources for the Future, each of six sets of public lectures dealt with one area in which advances in the natural sciences are of large significance to resources and their management. Each section of this book is based on one Forum program. In the first essay of a section a leading natural scientist describes in nontechnical terms the present status of important lines of research in his area of special interest and the prospects, insofar as they can be foreseen, of where the next gains will come. In the other two essays authorities in fields other than natural science discuss the implications of scientific progress to the resources picture, each from his own viewpoint—businessman, government administrator, economist, political scientist, etc.

With the wide range of possible subjects, it was hard to confine the series to six. Two of the several interesting areas of research that had to be left out were solar energy and marine resources, including desalting of sea water. It may well be that some of the dramatic research breakthroughs of the next few years will come in one or more of these passed-over fields. All that can be said is that at the time of selection, the lines of research chosen were those that seemed among the most significant and most in need of public presentation and discussion.

Four of the topics finally chosen—minerals exploration, weather modification, chemical technology, and nuclear energy —are concerned directly with particular resources or groups of resources. The other two—genetics and outer space, which comprise the first and last sections of the book—deal more with the general climate in which resources of many kinds are produced and used.

In many ways the design of this book complements that of *Perspectives on Conservation,* which resulted from the 1958 RFF Forum. The earlier volume looked at the nation's resources situation from the standpoint of the first 50 years of the conservation movement, 1908-1958. The treatment was largely historical and from the inside, with emphasis on eco-

nomics and politics. The present volume largely looks ahead, from the standpoint of outside influences upon resources from the laboratory and industrial plant. Together, the two books supply much of the broad background of contemporary thought and affairs without which no consideration of natural resources problems and issues can go very deep.

As for any generalization of what the experts think about the shape of things to come, the editor can do no more than invite the reader to read on and see for himself. The essays that follow resist pigeon-holing, for each distills in a few pages the accumulated thought and experience of men of varied viewpoints and strong convictions. Although the pattern of the book is neat and simple, the execution is not neat at all. The idea of having the scientists present the research background was generally adhered to, but their own interpretations and conjectures and those of the nonscientific commentators ranged far and wide and sometimes, to put it mildly, fell short of complete agreement.

Neither the authors as a group nor Resources for the Future, as sponsor of the Forum and this book, attempted to resolve the variety of facts and opinions or to set down any formal conclusions. Nevertheless I believe it would be difficult for anyone to come away from the whole collection of essays without some impressions of the pace and direction of advances in science and technology and of their impact on people and resources. By way of example, here are a few of the things the book set me to thinking about . . . .

On the advancing frontiers of knowledge: It seems clear that some of the current lines of research are truly seminal. Old limits and relationships are dissolving. In the future the top limit of fresh water supply in any given area may no longer be imposed by nature's hydrologic cycle of evaporation, rainfall, and runoff. New materials tailor-made by chemical technology may change the whole concept of total supplies; the ultimate resource base would be measured in molecules rather than tons of ore, board feet of timber or acres in cotton. De-

liberate modifications of the size and perhaps characteristics of future populations may influence future patterns of demand. Joseph Lerner, until recently of the RFF staff, once announced with a straight face that a good way to solve problems of resources shortage might be to breed smaller people; however hard he may have been pulling his colleagues' legs, the possibilities of altering human requirements are nonetheless plain. The possibilities of penetrating outer space add a new dimension to the man-resources relationship; even if the prospects are remote and uncertain they cannot be entirely discounted in a civilization that centuries ago had the imagination and audacity to fix the position of a ship at sea by taking sights on the stars.

On scarcity or abundance: The book seems to leave this classic resources question as open as it was before. Even though most of the developments explicitly discussed will work in the direction of increasing resource supplies, through better methods of discovery, extraction, and processing, there is little to suggest that technology has, or will have, the complete answer. Two significant undercurrents that don't encourage complacency run through the essays. One is the continuing pressure of rising world population and of levels of living, especially in what are now the poorer areas. Although the curve can't rise forever* and needs and tastes may change considerably over the long run, the outlook for many years to come is one of more people wanting more resource products. The second is the tendency of many technological improvements to increase the draft on resources. This is the same long-standing trend that in 1952 caused the Paley Commission to remark with some awe that *domestic* consumption of most fuels and minerals since the start of the first World War exceeded the total world consumption in all the preceding centuries.

* Recently Harold Barnett of RFF, simply to show where mathematical projections can lead, cited a calculation that if the world's population should increase at the rate assumed by Malthus the total weight of population in the year 3000 would exceed that of the earth. An alert reader, remembering the law of the conservation of matter, promptly asked: "What will they be made of?"

On human responsibility: The new possibilities of surmounting some of the old limits and barriers on resource supplies and use put a new burden on the modern citizen. Until recently man accepted the main characteristics of his environment pretty much as he found them. He survived, and sometimes prospered, by ingenuity, adaptability, and fortitude. These virtues doubtless will remain indispensable, but new possibilities of choice are now being added. As Edward A. Ackerman puts it in his essay, "Do we know what kind of weather or climate we should like to have if we could change it to order?" It can be argued, of course, that the difference is only in degree, since science still consists in understanding natural phenomena. But this really would be to beg the question, considering the basic quality of some of the things man is beginning to understand, the scale on which he seeks to alter his environment, and the possible side effects of his interference with processes and relationships that used to be thought of as unchanging. There is need of wisdom in making the choices as they open up. Sometimes the risks may be greater than the possible gains. George Beadle, for example, points out that while modern man already *knows* enough he is not yet by any means *wise* enough to take a hand in consciously shaping his own genetic future. More and more, as technology advances, must planners, administrators, and ordinary voters be aware of the physical and biological possibilities and limitations of their plans and aspirations; and scientists and technologists must recognize the social and economic meaning of the applications of their research.

Henry Jarrett, *Editor*
Resources for the Future

May, 1959

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