ation of weather modification" James A. Crutchfield points out that the benefits to agriculture of an artificial increase in precipitation must be weighed against the benefits resulting from alternative adjustments to precipitation shortages, such as shifts to drought-resistant crops or water-conserving cultivation techniques. He states, "Despite the general lay opinion, it is not at all clear that the marginal net economic benefit from expanded application of water to land is as great—in total, or by specific area and type of agriculture—as could be achieved by investment in increased quantities or improved quality of other agricultural inputs." In this situation research into the cost-benefit relationship of potential effects of artificial increases in precipitation should be given priority even over theoretical, laboratory, and field studies to determine the circumstances under which seeding can produce consistent increases.

For other applications of weather modification, such as fog dispersal, lightning suppression to prevent forest fires, and hail prevention, the economic benefits are more definite, but only for dissipation of supercooled fog (liquid drops below 0°C) are techniques of proven effectiveness available.

The impact of weather modification, in addition to economic aspects, on human activities and the ecological balance of nature is considered in chapters by W. R. D. Sewell and W. T. Edmondson. Their conclusion is that investigation of the ecological and social consequences should precede or be concurrent with the development of any program to modify the weather, to insure that undesirable "side effects" do not outweigh the expected benefits.

Gordon J. F. MacDonald, in his chapter on "Federal government programs in weather modification" (as well as in his article based on it in the *Bulletin of the Atomic Scientists*, Oct. 1968), advocates "a major reorganization of federal programs, in which a new agency, preferably an independent one, is given primary responsibility for promoting research in environmental prediction and modification." He would leave weather modification operations to the various mission-oriented agencies, and "support for fundamental studies through grants and fellowships" to the National Science Foundation.

If establishment of a new independent agency would attract appropriations for research adequate to the magnitude of the problems involved in fully understanding atmospheric processes on all scales, one can heartily endorse the proposal. MacDonald points out that eight federal agencies participated in weather modification activities in 1966. A new agency might represent a ninth hand competing for a share of federal funds, with the result being further fractionation of resources instead of the development of a program large enough to exceed the "critical mass" required.

A further concern is whether it would be possible to find enough well-qualified personnel to man such a new agency. At present most of the experts in atmospheric sciences in the country are employed by the Environmental Science Services Administration. ESSA's predecessor (now one of its components), the Weather Bureau, has been criticized as having been unduly conservative and having failed to exercise leadership in the field of weather modification. However, the justice of these criticisms may be questioned in the light of the uncertainties which still remain concerning the efficacy of rainmaking and the inadequacy of the appropriations with which the Bureau has had to carry out its extensive observational, informational, and forecasting activities, even without the undertaking of extensive investigations of weather modification. Perhaps it would be best to take full advantage of the expertise resident in ESSA, rather than to attempt to build a competent staff from scratch in a new agency.

Extensive hearings have been conducted by Congress in the attempt to resolve the conflicts of viewpoint among scientists, commercial operators, consumers, and governmental agencies. The need for a well-defined policy is recognized by all groups, and particularly by Congress. Regrettably, the foundations for such a policy in terms of the economic, social, and ecological objectives, the legal constraints, and the scientific and technical potentials and limitations are shown by this book to be not yet available. The intelligent interim policy would be to foster and adequately support research to find answers to these questions. Also regrettably, it is easier to get support for a premature program to augment precipitation or prevent hail than for the basic research which will render these objectives possible.

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Processing the Future

Technological Forecasting and Long-Range Planning. ROBERT U. AYRES. McGraw-Hill, New York, 1969. xviii + 238 pp., illus. $12.50.

In the last few years, because of the needs of the present a new breed of professionals called "futurists" has come into being. This breed contains a strange mixture of sociologists, technologists, physicists, and others, some charlatans, some poets, some meticulous workers, and others even geniuses. Most of them have considerable imagination. Many of their customers or semi-allies, however, belong to the penumbral areas of corporate or military management; and imagination there is often lacking. If it can be said of the teaching profession that "those who can, do; those who can't, teach," it can be said of the planning profession in U.S. corporations and military, "Those who can, run the show; those who can't, run the planning department."

This is a useful book for those of us who teach or run planning departments. The references and the introductory history are handy and cannot be found in any other single source that I am aware of. It is a book which will be of considerable use in many corporations, government agencies, and the type of consulting firm that is known as an "also-RAND." Given the scope of the book—it attempts to cover all technological forecasting and long-range planning methods—it is well organized and manages to go over a great deal of terrain. I do, however, get the feeling that it plays down and somewhat underestimates behavioral and organizational problems and is light on the dynamics of planning. There is also a lack of attention to the interrelation of planning, responsibility, and decision-making.

I am glad I read the book, it is useful, but it is not exciting. And I happened to be handicapped in my reading of it by knowing a great deal about some of the particulars in it. That is always dangerous to a book. For example, in reading Toynbee, if one happens to have a deep knowledge of any particular culture the charm of seeing the world as a whole soon disappears. It is to some extent unfair to fix on specifics when a man is trying to paint the broad picture. However, if nothing else the examination of specifics helps us form some criteria for judging the whole. So, let us look at some of these in this book.

To an economist, it was rather comforting to learn on page 3 that "as

businessmen, bankers, actuaries, or government officials we can make quite good aggregate estimates of such things as 'future labor force, employment level, demographic distribution, birth rate, annual inflation rate, etc., etc.' " But it would have been helpful to have both a time period and a comparison with something else to justify the use of the words "quite good." In general, demographic long-range forecasting has been particularly bad, and so have the forecasts of annual inflation rates. We all make them, but it is quite likely that value is more in the system than in the numbers the system produces.

The description of types of forecasts presented on page 34 might better have been presented at the beginning of the book. Furthermore, the concept of causative anticipation is scarcely discussed. There are many situations in which forecasting may be quite possible because the group doing the forecasting happens to control its environment. Hitler was probably in better shape to forecast the invasion of Poland than most other people were.

In two parts of the book (pp. 54 and 205) Project Hindsight is mentioned as having confirmed the growing suspicion that non-mission-oriented research has been ineffective in contributing to military programs (a result that is being used to block military sponsorship of fundamental research). Possibly I have a more cynical view of studies like Project Hindsight than does the author. In general all one needs to know about a review project is who is the sponsor, who is inventing the criteria for judgment, and who is running the project; at that point the odds are overwhelming that the conclusions can be guessed before the study has been done. It is my belief that Project Hindsight had many of the signs of a hatchet job and Ayres is being naive in his treatment of it.

Ayres notes that "the social impact of the new forms of communication has been explored most deeply by Marshall McLuhan" (p. 65). Even if that is so, Ayres should be aware at least of Harold Adam Innis, from whom McLuhan learned much of his approach to communication and who provided much of the basis for McLuhan's writings.

Probably where I am most skeptical of this book is in chapter 5, where Ayres discusses "morphological analysis." This phrase was coined by Fritz Zwicky, who used the method successfully to obtain a taxonomy of possible technical devices. On pages 85–87 Ayres talks about using morphological analysis for future worlds. Again on page 157 we are told that "with the help of electronic data processing it becomes possible to 'look' at hundreds of thousands of cases, whereas plodding human players might take several days to go through a single one." It is my considered opinion that, especially in areas where the problem is not particularly well defined, where the variables are hard to measure, and where the number of alternatives can be extremely high, human organizations at this time with all the computers in the world are fortunate if they have the time and the resources to explore meaningfully 10 or 20 alternative scenarios, let alone a hundred thousand. Exploration costs time. We are still at the stage where some human being has to interpret the outputs from a computer in most planning exercises. Tons of pages of computer output are in general a sign of a badly understood job. Most simulations have a value inversely related to the fourth power of the quantity of computer output. Corrective reading may be obtained by looking at Miller's classic essay "The Magic Number 7 Plus or Minus 2."

As someone who was intimately connected with the evaluation of a large-scale simulation and war game called TEMPER, I was fascinated to find out on page 158 that TEMPER "is actually a rather sophisticated man-machine system designed to relieve the participating human players of a great deal of tedious computation and data manipulation and thereby increase their ability to zero in on the real issue . . . explored." This human player found the real issues rather fascinating on discovering from TEMPER that, unless the United States actively supported Israel in a war in the Middle East, then were say Lebanon or Jordan to fight Israel alone Israel would lose that war. Possibly I do not appreciate the value of calculating all possible outcomes for all possible worlds.

A reasonably good discussion of the work of Olaf Helmer and company on the Delphi method is given on page 149. A balanced view is presented; however, the reader should also be aware of the work of Norman Dalkey in attempting to construct methods to validate the Delphi procedure.

If you want to get a reasonably good coverage of methodology and the developing methodology in some parts of long-range forecasting, this book is worth going over. It should, however, be read with a considerable dose of skepticism. The book is partly a product of the Hudson Institute. However, unlike the works of Herman Kahn it does not bear the stamp of the outrageous which enables many of us to read those works with enjoyment and reinforced skepticism. Because Ayres's book is far more sober, one needs to be far more careful.

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Rock Structure

Metamorphic Textures. ALAN SPRY. Pergamon, New York, 1969. viii + 352 pp. + plates. Cloth, $10; paper, $8. Commonwealth and International Library: Geology Division.

Metamorphic textures have been rather neglected in books on metamorphism since Harker's classic work. Although there are signs that the situation is improving, there is clearly a need for a full exposition of the modern approach to this subject. Spry, whose wide experience of metamorphic fabrics is fortified by a knowledge of the physics of crystal growth in the solid state, stresses that his approach is to regard metamorphism as "a series of structural transformations rather than as chemical reactions . . . [these transformations] affect real, not ideal crystals." No one can quarrel with the view that metamorphic rocks must be treated as kinetic systems; indeed one can only be perturbed if it requires underlining at this time. More than half the book is concerned with the principles of crystal growth. Geologists will be grateful for the comprehensive review of such difficult topics as grain boundaries, mineral transformations (both stress-activated—like gliding, kinking, and twinning—and thermally activated), nucleation, and the factors controlling the size and shape of crystals. I suspect that the research worker will find these sections (covering about 170 pp.) more valuable than the remainder of the book, which deals (at too great a length) with the textures of thermal, regional, and dynamic metamorphism.

Spry believes that metamorphic petrology is at present undergoing a change of emphasis, marked by the considerable number of papers dealing with metamorphic textures that have been published in recent years. Certainly there have been notable successes—