in various parts of the world to determine the applicability in local situations of water fluoridation or fluoride provision through some other vehicle. McClure justifiably affirms the safety of fluoride ingestion at recommended levels with regard to all aspects of health. The reproducibility of the dental benefits around the world without even the complication of esthetically undesirable levels of dental fluorosis in various cultural scenes is becoming increasingly clear.

The last part of the book is devoted to the winning of approval for the initiation of fluoridation in the first trial communities, the extension of fluoridation throughout the United States and the world, the various legal tests through which fluoridation has received approval, and the questions and problems raised by those opposed to fluoridation on various grounds. Some interesting thoughts are included on the views of political and social scientists on the nature of the fluoridation controversy at the polls. Fluoride ingestion by man, and particularly fluoridation of public water supplies, have become subjects of intense debate, fear campaigns, and acrimony whenever and wherever the public is confronted with the opportunity to elect or reject the adoption of water fluoridation at a referendum. On these occasions, such considerations as the ubiquity of fluorides in soils, foods, and water supplies, the identity of the fluoride occurring natively in water supplies with that added in water processing plants, and the high efficiency of the human body to excrete fluoride are often forgotten. The vast amount and the varied types of research that have been conducted on fluorides and human health tend to be submerged by rhetoric under vague allegations of potential danger to many facets of health.

The author of this volume was a pioneer in the field of fluoride metabolism and did or supervised much of the analytical work on fluorides at the National Institute of Dental Research throughout approximately three decades. His tenure as chief of the laboratory of biochemistry spanned the time from the early recognition of the dental benefits of optimal fluoride ingestion to his retirement in 1966, when fluoridation of public water supplies had been demonstrated to be safe and had been widely accepted in the United States and was being adopted in many countries of the world. He knew many of the pioneers in dental epidemiology, biochemistry, and physiology who were responsible for the development of our current knowledge about fluorides. His personal warmth is very evident throughout the book. It is almost a diary made up of quotes, figures, and tables from key letters and scientific papers written over a 70-year period interlaced with comments about the import of the data and how they related to events past and yet to come. In addition, numerous vignettes are included of the men who made history through their participation in the development of the fluoride saga.

This book is good scientifically both for its textual content and its references. More than that, McClure portrays the human side of science by recording his insights about the enthusiastic, dedicated men who in the face of opposition and controversy persevered until overwhelming supporting evidence of benefit and safety had been obtained.

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Aerial Surveying

Remote Sensing in Ecology. Proceedings of a symposium, Madison, Wis., June 1968. PHILIP L. JOHNSON, Ed. University of Georgia Press, Athens, 1969. x, 246 pp., illus. $8.

Remote Sensing. With Special Reference to Agriculture and Forestry. National Research Council Committee on Remote Sensing for Agricultural Purposes. National Academy of Sciences, Washington, D.C., 1970. xvi, 424 pp. + plates. $12.95. NAS Publication No. 1723.

These two symposia bring together a wide variety of papers on uses and techniques in remote sensing and results of projects using different techniques. Johnson, in his résumé, stresses that ecological study is necessary for the solution of the real and extensive environmental problems facing mankind and mentions four phases of ecological study that can profit from the use of remote sensing techniques. To survey the potential of aerial surveys for answering specific environmental questions was the goal of the study of which the National Research Council volume is a result.

Inventory and mapping of environmental resources can be done economically and rapidly with remote sensors. A few features that lend themselves to assessment by remote sensing are crop acreage and yields, land use, pest and disease infestations, water quality, forest inventory, and some aspects of wildlife management. Remote sensing is no panacea, and many contributors to these volumes emphasize the need for "ground truth." Ground truth pertains to the identity of the image and to the relationship of the subject to the environment. Both of these entities are revealed solely by study on the ground.

Remote sensing has come a long way since the first aerial photographs were taken from a balloon during the Civil War. Black-and-white photography remained the only technique available until just a few years ago, but recent advances in infrared and color photography, electronics, and optics have now provided a wide range of sensors. Different kinds of infrared film, black-and-white and color film, radar, very-short-wavelength radiation, ultraviolet imaging, multispectral sensing, and nonphotographic scanners are some of the new developments useful in obtaining synoptic compilations of study areas.

Because plants are the primary subject of interest, or at least are a large part of the image, in agriculture and ecology, properties of plants that affect imagery need study. Several such properties have been studied in both the laboratory and the field; these are reflectance, transmittance, and absorptance of radiation. Findings of these studies aid in establishing the accuracy and significance of image analyses.

Several papers in both symposia deal with results obtained by means of remote sensing techniques, suggesting that the methods can be used in a wide range of environmental studies. Crop vigor, moisture stress, and disease are but three characteristics of plants that have been sensed with photography. Infrared sensing, using both film and nonphotographic scanners, has proved invaluable in inventorying large animal populations. Infrared photography also is being used successfully to detect hot areas at the ground surface caused by geothermal activity. Such patterns often go unnoticed on the ground, and their detection facilitates the selection of study sites. With airborne scanners, the distribution of visible light from the sea makes possible the rapid identification of water masses. Aerial photographs also have been used successfully to map bottom biota, sediments, and topography in shallow bodies of water.

The two volumes complement each other and are necessary reference works for anyone considering the use of remote sensing techniques in environmental work. Both contain references following each paper, and Johnson's symposium includes an extensive, selective bibliography. The rhetoric, as in most symposia, is varied, and some papers seem wordy. One is particularly difficult to read, having "fog" indices (Robert Gunning, *The Technique of Clear Writing*, McGraw-Hill, 1952) ranging from 17 to 22.

Studies of environmental problems through remote sensing methods may well create a trend toward a more geographic view of ecological problems and away from plot studies. Remote sensing will be invaluable, especially when the investigators realize that knowledge of the significance of the phenomena in question on the ground is essential in the interpretation of the imagery.

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Geology and Investment-Planning

Natural Resource Information for Economic Development. ORRIS C. HERFINDAHL. Published for Resources for the Future by Johns Hopkins Press, Baltimore, 1969. xvi, 212 pp., illus. $7.

How important to a country's economic development is information about its natural resources, and how should it decide how much and what kind of such information to gather? This is the question to which Herfindahl, "with the problems of developing countries in mind," addresses this book, relying much on his experience in Chile and Peru, countries that have governmental resource-planning agencies.

Herfindahl's key proposal is that expenditures on natural resource information should be judged as ordinary capital investments, competing with other investment opportunities on the basis of their rate of return. ". . . the goal should be to increase expenditure on information to the point where additional return generated is balanced by the cost of this information—but no further" [p. 94]. "The quantity of the information collected should be increased so long as the present value of the investment opportunity (or cost savings if this is the use to which the information is put) is increased by more than the cost of the information" [p. 124].

These objectives are correct in principle; the difficulty lies in applying the principle. The author conditions the undertaking of a resource survey to a specific investment opportunity previously singled out by a government planner, who would then decide when, how, and how much information is to be obtained. A feasibility study of the project would follow the resource survey.

Such a model, by replacing an unknown agenda of various investment possibilities by one, underestimates the potential economic benefits while charging all the cost of the resource information to one project. But to prepare an exhaustive agenda of potential projects is often not possible or not feasible. For how can the location and extent of mineral deposits, for example, be known ahead of the geologic mapping which is needed to find them? Government surveys of the resources of a region provide a common basis for the various facets of an economy—mining, oil and gas industry, forestry, water utilization, road construction, flood control, irrigation, land utilization, and so on. In some cases such surveys play a catalytic role in focusing the attention of the private sector on certain areas, which may be undeveloped or economically depressed. It would seem that such surveys are a precondition to any further planning or actions by government or private enterprise. They provide a minimum threshold of publicly available knowledge.

A second difficulty with the author's proposal is that, except in collectivist countries, one cannot assume a simple deterministic link between a decision to invest in resource information and the decision to invest in a specific project. The author says that "the appropriate division of functions between government and private enterprise does not bulk very large" in his discussion. What appears therefore to be overlooked is that private entrepreneurs are bound by considerations other than those of government planners and their investment decisions may break the simple chain of the author's model. The proper model is not a simple sequence but one involving multiple alternatives, with uncertainties and risks. To prepare it, however, would require a vaster and keener knowledge—of the various engineering, technological, and industrial factors, and of the investment opportunities—than is available to governmental natural-resource planning agencies.

On the basis of his experiences in Chile and Peru, the author recommends that a developing nation should maintain a central bureau to plan resource development and gather the necessary information. The history of Chile and Peru indicates, however, that their natural-resources planning bureaus have so far played a very much smaller role than the one he assigns them. In both these countries there are stronger specialized agencies that, as part of their activities, procure information on various aspects of natural resources. In Chile we can mention the National Development Corporation, the National Oil Company, the National Electricity Company, the Geological Institute, and the numerous technological organizations of the Agriculture Department. Moreover, nowadays in developing nations the truly effective economic planning, not merely in the resources field, rests in national planning offices usually attached to the office of the president of the nation.

The dangers of ignoring technological factors are evident from the author's comparisons of unit costs for various types of natural resource information. For instance, he is perplexed about the apparent wide disparities, in the costs per square mile of geologic mapping, between the U.S. Geological Survey and Canadian surveys. In his comparisons, he has ignored or inadequately allowed for the following factors that greatly influence the unit costs: (i) effect of map scale, (ii) effect of the size of the area mapped in a given campaign, (iii) extent of back-up office and laboratory work, (iv) differences between a two-dimensional and a three-dimensional geology, and (v) the number of consecutive mapping efforts that may be required to unravel the geology of an area.

Elaborating only on the first factor, we note that the choice of scale is a deliberate decision. There is a minimum dimension of the details which can be readily grasped with the naked eye on a map. This defines a minimum dimension of the details to be acquired in the field—their ratio being the scale, say, $1 : S$. Moreover, in selecting the field minimum detail we meet a situation similar to that in the sampling of a time function, wherein the sampling interval determines the Nyquist or high cutoff frequency. Now, the number of