SCIENTIFIC BOOKS

The Rôle of Research in the Development of Forestry in North America. By I. W. BAILEY and H. A. SPOEHR. The Macmillan Company, 1929. 118 pp.

THIS volume presents the results of a study of the problems of research in forestry conducted under the auspices of the National Academy of Sciences and supported by a grant from the General Education Board. The inquiry was directed especially to the status and needs of research in the sciences underlying forestry and more particularly those aspects of forestry comprised under the general head of forest production. The problems of forest utilization and the economics of forestry were considered only in their bearing on the central feature of forest production.

The investigation sponsored by the National Academy of Sciences was designed to determine the need for research of a more basic character than that now being carried on and to discover the principles that should underlie such a program of fundamental research as might prove necessary. The academy wisely delegated the responsibility of the inquiry to two scientists of note who were able to bring to the study a wide knowledge and experience in the experimental sciences. Messrs. Bailey and Spoehr have shown in their report an extraordinary grasp of the problems and methods of forestry, and of the peculiar conditions, economic and otherwise, which affect the extension of applied silviculture. The inquiry and the admirable report are of capital importance at this juncture. Forestry is rapidly passing out of the stage of mere protection from fire. In portions of the country silviculture is already being applied on a large number of forest tracts. The efforts so far made are chiefly based on empirical knowledge. American foresters are already faced by countless questions that can be answered only through research. To meet this situation the federal government is expending large sums for investigations in forestry, and there is, in the aggregate, considerable research conducted by the states, by universities and by the forest industries. It is of great value to have a critical study made of this work to determine its adequacy and to clarify many problems that have tended toward confusion among the foresters. The great importance of the report of Messrs. Bailey and Spoehr lies in the clear definition of forestry from the scientific standpoint, the interpretation of the character of the research that is required and the constructive proposals for the development of the investigative work needed to place forestry on a sound and enduring foundation.

At the outset the authors emphasize the distinctive character of forestry, in research and in the application of silviculture. Two peculiar characteristics of the forest must constantly be kept in mind in considering the problems of research: first, its extreme complexity as a biological unit, and, second, the long period of time required for trees to come to maturity.

The forest is very complex in its constitution, in its life processes and in its reactions under disturbing influences. A forest is not merely an aggregation of trees, representing often a considerable variety of species; it comprises also many shrubs and herbaceous plants, insects, fungi, herbivorous animals and a soil fauna and flora of great complexity, all having an influence on the life processes of the trees and of the forest as a whole. If a forest remains undisturbed for a long period of time there is established a relatively stable equilibrium. Such changes as occur, through the death of occasional trees or otherwise, do not materially affect its general character and form. This equilibrium is quickly upset by such disturbing factors as fire, windfall, insect infestations, lumbering and the grazing of live-stock. The changes that take place when a natural forest is disturbed are many and varied. The consequences of abuse are always serious. The forest may be entirely destroyed and the land laid waste by destructive cutting and fire, or unintelligent exploitation may result in a progressive deterioration of the forest, from the standpoint of its utility and economic service. On the other hand, skilful treatment may maintain and improve the productive capacity of a forest, and this fact is utilized in applied silviculture. In any case, the processes of nature are slow. The correction of abuse is a long and often an expensive process.

These facts are of importance in understanding the very nature of forestry. Ordinarily it is not possible to employ cultural methods, comparable to those in agriculture, to bring a forest into good productive condition. Forests are largely reproduced by natural means, growth is enhanced by improvement thinnings, abuses and mistakes in management are corrected by a gradual process of natural growth aided by skilful cuttings and auxiliary planting. These and other circumstances have been described with extraordinary clarity by Messrs. Bailey and Spoehr, in outlining the character of forestry and of the research problems.

Every forester will welcome the distinction drawn by the authors between the different types of research in forestry. As expressed by the authors, ". . . there are two distinct methods of investigating complex biological phenomena, one the extensive observational method of the descriptive sciences and the other the intensive analytical method of the basic experimental sciences." The descriptive sciences as applied to forestry are systematic botany, entomology, mycology, morphology, ecology, meteorology, physiography, etc., and the basic experimental sciences,

physics, chemistry, genetics and the physicochemical aspects of plant physiology and soil science. The authors state that at the present stage of forestry "in all probability the basic sciences can contribute most effectively to the extension of silviculture by helping to systematize and accelerate the process of accumulating essential data and by aiding in their analysis and interpretation, rather than by attempting prematurely to originate fundamentally scientific, silviculture techniques." The aim of research in the basic sciences should be directed, then, to a "concerted attack which aims to advance the general status of knowledge concerning forest phenomena."

Most of the research in forestry so far carried on has been of the descriptive and empirical type. The authors give recognition to the importance and character of the work that has been done by the public agencies and educational institutions. In the pioneer stages of silviculture it has been necessary to resort to the extensive observational methods of the descriptive sciences, coupled with simple experimentation, to secure quickly the basis for the practical application of forestry. "Forestry can not now wait for ultimate explanations of the extremely intricate biological phenomena of silviculture which eventually must be supplied through exact and time-consuming research in the basic experimental sciences." Nevertheless, with the intensification of silviculture, the pressure of knowledge that can be derived only from research in the basic sciences will increase rapidly, and it is important to initiate as soon as possible a program of research that reaches deeper than that which is now under way.

The authors devote a chapter to an illuminating contrast between the problems of research in forestry and those in agriculture and medicine. The difficulties in forest research center around the complexities of the physiological phenomena in the forest, the time element in experimentation with arborescent plants and the problems of controlling the environmental factors. On account of their size and longevity, trees must be studied *in situ;* they can not be grown to maturity in the laboratory as are many agricultural plants. The authors conclude that a "special physiological technique must be elaborated for their investigation."

The book contains chapters describing the progress of the movement of forestry and the work in research that has been undertaken by different agencies. In referring to the forest schools, attention is called to the lack of adequate facilities for training men for research. Most of the schools are organized primarily for the education of general practitioners in forestry. Only a few of them are sufficiently well financed to allow the staff to conduct research. This means that only a few forest schools have the personnel and the facilities to direct graduate work. Still, again, a large part of the research work carried on by the schools is observational and descriptive in character. The stronger schools are able to offer facilities for graduate work of a character to equip men for much of the work of the federal forest experiment stations, but are less well qualified to train men for the more basic work in the exact sciences underlying forestry.

The importance of developing facilities for training research workers in the fundamental forest sciences can not be overestimated. The success of research in forestry will depend on the ability of the educational institutions to recruit men who possess natural aptitudes for research and to provide an adequate training for their development. It may be said in this connection that one reason why more men of promise have not prepared themselves for investigative work is that the occupation of forest research is not yet sufficiently stabilized to attract them. One way to meet this situation is to provide more fellowships to enable students of special ability to devote the time necessary to prepare them for research.

The book contains a discriminating discussion of the agencies now engaged in research in forestry. It is the opinion of the authors that these agencies can not be counted on to conduct the basic experimental research deemed to be essential. This is particularly true of research underlying forest production. The federal and state agencies are handicapped in fundamental research by the sheer pressure to acquire information urgently needed in applied forestry. Even a casual survey of the unsolved problems faced by the American forester indicates the extent of the information of a descriptive character that is immediately needed. It is inevitable that public appropriations for research will be made chiefly for investigations and experiments of the descriptive and empirical type rather than for work in the basic sciences.

The authors point out that the very character of the problem of basic research in forestry requires the close working together of groups of specialists in the various sciences, in physics, chemistry, genetics and the physicochemical phases of plant and soil science. This is particularly difficult to secure in the federal and state agencies. For somewhat different reasons, the common attack on a group of fundamental problems is difficult in the universities as they are now constituted. Departmental inertia, individualistic tendencies of faculty members, obligations in teaching and committee work, personnel weaknesses in some of the departments, in addition to lack of financial support, are among the reasons that militate

against the contemplated cooperation in research in the universities. Botanical gardens and arboreta are also deemed better suited to investigative work of the descriptive character than to research in the basic sciences.

The authors emphasize that the foregoing conclusions apply particularly to the problems underlying forest production. The situation is somewhat different in the field of forest utilization, where the problems are more closely analogous to those of the engineering industries. Existing agencies are already conducting researches of basic character in the properties of cellulose, lignin and oleoresins, in wood preservation and in the physical qualities of wood.

The final chapter of the book deals with the need of creating a new agency to develop the research required as a foundation of silviculture. The authors make clear at the beginning that they do not propose a great institution for the centralization of basic forest research. It is the purpose rather to provide a special administrative agency, analogous to the Kaiser Wilhelm Gesellschaft of Berlin, which would be authorized to receive and administer funds for research and would build up centers of scientific work at universities which are deemed to be qualified to carry forward carefully planned projects of a basic character. The plan would not divorce forest research from the universities and other competent agencies, nor would the outstanding scientific workers be drawn off from their university associations. As expressed by the authors:

> These activities [of the central institute] should not involve the creation of a large, isolated research institute, but rather the development ultimately of several smaller research units which should be located in university centers and affiliated informally with existing scientific departments. Research thrives best and is most productive in compact semiindependent units of moderate size where the investigators are closely and informally associated, but where they are able to maintain contacts with general scientific and intellectual interests.

The first task of the new agency would be to study the status of the different basic sciences in relation to forestry. In this study the view-points of the different sciences would be brought into correlation and, in its subsequent activities, the central agency would render an important service in coordinating individual efforts in solving basic forestry problems.

The authors do not endeavor to suggest the specific lines of endeavor of the central agency. They emphasize, however, the study of the life processes of trees and forests, as fundamental to the successful practice of silviculture. "A new science of forest physiology, involving both physiology of the tree and of the forest, must be developed."

In the space of a brief article it is impossible to do justice to the many interesting features of the report of Messrs. Bailey and Spoehr. It merits careful study not only by foresters but by scientific men generally.

HENRY S. GRAVES
YALE FOREST SCHOOL

SCIENTIFIC APPARATUS AND LABORATORY METHODS

NEW FORMS OF DRY AND WET BULB THERMOMETERS

DRY and wet bulb thermometers are used mainly to obtain relative humidity. There are several well-known forms of hygrodeiks which by simple manipulation of index hands enable one to read on an adjacent chart the relative humidity and the dew-point; but in general, meteorological stations use a sling or whirled psychrometer, and have recourse to tables for the values mentioned above. For approximate values of the relative humidity at places where tables are not always at hand, there has been proposed lately a short-cut method.[1]

This method meets the approval of the Royal Meteorological Society but to us seems less satisfactory and convenient than a method which has been in use at Blue Hill Observatory for some years.

The Poulter formulas are:

$$(1)\quad \text{R. H.} = 100 - 350\, d/_T$$

$$(2)\quad \text{R. H.} = 100 - d d/_2$$

in which d is the difference between the dry and wet readings of the thermometers. For example, if the dry read 69° F. and the wet 59° F. the relative humidity would be 49 per cent. by (1) and 50 per cent. by (2). These values, however, are in error about 5 per cent. if we use the generally accepted formula

$$(3)\quad e = e^1 - .00367\ P\ (t - t_1)\ \left(1 + \frac{Z - 32}{1571}\right)$$

in which the units are inches of mercury and Fahrenheit degrees. For the values given above (69° F. and 59° F.) this reduces to .387 inch divided by .707 inch (the respective wet and dry saturation pressures, or 55 per cent. relative humidity).

The process becomes much simplified if units of force for pressure and kilograds for temperature are employed. Thus for a megabar pressure, *i.e.*, megadyne per square centimeter, or the new standard atmosphere, the relation is

$$(4)\quad p_s = p_e - .20\, d$$

[1] *Quart. Journ. Roy. Meteor. Soc.*, October, 1928, method of R. M. Poulter.