

ney long distances, many from the south and the west, to attend the New York meeting.

The relation to agriculture of considerable parts of the programs of various sections and affiliated societies seems increasingly greater with each succeeding meeting. Perhaps it is because our interest is broadening. Perhaps it is because the investigation in agriculture is leading more and more deeply into the realm of the sciences. And undoubtedly it is because interest in these problems is becoming more widespread, for the problems of agriculture are now attracting the attention of very many men and women identified with nonagricultural institutions. The biological chemists, the various botanical organizations, the entomologists, the zoologists, the geneticists, the ecologists, all had papers of immediate import to agricultural investigation. Indeed, there were so many of these contributions and discussions that the difficulty was to hear more than a small part and to make a selection.—*Experiment Station Record*.

SCIENTIFIC BOOKS

Plant Succession. An Analysis of the Development of Vegetation. By FREDERIC E. CLEMENTS, Carnegie Institution of Washington, Publication Number 242, Washington, D. C., 1916. Pp. xiii + 512, 61 half tone plates of two to three figures each, and 51 figures in the text.

For nearly a quarter of a century the author of this large and attractive volume has been investigating numerous problems in the field of phyto-ecology and related subjects as he has found them in the great out-of-door laboratory of western United States. This area is particularly stimulating for such work since so many of the natural life phenomena have been preserved to the present in nearly their original conditions. During these years the author has been favored with unusual facilities for the conduction of his investigations. Because of these facts, as well as because of the well-known leadership which American ecologists enjoy, this latest work from Clements will attract the attention of botanists and biologists in general throughout the world.

The reader must understand that this work is not in any sense a treatise on general plant ecology. It represents a careful examination of the facts and principles of plant succession, an analysis of the development of vegetation in the past as well as the present, together with a digest of the methods for investigating successional phenomena.

The subject-matter of the monograph is arranged in fifteen subdivisions or chapters. In Chapter I. the author rewrites his rather familiar views as to the fundamental nature and causes of succession. He points out that "the developmental study of vegetation rests upon the assumption that the unit or climax formation is an organic entity." As a living entity this unit arises, develops, matures and eventually disappears. All such entities or formations develop as a result of succession which may occur again and again in the history of each climax unit. The most striking external feature of succession lies "in the movement of populations, the waves of invasion, which rise and fall through the habitat from initiation to climax."

An excellent historical summary beginning with King (1685) and including the work of twentieth century ecologists is included in Chapter II. This is a valuable summary of the concepts that have helped in shaping modern ideas with regard to plant succession.

Then follows a long chapter on the causes of succession. "Initial causes" are discussed under the captions: Topographic Causes, Erosion, Deposit, Elevation and Subsidence, Edaphic Causes, Climatic Causes, Biotic Causes, while "ecesis causes" are enumerated as Aggregation, Migration, Ecesis, Competition and Invasion. This chapter is followed by a study of stabilization and the development of the final or climax community.

The structure and units of vegetation are treated at length and the views of various ecologists upon these subjects summarized. One of the most interesting, as perhaps most valuable, parts of the book is the attempt of the author to focus attention more sharply than has ever been done before upon the fact that plant communities may and should be

classified by means of seral units as well as by climax units. Both methods have been used by various investigators rather indiscriminately, or at least no particular model (if there be such) has been followed consistently. Clements rightly emphasizes the desirability of working out and adopting a set of terms to cover these two concepts of vegetation and he goes so far as to propose terms by means of which the various climax and seral features of the plant formation may be described. The reviewer is aware of the advantages and disadvantages of the various systems which have been proposed in the past and we must confess that this latest proposal is perhaps still far from the ideal, and yet it represents an advance, it marks progress. At least it serves to focus the attention upon the dynamic phases of vegetation as apart from the static. The author may be criticized for the introduction of new terms in this connection, but new concepts or relations may be expressed only by appropriate words. Scientific men should not be confounded by the introduction of an occasional new term.

The *climax* units which Clements proposes are: *associations*, climax communities which associated regionally constitute the formation; *consociations*, the units of the association, characterized by a single dominant species; *societies*, communities within an association or consociation controlled by one or more subdominant species; and *clans* or aggregations of secondary species within either of the above subdivisions. The clan is quite local and often not sharply delimited from the society.

Seral units are analogous to climax units or communities throughout the course of succession. These units are proposed in order to point out sharply the distinctions between the developmental or dynamic and climax or static phases of vegetation. The *associes* is the developmental equivalent of the association, differing from the latter only in its transient nature. The *consocieties* corresponds to the consociation in the same manner that *associes* corresponds to association. "The *consocieties* is a seral community marked by the striking or complete dominance of one species,

belonging, of course, to the life-form typical of that stage of development." The *societies* is likewise the developmental equivalent of the society. The *colony* is an *initial* community of two or more species. Colonies resemble clans in their limited size and absence of clearly defined relation to the habitat. From their appearance in bare areas colonies are nearly always sharply delimited. The invasion of weeds frequently follows the colony type of grouping. The *family* is a group of individuals belonging to one species. Because of this nature families are quite rare in general, but they are common in bare areas and in the initial stages of a succession. This attempt to work out a classification of vegetation types founded upon the developmental basis should appeal to all broad-minded students of plant ecology.

Another valuable portion of Clements's book is the part devoted to the climax formations of North America as summarized from the available literature.

Successional studies in Eurasia are also abstracted.

An extended portion of the monograph is devoted to a discussion of "past climates and climaxes" or to the succession of vegetation in remote times as revealed in the geological record. "The operation of succession was essentially the same during the geological past that it is to-day: from the nature of their vegetation forms, the record deals largely with the ultimate stages of such successions. It is evident that geological succession is but a larger expression of the same phenomenon, dealing with infinitely greater periods of time, and produced by physical changes of such intensity as to give each geological period its peculiar stamp. If, however, the geological record were sufficiently complete, we should find unquestionably that these great successions merely represent the stable termini of many series of smaller changes, such as are found everywhere in recent or existing vegetation. . . . In short, the development and structure of past vegetation can be understood only in consequence of the investigation of existing vegetation."

The investigations of Douglas on "Weather Cycles in the Growth of Big Trees" and "A Method of Estimating Rainfall by the Growth of Trees," of Huntington on the climatic factor, and of Humphreys on the relation of volcanic dust to climatic changes, etc., appear to have been the chief inspiration and sources for this particular portion of the monograph.

This is a very new field for the modern student of plant succession. The author states that: "The interpretations of past vegetations rests upon two basic assumptions. The first is that the operation of climatic and topographic forces in moulding plant life has been essentially the same throughout the various geological periods. This is a direct corollary of the conclusions of Lyell as to geology, and of Huntington, Humphreys and others as to climatology. The second assumption is the one already quoted, namely, that the operation of succession as the developmental process in vegetation has been essentially uniform throughout the whole course of the geosere. From these two assumptions naturally follows a third to the effect that the responses of animals and man to climate and to vegetation, both as individuals and in groups, have remained more or less identical throughout geological time. As a consequence of Darwin's work, this has long been accepted for the individual, but as to the community it still awaits detailed confirmation by the new methods of zoecology. Further, if all these be accepted as necessary working hypotheses, it is evident that what is true of the parts must be true of the whole plexus of geological causes and biological responses in the past."

The attempt is then made to trace the successions through the various geological eras with their shifting climates and climaxes. But here again the details are so numerous and so many biological principles are involved that only first-hand examination of these chapters can give the reader an adequate conception of the matter handled in this way. In passing it is interesting to note that Clements has used vegetation rather than animal life as the basis for the recognition of eras of the

geological record, somewhat after the fashion of Saporta (1881). Thus we read: Eophytic, Paleophytic, Mesophytic, Cenophytic.

These latter chapters should be particularly suggestive and stimulating to the animal ecologist and the paleo-ecologist as well as to others with an interest in the phenomena of living thing of past ages.

The bibliography of nearly a thousand titles, the most of which have been abstracted or noted somewhere in the text, is still another valuable part of the book. This is probably the most nearly complete collection of titles on succession and related phenomena available.

It may be said, after securing a bird's-eye view of the book as a whole, that Clements's monograph presents an invaluable summary of our knowledge of plant succession and that it must become at once the indispensable reference and guide for the student of vegetative cycles in all parts of the world.

RAYMOND J. POOL

THE UNIVERSITY OF NEBRASKA

SPECIAL ARTICLES

RECENT INVESTIGATIONS OF TRACTIVE RESISTANCES TO MOTOR TRUCKS ON ROADS AND PAVEMENTS

AN experimental investigation was carried on in the research division of the electrical engineering department, at the Massachusetts Institute of Technology, during the year 1915, under a fund contributed for researches on motor trucks, for the purpose of determining the tractive resistance of a motor delivery wagon with four wheels and solid rubber tires on various level urban roads and pavements. The complete report on this research was published in the *Proceedings of the American Institute of Electrical Engineers*, June, 1916.

By "tractive resistance" is meant the horizontal force necessary to apply to the truck in order to keep it at a constant speed in still air after deducting axle frictions and internal-mechanism losses. It is, therefore, the reactive force offered by the truck, assumed