THE PRIMARY PLANT ASSOCIATIONS OF OHIO

THEIR DISTRIBUTION AND THEIR SIGNFICANCE AS HABITAT INDICES.*†

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INTRODUCTION.

The idea of natural plant associations as indices of habitat differences is a very old one. Pioneers everywhere have used it. There is now no adequate record of these primeval plant associations, and they have been so obscured by the effects of civilization that if we wish to use them as natural indices to habitats, we must first reconstruct them from present remnants and the secondary associations that follow clearing, grazing, and other destructive processes of man.

The reconstruction of the vegetation of the past from present day conditions is often a difficult task, and it is frequently neglected in field surveys. As evidence one may cite the relatively large numbers of papers intended as descriptions of natural plant associations in various parts of the country in which the authors fail to recognize secondary associations and actually describe them as original vegetation. The distinction between primary and secondary associations is one of the first problems that should be met and solved by anyone wishing either to describe the vegetation of a region, or to discover the relations of natural vegetation to soils, climatic factors, or other natural phenomena.

The map before you is the result of an attempt by Dr. E. N. Transeau and myself to determine the distribution of the natural vegetation of Ohio as it occurred about a century and a half ago, *i. e.*, before it had been disturbed except by Indian occupancy. The data obtained in the field surveys and the conclusions reached are being checked wherever possible by data available in the earlier reports on the vegetation of the state found in county histories, reports of travelers, early

* Paper read before the general session of the Ohio Academy of Science, April, 1927.

† Papers from the Department of Botany, The Ohio State University, No. 189.

geological surveys, and surveyors' records. Sears* has recently published a map of the "Ohio Virgin Forest" based upon data obtained from these early records. Some of the plant associations recognized in our field survey are indicated on this map. Their general distribution in the state as determined by Sears from early records agrees with the general distribution we have assigned them by field studies. This map is of value, therefore, as a check on the reliability of our field methods of reconstructing the original vegetation.

Several vacation periods were spent in studying the least disturbed areas, remnants of original forests, and numerous secondary forests in various parts of Ohio and neighboring states. In this preliminary work emphasis was placed on learning to recognize the several plant associations, both primary and secondary, and also the successions that might occur among them. We then began to map the distribution of the orignal plant associations of the entire state. Last summer Dr. L. L. Huber, Dr. J. S. Houser, and Director Williams of the Ohio Experiment Station saw that our data had a bearing on some of the problems in which they are interested and furnished us financial aid. If this assistance continues we shall have the vegetation map ready for publication much sooner than we had anticipated.

Geological and soil maps of the state have been published and attempts have been made to correlate the natural vegetation with these maps. It is mainly of these mutual interests that I wish to speak today: to point out (1) some of the features of the natural vegetation that should be considered in future attempts to determine such correlations as exist, and (2) that the distribution of the natural plant associations of the state is itself an index of environmental conditions with potentially distinct uses and value.

THE PRIMARY PLANT ASSOCIATIONS.

Previous to the nineteenth century there were more than thirty well recognized primary plant associations in the state. Four of these associations: Beech-Maple, Elm-Ash-Maple, Oak-Hickory, and Mixed Mesophytic are of first importance on the basis of area covered. Their distribution is indicated on the

*Sears, P. B. The natural vegetation of Ohio. Ohio Jour. Sci. 25:139-149, 1926.

map.* Of secondary importance on the basis of area covered by the association are: Willow, Alder, River Birch, and Maple-Cottonwood-Sycamore Associations along some of the streams; Oak-Chestnut or Oak-Chestnut-Hickory on sandy or gravelly areas, dryer talus and hill tops, and certain stages of cliff erosion; White Pine in northeastern Ohio and Pitch Pine in southeastern Ohio as cliff associations; Post Oak-Bur Oak between Oak-Hickory and prairie and as isloated groves on the prairie; Oak-Maple as a transition between Beech-Maple and Oak-Hickory near the prairie, but usually not elsewhere; Slough Grass and Andropogon associations of the wet and dry prairies respectively; Scirpus-Typha-Phragmites marshes; Cranberry, Alder, Tamarack, Aborvitae, White Pine and Hemlock associations of bogs; Birch, Hemlock-Birch, and Beech-Maple-Hemlock-Birch associations in gorges, deep ravines, and on steep slopes. The last named association also occurred on uplands in the extreme northeastern part of the state. Since the map is on display where you may observe the distribution of these associations at your convenience, further details of distribution will be omitted at this time.

The present distribution of these associations represents the latest moves in a long series of successions. The succession of plant associations is now a well established law in biology and should be recognized in all modern field studies. As the habitat factors change, the associations change, and these changes follow orderly sequences that may be detected by appropriate methods of investigation.

The successions that should be kept in mind in studying natural vegetation in this state are of three types. First, the historical successions of a geographical order including (a) successions following the retreat of the glacier, (b) successions during the post-glacial xerothermic period, (c) successions subsequent to that period. Second, the primary successions accompanying the changes in soil and atmosphere of the present time. Third, the numerous secondary successions following clearing and other activities of man. Several associations in the state are lingering relics of the first type of succession noted above.

* Since this is mainly a report of progress and suggestions for future investigations, the map in its present stage of development is omitted from publication.

Significance of the Primary Plant Associations as Habitat Indices.

The first point of importance is that the primary plant associations represent a summation of both the atmospheric and soil factors acting over a period of years.

As a point in evidence it may be noted that their general distribution in the state is not coincident with geological formations, glaciation, soil types, temperature, rainfall, or any other single environmental factor or restricted group of environmental factors. Their distribution is a resultant of all the atmospheric and soil factors acting simultaneously.

The effects of certain environmental factors are of course more prominent than those of others. But the factors showing the most prominent effects in one locality of the state, are not necessarily the most prominent in effect in another locality. For example as we approach the prairie areas of Ohio Beech-Maple disappears, first from the uplands then from the ravines. Oak-Maple becomes the usual forest for a few miles, then Oak-Hickory becomes the common forest on all the uplands. Exactly the same changes in forests occur as we go westward and approach the prairie climate of the Central States. This similarity in the changes of forests in the two cases indicates that atmospheric factors are most effective in determining the Oak-Hickory association in certain parts of the state. On the other hand, topography and soil factors becoming unfavorable for Beech-Maple are as clearly the most effective factors accounting for Oak-Hickory in certain other localities.

As another example we may choose a single soil type*, say Wooster loam, and if a rather extensive area of this soil type is traversed we can find growing upon it associations of Oak-Chestnut, Oak-Hickory, Beech-Maple, Oak-Maple, and Mixed Mesophytic. This dissimilarity of plant associations on the same soil type results mainly in some instances from differences in atmospheric factors, in other instances from changes in the soil factors most effective in plant growth but not given the most weight in classifying the soil type. Furthermore these same five associations occur on other soil types in other parts of the state. Or the same association, such as Beech-Maple, occurs on numerous soil types. This similarity of plant associations on different soil types shows that some of the soil character-

* The distribution of soil types was obtained from published maps.

istics chosen to distinguish soil types may hold a very minor position among the factors that affect plant development and distribution. Where soil types are distinguished on the basis of variations in water and oxygen content, interesting relations of soil type and vegetation do occur locally.

Another condition that should be recognized is that the relative effects of soil and atmospheric factors varies geographically. Transeau emphasized this point several years ago in his paper on "Forest Centers."* He recognized in each of the climatic plant formations of the continent a "center of distribution" in which the plants of that formation reached their best development. One of the characteristics of this center of distribution is that the differential effects of topography and other soil factors are less effective there than elsewhere in the formation, and that as one departs farther and farther from the center of distribution the relative effects of topography and soil become more noticeable.

It must also be remembered that the effect of one plant association upon another, the biotic effect, is a factor in their distribution. So far as climate and soil alone are concerned the Oak-Hickory association would occupy most of the area of the state. But when these conditions become suitable also for Beech-Maple or Mixed Mesophytic forests, Oak-Hickory is shaded out. However if clearing continues, secondary Oak-Hickory will occupy most of the area originally covered by these associations. The chief exceptions are the secondary forests of swamp forest species following the clearing of Beech-Maple on poorly drained areas.

A second point of importance is that if we may add to our knowledge of the primary associations an understanding of the secondary associations that follow the first clearing of the primary, we shall have a still better basis for the evaluation of the atmospheric and soil factors.

The secondary forests following a single clearing of the primary associations are not the same in different parts of the state. As an example, the secondary forests that may follow a single clearing of the Beech-Maple association in various parts of the state are: Beech-Maple, Maple-Beech, Oak-Maple, Oak-Hickory, Oak-Chestnut, Mixed Mesophytic, and Elm-Ash-Maple.

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*Transeau, E. N. Forest Centers of eastern North America. Am. Nat. 39:875–889, 1905.

An interpretation of these variations in secondary forests in relation to atmospheric and soil factors in a given region can frequently not be made without a thorough knowledge of the biotic factors involved, both present and historical. A knowledge of these secondary associations following the first, second, and third clearings would have its uses, particularly in the field of forestry. Clearing is making an enormous change in the proportion of the state occupied by each of the several forest associations.

The third point of importance is that since the natural plant associations represent a summation of the atmospheric and soil factors, they ought to serve as convenient indices of biological habitats in the study of certain agricultural problems. Along with other general indices of habitats, such as geological formations, soil types, and summations of atmospheric conditions, they should serve as an additional and a distinctly different type of measure of habitat conditions. No single index or unit of measure will suffice.

Is there any evidence that the natural plant associations may be used as indices to biological habitats in the state under present agricultural conditions? I have already indicated their possible relations to forestry problems. We are of the opinion that a knowledge of the primary and secondary associations and of the successions among them, will furnish a valuable foundation upon which to predict the types of forests that may most readily be maintained in different parts of the state. But the final working out of these correlations must be delegated to the forester.

The most carefully analyzed correlation to date is that between the distribution of natural plant associations and certain insect infestations in the state. In 1924 Mr. Merlin Jones a student in entomology at this University furnished us a map of the distribution and of the degree of infestation of the Mexican bean beetle in this state. When Jones' map was superimposed upon our vegetation map there was seen to be a close correlation between the distribution of the Mixed Mexophytic forest and the areas in which the Mexican bean beetle was doing commerical damage. Field studies last summer by Dr. Transeau and Mr. N. F. Howard of the U. S. Bureau of Entomology showed this correlation to be surprisingly constant.

When the corn borer invasion became alarming, Dr. Transeau suggested that it would probably not do commerical damage in all habitats and that the natural plant associations might furnish an index to the habitats in which it would do commerical damage. Dr. L. L. Huber had already noted in 1924 that the degree of infestation varied locally with certain habitat conditions. The Experiment Station agreed that the idea was worth investigation.

The conditions in Ontario were used as a preliminary test case. We determined the distribution of the primary plant associations in the entire corn borer area of Ontario. When our vegetation map was compared with maps of the corn borer infestation furnished by the entomologists* it was found that the corn borer had been doing commerical damage in Ontario only in those areas originally occupied by the Swamp Formation, *i.e.*, the series of successions from marsh grasses through intermediate associations of bog and swamp vegetation to the Elm-Ash-Maple swamp forest association of the Eastern Deciduous Forest. The borer had been present equally long in other habitats in Ontario but its devastation there had not been considered of commerical significance. The survey was then extended to include the corn borer area in Ohio and neighboring states. At the close of the season our vegetation maps were compared with Dr. Huber's maps of the distribution and the degree of infestation of the corn borer. The correlation discovered in Ontario was found to hold throughout the entire region investigated.† These two examples of insect devastation indicate how the natural plant associations may serve as convenient indices in predicting the habitats in which the depredation of certain insects should either be controlled or avoided.

Perhaps the behavior of some of our cultivated plants will show equally interesting correlations. But students familiar with the behavior of cultivated plants must be persuaded to help supply and evaluate the data necessary to bring out such correlations as exist. Mr. J. H. Gourley of the Ohio Experiment Station suggested in conversation that most of the com-

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*Numerous entomologists contributed data and personal assistance. General acknowledgment is made to Dr. L. L. Huber and Dr. C. R. Neiswander, of the Ohio Experiment Station; to H. G. Crawford, Chief of the Division of Field Crops and Garden Insects, Canada; and to Dr. E. P. Felt, State Entomologist, New York.

† A paper on "Vegetation Types and Insect Devastation," by E. N. Transeau, is to appear in the July number of Ecology, and may be consulted for a more detailed account of this topic.

mercial orchards in Ohio are in that part of the State where our map shows an abundance of the mixed mesophytic forest in the valleys and of Oak-Hickory on the hilltops. Orchard trees as perennial plants are subject to the environmental factors of the habitat during the entire year just as are the natural plant associations, while many other cultivated plants are annuals and subject to the factors of the habitat only during the growing season. It is beyond the scope of this paper to attempt an enumeration of the complexities of the situation. I wish merely to call attention to two more conditions that are in keeping with the general tenor of this discussion.

First, agricultural practices modify many of the factors of the natural habitat. The general effects of these modifications can be appreciated at once if we direct our attention to the manner in which external factors frequently affect plant development and distribution. The general conclusion that may be drawn from the data of numerous field studies and experimentation on the causes of the differences in distribution of the plant associations characteristic of this region is that the external factors foremost in limiting the distribution of these associations in Ohio are the factors that bring about within the plant either desiccation, starvation, or suffocation. The first condition is usually brought about by a deficiency in external moisture, at least during the growing season; the second usually by overshading by other plants; and the third by excess water leading to oxygen deficiency. The effects of other factors are less prominent, except perhaps for a few individual species. For example the species of the Oak-Hickory association can not withstand the desiccation of the most arid habitats in the state, their roots suffocate during the long submergence in swamps and floodplains, and they are unable to manufacture food as rapidly as they use it in the shade of beech and maple. Any agricultural practice that modifies either of the three sets of conditions named above may bring about modifications in expected correlations.

The second point is that any attempt to correlate the behavior of cultivated plants with the natural associations should not ignore the successional history of different localities. For example, two years ago I listed the successional series that have led to the Oak-Hickory and Elm-Ash-Maple associations in northeastern Ohio. The Oak-Hickory association was found to have succeeded such xerophytic associations as Pine and Oak-

Chestnut, prairie vegetation, and even swamp forest on a peculiar hdyrophyllous clay soil. As a secondary association it had succeeded Beech-Maple and Mixed Mesophytic. The Elm-Ash-Maple swamp forest association had succeeded the swamp vegetation of marshes, pioneer floodplain forests, and relic bog vegetation. As a secondary association it had succeeded tamarack and other conifers on bogs, and Beech-Maple on poorly drained areas.

These different successional series of vegetation leave different effects in the soils upon which they occur and these differences may be reflected in the behavior of cultivated plants. In such cases a uniform correlation would not occur.

It is apparent that such correlations and lack of correlations as I have cited can be determined only by having each kind of survey made by specialists in the fields concerned. Our chief interest in this survey is to discover and interpret the behavior of natural plant associations. The vegetation map is of value to us as a basis in selecting critical stations for quantitative studies of the relative effects of environmental factors throughout the season. In the last analysis understanding and practice both require an evaluation of the external factors in their relation to the physiology and development of the different species and varieties. General indices to habitats have certain values, but they will not remove the need of studies of the relative effects of the separate factors of the habitat during critical periods of the year and at different stages in the development of the plant.

NEW BOOKS.

The Century Company has recently issued two attractive books on scientific subjects which we are glad to bring to the attention of our readers. One of them, *Oxidation-Reduction Reactions In Inorganic Chemistry*, by Eric R. Jette, will be of interest to chemists, and the other, *Host Parasite Relations Between Man and His Intestinal Protozoa*, by Robert Hegner, will interest both the zoologist and the public health worker. The publisher's statements regarding these volumes are given below:

Host-Parasite Relations Between Man and His Intestinal Protozoa—By Robert Hegner, Ph. D., Professor of Protozoology in the School of Hygiene and Public Health of the Johns Hopkins University. Price, $3.50.

The purpose of this book is to present the more relevant data regarding the host-parasite relations of the intestinal protozoa of man in such a manner as to show the present state of our knowledge and to focus attention on the need for more systematic and intensive research in the subject. The distinguishing feature of this study is its effort to co-ordinate the zoological phases of the subject with the medical phases and both the zoological and medical phases with methods of prevention and control. The control of the parasitic species, to be effective, must be based on a knowledge of the relations between the parasite and its host. What these relations are and the little we know about them is explained in this book.

This volume is the first to appear in The Century Biological Series, of which Dr. Hegner is the general editor. It is illustrated with charts, diagrams, and half-tone plates and contains a valuable twenty-five page list of references to the literature in the subject and an index of the authors quoted or referred to in the text.

Oxidation-Reduction Reactions In Inorganic Chemistry—By Eric R. Jette, Ph. D., Assistant Professor of Chemistry at the Washington Square College of New York University. Price, $1.10.

This book presents a comprehensive discussion of oxidation-reduction reactions for the student who has had enough training in chemistry to understand ordinary chemical terminology, but who has not had the benefit of a course in physical chemistry. It emphasizes the qualitative, rather than the quantitative, aspects of the subject; and presents both the valence change and the ion-electron methods of balancing equations in order to enable the student to balance the equations for the greatest possible number of oxidation-reduction reactions. The book aims to develop the fundamental basis of each of these methods and, to this end, introduces the modern concepts of atomic structure, the ideas of polar and non-polar compounds, and certain elementary principles of electrochemistry. The ion-electron method is discussed in detail with numerous applications which illustrate the effect of solubility, degree of ionization, concentration of ions, complex-ion formation, etc., on oxidation-reduction reactions taking place in aqueous solutions.