ORIGIN AND DEVELOPMENT OF THE CONCEPT OF THE PRAIRIE PENINSULA

Ronald L. Stuckey
Department of Botany
College of Biological Sciences
The Ohio State University
1735 Neil Avenue
Columbus, Ohio 43210

Scientists have attributed many distinguishing characteristics to the region of North America called the Prairie Formation or Prairie Grassland. These broad characterizations have developed from studies of the composition of the flora and fauna, climatic factors, soil types, role of fire, and past history. It is not my intention to attempt an explanation of the origin of the prairies from these various viewpoints, even though Transeau (1935) strongly believed that the prairies were an ideal vegetational type in which one could study ecology from many diverse points of view. My objective, however, is to reconstruct the ideas and events that led to the origin and development of the concept of the Prairie Peninsula in North America. My efforts recount the life and work of those individuals who have researched and written on this subject (Stuckey, 1981:24.). The development of the concept is discussed in detail, first with respect to Dr. Transeau's contribution, followed by several contributors contemporary with Transeau. The "true" origin of the idea is established later in this paper.

The Prairie Peninsula is the name applied to the wedge-shaped or peninsula-like projection of prairie vegetation (or prairie biota) extending from the prairie grasslands eastward into the deciduous forest. Geographically, this prairie biota extended eastward from the Mississippi River across Illinois and western Indiana, with outliers as far east as central Ohio and as far north as southern Wisconsin and southern Michigan. Its southern limit in Illinois and eastward approximates the maximum extent of continental glaciation in that region, although no agreement exists on the location of the Prairie Peninsula's southern boundary. The eastern extension of this prairie biota is considered to have been much greater in the past than at present, having been brought about by a period or periods of prolonged drought conditions in North America during either late postglacial or prehistoric time (Fig. 1). During this prolonged dry period, known as the "Xerothermic Period" or "Xerothermic Interval" (Sears, 1942), it is believed that an extension of the biota of the Grassland Province was shifted eastward through the lower Great Lakes region and into the Mohawk River valley in New York. Most recent botanical writers have attributed the development of the concept of this eastern extension of the prairie to Henry Allan Gleason and Edgar Nelson Transeau (Dansereau, 1957; Benninghoff, 1964; Wright, 1968; McIntosh, 1975). Gleason is generally given credit for first identifying and characterizing this prairie region on a purely floristic basis in his classic paper, *The Vegetational History of the Middle West* (Gleason, 1923), while Transeau is identified as providing the name, "Prairie Peninsula," mapping its geographical boundaries, and discussing its climatic characteristics in his often-cited paper, *The Prairie Peninsula* (Transeau, 1935). Authors discussing the prairie prior to 1900 and into the first one-third of the twentieth century referred to the region as the eastward extension of the Prairie Province (Pound and Clements, 1898b; Woodward, 1924), Prairie Region (Harshberger, 1911), Prairie Formation (Schaffner, 1926), or just Prairie, as a part of the Grassland Formation (Weaver and Fitzpatrick, 1934). Prior to 1935, Gleason himself did not use the term Prairie Peninsula, always referring to it as a part of the Prairie Province or Prairie Formation. Gleason (1909a) earlier pointed out that the term "prairie" was taken from a French word used to refer to the grassland of the region explored by the early French travelers in North America, and therefore the word should be applied only to the tallgrass vegetation characteristic of the Prairie Province that occurred in the Middle West. Transeau (1923) used the term Prairie Province in his textbook, *General Botany*.

CONTRIBUTION OF EDGAR NELSON TRANSEAU

Edgar Nelson Transeau is perhaps best known to botanists for his lifetime of support and encouragement of botanical science in its broadest sense, making substantial contributions to plant ecology, algology, and botanical education at all levels, from high school to graduate school (Meyer, 1956, 1958). Born near Dickinson Seminary Campus in Williamsport, Pennsylvania, 21 October 1875, young Transeau at the age of ten began taking an interest in the natural world when he made collections of minerals and fossils, and later, while in high school, of birds, butterflies, and plants. He early developed leadership qualities, serving as class president in high school, editor-in-chief of his college yearbook, and a volunteer biology assistant while an undergraduate student (Transeau, undated). His leadership abilities were considerable, and ultimately led him to the chairmanship of the Department of Botany and Plant Pathology of The Ohio State University, a position he held for 28 years. During that time he built the department into one of the largest and most prestigious in the country. His success was not of the extrovertive or aggressive type, but one of using great talent, generating loyalty and respect from students, co-workers, and friends. Botany as a worthwhile field for human endeavor was instilled in all who came under his influence (Meyer, In preparation). Quietly and steadily through the years his classes in ecology attracted serious future specialists in a wide range of pure and applied biology. Thanks to Transeau's rigorous, often Socratic method of teaching, his students enjoyed a remarkable discipline in clarity of thought and expression. This service, whose benefits range far beyond the confines of botany, Sears (1960) rated as Transeau's greatest contribution. At age 85, Transeau died on 25 January 1960 (McQuate, 1960).

The early development of Transeau's professional career is extremely diverse, for he traveled widely and came under the influence of many individuals. He took the classical course at Franklin and Marshall College, Pennsylvania, and graduated with the bachelor of arts degree in 1897. For the next five years he engaged in many educational pursuits. He taught high school science classes, attended the Marine Biological Laboratory at Cold Spring Harbor on Long Island, spent five quarters at the University of Chicago, and took field trips and led field trips in various parts of the country—western Pennsylvania, various areas of New York, northern Michigan, mountains of Colorado, and throughout the Midwest. This field work enabled him to become well-acquainted with the flora of the plains, prairies, and forest-border. He was influenced by excellent teachers and enthusiastic researchers. At the University of Chicago, he worked under John M. Coulter, Charles J. Chamberlain, Henry C. Cowles, Charles R. Barnes, all in botany; Rollin D. Salisbury in geology; and Stuart Weller in paleontology (Transeau, undated). However, it was Professor Cowles who had a particularly significant influence on him. Transeau made a point of this influence when, in the opening paragraph of his "Prairie Peninsula" paper written 35 years later, he noted the importance of Cowles' clearly presented lectures on the factors involved in the origin and development of vegetation.

In the summer of 1902 Transeau accepted the Ferry Fellowship, sponsored by the Ferry Seed Company, at the University of Michigan and began a study of bogs and bog plants under Professor Volney M. Spalding. His dissertation, *The Bogs and Bog Flora of the Huron River Valley*, was completed in the spring of 1904 under the direction of Professor Frederick C. Newcombe and subsequently published

(Transeau, 1905-1906). In the acknowledgements, Transeau expressed sincere thanks to both individuals for helpful suggestions and appreciation to his friend and former instructor, Dr. Henry C. Cowles, to whose writings and lectures he owed his interest in ecological botany. As stated by Sears (1960, 1971), this classic work was carried out with scant encouragement and in spite of a then-skeptical view of ecology at the University of Michigan. This viewpoint was also expressed by Burton L. Livingston (1948: 233-234), a student at the University of Michigan a few years before Transeau arrived. Livingston noted that no one cared for taxonomic botany of the higher plants. Spalding understood natural vegetation very well but knew little ecology; and Newcombe, a physiologist, was not interested in ecology. Transeau (undated) later provided his own version of the difficulty and lack of encouragement:

> [In September 1902, I] entered upon the study of bogs and bog plants under Professor V. M. Spalding. Bogs abundant, but ideas scarce! Spalding was taken ill in November and went to Tucson, Arizona, —never saw him again . . . I continued to work under my own direction until May 1904. Prof. Newcombe, the acting head of the department, came to me on May 1 and . . . I told him I . . . wanted my degree in June. He said he did not think I had any material for a thesis. I telegraphed immediately to Cowles, and Cowles said I could have my degree at Chicago in the Summer Quarter, if I would come there. So I told Mr. Newcombe that I would either get the degree in June at Ann Arbor, or at Chicago in September. He said I would have to hand in my thesis by the 10th of May. I handed in a 200 page typewritten thesis on that day by working 18 hours a day. It was accepted, I passed my examination, and I got my degree, Ph.D., in June 1904. During the two years at Ann Arbor I had never discussed my problems with Newcombe at any time, and he said he was surprised at the contents of the thesis. Since I was Spalding's student he could have nothing to do with me. That was the code at Ann Arbor!

This incident seems to have been an ironic occurrence, for both Spalding (1898) and Newcombe (1904) had advocated surveys of the natural vegetation in Michigan in their presidential addresses before the Michigan Academy of Arts, Sciences, and Letters. Later, Newcombe (1913) discussed the need for and the importance of state natural history surveys in an address before the American Association for the Advancement of Science in 1912 in Cleveland. Following graduation, Transeau began his college teaching career as Professor of Biology at Alma College, Alma, Michigan, where he remained from 1904 until 1906.

While at the University of Michigan, Transeau (1903) published his first scientific paper, *On the Geographic Distribution and Ecological Relations of the Bog Plant Societies of North America*. In this paper he began to develop several ideas that were important in his later research. One of these ideas became apparent after mapping the distribution of the bogs and certain of their characteristic species (Fig. 2). He noted that their distribution was centered in the glaciated area of North America extending from the Atlantic Ocean to the Mackenzie basin. This area represented a great center where the plants had a wider range of habitats, attained their greatest size in physical development, and were more abundant than elsewhere. In this center he considered that the plants had a wider life-range than outside the center. The major controlling factor in determining the center was

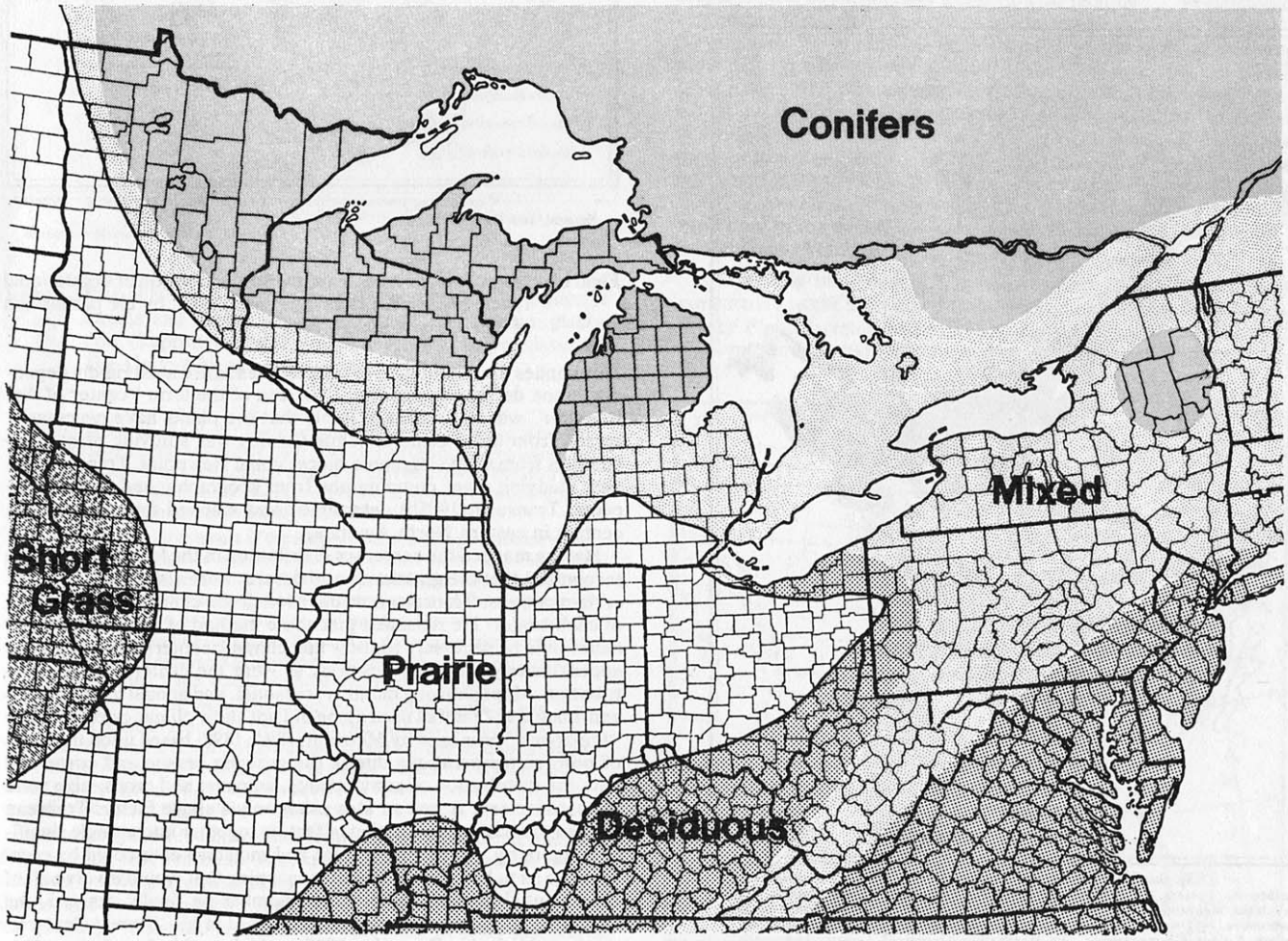


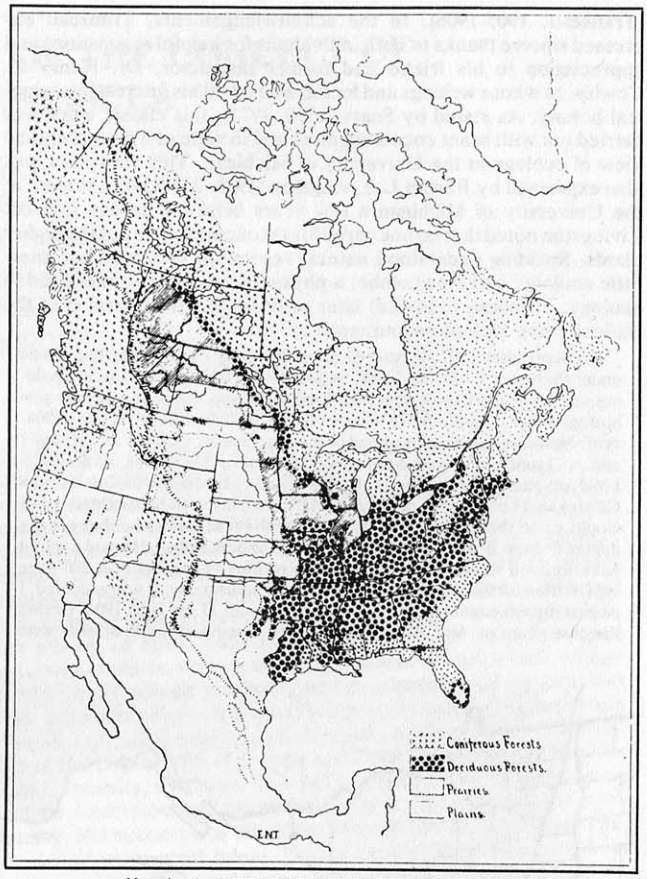
Figure 1. Map of north-central United States showing peninsula-like projection of prairie vegetation between the shortgrass region and the forested areas at the time of the "Xerothermic Period" as viewed by Transeau. (From an original unpublished map prepared by E.N. Transeau and redrawn for this publication by Laurie Fletcher. The original map is a glass lantern slide in the possession of R. L. Stuckey.)

climate. In this situation, it appeared that a moist climate, subject to very great temperature extremes, was required. Farther away from this center, the plants showed the effects of climatic change by exhibiting more restriction in their habitat type, in diminished size, and in frequency of occurrence. He could not find any relationship between the distribution of this group of plant societies and the "life zones" as distinguished by Merriam (1894, 1898). Transeau (1903) also discussed the history of the bog plant societies during and following glaciation, their successional relationships, and the distinctions between bogs and swamps and their evolutionary history. In this same paper, he published two maps of North America, one illustrating the natural vegetational zones (Fig. 3) and the other showing the position of the vegetational types at the maximum extent of glaciation (Fig. 4). The vegetational map, which Transeau derived primarily from Sargent's maps in the Tenth Census Report of 1884, was one of the earliest maps of its kind published.

Transeau's most significant contribution to his idea of "center of distribution" was fully developed in his most frequently cited paper, *Forest Centers of Eastern North America* (Transeau, 1905b). Two of his original ideas, the "center of distribution" and the "rainfall-evaporation ratio" as an index to climatic conditions are discussed in detail in this paper. The "center of distribution" implied distribution about a region where the plants attained their best development. It was based upon the premise (Transeau, 1905b:877) that the "complex of climatic factors most favorable to the development . . . [of a particular] type of vegetation is here localized, and that as we depart from such centers we find conditions more and more unfavorable.

Map showing distribution of bog plants. (1) Drosera, Dulichium. (2) Sarracenia, Drosera, Dulichium, Eriophorum, Chiogenes, Chamaedaphne. (3) Dulichium, Menyanthes. (4) Drosera, Comarum, Menyanthes, Eriophorum, Ledum, Andromeda. (5) Drosera, Comarum, Menyanthes, Eriophorum, Oxycoccus, Andromeda, Ledum, Kalmia, Chamaedaphne. (6) Menyanthes, Oxycoccus, Ledum, Andromeda, Kalmia. The presence of a large number of shrubs in Alaska and Greenland is probably connected with their preservation there during glacial times.

Figure 2. Map of North America showing distribution of certain species of bog plants. (Reprinted from Transeau, 1903, by the permission of The Univ. Chicago Press.)



Map showing present distribution of forest, prairie and plains. (After Sargent, 10th Census, Vol. 9.)

Figure 3. Map of North America showing distribution of vegetational types. (Reprinted from Transeau, 1903, by the permission of The Univ. Chicago Press.)

This implies the elimination of such species as are most rigidly dependent upon definite conditions." His use of the term "center of distribution" was not meant to imply that the plants have necessarily spread from these centers. While Cowles was studying plant communities from a physiographic successional viewpoint, Transeau was now studying plant communities from geographic and climatic aspects. Transeau (1905b) determined and mapped four great forest centers in eastern North America.

Having mapped the centers of distribution of the forests and having recognized that the grasslands and deserts were also arranged about certain centers, Transeau now questioned the climatic determinants of each center. He reasoned that some method of mapping climatic data would be necessary to show that climatic centers were located in approximately the same positions as were the centers of plant distribution. Maps showing monthly, seasonal, and annual temperatures and amounts of rainfall used alone did not show climatic centers. The "life-zones" proposed by Merriam (1894, 1898) based upon the sums of positive temperatures during the growing season and correlated with the distribution of native plants, animals, and crops, also were not satisfactory. It was an idea using only a single factor. Transeau wanted to bring a combination of factors together into a single significant figure by which temperature and moisture data could be combined so as to have a new basis for mapping that would involve all of the essential climatic factors. The number he finally derived, the rainfall-evaporation ratio, is fully described in his "Forest Centers" paper, published in December 1905, and it is to this description of his that most subsequent authors have credited the concept. However, on 1 April 1905, Transeau had presented a complete discussion of the idea at the annual meeting of the Michigan Academy of Arts, Sciences, and Letters in his paper, *Climatic Centers and Centers of Plant Distribution*, which was published later that year. Transeau (1905a:73-74) reasoned as follows:

Map showing hypothetical distribution of forests and tundra during maximum glaciation of the Wisconsin Epoch.

Figure 4. Map of North America showing hypothetical distribution of forests and tundra during maximum Wisconsinan glaciation. (Reprinted from Transeau, 1903, by the permission of The Univ. Chicago Press.)

Investigation shows that forests, grasslands and deserts are arranged about certain centers, which owe their positions on the continent mainly to climatic causes. That such centers cannot be correlated with the distribution of heat or rainfall alone is evidenced by an examination of the monthly, seasonal and annual distribution of these climatic elements.

The fact that so large a part of the adaptations shown by plants are more or less directly connected with transpiration, led the writer to construct a map [see my Fig. 5] combining the figures for rainfall and evaporation. The amount of evaporation depends upon the temperature of the evaporating surface, the relative humidity of the air and the velocity of the wind. Therefore if we combine the figures for rainfall and evaporation we have a number which will represent at least four climatic factors, that must powerfully influence the water relations and distribution of plants.

The Great Plains are marked by an amount of rainfall equal to from 20 to 60 per cent of the evaporation. Where the ratio rises to between 60 and 80 per cent, the prairie region, where dense forests are confined to the river bottoms, is indicated. The region where "open forests", "oak openings" and "groves" occur on the uplands and dense forests on the low grounds, is indicated by the 80 to 100 per cent ratios.

It was during the development of the possible climatic determinants of each center that Transeau was led to ask several questions, one of which was, "What are the causes of the 'prairie peninsula' in Iowa, Illinois, and Indiana; and the region of open forests adjoining it?" In this question, Transeau used for the first time in print the words "prairie peninsula" to identify the tallgrass region of the Midwest. The year was 1905, thirty years before his classic paper, *The Prairie Peninsula*, was published; however, as will be pointed out later in this paper, the origin of this phrase and concept was earlier. Transeau had made the correlation between the centers of plant distribution and the climatic centers determined by the rainfall-evaporation ratio, and he and other botanists were now ready to test this idea. It appeared to him that the correlation was least satisfactory for the prairie vegetation, which had the widest climatic range, a ratio of 60 percent to 100 percent. Transeau was ready to study the climatic limits of the prairie vegetation.

Armed with a new device, the atmometer, the ecologists in the United States now had a simple instrument, consisting of an exposed porous cup connected to a water reservoir, which was designed to be placed in the field to measure the evaporating power of the air (Livingston, 1910, 1935). The instrument functioned like an artificial plant, and the loss of water from it could be measured and related to what might be expected in transpiration by the plants. The use of the atmometer was introduced by Burton E. Livingston in 1906 in connection with his studies on the relation of desert plants to soil moisture and to evaporation (Livingston, 1906). Livingston had a viewpoint that was outstandingly ecological and was one of the first to carry physiological methods into the field. He directed research toward precise measurement of the natural environment during the formative years of the development of ecology. Livingston (1907; 1908a, b) published the results of his studies on the relationship of evaporation to plant development, plant habitats, and centers of distribution. In the third paper, Livingston (1908b) set out to test Transeau's relationship between the centers of distribution and the rainfall-evaporation ratio. During the summer of 1907, porous-cup atmometers were established at 24 selected stations in the United States for the purpose of obtaining a series of direct field observations on the amounts of evaporation during the summer months. The conclusion was that "the summer evaporating power of the atmosphere seems to offer as satisfactory a criterion for relating . . . vegetational centers to climatic factors as do the precipitation ratios of Transeau" (Livingston, 1908b:112). A similar survey of the rates of summer evaporation were carried out in the United States in 1908, and later Livingston (1911:221) reported that "the summer evaporation intensity alone furnished a climatic criterion for studying the different vegetation centers with which we have to deal at least as promising as the criterion furnished by any other meteorological element." The prairie region "appears to be climatically a *potential deciduous forest* . . . The grassland represents the transition from the evaporation conditions of the deciduous forest center to those of the arid region" (Livingston, 1911:220).

During this same period, Transeau (1908b, 1910, 1911a) himself contributed to the literature on evaporation, publishing on *The Relation of Plant Societies to Evaporation* and designing instruments to measure the evaporation-transpiration phenomenon. In summarizing

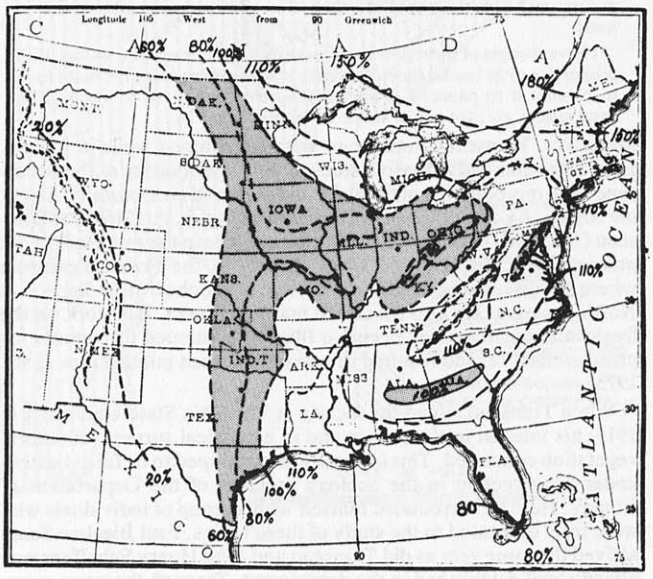


Figure 5. Map of eastern United States showing the ratio of rainfall to evaporation in percentages in different regions; prairie region is the 60 percent to 100 percent ratio. (From Transeau, 1905a, permission granted by Enoch Brater, ed., Mich. Acad. Arts, Sci., and Letters.)

the results of their research on various applications of the rainfall-evaporation ratio, Livingston and Shreve (1921) noted that the employment of the ratio of precipitation to evaporation was the nearest approach as yet possible toward an ideal index of the external moisture-relations of plants. They stated (p. 518):

> The importance of the moisture ratio in controlling the leading vegetations was shown by Transeau for the eastern United States, and our investigation has served to confirm his deductions, as well as to extend their application to the entire country. The comparisons which we have made between the vegetational areas and the various other climatic conditions have served to emphasize the importance of the moisture ratio even more than was done by Transeau, since no other single datum has been found in our work to approach it as an expression of the controlling conditions for forest, grassland and desert.

Transeau's introduction of the rainfall-evaporation ratio marked a very definite and important forward step in understanding the relationship between climate and vegetation, despite the later criticism from Malin (1947:243-244) who wrote that "Evaporation is linked with too many factors to be subjected to measurement as a practical procedure—temperature, topography, soil texture, wind, character of the vegetational cover, and water requirements of plants."

In 1907, Transeau became a faculty member at the Eastern Illinois Teachers College. The next year the Illinois State Academy of Science developed a state ecological survey; Transeau (1908a) promoted this survey to serve, not only as a record of the past and present conditions, but also for the understanding of certain fundamental biological problems. To him the basic plan should be geographic involving the entire state, the methods should be ecological, and taxonomic work should be subordinated. The geographic position of Illinois offered exceptional opportunities for the investigation of the factors involved in the development of the prairie and the forest. During several summers he cooperated with Charles C. Adams of the Illinois State Laboratory of Natural History and Thomas L. Hankinson of his own college on an ecological reconnaissance in the vicinity of Charleston where they studied representative remnants of the original prairies and forests (Adams, 1911 [1912]; Forbes, 1910, 1911 [1912], 1913, 1914). Adams (1915) published his ecological investigations on the prairie and forest invertebrates; Hankinson (1915) wrote on vertebrate life of certain prairie and forest regions; and Transeau, who was describing the vegetation and plant formations, never published his portion of the study. One reason may be found in Transeau's own words, when he expressed his frustrations with the study in a letter to Adams (Transeau, 1911b):

> I have worked betimes on my annotated list of prairie plants and have collected about 100 catalogue cards pretty well filled with data. It is an endless task digging it up, but I have a lot of broadening information at hand.
>
> I have thought of the report I will make on last summers work—out of all proportion to its importance. For really it is mostly so tentative that I hate to commit it to paper. I don't know where I am at so to speak. The associations etc. are not in shape for publication . . . .

Moreover, Transeau found a new research interest while in Illinois. Here he conducted extensive studies on the periodicity of the occurrence and reproduction of the algae and prepared an *Annotated List of the Algae of Eastern Illinois* (Transeau, 1913a, b, c; 1916). As Transeau (1953) was to note some years later, it was in the remnants of old prairie ponds, ditches, and small streams of the Prairie Peninsula where he discovered a rich algal flora, the richest then known in North America. He also described many new taxa. His work on the freshwater algae, having begun in Illinois, continued throughout his professional life, and resulted in many significant publications (Taft, 1973).

When Transeau joined the faculty at The Ohio State University in 1915, his interest in the prairie and in ecological surveys of natural vegetation continued. This interest was developed to its fullest extent under his direction in the ecology program of the Department of Botany. Here he surrounded himself with a group of individuals who were truly dedicated to the study of these topics. Paul Bigelow Sears arrived the same year as did Transeau and John Henry Schaffner was already well-established in the department. Through the years many students were to be associated with Transeau and to aid him in his research.

Sears, a native Ohioan who had taken his master of arts degree at the University of Nebraska, was beginning his studies on the natural vegetation of Ohio (Anonymous, 1965; Sinnott, 1955). His association with Transeau must have been inspiring, but was of short duration, as he left in 1917 for military service, returning for the first half of the year 1919. Later that year, while an assistant professor at the University of Nebraska, Sears developed techniques for mapping original vegetation, presented papers on mapping Ohio's original prairies and forests at meetings of The Ohio Academy of Science, and published three significant papers on the natural vegetation of Ohio (Sears, 1921, 1925, 1926a, b). These maps and papers were the first attempts of this type of research on Ohio's plant life. With respect to the prairies, Sears noted their relationship to the physiography of the state. In general, the prairies occupied areas of inadequate drainage or actual ponding upon glacial outwash best developed in the preglacial valleys near the apices of the various morainal lobes and along the ancient lake shorelines within the Lake Erie Basin. Sears' work on these topics appears to have developed independently from that of Transeau, and must have been influenced by the physiographic ecologist, Henry Cowles, with whom Sears studied at the University of Chicago and where he took his Ph.D. degree in 1922.

Schaffner, who was primarily a taxonomist and evolutionist, had spent many summers since the days of his boyhood in the Kansas prairies (Waller, 1941). He had written papers on the spreading of the buffalo grass and the characteristic plants of a typical Kansas prairie (Schaffner, 1899, 1913). Transeau urged Schaffner to publish his extensive observations on the grasslands of the central United States, which he did in 1926. Schaffner (1926:50-51)noted that

> As one goes westward from Ohio and Indiana, the great central deciduous forest . . . gives way to a typical tall-grass prairie . . . the true prairie of North America . . . It extends from Western Indiana to Eastern Kansas and Nebraska with arms stretching far to the northwest into Canada and southwest into Texas.

This description clearly outlined a Prairie Peninsula, but Schaffner did not use that identifying term. He also emphasized the climatic factor of the ratio of rainfall to evaporation as the primary cause of the prairie.

Adolph E. Waller, who had come from Louisville, Kentucky, was Transeau's first doctoral candidate at The Ohio State University, taking his degree in 1918 (Hahnert, 1975; Waller, 1918a). Waller was interested in crop ecology and developed his dissertation on the relation of plant succession to crop production (Waller, 1921). Earlier, Waller (1918b) showed that the crop centers of the United States coincided with the climatic centers based on the rainfall-evaporation ratio that had been developed by Transeau. In that respect, Waller wrote (p.80) that "the corn and winter wheat belts correspond to the deciduous central forest and the prairie climaxes." Waller (1925) also urged that the natural vegetation of Ohio be mapped. He believed that such a survey would be important in a fundamental way to the future development of agriculture in the state.

Transeau was charged by the administration of The Ohio State University to develop a first-rate program in general botany that would serve the needs of the students in agriculture. In 1917, he brought to the campus Homer Cleveland Sampson to head this program, which Sampson did until his retirement in 1955 (Giesy, 1964). Sampson, who was known as the master of The Ohio State University's general botany teaching program, had published an extensive ecological survey of the prairie vegetation of Illinois (Sampson, 1916, 1921). Although this work was undertaken in the summers of 1915 and 1916, and was carried out under the direction of Drs. Henry C. Cowles and George D. Fuller, it even had earlier beginnings. Sampson expressed many obligations to Transeau, who first introduced him to the problems of the prairie in the summer of 1910, when he was an undergraduate student at Eastern Illinois Teachers College. While in Ohio, Sampson (1927, 1930a, b) published papers on the primary plant associations of Ohio, the succession in the swamp forest in northern Ohio, and the mixed mesophytic forest community of northeastern Ohio. He was interested in the relation of the soil types to the natural vegetation (Sampson, 1930c, d). Most of this work was conducted in Marion County, where several different vegetational types and soil types occurred, including one of the most extensive prairie areas in Ohio. Together, Transeau and Sampson (1935) prepared a preliminary map of the primary vegetational areas of Ohio. This version of the map was drawn in 1934 and apparently represented a modification of one that they had displayed in 1927 at the annual meeting of The Ohio Academy of Science (Fig. 6). A description of some of the features, as well as some indication of the value and usefulness, of this early version of the natural vegetational map of Ohio was provided by Sampson (1927). Two copies, believed to be of

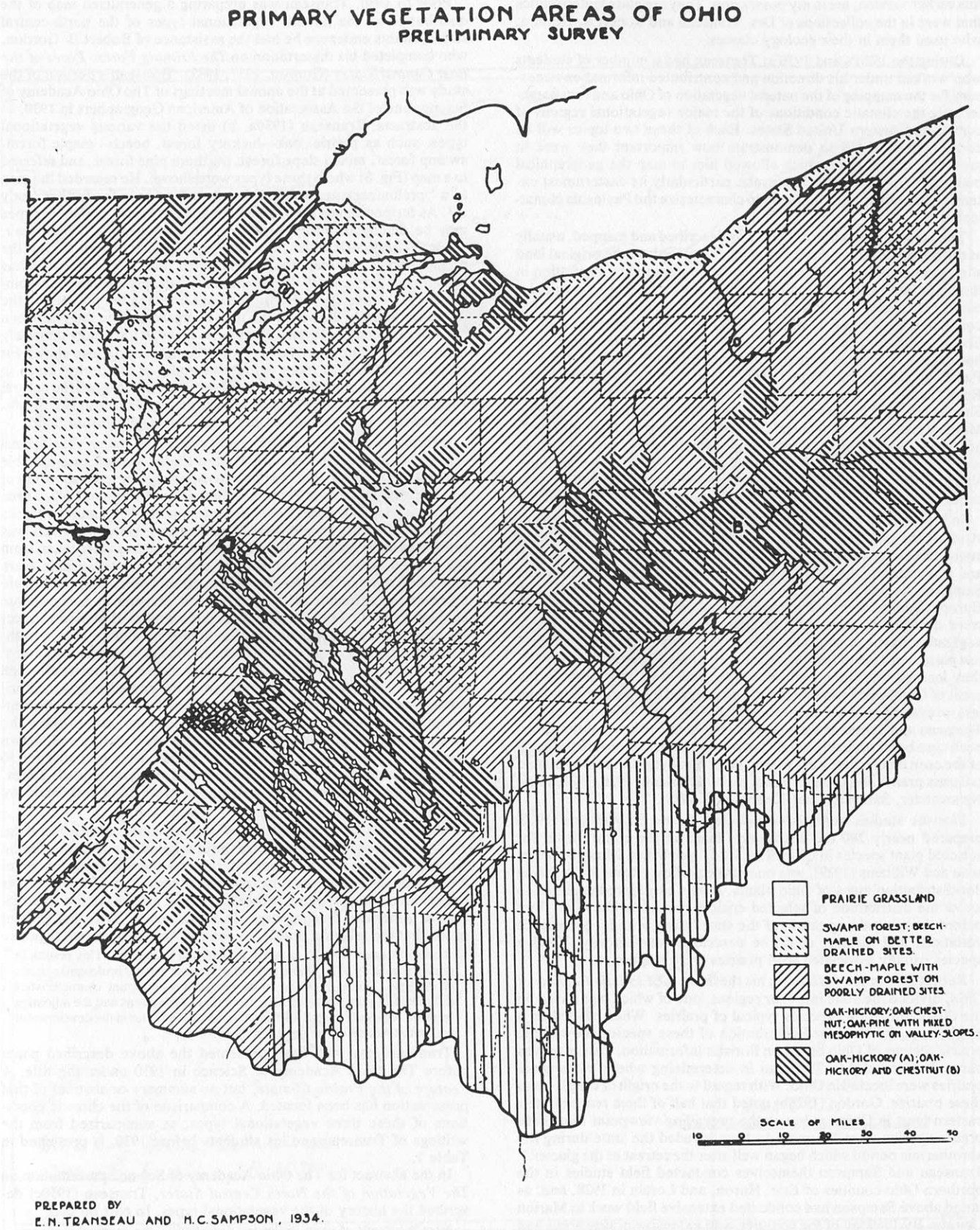


Figure 6. Transeau and Sampson's preliminary map drawn in 1934 showing primary vegetational areas in Ohio. (From Transeau and Sampson, 1935.)

this earlier version, are in my possession. They are glass lantern slides that were in the collections of Drs. Transeau and Robert B. Gordon, who used them in their ecology classes.

During the 1920's and 1930's, Transeau had a number of students who worked under his direction and contributed information necessary for the mapping of the natural vegetation of Ohio and for characterizing the climatic conditions of the major vegetational regions of central and eastern United States. Each of these two topics will be considered in detail to demonstrate how important they were in providing a data base which allowed him to map the geographical boundaries of the Prairie Peninsula, particularly its easternmost extension in Indiana and Ohio, and to characterize the Peninsula climatically.

The natural vegetation of Ohio was described and mapped, usually at the county level, primarily by using the records of the original land surveyors combined with surveying the contemporary vegetation in the field. Each student usually selected or was assigned a particular county for study. The first of these natural vegetational surveys was conducted by Vernon T. Sheets (1922) who wrote his thesis on *An Ecological Survey of Delaware County, Ohio*. Counties which once had extensive prairies were popular ones for study, such as those for Pickaway County by Shupe (1930), Meigs County by Jones (1936), Ross County by Crowl (1937), and Wood and Henry Counties by Shanks (1938). The survey of the vegetation of the northern Virginia Military Lands of west-central Ohio by Raymond A. Dobbins (1937) has been considered an outstanding example of this type of survey work conducted under Transeau (Gordon, 1969:3). The northern Virginia Military Lands contained extensive prairie vegetation; consequently, this study was of particular importance to Transeau.

In his research on the mapping of the natural vegetation, Transeau stressed the practical value of such maps made by competent plant ecologists and pointed out their usefulness to agronomists, foresters, and geographers. As an example of this practicality, Transeau and Sampson studied the distribution of the Mexican bean beetle and European corn borer in Ohio, and showed that the insect infestations were destructive principally in areas once dominated by a single vegetational type or natural sequence of closely related communities in a particular kind of habitat. In the case of the European corn borer, they learned that the insect infestation was most prominent in the areas of Ohio which were once wet and covered by swamp forests and less prevalent in drier areas dominated by oak—hickory forests. Transeau and Sampson were therefore able to predict that the European corn borer probably would not become a serious pest in the heart of the corn belt farther west where the original vegetation was upland tallgrass prairie and the shortgrass plain (Transeau, 1926, 1927, 1928; Neiswander, Sampson, and Kelsheimer, 1928).

Floristic studies were also conducted. Pearle E. Williams (1926) prepared nearly 200 dot-distribution maps at the county level for selected plant species in Ohio. This study, published jointly by Transeau and Williams (1929), was one of the earliest efforts in preparing dot-distribution maps of Ohio plants. It was considered essential to know the distribution of selected critical species of the Ohio flora before the natural vegetation of the state, along with its geographic variations and history, could be described satisfactorily. Twelve species usually associated with prairies were mapped.

Robert B. Gordon (1928a), in his thesis on the *Floristic Regions of Ohio*, divided the state into four regions, one of which was based on the distribution of 45 species typical of prairies. When plotted on a single map, the combined distribution of these species showed the prairie regions of Ohio based on floristic information. This map was particularly helpful to Transeau in determining where the original prairies were located in Ohio. With regard to the origin of the plants of these prairies, Gordon (1928b) noted that half of them reached their eastern limit in Ohio, and gave the prevailing viewpoint that these prairie species were "thought to have invaded the state during the xerothermic period which began well after the retreat of the glacier." Transeau and Sampson themselves conducted field studies in the northern Ohio counties of Erie, Huron, and Lorain in 1928, and, as noted above Sampson had conducted extensive field work in Marion County. By 1940, all of the counties with extensive prairie areas had been surveyed. From the 1930's on, the prairie areas of Ohio had been shown on base maps of Ohio at various times: by Transeau and Sampson (1935), in *The Prairie Peninsula* paper itself by Transeau (1935), in a paper on the vegetation of Ohio prairies by Jones (1944), by Transeau (1950 and see my Fig. 7; 1956a), Weaver (1954:177), and by Gordon (1966).

Prior to 1930, Transeau was preparing a generalized map of the distribution of the natural vegetational types of the north-central states. In this endeavor he had the assistance of Robert B. Gordon, who completed his dissertation on *The Primary Forest Types of the East Central States* (Gordon, 1931, 1932). Transeau's portion of the study was presented at the annual meetings of The Ohio Academy of Science and of the Association of American Geographers in 1930. In the abstracts, Transeau (1930a, b) listed the various vegetational types, such as prairie, oak—hickory forest, beech—maple forest, swamp forest, mixed slope forest, northern pine forest, and referred to a map (Fig. 8) where these types were shown. He regarded the map as a "preliminary one suitable for a working base for further study . . . As further details are worked out various variants of these types may be distinguished by appropriate color schemes." (Transeau, 1930c). The prairie must have been his major concern during the preparation of this map, for he also noted that "The field work has brought out very clearly the distinctions of the prairie and the adjoining forest" (Transeau, 1930b). The lines between the prairie and the forest are sharply drawn on the map compared to the lines between the other vegetational types. The prairie areas also are more definitely delineated in Illinois and farther west, compared to those shown for Indiana and Ohio. A more definite mapping of the prairie areas in these states was completed by Gordon (1936) who mapped the natural vegetation of Indiana beginning in 1928 and by Transeau (1935) who mapped the prairie areas of Ohio in his *Prairie Peninsula* paper.

Information on the climatic conditions of the major vegetational regions of central and eastern United States was of considerable interest to Transeau, if he was to provide an answer to his question of what caused the Prairie Peninsula, first asked by him in 1905. Three students, Gladys Kirsch (1930), Mary Leonard (1930), and Ica Marks (1929), studied the relationship of rainfall to vegetation, which was presented as their theses. Rainfall records in inches were taken from the United States Weather Bureau reports, and these data were plotted on a polar chart having twelve coordinates, each coordinate representing a month of the year. Each division of a coordinate equaled 1 inch (2.5 cm) of rainfall. A line was then drawn to connect the points which represented the amount of rainfall for each month. The resulting polygraph illustrated the rainfall or precipitation pattern for one year. The portion of the graph above the horizontal line represented the dormant season, whereas the portion below the horizontal line represented the growing season. Twelve polygraphs representing 11 years of rainfall data (1910-1920) and one to show the mean amount of rainfall were prepared for each station and shown together on one page. In these theses, graphs were prepared for 56 different stations throughout central and eastern United States. Selected examples of these polygraphs were later published by Transeau (1935).

With results from the studies of rainfall along with other data, Transeau was ready to summarize the precipitation conditions for the shortgrass plains, the tallgrass prairie, and the adjoining forest regions with respect to monthly and annual variability of rainfall. This information was presented before the annual meeting of the Association of American Geographers. In the abstract, Transeau (1930a) noted that the tallgrass prairie, in contrast to the other two regions,

> shows extremes both in monthly and annual variations. This results in great irregularity of available soil water, and occasional prolonged periods of drought. This is believed to be one of the important characteristics differentiating the prairie climate from that of the plains and the adjoining forested regions. This has also been an important factor in the development and maintenance of the unique prairie soil type.

Transeau may well have presented the above described paper before The Ohio Academy of Science in 1930 under the title, *A Feature of the Prairie Climate*, but no summary or abstract of that presentation has been located. A comparison of the climatic conditions of these three vegetational types, as summarized from the writings of Transeau and his students before 1930, is presented in Table 1.

In the abstract for The Ohio Academy of Science presentation on *The Vegetation of the North Central States*, Transeau (1930c) described the history of the vegetational types. In part he said:

> After thousands of years [following deglaciation] the geographic succession gradually passed to oak-hickory forests on the uplands, swamp forests in the valleys and on wet upland depressions; and the extension of the beech-maple forests outward from the Alleghany plateau was quite certainly followed in comparatively recent times by a dry period in which the

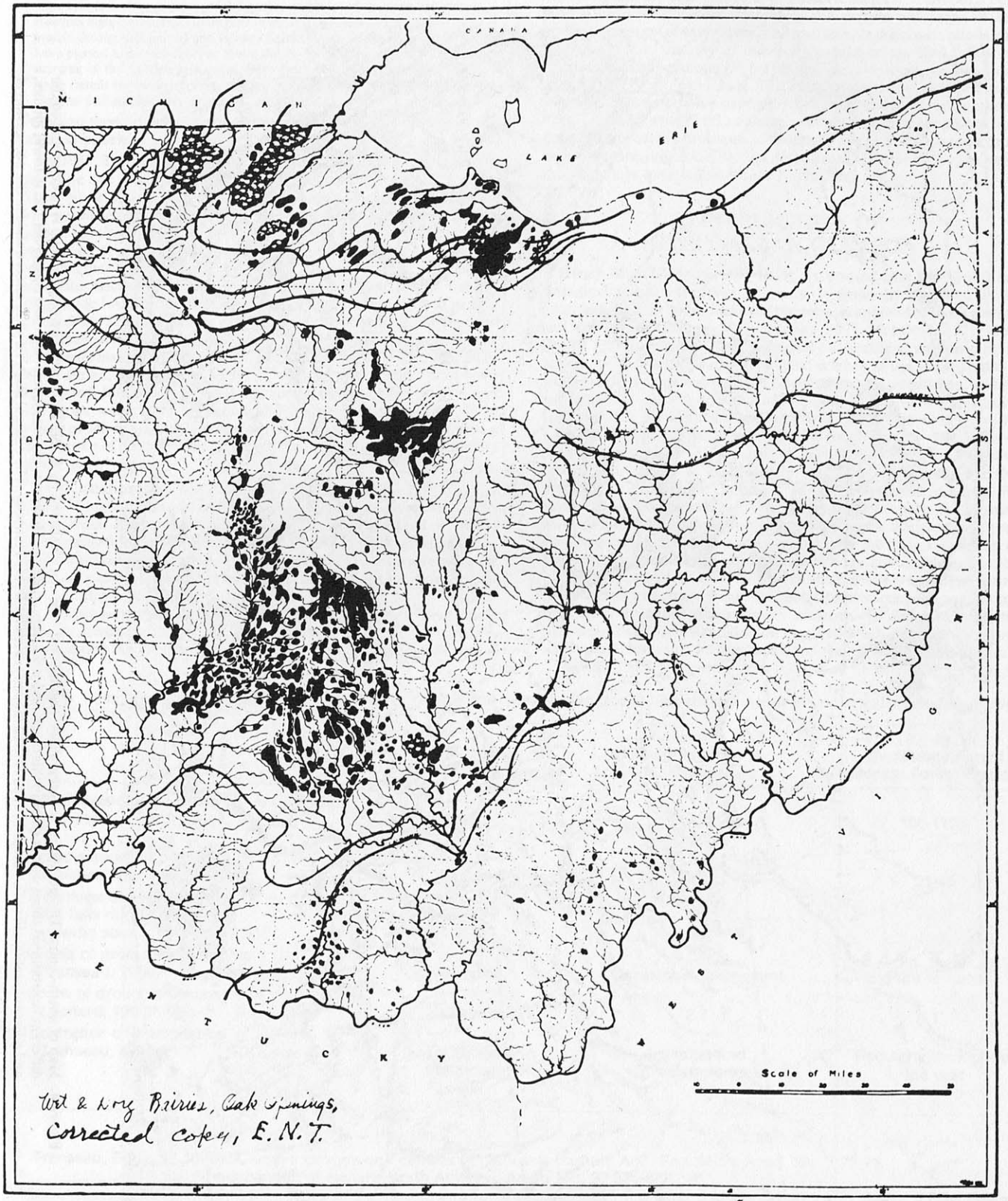


Figure 7. Transeau's unpublished map of "Ohio Vegetation: Prairies" originally printed in 1950. The version published here was one later revised by him showing areas of wet and dry prairies (black) and oak openings (circles). (Original in the office of the Ohio Biological Survey.)

Figure 8. Map of north-central United States showing major vegetational types as illustrated by E. N. Transeau. The original map is in color and so the different vegetational zones do not show in this black-and-white reproduction. However, the prairie region is most clearly defined in Iowa, Illinois, and adjacent states. (From an original unpublished map prepared by E. N. Transeau. The original map is a glass lantern slide in the possession of R. L. Stuckey.)

> prairies spread far to the east and north and on the return of a more uniformly moist climate left isolated remnants in the forests of Kentucky, Ohio, Michigan, and Wisconsin, just as the northward migration of the northern coniferous forest types left pine, hemlock, tamarack, and arbor vitae relicts in deep ravines, rocky gorges and bogs of the corn belt states. It seems highly probabl[e] that some of the bogs passed directly from bog to prairie during this period and in very recent times a few of them in Ohio have passed to swamp forests. Since the dry period the wet prairies at the margins of the 'prairie peninsula' have been invaded by bur oak and to some extent by swamp forest, the dry prairies have passed to scrub oak barrens and oak-hickory forests.

Transeau then summarized the characteristics of the climate of the tallgrass prairie.

By 1932, Transeau was ready to discuss in print the Prairie Peninsula. The title of his paper for that year's annual meeting of The Ohio Academy of Science was *The Prairie Peninsula,* and a short abstract was published (Transeau, 1932). He noted that the causes of the tallgrass prairie and Prairie Peninsula continued to be debated as if the only problem involved was grassland versus forest, with an answer of two alternatives, climate or soil. But Transeau pointed out that an adequate discussion of the prairie had to account for its natural geographic boundaries, the occurrence of prairie species and prairie colonies far distant from the main body of the prairie, the dominance of grasses on both well-drained and poorly drained sites, the nature of the forests bordering the prairies, the dominance of prairies for 20 to 30 centuries, and the unique types of soil "prairyerths" that have developed. Moreover, a consistent correlation between prairies and soil types was yet to be detected. His conclusion was that "The prairie problem is a highly complex one, and its solution will involve a large group of contributing factors of the present and the geologically recent past."

In his classic paper, *The Prairie Peninsula,* Transeau (1935) enumerated 21 major ideas. All of these ideas, according to him, needed to be explained and assimilated in order to develop any kind of "complete integration" of the concept of the Prairie Peninsula. As an aid in explaining his interpretation, Transeau offered 15 observations based on his own or his students' research. Six of these observations represented climatic factors, including the importance of the precipitation-evaporation ratio for a large geographical area, midsummer relative humidity, and the occurrence and pattern of precipitation during the year and over successive years. The other observations involved the nature of the soil or "prairyerths," evidence from succession of plant communities, fire as an aid in maintaining prairie, development of the Xerothermic Period, modification by human occupation, and the importance of prehistoric factors. Transeau's purpose was to locate more accurately the eastern extension of the prairie at the time of settlement, and to assemble the observations and problems which directly or indirectly would be clarified following satisfactory explanations of the origin, development, and maintenance of the Prairie Peninsula. The detailed map of the Prairie Peninsula (Fig. 9) has certainly been one of the major lasting contributions from Transeau's paper. He assembled a number of observations and pointed out various problems, concerning the prairie, but the explanations for the origin, development, and maintenance of the prairie in the Peninsula were left to future researchers.

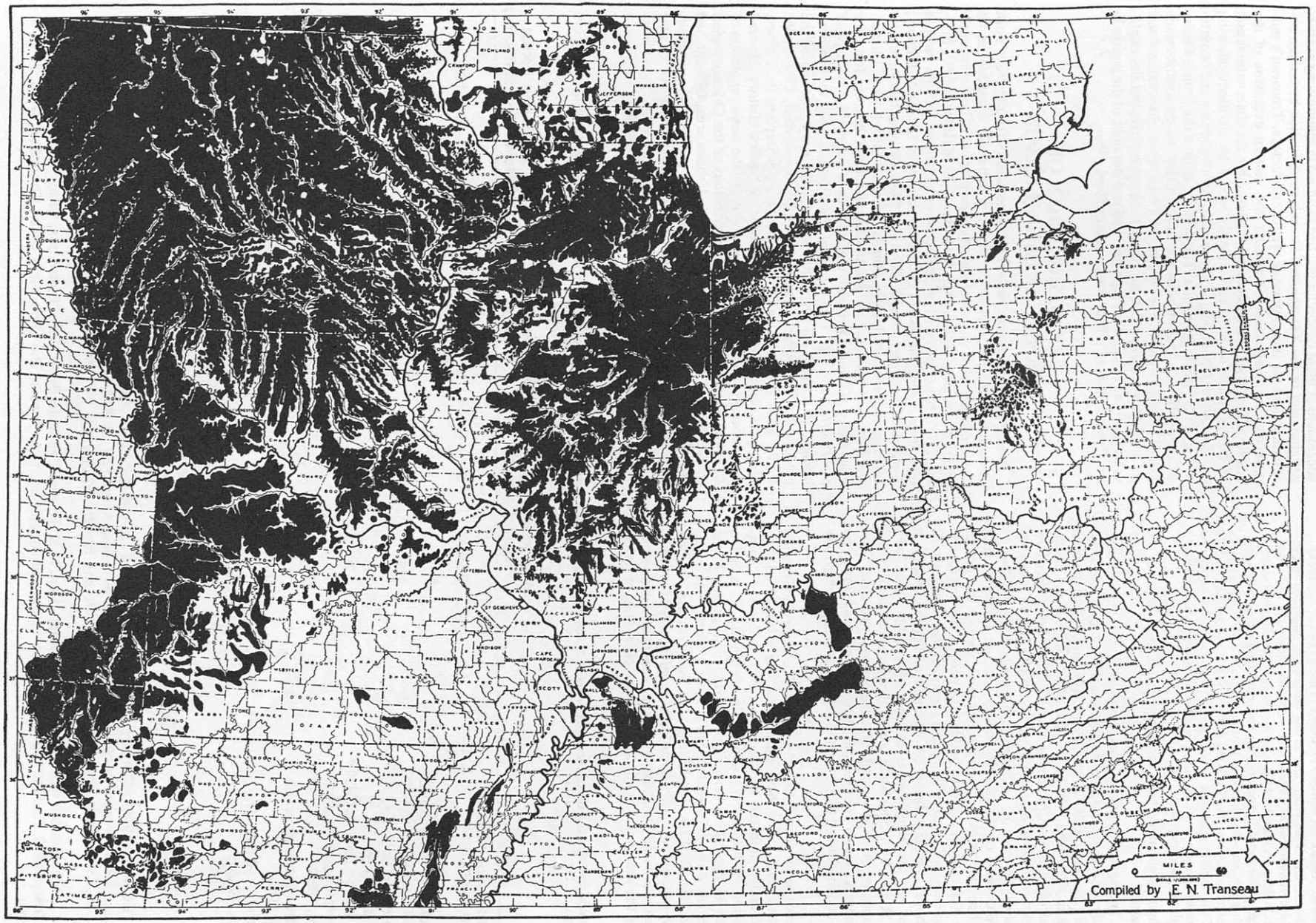
CONTRIBUTION OF HENRY ALLAN GLEASON

Henry Allan Gleason (1882-1975), associated with the New York Botanical Garden for over 50 years, is generally regarded as an outstanding plant taxonomist and phytogeographer of both temperate and tropical floras (Cain, 1959; Maguire, 1975; McIntosh, 1975; Muller, 1975). His relatively few ecological publications, written early in his career during the rise of ecological science in the United States, were mainly concerned with the prairie flora and vegetation, and its successional relationships in Illinois. Born in Dalton City, Illinois, Gleason took his bachelor and master of science degrees from the University of Illinois writing a thesis for each degree — *The Flora of the Prairies* and *The Vegetation of the Ozark Region in Southern Illinois,* 1901 and 1904 respectively. As a student Gleason had the guidance of Professors Thomas J. Burrill, taxonomist; Charles W. Rolfe, geologist; and Charles C. Adams and Stephen A. Forbes, ecologists of the Illinois State Laboratory of Natural History. He read the pioneering papers on plant succession of the dune vegetation of Lake Michigan and the physiographic ecology of the Chicago region by Henry C. Cowles (1899, 1901a). In the Urbana area, Gleason had no lake dunes to study, but he did notice that succession was occurring on river dunes and in areas between the forest and prairie (Gleason, 1953). In 1906, Gleason received his doctoral degree from Columbia University, having written on the taxonomy of *Vernonia,* a

Table 1. Comparison of the climatic conditions of three vegetational types as summarized from the writings of Transeau and his students before 1930.

	Shortgrass (Plains)	Tallgrass Prairie (Prairie)	Deciduous Forest (Border Forest Region)
Rainfall/evaporation rates (Transeau, 1905a,b)[1,2]	20-60%	60-80% 80-100%	100-110%
Annual amount of precipitation in inches (Transeau, 1930a)[3]	15-30	30-40	35-45
Percentage of annual rainfall that falls during the growing season (Marks, 1929)[4]	73%	69%	53%
Periods of prolonged droughts (Transeau, 1930)[2]	Regular	Occasional to frequent	Rare to none
Length of droughts in months (Leonard, 1930)[5]	Not studied	2.7	1
Occurrence of precipitation (Transeau, 1930a)[2]	Local showers in the growing season	Irregular and extremely variable	Regularly throughout the year

[1] Transeau, Edgar N. 1905a. Climatic centers and centers of plant distribution. Ann. Rep. Mich. Acad. Sci. 7:73-75.
[2] _____. 1905b. Forest centers of eastern North America. Amer. Nat. 39:875-889.
[3] _____. 1930. Precipitation types of the prairie and forested regions of the central states [Abstr.] Ann. Assoc. Amer. Geogr. 20:44-45.
[4] Marks, Ica. 1929. Rainfall types in relation to vegetation. M.S. Thesis, The Ohio State Univ., Columbus, Ohio. 73 p.
[5] Leonard, Mary. 1930. Rainfall types in relation to natural vegetation. M.A. Thesis, The Ohio State Univ., Columbus, Ohio. 70 p. + bibliography.



The Prairie Peninsula with outliers. West of Ohio the areas were compiled from many published sources. The prairies of Indiana were mapped by Dr. R. B. Gordon, and the Barrens of Kentucky by Dr. S. N. Dicken.

Figure 9. Transeau's original published map of the Prairie Peninsula. (From Transeau, 1935.)

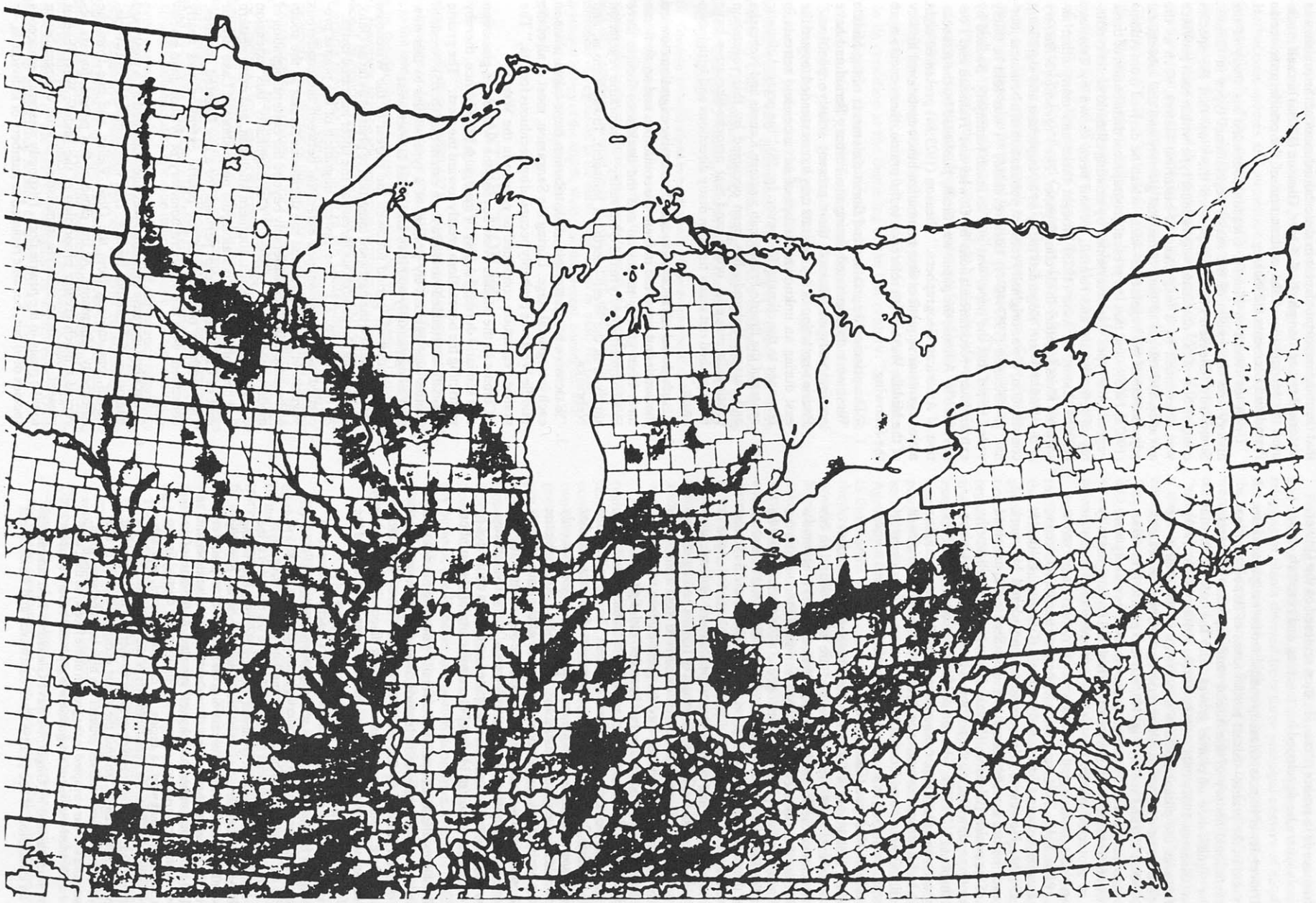


Figure 10. Map of north-central United States showing the prairie-forest border areas as viewed by Transeau. (From an original unpublished map prepared by E.N. Transeau. The original is a glass lantern slide in the possession of R. L. Stuckey.)

genus of ironweeds in prairie areas. He then returned to the University of Illinois where he developed his teaching and research career until 1910.

At the University of Illinois, Gleason conducted investigations into the succession in the prairie—forest border areas of Illinois, writing on the vegetational history of the inland sand deposits, the virgin prairie, the significance of prairie groves, and the role of fire in succession (Gleason, 1907, 1908, 1909b, 1910a, 1910b, 1912a, 1913). To him, fire was the potent cause of succession in the prairie. He wrote that the forest was "everywhere pushing out upon the prairie" (Gleason, 1909a: 270 and see my Fig. 10), but that prairie fires determined the present forest distribution. As the prairie fires usually were swept by winds from the west, the surviving isolated forests generally occurred in protected places on the eastern sides of streams or sloughs, on bluffs, or in rugged valleys where fire was less prevalent (Gleason, 1912a, 1913). This successional phenomenon he referred to as the "struggle between forest and prairie" (Gleason, 1910b:45, 116-117; 1912b). However, Gleason never considered his work finished, and, before leaving Illinois, he described eight unsolved problems of the prairie (Gleason, 1909a), all of which are still worthy of consideration today. During the portion of his career at the University of Michigan (1910-1919), Gleason did little research on prairies, publishing only one short paper describing a small prairie near Ann Arbor that had a strong resemblance to the hydrophytic prairies of northern Illinois. He considered it to represent a relict colony of prairie plants, persisting from a time when prairies occupied a wider area in southern Michigan (Gleason, 1917).

The earliest indications of Gleason's development of a concept of the eastern extension of prairie grassland are to be found in his bachelor of science thesis. In this work, Gleason (1901) presented a detailed review of the nineteenth century descriptive literature on the origin and history of the prairies; a catalogue of 415 species based on data from the literature, herbaria, and his own field work; and an analysis of the geographical distribution of the prairie flora in Illinois. In this latter aspect, Gleason noted that prairie plants belonged to cosmopolitan families, and to both cosmopolitan and endemic genera. With respect to species, the prairie flora of Illinois belonged to no one geographical source, but was a complex derived from a number of sources. One of the main sources was the great eastern woodlands, from which about half of the species had been derived. Species farther west, in the flora of Kansas and Nebraska, Gleason hastened to add, belonged mainly to western and southern sources. The prevailing idea was that the prairie flora contained large numbers of species peculiar to it, but Gleason considered this idea erroneous and noted that only 55 species could be regarded as distinctive to prairies. Concerning the future of the prairie flora, he predicted that more of the prairie plants would disappear, many would find homes in the woods as some had already done, and some would persist as "weeds" in cultivated land. How many species would become extirpated in Illinois could not be conjectured, but he wrote (p. 14) that "there will certainly be numbers of them."

In April 1906, while at Columbia University pursuing his doctoral degree, Gleason (1906) presented a lecture, *Some Phytogeographical Features of the Prairies*, to the members of the Torrey Botanical Club. This lecture, which evoked an interesting discussion following its presentation, was summarized by C. Stuart Gager, secretary of the Club, as follows:

> An eastern extension of the great western prairies reaches across Iowa into Illinois and Indiana and portions of the adjoining states. Its flora is characterized by large numbers of western plants, although a majority of the species are of eastern distribution and constitute a derived element of the flora. The origin of the prairies has been referred to the character of the soil, the distribution and amount of rainfall, the direction of the prevailing winds, the grazing of bison and to forest fires. Each of these has probably had some influence in accelerating or retarding the invasion of the prairie or forest after the retreat of the continental ice sheet, but the most important factor of all is historical rather than physical in nature. At the close of the glacial period the territory since occupied by prairies was opened first to invasion from the southwest, a region of climatic prairies, and subsequently to invasion from the climatic forests of the southeast. The two floras, on meeting, adjusted themselves to each other and to the physical factors of the environment, so that the forest occupied the bluffs and valleys along the streams, and the prairies the high lands between them. The climate and soil were adapted to the growth of the forest, so that, until extensive cultivation was begun, the prairie was gradually being displaced.

Here, as summarized by Gager, we have Gleason's first characterization of an extension of the prairie flora eastward, and a statement that the most important factor in the establishment of the prairie was historical rather than physical. Later, Gleason (1909a) himself attributed the recognition of the eastern arm of the prairie province to Pound and Clements (1898b).

Upon his return to Illinois, Gleason continued his study of the history and succession of the major vegetational types in Illinois. Summarily, Gleason (1910b) expressed the view that the species composition of the dominant vegetational type within each province was determined by a long chain of historical factors, such as the advance and retreat of the continental glaciers and the subsequent adjustments of the vegetation—ideas which he derived from Adams (1902a, 1905)—and that the present geographical distribution of these vegetational types was determined by existing climatic factors, notably of temperature and rainfall, as had been shown by Transeau (1905b). Later, Gleason (1923) brought these and many other associated ideas together in his classic paper, *The Vegetational History of the Middle West*. Regarded today as an important and significant contribution, it was originally refused publication in a botanical journal. As Gleason (1953:40-41) later revealed, "I was told in thinly veiled terms that the paper was just so much tommyrot. Backed by extraordinary recommendations by Cowles and Transeau and I believe also by Adams, the paper was finally published by the Association of American Geographers." Gleason (1923:84) presented eight major events or sequences that summarized the vegetational history of the Middle West. With reference to the prairie, these events were the following:

1. "The principal vegetation and floristic elements of the Middle West were differentiated during the Tertiary Period and have continuously maintained their present relative position." Prairie vegetation of dry habitats may have extended toward the east during an unknown number of advances and retreats in response to the climate. However, (p. 58) "the present climatic center of the Prairie Province in western Kansas and Nebraska and eastern Colorado has been occupied by this vegetation continually since its origin, and that amoeba-like arms have been pushed out many times in many directions and withdrawn again."
2. "Each glacial advance has induced extensive migrations toward the south and west, but in them the coniferous and arctic floras have been greatly narrowed and the deciduous forests have lived uninterruptedly in the Ohio valley." The prairie vegetation survived in the West—northern Missouri, Iowa, Kansas, and Nebraska.
3. "Extensive readjustments of distribution have taken place in each interglacial stage. During the Sangamon, most of all of the Middle West was probably occupied by deciduous forests." The prairie vegetation continued to remain in the West.
4. "Climate in the Middle West beyond the Wisconsin glaciation was semiarid during the time of maximum ice advance, thereby restricting the boreal flora greatly toward the west." The prairie vegetation extended eastward to an extent that (p. 65) "western Illinois was exclusively prairie, of a type similar to that now prevailing possibly 400 [640 km] miles farther west."
5. "A xerothermic period followed the retreat of the Wisconsin ice, and caused the eastward migration of prairies as far as Ohio, succeeding the coniferous forests as the latter migrated north." At that time (p. 71) "The eastern migration of the prairie proceeded as a wedge-shaped extension between the coniferous vegetation at the north and the deciduous forests at the south and reached limits considerably beyond the eastern migration of modern continuous prairies." Geographically this extension was into eastern Indiana, southern Michigan, and northwestern and central Ohio, but not along the north shore of Lake Erie or east of Cleveland, except perhaps for a few isolated colonies. The southern boundary of the prairie extension was nearly coincident with the southern boundary of Wisconsinan glaciation.
6. "A gradual increase in rainfall was accompanied by a westward migration of deciduous forests. This was composed of two elements, one moving from the Ohio Valley and one from the Allegheny Mountains. At the close of this period, forests occupied a much greater proportion of the Middle West than at present." With an increase in moisture, drastic changes began to take place in the prairie flora. Distinctly western herbaceous species died out, became reduced in numbers of individuals, or

became restricted to extreme habitats where edaphic conditions compensated for the increased rainfall. Some of the species survived as relicts, or as relict colonies, in xerophytic habitats. Herbaceous species and numerous grasses from the deciduous forested lands of the southeastern United States migrated into the prairie habitats. As the rainfall increased, this southeastern herbaceous floristic element dominated the prairie lands and eventually succeeded the western prairie species. Many of these southeastern species arrived through selective migration accompanied by evolution in the new environment. According to Gleason (p. 77-78), "In fact, the four most important grasses of the Illinois prairies, *Andropogon furcatus* [*A. gerardii*], *A. scoparius*, *Sorghastrum nutans*, and *Spartina Michauxiana* [*S. pectinata*], are all of eastern origin . . . Here we have the origin of the flora of the eastern arm of the Prairie Province, early recognized by Pound and Clements as distinct from that of the western plains, and designated by them the prairie-grass formation . . . The numerous ponds of the eastern arm of the Prairie Province were also formed at this time, in response to increasing rainfall in a region physiographically immature. They were of necessity colonized almost completely by species of southeastern origin, since true hydrophytes were not found in the western vegetation."

7. "With the arrival of the Indian and prairie fires, prairies again began to encroach on the forests and reduced the forested area to its condition at the beginning of the last century."
8. "During the nineteenth century extensive afforestation took place, continually until the land was placed under cultivation." Much of the prairie grassland was plowed for agriculture, and the vegetation was destroyed. The natural struggle between the forest and prairie had virtually ceased.

The importance and significance of Gleason's paper has been evaluated by Cain (1959), who described it as a distinguished study with a strong Gleasonian imprint, being a lineal descendant of the writings of Charles C. Adams, Adolph Engler, and Asa Gray. Cain (p. 107) further wrote:

> Dr. Gleason's work helped bring dynamic biogeography back to North America where it had started half a century before. In this great study he worked with present materials under his own observation: the present areas of species and major communities, their relations to present climate, terrain and the evidences of glaciation, and above all, the significant relic[t] stands of vegetation, different ones of which were related to the mass occurrences of vegetation to the north, east, south or west. He read the vegetational history of the Middle West from the present, coming out with an understanding which subsequent palynology still is in the process of confirming.

CONTRIBUTION OF EMMA LUCY BRAUN

Emma Lucy Braun (1889-1971), pioneer ecologist contemporary with Transeau and Gleason, is primarily recognized for her contributions to the understanding of the associations and ecological relationships in the deciduous forests of eastern North America (Stuckey, 1973). However, in her early ecological writings Dr. Braun developed a concept of prairie vegetation and its eastward extension from the main prairie province farther west in the United States. Born and educated in Cincinnati, she earned all of her degrees at the University of Cincinnati. The doctor of philosophy degree was taken in 1914 on *The Physiographic Ecology of the Cincinnati Region* (Braun, 1914, 1916). Her entire teaching and research career was with the University of Cincinnati until early retirement in 1948, following which she continued her research and writing to the time of her death. Dr. Braun's basic philosophy of plant geography was derived in a large measure from the ideas of vegetational history and development as outlined by Cowles with whom she studied in the summer of 1912. She was strongly influenced by Gleason in her floristic, phytogeographic, and even ecological thinking. Her training and experience in geology and physiography, under Nevin M. Fenneman, appear to have been far more extensive than was the case for most outstanding plant ecologists and plant geographers at the time. However, her published contributions stand apart from the contemporary literature because of the originality in her thinking. This characteristic is also shown in her investigations of the prairie vegetation in southwestern Ohio, particularly in unglaciated Adams County (Braun, 1928a, b).

Following her doctoral study, Braun (1921) viewed the composition and sources of the flora of the Cincinnati region as a result of the mingling of plants derived from three principal centers of dispersal: the southeastern center, which was the most prominent center, and the prairie and desert centers farther west in the United States, which were less influential. With respect to the paths of invasion for the western elements of the flora, she noted (p. 162) that they were "marked by broken lines of related plant communities which occupy a series of continuous or almost continuous, similar, but gradually changing habitats with no great geographic barriers between them." One pathway was "the eastern extension of the prairie across Indiana into western Ohio." This description was Braun's first statement of an eastern extension of prairie flora in the United States. At no time prior to 1935 did she use the term Prairie Peninsula.

In 1928, Braun analyzed the glacial and postglacial migrations of the flora in Ohio based on the floristic composition of relict colonies in the Wisconsinan drift area, the Illinoian drift area, and in the unglaciated area. With reference to the relict colonies of prairie vegetation, Braun (1928a) noted several basic differences in these three regions. The prairies were generally distributed, but more concentrated in west-central Ohio on the Wisconsinan drift, very limited or essentially absent on the Illinoian drift, and numerous but local in the unglaciated territory of Adams County. Braun's analysis of these prairies on the Wisconsinan drift was that they were mesophytic, secondary in the successional stage, and post-Wisconsinan in age. Agreeing with Sears (1926b), Braun noted that these prairies occurred in those areas where a mature drainage had not yet developed, and they represented the dwindling remains of the greatly extended prairies from the West that survived from the post-Wisconsinan Xerothermic Period as outlined by Gleason (1923). Conversely, the prairies in the unglaciated territory were either mesophytic or xerophytic, although the latter predominated, were primary in the successional stage, and were pre-Illinoian in age. These prairies occurring on a mature topography represented a "pre-Illinoian prairie extension . . . the southeastern limit of a prairie arm extending down from the northwest, all evidence of which was obliterated by the Illinoian glacial advance" (Braun, 1926b:292). This relict flora was also considered to be of western origin, although there were numbers of southeastern and Ozarkian xerophytes present.

After analyzing these observed differences in the prairies of the two regions, Braun (1928a:296) came to the conclusion that "there were at least two xerothermic periods, the first pre-Illinoian, the last, Wisconsin and early post-Wisconsin. It means, that there were at least two eastward migrations of prairie, remnants of both of which are still preserved in relic colonies." She listed six facts which favored a pre-Illinoian age interpretation of the *Andropogon scoparius–Bouteloua curtipendula* prairie of the unglaciated region in Adams County (1928a). In her presidential address to The Ohio Academy of Science, Braun (1934) reiterated her viewpoint that the prairie vegetation advanced from the western grasslands during at least two warm dry periods, pre-Illinoian and post-Wisconsinan. Gleason (1923) and Sears (1926b) were unaware of treeless areas or prairies in the unglaciated region of Ohio, and therefore this flora was not taken into consideration in their description and history of the prairie floristic element in Ohio.

INTEGRATING THE IDEAS

By 1930, Braun, Gleason, and Sears were essentially in agreement on the floristic origin and age of that portion of the Prairie Peninsula formerly covered by the Wisconsinan ice sheet in Ohio; on the contrary, Transeau disagreed with both Gleason and Braun on the floristic origin and age of the Prairie Peninsula, as well as on the dating of the Xerothermic Period in Ohio. Transeau did not state with whom he was disagreeing, but by the nature of his statements on each point, these inferences can be clearly drawn. In disagreement with Gleason on floristic origin, Transeau (1935:426) wrote:

> The tall prairie grasses did not 'come out of the deciduous forest' and they probably did not cross the Allegheny mountains, but reached the eastern seaboard by way of the New York State lowlands and the ancient southern coastal plain. From there they have followed up many of the rivers to the eastern slopes of the Alleghanies.

Opposing Braun's ideas on the age, he (p. 426) noted that

> There is no need to go back to pre-Wisconsin epochs to account for any of the prairie communities in Ohio. It is quite possible that some of the

prairies south of the glaciated region had developed before the last glaciation, but neither criteria nor substantial evidence have been published that differentiates them from the recent prairies.

As to the dating of the Xerothermic Period, Transeau disagreed with both Gleason and Braun, for he (p. 426) said that

> . . . there is no evidence that a dry period caused the retreat of the last ice sheet, nor is there satisfactory evidence for an *early* postglacial xeric period. There seems to be more evidence to the contrary.

Transeau (1935) believed this late postglacial prehistoric dry period was supported by certain bog pollen studies; by soil profiles; by the succession indicated in bog profiles; by the absence, or rare occurrence, of many tree, shrub, and herbaceous species from the region of the Peninsula; and by the present distribution of prairie colonies and prairie species. However, he did not cite any examples or papers on these topics. Transeau so strongly believed in his own sources of evidence he (p. 435) wrote that

> If pollen studies of the upper layers of peat within the Peninsular region fail to show a period of this kind either the methods of pollen analysis or the assumptions upon which they are based need further investigation.

It does not appear that Transeau (1935, 1941) published a date for this late dry period, but on one of his maps used in his ecology class, he noted, "Xeric Period 3000 years ago." This date agrees remarkably well with the later writing of Sears (1967), who gave the dates of the Xerothermic Interval in Ohio at 1300 to 3600 years B.P., a date based on the pollen stratigraphic research of Ogden (1966).

No further dialogues or debates on these differences concerning the Prairie Peninsula are known to have been published by the authors involved. However, many verbal stories are told among former students at The Ohio State University that Braun and Transeau continued their disagreements. Braun's student, Isabel Thompson (1939) and Transeau's student, Clyde H. Jones (1944) each pointed out the Braun-Transeau disagreement on the age of the prairies in Ohio. Both authors indicated the complexity of the problem and acknowledged that the dry prairies of Adams County are considerably different in floristic composition from the wet prairies in glaciated Ohio, thereby allowing for an interpretation that the origin of the Ohio prairies occurred, as stated by Jones (1944:538) in "pre-, inter, or post-Pleistocene times." In an attempt to obtain evidence on the age and origin of the dry and wet prairies in Ohio, DeSelm (1953) analyzed populations of big and little bluestems from the dry prairies of Adams County in unglaciated Ohio and the wet prairies of Marion County in glaciated Ohio. He made morphological comparisons with populations of plants from the prairie center farther west in the United States and concluded that each of the Ohio populations showed a closer relationship to populations farther west than they did to each other. Although not stated by DeSelm, these data may suggest a separate spacial and temporal origin for the plants of the dry and wet prairies in Ohio. The major problem with these differences in interpretation of the Prairie Peninsula is that Gleason and Braun based their evidence primarily on floristic and historic data, whereas Transeau did not develop a broad floristic base but was mainly interested in the climatic limitations. Transeau (1941), who also considered historic factors, seems to have interpreted them differently than did Gleason and Braun.

ORIGIN OF THE CONCEPT

When considering the origin of an idea, any historian must be careful if he points to a single individual or event as the beginning of the idea. In the case of the origin of the concept of the Prairie Peninsula, it appears that a rather definite beginning point is evident. The tallgrass prairie of the Middle West was a vegetational type not encountered in Europe or eastern North America. The early American naturalists, whose roots were European, described much of the tallgrass prairie, but they did not have sufficient data, nor the need for or interest in analyzing its floristic composition, mapping its geographical extent, and/or defining its climatic causes. To develop a dynamic understanding of the biological relationships of the prairie required new approaches and viewpoints that were to emerge from the disciplines of plant ecology and plant geography. In a pioneer paper on North American plant geography, Asa Gray (1878) recognized that moisture was a factor in the distribution of vegetation with a greater aridity in grassland areas compared to forest regions. He acknowledged the puzzle of the eastern prairies as outliers within the forest, and he (p. 93-94) wrote:

> . . . the prairies of Iowa and Illinois . . . form deep bays or great islands in our own forest region . . . The cause or origin of our prairies . . . are not directly due to the deficiency of rain . . . I am disposed . . . to think that the line of demarcation between our woods and our plains is not where it was drawn by Nature. Here . . . there must be a debatable border, where comparatively slight causes will turn the scale either way . . . I suspect that the irregular border line may have . . . been carried eastward wherever nature of soil or circumstances of exposure predisposed to it.

In the late 1800's the infant sciences of plant ecology and plant geography were becoming academically viable in North America through the teaching of Asa Gray's student, Charles E. Bessey at the University of Nebraska (Brewer, 1960; Egerton, 1976; Gleason, 1936; McIntosh, 1976; Sears, 1956). Here, Pound and Clements (1898a, b) published a book on the *Phytogeography of Nebraska* and a separate paper that outlined and mapped the vegetational regions of the prairie province, showing an extension as far east as Illinois (Fig. 11). For a better understanding of this eastern extension of prairie grassland, it is necessary to look to individuals in schools farther east in the Prairie Peninsula itself. Throughout this paper, two individuals, Henry Chandler Cowles and Charles Christopher Adams, have frequently been mentioned in one or more contexts as having influenced the thinking of Transeau, Gleason, and Braun.

Henry C. Cowles (1869-1939), who was born in Connecticut and took his bachelor of arts degree at Oberlin College in 1893, came to the

Figure 11. Map of central portion of North America showing vegetational types of the Prairie Province, divided into three regions. I. The prairie region, II. The Sand Hill region, and III. The foothill region. (From Pound and Clements, 1898.)

University of Chicago where he earned his doctor of philosophy degree in 1898, working with John M. Coulter in botany, and Rollin D. Salisbury and Thomas C. Chamberlain in Pleistocene paleobotany (Adams and Fuller, 1940). At the University of Chicago, Cowles rapidly developed new dynamic concepts of plant distribution and vegetational change through his prolonged and indefatigable field studies in the dune region at the southern end of Lake Michigan (Cowles, 1899, 1901a). He also wrote on the influence of underlying rocks on the character of the vegetation (Cowles, 1901b). By combining his knowledge of floristics, glacial geology, and physiography, he became a remarkably successful teacher and recognized leader in the field of physiographic plant ecology. He urged studies in ecological plant geography that considered the broad factors of the origin and development of plant societies or formations, such as the prairies, deciduous forests, or arctic tundras (Cowles, 1901a). The University of Chicago became one of the world's most active centers of ecological study, as Cowles' many students extended his methods and concepts in many ways. With reference to the prairie, Cowles (1928:382) believed that "the evolution of a prairie soil through the influence of prairie vegetation favors the persistence of the prairie . . . ." His major contribution, however, was in the approach and method of investigation which students like Transeau obtained from his classroom lectures and which Gleason and Braun extracted from his publications.

Charles C. Adams (1873-1955), who was born in Illinois and studied under Cowles while at the University of Chicago from 1900 to 1903, became a strong leader of ecology in its early years of development in North America (Palmer, 1956). During the years 1903-1906, while curator in the museum at the University of Michigan, Adams led field parties to Isle Royale for ecological studies which resulted in *An Ecological Survey of Isle Royale, Lake Superior* (Adams, 1909). He is also credited with writing the first textbook of animal ecology (Adams, 1913), as well as other important ecological papers (Adams and Robinson, 1961). It was while in Chicago and Ann Arbor that Adams (1902a, b; 1905) wrote three significant theoretical papers on the post-glacial origin and dispersal of the fauna and flora of North America. He emphasized the southeastern United States as a major center of geographical distribution and spoke of "waves" of biota migrating into the glaciated territory from various centers of distribution in the unglaciated area. In the second paper, Adams (1902b:354-355) wrote of these "waves" in reference to the prairies:

> While the southeast has undoubtedly been the most important centre of dispersal for the third wave types, it has not been the only one. The smaller element from the west and southwest must be given its due, though small, credit. This western influence, as might be anticipated, is most conspicuous in the more prairie sections of Iowa, Minnesota, Wisconsin, and Illinois. These prairies have furnished a favorable home for a number of plants and animals whose relationship and origin assuredly point to the west and southwest. The distribution of pocket-gophers and ground-squirrels indicate such an origin. Many typical forms of the Great Plains are evidently of southwestern origin, the Plains having been their outlet or highway from the far southwest. The Plains as a highway of dispersal have previously been noted. It is instructive to determine the geographical origin of the elements into which the life of a region may be reduced upon analysis. Our investigations should not stop at this stage, but should include, if possible, a study of the conditions which determine the presence of these different elements and the pathway along which they must have travelled in order to reach their present destination.

Then, in the next paragraph, Adams (1902b:355) proposed a Prairie Peninsula as follows:

> From the Great Plains east there is a prairie highway reaching as far east as northern Indiana, and forming a sort of peninsula extending east from the Great Plains into a densely forested region. This peninsular highway is composed of parts of northern Iowa and Illinois, and of southern Minnesota and Wisconsin. While the general direction of the prairie peninsula is toward the east, in reality it functions as a southwestern highway, because many of the types of the Great Plains are of distinctly southwestern origin. This is a highway for land forms only, because it does not coincide with any drainage system; in fact, it runs counter to those occurring within its limits.

It would seem most probable that both Transeau and Gleason took the concept of a Prairie Peninsula directly from Adams. Three years after Adams' proposal of a Prairie Peninsula, Transeau (1905b) used the term in his "Forest Centers" paper when he questioned the climatic causes of the Prairie Peninsula. It is not known when Adams and Transeau first met, but both gentlemen could have discussed the concept when they were associated with the University of Michigan in 1903 and 1904. In his autobiographical notes, Transeau (undated) does not mention Adams as one of his influential associates while he was a student, but the two ecologists and their families were known to have been close throughout their careers. Their work on the prairie plant and animal associations in Illinois has been noted earlier in this paper. On the other hand, Gleason (1965) referred to Adams as his former instructor at Illinois, and described his expedition to Isle Royale while a nonsalaried assistant to Adams in the summer of 1905. As a result of this work, Gleason (1909c) contributed a chapter on the ecological relations of the invertebrate fauna. In later years, Gleason (1965) was to write of his experiences on the expedition and noted that "Adams had already published his basic article on postglacial migration, and I learned many valuable ideas from him." Gleason's first statement of an eastern extension of the prairie flora was to come the following spring in 1906, when he spoke to the Torrey Botanical Club as noted earlier in this paper. Braun's ideas on the Prairie Peninsula appear to have developed independently from those of Adams, and accordingly reaffirm earlier statements made about the originality and independence of her ecological investigations.

CONCEPT OF THE PRAIRIE PENINSULA SINCE TRANSEAU

Since the publication of Transeau's paper on the Prairie Peninsula in 1935, 45 years have passed, and in that time the "shadows" have lengthened and many of the original ideas of Transeau, Gleason, and Braun have been retained, restated, and refined. New information has been added, and a few items listed in chronological order appear to be noteworthy:

1. Gordon (1940:72-74) considered the viewpoint for the existence of a Prairie Peninsula in western New York state and came to the conclusion, based on present-day floristic evidence, that there was an extension of oak openings and migration of prairie species from the west in earlier times.
2. McComb and Loomis (1944), in a review of the prairie, stated that the prevalence of prairie in Iowa and Illinois was not due to a recent Xerothermic Period, but probably dated back to soil disturbances initiated by the first or Nebraskan glaciation. Therefore, these prairies, being on glacial till plains, were considered semipermanent, edaphic, and not climatic, climax.
3. Borchert (1950), in a comprehensive review of the climate of the central North American grassland, concluded that the postulated postglacial fluctuation of the grassland provinces and distribution of the prairies are consistent with present and past climatic changes that are fundamentally related to the general circulation of the earth's atmosphere.
4. Weaver (1954) in his book, *North American Prairie*, reproduced a revised version of Transeau's map of the Prairie Peninsula (p. 176-177) and thereby continued to give the concept visability.
5. Benninghoff (1964), in a review of the concept of the Prairie Peninsula, analyzed pollen diagrams and came to the conclusion that the Prairie Peninsula originated in the late glacial stage before the pine stage of post-Wisconsinan time, and served as a filter barrier to the migration of beech and hemlock from the southeast into western Ohio and northern Indiana.
6. Sears (1967), in a study based on pollen analysis at the Castalia Prairie in northern Ohio, noted that peaks of prairie pollen occurred within the coniferous pollen indicating that representatives of the western grassland community were available before the onset of the xerothermic conditions. He concluded that the development of prairie vegetation in the Prairie Peninsula resulted as an earlier gradual, and orderly migration, rather than as a sudden, catastrophic leap.
7. Wright (1968), in a paper on the history of the Prairie Peninsula, concluded from pollen and seed stratigraphic studies on the northern flank of the Peninsula in Minnesota that the Xerothermic Interval occurred between 8000 to 4000 B.P. during which time the Prairie Peninsula was formed. Geis and Boggess (1968) reviewed and discussed the invasion of the forest elements into the Prairie Peninsula.
8. Hurst (1971), in an analysis of the geographical relationships of the prairie flora at the Castalia Prairie in northern Ohio, showed that 83 of 230 indigenous, terrestrial herbaceous species could be considered as belonging to the prairie flora element. Of these 83 species, only 11 have distributions with their eastern limit

nearly coincident with the concept of the Prairie Peninsula as mapped by Transeau. The remaining species have distribution patterns composed of species whose ranges extend much farther east and southeast, suggesting, as did Gleason, that a major source of the wet prairie flora in glaciated Ohio is of southeastern in origin.

Most of the evidence reviewed so far has been concerned with plants. However, Ruthven (1908), who was associated with Adams in the museum at the University of Michigan, wrote a short paper, *Faunal Affinities of the Prairie Region of Central North America*. He listed three observations: (1) The peculiar environmental conditions of the prairie region had an effect upon the vertebrate fauna. (2) Most of the forms which inhabited the prairie region either extended also into the eastern forest region or into the plains region, or rarely both, few being confined to the prairie region. (3) There is a great difference in the extent to which the forms of eastern North America push westward, or the plains forms push eastward, into the prairie region before becoming modified or checked. He cited examples from among birds, snakes, and other vertebrates. His conclusion (p. 393) was that

> . . . as far as terrestrial vertebrates are concerned, the intermediate character of the environmental conditions makes of the prairie region an extensive area of transition between the plains and eastern forest regions, but that the environmental conditions are not either intensive or extensive enough to mold the forms into a peculiar fauna.

Perhaps his concluding statement stifled research on the topic until 30 years later when Schmidt (1938), three years after Transeau's paper, published his study of the reptiles and amphibians, and showed that the distribution of many of them supported a postglacial eastward extension in North America. Among reptiles, the prairie garter snake or eastern plains garter snake, *Thamnophis radix radix,* which is disjunct from the West eastward to Ohio and confined to the prairie area of Marion and Wyandot Counties, Ohio, has become a classic example of a Prairie Peninsula animal (Conant, Thomas, and Rausch, 1945; Conant, 1975:161, map 118). Moreover, Thomas (1951) has mapped several species of Ohio animals whose distributions show a relationship to the Prairie Peninsula, and Trautman (1957:10-12, 280-282, 455-457, 376) has called attention to certain species of fishes in Ohio that show the Prairie Peninsula distribution. In a comprehensive distributional analysis of eastern North American terrestrial vertebrates (amphibians, reptiles, and small mammals), Smith (1957) noted that the distributional evidence from these animals permitted generalizations remarkably parallel to inferences drawn from other biogeographic data, particularly pollen data, and that this fauna was reoccupying the Prairie Peninsula wherever suitable habitat reappeared. In addition, the dynamic dispersal of eastern species is particularly well-shown by the various stages in the reoccupation of the forested Mississippi River valley and associated bluffs. Twenty years following Transeau's "Prairie Peninsula" paper, a significant amount of faunistic evidence supporting a Prairie Peninsula had been assembled.

Transeau, Gleason, and Braun all lived many years after their original studies of the prairie were published. In these later years they offered a few comments. In describing the Grassland Province of central North America in their book, *The Natural Geography of Plants,* Gleason and Cronquist (1964:345-346) used the terms Prairie Peninsula and precipitation/evaporation ratio as an integral part of the description. Braun (1950:185-191), in her book on the *Deciduous Forests of Eastern North America,* also used the term Prairie Peninsula and discussed the forests of that region, and in her paper on the phytogeography of unglaciated United States, Braun (1955:320-326) continued to advocate that the prairies of unglaciated Ohio were pre-Wisconsinan or earlier in age, citing examples of the distribution of selected species to support her viewpoint. Transeau did not publish any further information, although he did revise his maps of the prairie areas in Ohio and the Prairie Peninsula map itself (Transeau, 1950, 1956a). He also left as a manuscript, *The Vanishing Prairies of Ohio,* which is published in these proceedings (Transeau, 1981:61). In a letter to his student, John N. Wolfe, Transeau (1956b) wrote:

> Several months ago I brought home a copy of the 'Prairie Peninsula' paper and read it over very critically and decided it could be made more convincing if it were brought up to date and referred to more recent literature. Paragraph 9 is the reference to bacterial factor especially the nitrate accumulation. A more important factor the air-mass flow that determines the pattern of the peninsula should be rewritten. Well I went over to my office and I could not find any of the papers bearing on the subject,—so I dropped the task which is so easy to do. Perhaps you might someday rewrite the whole paper and have enough energy to add a pertinent bibliography! I agree that it is worthy of a rewrite, I am not sure of reprint!

In the "shadow of Transeau," it is worthwhile to reflect on the written research of the Prairie Peninsula and to note that research remains to be done on the geographic affinities, age, and habitat requirements of its biota.

ACKNOWLEDGEMENTS

I am indebted to several individuals at The Ohio State University who have provided information for and insight into the development of this paper. Among these were Drs. Gareth E. Gilbert, Charles C. King, Bernard S. Meyer, Emanuel D. Rudolph, Clarence E. Taft, Milton B. Trautman, and Clara G. Weishaupt. Dr. Robert B. Gordon of Honey Brook, Pennsylvania, very willingly shared his memories and memoranda. Drs. Carol and Jerry Baskin, Jane L. Forsyth, James S. Pringle, and Paul B. Sears have read the manuscript and contributed many suggestions. Those who answered my requests for information on Dr. Adams were Harriet Dyer Adams, Albany, New York, and Dr. Richard Brewer, Western Michigan University, Kalamazoo; for information on Dr. Braun was Lucile Durrell, Cincinnati; and for information on Dr. Gleason were Dr. Almut G. Jones, University of Illinois, Urbana, and Charles R. Long, New York Botanical Garden. Thanks is also extended to my students, William R. Carr, Carol J. Decker, and Mark F. Reinking, who also shared in this experience.

LITERATURE CITED

Adams, Charles C. 1902a. Southeastern United States as a center of geographical distribution of flora and fauna. Biol. Bull. 3:115-131.

———— . **1902b.** Postglacial origin and migrations of the life of the northeastern United States. J. Geogr. 1:303-310, 352-357.

———— . **1905.** The postglacial dispersal of the North American biota. Biol. Bull. 9:53-71.

———— . **1909.** An ecological survey of Isle Royale, Lake Superior. Rep. Board Geol. Surv. for 1908. Wynkoop Hallenbeck Crawford Co., Lansing, Mich. xiv + 468 p.

———— . **1911 [1912].** Ecological studies of the prairie and forest in Illinois. Trans. Ill. State Acad. Sci. 4:133.

———— . **1913.** Guide to the study of animal ecology. The Macmillan Co., N.Y., N.Y. 183 p. (Reprinted 1977, Arno Press, N.Y., N.Y.)

———— . **1915.** An ecological study of prairie and forest invertebrates. Bull. Ill. State Lab. Nat. Hist. 11:33-280 + 63 pls.

Adams, Charles C., and George D. Fuller. 1940. Henry Chandler Cowles, physiographic plant ecologist. Ann. Assoc. Amer. Geogr. 30:39-43 + photogr.

Adams, Harriet Dyer, and Thane S. Robinson. 1961. An ecological bibliography of Charles Christopher Adams. Occas. Pap. Adams Center Ecol. Stud. 2:1-6.

Anonymous. 1965. Paul B. Sears, eminent ecologist. Bull. Ecol. Soc. Amer. 46:151-152.

Benninghoff, William S. 1964. The Prairie Peninsula as a filter barrier to postglacial plant migration. Proc. Indiana Acad. Sci. (1963) 72:116-124.

Borchert, John R. 1950. The climate of the central North American grassland. Ann. Assoc. Amer. Geogr. 40:1-39.

Braun, E. Lucy. 1914. The physiographic ecology of the Cincinnati region. Ph.D. Diss., Univ. of Cincinnati, Cincinnati, Ohio. 137 p.

———— . **1916.** The physiographic ecology of the Cincinnati region. Ohio Biol. Surv. Bull. 7:115-211.

———— . **1921.** Composition and source of the flora of the Cincinnati [Ohio] region. Ecology 2:161-180.

———— . **1928a.** Glacial and post-glacial plant migrations indicated by relic[t] colonies of southern Ohio. Ecology 9:284-302.

———— . **1928b.** The vegetation of the Mineral Springs region of Adams County, Ohio. Ohio Biol. Surv. Bull. 15:375-517.

———— . **1934.** A history of Ohio's vegetation. Ohio J. Sci. 34:247-257.

———. **1950.** Deciduous forests of eastern North America. Blakiston, Philadelphia, Pa. xiv + 596 p. + map. (Facsimile Editions 1964, 1967, and 1972, Hafner Publishing Co., N.Y., N.Y.)

———. **1955.** The phytogeography of unglaciated eastern United States and its interpretation. Bot. Rev. 21:297-375.

Brewer, Richard. 1960. A brief history of ecology Part I—Pre-nineteenth century to 1919. Occas. Pap. Adams Center Ecol. Stud. 1:1-18.

Cain, Stanley. 1959. Henry Allan Gleason: Eminent ecologist 1959. Bull. Ecol. Soc. Amer. 50:105-110.

Conant, Roger. 1975. A field guide to the reptiles and amphibians of eastern and central North America. Second edition. Houghton Mifflin Co., Boston, Mass. 429 p.

Conant, Roger, Edward S. Thomas, and Robert L. Rausch. 1945. The plains garter snake, *Thamnophis radix*, in Ohio. Copeia 1945:61-68.

Cowles, Henry C. 1899. The ecological relations of the vegetation of the sand dunes of Lake Michigan. Bot. Gaz. 27:95-117, 167-202, 281-308, 361-391. (Reprinted 1977, American Plant Ecology 1897-1917, Arno Press, N.Y., N.Y.)

———. **1901a.** The physiographic ecology of Chicago and vicinity: A study of the origin, development, and classification of plant societies. Bot. Gaz. 31:73-108, 145-182. (Reprinted 1977, American Plant Ecology 1897-1927, Arno Press, N.Y., N.Y.)

———. **1901b.** Influence of underlying rocks on the character of the vegetation. Bull. Amer. Bur. Geogr. 2:163-176.

———. **1928.** Persistence of prairies. Ecology 9:380-382.

Crowl, Gordon S[herman]. 1937. A vegetation survey of Ross County. M.S. Thesis, The Ohio State Univ., Columbus, Ohio. 176 p.

Dansereau, Piere. 1957. Biogeography: An ecological perspective. The Ronald Press Co., N.Y., N.Y. 394 p.

DeSelm, Henry Rawie. 1953. Variation in *Andropogon gerardi*[*i*] Vitman and *A. scoparius* Mx. in two Ohio prairie areas. Ph.D. Diss., The Ohio State Univ., Columbus, Ohio. 139 p.

Dobbins, Raymond Anson. 1937. Vegetation of the northern "Virginia Military Lands" of Ohio. Ph.D. Diss., The Ohio State Univ., Columbus, Ohio. 161 p.

Egerton, Frank N. 1976. Ecological studies and observations before 1900, p. 311-351. *In* Benjamin J. Taylor and Thurman J. White, eds. Issues and ideas in America. Univ. Okla. Press, Norman, Okla. 380 p. (Reprinted 1977, Arno Press, N.Y., N.Y.)

Forbes, S. A. 1910. Report of committee on an ecological survey. Trans. Ill. State Acad. Sci. 3:51-56.

———. **1911 [1912].** Committee on ecological survey. Trans. Ill. State Acad. Sci. 4:24-26.

———. **1913.** Report of the committee on an ecological survey. Trans. Ill. State Acad. Sci. 6:18-23.

———. **1914.** Report of the committee on an ecological survey of the state. Trans. Ill. State Acad. Sci. 7:12-16.

Geis, J. W., and W. R. Boggess. 1968. The Prairie Peninsula: Its origin and significance in the vegetational history of central Illinois, p. 89-95. *In* Robert E. Bergstrom, ed. The Quaternary of Illinois: A symposium in observance of the centennial of the University of Illinois. Univ. Ill. Coll. Agric. Spec. Publ. 14 Urbana, Ill. 179 p.

Giesy, Robert M. 1964. Homer C. Sampson [1885-1963]. Ohio J. Sci. 64:301.

Gleason, Henry Allan. 1901. The flora of the prairies. B.S. Thesis, Univ. Ill., Urbana, Ill., 79 p.

———. **1904.** The vegetation of the Ozark region in southern Illinois. M.S. Thesis, University Ill., Urbana, Ill. 111 p. + 9 illustr.

———. **1906.** Some phytogeographical features of the prairies. Torreya 6:126-127. Communicated by C. Stuart Gager. (Also Science, 1906, N.S. 23:874.)

———. **1907.** A botanical survey of the Illinois River valley sand region, p. 149-194. *In* Charles A. Hart, and Henry Allan Gleason. On the biology of the sand areas of Illinois. Bull. Ill. State Lab. Nat. Hist. 7:131-272 + pls. 8-22.

———. **1908.** A virgin prairie in Illinois. Trans. Ill. State Acad. Sci. 1:62.

———. **1909a.** Some unsolved problems of the prairies. Bull. Torrey Bot. Club 36:265-271 (Reprinted 1977, American Plant Ecology 1897-1917. Arno Press, N.Y., N.Y.)

———. **1909b.** The vegetational history of a river dune. Trans. Ill. State Acad. Sci. 2:19-26.

———. **1909c.** The ecological relations of the invertebrate fauna of Isle Royale, Michigan, p. 57-78. *In* Charles C. Adams. An ecological survey of Isle Royale, Lake Superior. Rep. Board Geol. Surv. for 1908. Wynkoop Hallenbeck Crawford Co., Lansing, Mich. xiv + 468 p.

———. **1910a.** The vegetational history of a blowout. Trans. Ill. State Acad. Sci. 3:17.

———. **1910b.** The vegetation of the inland sand deposits of Illinois. Bull. Ill. State Lab. Nat. Hist. 9:23-174 + 20 pls.

———. **1912a.** An isolated prairie grove and its phytogeographic significance. Bot. Gaz. 53:38-49.

———. **1912b.** Struggle between forest and prairie. Amer. Bot. (Binghamton) 18:13-14.

———. **1913.** The relation of forest distribution to prairie fires in the Middle West. Torreya 13:173-181.

———. **1917.** A prairie near Ann Arbor, Michigan. Rhodora 19:163-165.

———. **1923.** The vegetational history of the Middle West. Ann. Assoc. Amer. Geogr. 12:39-85. (Also N.Y. Bot. Gard., 1923, Contrib. No. 242.)

———. **1936.** Twenty-five years of ecology, 1910-1935. Brooklyn Bot. Gard. Mem. 4:41-49.

———. **1953.** [Autobiographical letter.] Bull. Ecol. Soc. Amer. 34:40-42.

———. **1965.** Letter to Adolph E. Waller, 26 October, with two chapters from Gleason's diary written before 1939. 16 p. (Xerox copy in the possession of Ronald L. Stuckey.)

Gleason, Henry Allan, and Arthur Cronquist. 1964. The natural geography of plants. Columbia Univ. Press, N.Y., N.Y. 420 p.

Gordon, Robert B. 1928a. The floristic regions of Ohio. M.S. Thesis, The Ohio State Univ. Columbus, Ohio. 41 p.

———. **1928b.** The floristic regions of Ohio. [Abstr.] Ohio J. Sci. 28:146-147. (Also Proc. Ohio Acad. Sci. 8:168-169.)

———. **1931.** The primary forest types of the east central states. Ph.D. Diss., The Ohio State Univ., Columbus, Ohio. 65 p.

———. **1932.** The primary forest types of the east-central states. Abstr. Doctors Diss. No. 8:42-52. The Ohio State Univ. Press, Columbus, Ohio.

———. **1936.** A preliminary vegetation map of Indiana. Amer. Midl. Nat. 17:866-877.

———. **1940.** The primeval forest types of southwestern New York. N.Y. State Mus. Bull. 321. 102 p.

———. **1966.** Natural vegetation of Ohio at the time of the earliest land surveys. [Map.] Ohio Biol. Surv., Columbus, Ohio.

———. **1969.** The natural vegetation of Ohio in pioneer days. Bull. Ohio Biol. Surv. N.S.3(2):1-113.

Gray, Asa. 1878. Forest geography and archeology. Amer. J. Sci. 116:85-94, 183-196. (Reprinted 1899, Scientific Papers of Asa Gray selected by Charles Sprague Sargent, Volume 2. Essays: Biographical Sketches 1841-1886. Houghton, Mifflin and Co., Boston, Mass., and N.Y., N.Y. p. 204-233.) (Reprinted 1978, Essays on North American Plant Geography from the Nineteenth Century selected by Ronald L. Stuckey, Arno Press, N.Y. unnumbered p.)

Hahnert, W. F. 1975. Adolph E. Waller (1892-1975). Ohio J. Sci. 75:214.

Hankinson, T. L. 1915. The vertebrate life of certain prairie and forest regions near Charleston, Illinois. Bull. Ill. State Lab. Nat. Hist. 11:281-303 + pls. 64-79.

Harshberger, John W. 1911. Phytogeographic survey of North America. *In* A. Engler and O. Drude. Die Vegetation der Erde. XIII. Wilhelm Engelmann, Leipzig. lxiii + 790 p. + map + 18 pls. (Reprinted 1958, H. R. Engelmann (J. Cramer), Weinheim/Bergstr.)

Hurst, Stephen Joseph. 1971. Geographical relationships of the prairie flora element and floristic changes from 1890-1970 at the Resthaven Wildlife Area (Castalia Prairie), Erie County, Ohio, with an appended list of vascular plants. M.S. Thesis, The Ohio State Univ., Columbus, Ohio. 177 p.

Jones, Clyde H[arold]. 1936. The vegetation of Meigs County. M.S. Thesis, The Ohio State Univ., Columbus, Ohio. 185 p.

———. **1944.** Studies in Ohio floristics—III. Vegetation of Ohio prairies. Bull. Torrey Bot. Club 71:536-548.

Kirsch, Gladys Virginia. 1930. Rainfall types of the southeastern evergreen forest. M.A. Thesis, The Ohio State Univ., Columbus, Ohio. 76 p.

Leonard, Mary. 1930. Rainfall types in relation to natural vegetation. M.A. Thesis, The Ohio State Univ., Columbus, Ohio. 70 p. + bibliography.

Livingston, Burton Edward. 1906. The relation of desert plants to soil moisture and evaporation. Carnegie Inst. Washington, Washington, D.C. 78 p.

———. **1907.** Evaporation and plant development. Plant World. 10:269-276.

———. **1908a.** Evaporation and plant habitats. Plant World 11:1-9.

———. **1908b.** Evaporation and centers of plant distribution. Plant World 11:106-112.

———. **1910.** Operation of the porous cup atmometer. Plant World 13:111-119.

———. **1911.** A study of the relation between summer evaporation intensity and centers of plant distribution in the United States. Plant World 14:205-222.

———. **1935.** Atmometers of porous porcelain and paper, their use in physiological ecology. Ecology 16:438-472.

———. **1948.** Some conversational autobiographical notes on intellectual experiences and development: An auto-obituary. (Introduction by D.B. Lawrence.) Ecology 29:227-241. (Photograph opposite p. 227.)

Livingston, Burton E., and Forrest Shreve. 1921. The distribution of vegetation in the United States, as related to climatic conditions. Carnegie Inst. Washington, Washington, D.C. No. 284. 590 p.

Maguire, Bassett. 1975. Henry Allan Gleason, January 2, 1882—April 21, 1975. Bull. Torrey Bot. Club 102: 274-282.

Malin, James C. 1947. Grassland, "treeless," and "subhumid": A discussion of some problems of the terminology of geography. Geogr. Rev. 37:241-250.

Marks, Ica. 1929. Rainfall types in relation to vegetation. M.S. Thesis, The Ohio State Univ., Columbus, Ohio. 73 p.

McComb, A. L., and W. E. Loomis. 1944. Subclimax prairie. Bull. Torrey Bot. Club 71:46-76.

McIntosh, Robert P. 1975. H. A. Gleason — "Individualistic Ecologist" 1882-1975: His contributions to ecological theory. Bull. Torrey Bot. Club 102:253-273. (Reprinted 1977, History of American ecology, Arno Press, N.Y., N.Y.)

———. **1976.** Ecology since 1900, p. 353-372. *In* Benjamin J. Taylor, and Thurman J. White, eds. Issues and ideas in America. Univ. Okla. Press, Norman, Okla. 380 p. (Reprinted 1977, Arno Press, N.Y., N.Y.)

McQuate, A. G. 1960. Dr. Edgar Nelson Transeau. Ohio J. Sci. 60:253.

Merriam, C. Hart. 1894. Laws of temperature control of the geographic distribution of terrestrial animals and plants. Natl. Geogr. Mag. 6:229-238 + 3 maps.

———. **1898.** Life zones and crop zones of the United States. U.S. Dept. Agric., Div. Biol. Surv. Bull. No. 10. 79 p.

Meyer, Bernard S. In press. The Transeau regime. *In* Bernard S. Meyer. A history of botany at The Ohio State University: The first 100 years. Ohio Biol. Surv. Bull.

———. **1956.** Awards of certificates of merit at the fifieth anniversary meeting [of the Botanical Society of America]. Amer. J. Bot. 43:859-861. (Also Plant Sci. Bull. 2(4):1-2.)

———. **1958.** Awards of certificates of merit at the fiftieth anniversary meeting, p. 14-19 + photograph. *In* William Campbell Steene, ed. Fifty years of botany: Golden jubilee volume of the Botanical Society of America. McGraw Hill Book Co., N.Y., N.Y. 638 p.

Muller, C. H. 1975. Resolutions of respect: Henry Allan Gleason 1882-1975. Bull. Ecol. Soc. Amer. 56(4):25.

Neiswander, C. R., H. C. Sampson, and E. G. Kelsheimer. 1928. Correlation of borer population with vegetation types, p. 169-171. *In* L. L. Huber, C. R. Neiswander, and R. M. Salter. The European corn borer and its environment. Ohio Agric. Exp. Sta. Bull. 429. 196 p.

Newcombe, F. C. 1904. A natural history survey for Michigan. Annu. Rep. Mich. Acad. Sci. 6:28-36.

———. **1913.** The scope and method of state natural history surveys. Science 37:615-622.

Ogden, J. Gordon, III. 1966. Forest history of Ohio. I. Radiocarbon dates and pollen stratigraphy of Silver Lake, Logan County, Ohio. Ohio J. Sci. 66:387-400 + 3 foldout pls.

Palmer, Ralph S. 1956. Dr. Charles C. Adams. Bull. Ecol. Soc. Amer. 37:103-105.

Pound, Roscoe, and Frederic E. Clements. 1898a. The phytogeography of Nebraska. I. General survey. Jacob North and Co., Lincoln, Neb. 329 p. + 4 maps. (Reprinted 1977, Arno Press, N.Y., N.Y.)

———. **1898b.** The vegetation regions of the prairie province. Bot. Gaz. 25:381-394 + pl. 21.

Ruthven, Alexander G. 1908. The faunal affinities of the prairie region of central North America. Amer. Nat. 42:388-393.

Sampson, Homer C. 1916. An ecological survey of the vegetation of the Illinois prairies—a preliminary report. Trans. Ill. State Acad. Sci. 9:123-125.

———. **1921.** An ecological survey of the prairie vegetation of Illinois. Bull. Ill. State Lab. Nat. Hist. Surv. 13:519-577 + 48-77.

———. **1927.** The primary plant associations of Ohio:Their distribution and their significance as habitat indices. Ohio J. Sci. 27:301-309.

———. **1930a.** Succession in the swamp forest formation in northern Ohio. Ohio J. Sci. 30:340-357.

———. **1930b.** The mixed mesophytic forest community of northeastern Ohio. Ohio J. Sci. 30:358-367.

———. **1930c.** Vegetation types and soil types in Marion County, Ohio. [Abstr.] Ann. Assoc. Amer. Geogr. 20:40-41.

———. **1930d.** Advantages and limitations in the use of the distribution of soil types as a basis of mapping the distribution of vegetation types. [Abstr.] Proc. Ohio Acad. Sci. 8:390-391.

Schaffner, John H. 1899. The spreading of buffalo grass. Bot. Gaz. 27:393-394.

———. **1913.** Characteristic plants of a typical [Kansas] prairie. Ohio Nat. 13:65-69.

———. **1926.** Observations on the grasslands of the central United States. Ohio State Univ. Stud. Contrib. Bot. No. 178. 56 p.

Schmidt, Karl P. 1938. Herpetological evidence for the postglacial eastward extension of the steppe in North America. Ecology 19:396-407.

Sears, Paul B. 1921. Vegetation mapping. Science N.S. 53:325-327.

———. **1925.** The natural vegetation of Ohio. I. A map of the virgin forest. Ohio J. Sci. 25:139-149.

———. **1926a.** The natural vegetation of Ohio. II. The prairies. Ohio J. Sci. 26:128-146.

———. **1926b.** The natural vegetation of Ohio. III. Plant succession. Ohio J. Sci. 26:213-231.

———. **1942.** Xerothermic theory. Bot. Rev. 8:708-736.

———. **1956.** Some notes on the ecology of ecologists. Sci. Monthly 83:22-27.

———. **1960.** Resolution of respect: Edgar Nelson Transeau 1875-1960. Bull. Ecol. Soc. Amer. 41:62-64.

———. **1967.** The Castalia Prairie. Ohio J. Sci. 67:78-88.

———. **1971.** Toward design for the future. Bull. Ecol. Soc. Amer. 52(3):5-7.

Shanks, Royal Eastman. 1938. The original vegetation of a part of the Lake Plain of northwestern Ohio: Wood and Henry Counties. Ph.D. Diss., The Ohio State Univ., Columbus, Ohio. 124 p.

Sheets, Vernon T. 1922. An ecological survey of Delaware County, Ohio. M.A. Thesis, The Ohio State Univ., Columbus, Ohio. [44 p.]

Shupe, Lloyd Merle. 1930. The original vegetation of Pickaway County, Ohio. M.S. Thesis, The Ohio State Univ., Columbus, Ohio. 69 p.

Sinnott, Edmund W. 1955. Paul B. Sears. Science 121:227.

Smith, Philip W. 1957. An analysis of post-Wisconsin biogeography of the Prairie Peninsula region based on distributional phenomena among terrestrial vertebrate populations. Ecology 38:205-218.

Spalding, V.M. 1898. A natural history survey of Michigan. Science 7:577-585.

Stuckey, Ronald L. 1973. E. Lucy Braun (1889-1971), outstanding botanist and conservationist: A biographic sketch, with bibliography. Mich. Bot. 12:83-106.

———. **1981.** Contributors to the development of the Prairie Peninsula concept, p. 24. *In* Ronald L. Stuckey and Karen J. Reese, eds.

Stuckey, Ronald L., and Karen J. Reese, eds. 1981. The Prairie Peninsula — in the "shadow" of Transeau: Proceedings of the Sixth North American Prairie Conference, The Ohio State University, Columbus, Ohio, 12-17 August 1978. Ohio Biol. Surv. Biol. Notes. No. 15. 278 p.

Taft, Clarence E. 1973. Seventy years of phycology at The Ohio State University. Ohio J. Sci. 73:103-110.

Thomas, Edward S. 1951. Distribution of Ohio animals. Ohio J. Sci. 51:153-167.

Thompson, Isabel. 1939. Geographical affinities of the flora of Ohio. Amer. Midl. Nat. 21:730-751.

Transeau, Edgar N. Undated. [Autobiographical data]. Typewritten manu. 6 p. (Xerox copy in possession of Ronald L. Stuckey.)

———. **1903.** On the geographic distribution and ecological relations of the bog plant societies of northern North America. Bot. Gaz. 36:401-420.

———. **1905a.** Climatic centers and centers of plant distribution. Annu. Rep. Mich. Acad. Sci. 7:73-75.

———. **1905b.** Forest centers of eastern North America. Amer. Nat. 39:875-889.

———. **1905-1906.** The bogs and bog flora of the Huron River valley [Michigan]. Bot. Gaz. 40: 351-375, 418-448; 41:17-42.

———. **1908a.** A state ecological survey. Trans. Ill. State Acad. Sci. 1:61-62.

———. **1908b.** The relation of plant societies to evaporation. Bot. Gaz. 45:217-231.

———. **1910.** A simple vaporimeter. Bot. Gaz. 49:459-460.

———. **1911a.** Apparatus for the study of comparative transpiration. Bot. Gaz. 51:54-60.

———. **1911b.** [Letter to Charles C. Adams, 27 March 1911.] 3 p. Original copy in the Arch. and Regional Hist. Collections, Western Mich. Univ., Kalamazoo, Mich.

———. **1913a.** Annotated list of the algae of eastern Illinois. Trans. Ill. State Acad. Sci. 6:69-89.

———. **1913b.** The life history of *Gloeotaenium*. Bot. Gaz. 55:66-73 + pl. 3.

———. **1913c.** The periodicity of algae in Illinois. Trans. Amer. Micros. Soc. 32:31-40.

———. **1916.** The periodicity of freshwater algae. Amer. J. Bot. 3:121-133.

———. **1923.** General botany. World Book Co., Yonkers-on-Hudson, N.Y., N.Y. x + 560 p. (Reprinted annually, 1924-1937.)

———. **1926.** The corn borer and ecological habitats. A progress report of the present status of the European corn borer investigations and control in Ohio, September 23, 1926. Ohio Agric. Exp. Sta. Spec. Bull. p. 28-29.

———. **1927.** Vegetation types and insect devastations: Distribution of the Mexican bean beetle and European corn borer in Ohio. Ecology 8:285-288.

———. **1928.** Prairies may stop borer. Sci. News-Letter 13:75-76.

———. **1930a.** Precipitation types of the prairie and forested regions of the central states. [Abstr.] Ann. Assoc. Amer. Geogr. 20:44-45.

———. **1930b.** Progress in the survey of the vegetation types of the north central states. [Abstr.] Ann. Assoc. Amer. Geogr. 20:45.

———. **1930c.** The vegetation of the north central states. [Abstr.] Proc. Ohio Acad. Sci. 8:388-389.

———. **1932.** The Prairie Peninsula. [Abstr.] Ohio J. Sci. 32:349.

———. **1935.** The Prairie Peninsula. Ecology 16:423-437.

———. **1941.** Prehistoric factors in the development of the vegetation of Ohio. Ohio J. Sci. 41:207-211.

———. **1950.** Ohio vegetation: Prairies. Unpublished black and white line drawn map, 8½ x 11 inches. 1 p.

———. **1953.** [Letter to Mr. B. C. Patton, Rutgers University, 20 March 1953, with biographical notes with dates, miscellanea, and publications.] 6 p. (Xerox copy in possession of Ronald L. Stuckey.)

———. **1956a.** Prairie Peninsula. Revised unpublished black and white line drawn map. 11 x 15 inches. 1 p. (Reproduced in Weaver, 1954:176-177.)

———. **1956b.** [Letter to John N. Wolfe, 21 August 1956.] 1 p. (Original copy in the library of Joseph D. Laufersweiler, Univ. Dayton, Dayton, Ohio.)

———. **1981.** The vanishing prairies of Ohio, p. 61. *In* Ronald L. Stuckey and Karen J. Reese, eds.

Transeau, Edgar N., and Homer C. Sampson. 1935. Primary vegetation areas in Ohio, Part II, p. 10-11. *In* J.H. Sitterley, R.H. Baker, and J.I. Falconer. Major land-use problem areas and land utilization in Ohio. Dept. Rural Econ., The Ohio State Univ. and Ohio Agric. Exp. Sta. Mimeo. Bull. No. 79. Part I, 26 p.; Part II, 71 p.

Transeau, Edgar N., and P.E. Williams. 1929. Distribution maps of certain plants in Ohio. Ohio Biol. Surv. Bull. 20:179-217.

Trautman, Milton B. 1957. The fishes of Ohio. Ohio State Univ. Press, Columbus, Ohio. 683 p.

Waller, Adolph E. 1918a. The relation of plant succession to crop production. A contribution to crop ecology. Ph.D. Diss., The Ohio State Univ., Columbus, Ohio. 81 p.

———. **1918b.** Crop centers of the United States. J. Amer. Soc. Agron. 10:49-83.

———. **1921.** The relation of plant succession to crops production: A contribution to crop ecology. Ohio State Univ. Bull. 25(9): 1-74. (Bot. Contrib. No. 117.)

———. **1925.** Crop ecology and the primary vegetational survey. Ohio J. Sci. 25:1-10.

———. **1941.** Professor John Henry Schaffner (1866-1939). Ohio J. Sci. 41:253-286 + photogr.

Weaver, J. E. 1954. North American prairie. Johnsen Publishing Co., Lincoln, Nebr. 348 p.

Weaver, J. E., and T. J. Fitzpatrick. 1934. The prairie. Ecol. Monogr. 4:109-295.

Williams, Pearle E. 1926. The distribution of species in Ohio. M.A. Thesis, The Ohio State Univ., Columbus, Ohio. [43 p.]

Woodward, John. 1924. Origin of prairies in Illinois. Bot. Gaz. 77:241-261.

Wright, H. E., Jr. 1968. History of the Prairie Peninsula, p. 78-88. *In* Robert E. Bergstrom, ed. The Quaternary of Illinois: A symposium in observance of the centennial of the University of Illinois. Univ. Ill., Coll. Agric. Spec. Publ. 14. Urbana, Ill. 179 p.