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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

Edited By

RONALD L. STUCKEY

and

KAREN J. REESE

OHIO BIOLOGICAL SURVEY
BIOLOGICAL NOTES NO. 15

OHIO BIOLOGICAL SURVEY

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PREFACE

Interest in and concern for the prairies of Ohio date back nearly two centuries when the pioneer European settlers first saw the natural, tallgrass, open meadows within the dense, dark deciduous forest, as they crossed the Appalachian Mountains during their movement westward. Since the responsibility for the Sixth North American Prairie Conference and the subsequent publication of the Proceedings was with the Ohio Biological Survey, a certain flavor of interest in prairies of this state has been developed in this publication and can be seen throughout in the form of maps, pictures, and guides to Ohio prairie place names and the literature of Ohio prairies. This publication contains the manuscripts which were submitted by those individuals who presented papers during the Conference held in Columbus, Ohio, 12-17 August 1978. Of the ten invited symposium papers and the eighty contributed papers presented at the meeting, all of the symposium and forty-eight of the contributed papers are printed here. Abstracts are reprinted here for those papers not submitted.

In 1818, Caleb Atwater, regarded as Ohio's first historian, wrote in *Silliman's Journal* what is considered to be the first scientific paper on the origin of these prairies.[1] They were the prairies at the eastern end of the once great extensive grassland of the midportion of the North American continent, which region we now call the Prairie Peninsula. Atwater of Circleville, Ohio, recognized both wet and dry prairies with both occurring on alluvium and argued that their origin was from water having once covered the landscape. In the same journal the following year, Atwater's theory of the origin of the prairies was challenged by R. W. Wells of St. Louis, who, looking at the prairies farther west, argued for their origin by fires set by the Indians. Alexander Bourne, of Chillicothe, Ohio, immediately followed in this journal that same year with a middle position suggesting that the wet prairies, showing similarities to the fresh meadows on the East Coast, had their origin by water, whereas, the dry prairies or barrens, having remnants of partially burned trees, were created by reoccurring fires set by the Indians. The controversy did not subside nor end, and the scientific literature of the middle and latter half of the nineteenth century is heavily sprinkled with papers arguing for an origin of prairie by water, fire, wind, humidity, topography, temperature, and variable soil moisture conditions, among others. The principal, well-known authors were Leo Lesquereux, Alexander Winchell, James D. Dana, and John Strong Newberry. Many of their papers were published in *Silliman's Journal* which by the 1860's was better known as the *American Journal of Science and Arts*. In 1911, the observations of these and other writers were eloquently summarized along with a chronological bibliography in a classic study, *The Prairies,* by Bohumil Shimek of Iowa.

In the twentieth century, the study of the relationships of organisms to their environment, known as ecology, became more formalized and sophisticated. The biota of the prairie and those environmental factors affecting it were studied in considerable detail as an effort toward an understanding of the origin, development, and maintenance of the prairie grasslands. Henry C. Cowles, Charles C. Adams, Henry A. Gleason, Paul B. Sears, and Edgar N. Transeau were among the pioneer ecologists using these new approaches to organize information about the prairie. Subsequently, John E. Weaver of the University of Nebraska, who with his students, became the foremost authority on the prairie grasslands in the first half of the twentieth century. In Ohio, E. N. Transeau, both then and now, stands tall among the promoters of ecological studies, particularly those dealing with the prairie. He is best remembered for his classic paper, *The Prairie Peninsula,* published in Ecology in 1935. The "shadow" of Transeau extends into the future. The arrangements committee of this Prairie Conference then wisely chose as its theme, "The Prairie Peninsula—in the 'shadow' of Transeau," to provide an opportunity for reviewing and offering a tribute to Transeau's contributions, and also to make the results of this meeting a lasting reminder for present and future individuals who have an interest in all aspects of the prairie.

When our local committee for the arrangements of this meeting, in particular, Dr. Charles C. King, Ralph E. Ramey, and K. Roger Troutman, asked me to discuss the contributions of Dr. Transeau in a special symposium, "The Prairie Peninsula—in the 'shadow' of Transeau," for the Conference and to edit the Proceedings following the meeting, I was overwhelmed at this assignment and somewhat reluctant to become involved in a topic about which I knew so little. Aside from a common interest in the prairies of Ohio, about all I thought I had in common with Dr. Transeau was that we took our doctoral degrees from the University of Michigan, although 60 years apart. Now I am a professor at the same institution where Dr. Transeau taught for 30 years (1915-1946), and where he chaired the Department of Botany and Plant Pathology for 28 of those years. It was not my privilege to meet this highly respected, versatile botanical leader, for he passed away in 1960 during the first year I was in graduate school. However, in the "shadow of Transeau," I have had some wonderful experiences over the past two years researching and writing my article for the symposium, and editing these Proceedings. I have read many of Transeau's botanical papers and talked with individuals who knew him as an advisor, teacher, scholar, colleague, and/or friend. Various individuals, too numerous to mention here, have provided me with notes, pictures, maps, letters, and papers that belonged to Transeau or were about him and his work. Some of these were displayed at the meeting and selections from this display are included in the *Contributors to the Development of the Prairie Peninsula Concept* (p. 24), while other items are placed elsewhere throughout this book. To these contributors I give a hearty thanks for without these items, my symposium paper and my interest in editing these Proceedings could not have been sustained throughout.

Today, in some respects the concern for the prairie has changed little from the days of Atwater and his colleagues who argued about its origin. Those basic biotic and ecological studies of the prairie are still being discussed and the same questions are still being asked. We approach them with more knowledge and background as our thinking is revised. In recent years, however, we have come to consider more practical questions, such as how to secure, save, manage, preserve, and create prairies. To assist us in these endeavors, we need and use the ideas of our forebearers; so, what we have learned in the past about changing water levels and in the role of fire in the prairie is of utmost importance to the present in our efforts toward saving, managing, and creating prairies. The North American Prairie Conference is the meeting that brings individuals with all points of view together; the published Proceedings include the classic, as well as contemporary, approaches to the study of the prairie.

October 1979

Ronald L. Stuckey
Senior Editor of the Proceedings

[1] References referred to in this preface are included in the *Guide to the Literature of Ohio Prairies: A Selected Bibliography* (p. 72).

EDGAR NELSON TRANSEAU

Dedicated to the memory of Edgar Nelson Transeau (21 October 1875—25 January 1960) whose lifetime study, among other pursuits, was devoted to the climatic understanding of the North American prairie thus enabling us to have a better understanding of this diverse vegetational type.

CONTENTS

SUPPLEMENTAL FIGURES

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PART I. INVITED PAPERS

REFLECTIONS ON TRANSEAU THE MAN

Edward S. Thomas
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Edgar N. Transeau was the patron saint of ecology and prairie philosophy in Ohio. Of course, other earlier botanists in Ohio were excellent ecologists, for example, John H. Schaffner, who was curator of the state herbarium and promoted the idea of orthogenesis. He also was acquainted with the fact that prairies existed in Ohio. Transeau had a short, closely clipped mustache, and was rather slender in his younger years. He was an impressive looking person. He was admired and respected, especially by his co-workers.

You may wonder how he derived the material for some of the maps of the Ohio prairies which he constructed. He and Homer C. Sampson used to drive mile after mile, day after day, week after week, over the miserable back roads that existed then. On our field trip yesterday, as we drove over some of the smooth blacktopped roads in the prairie at Killdeer Plains, I reflected that the roads then were very different. I would like to have a dollar for every time that I have been stuck in the mud on those prairie gumbo roads. Transeau obtained data from the field by taking along topographic maps and marking the botanical and geologic features on them. I was very much impressed by his technique. I followed his methods and was able to provide him with some information. I would travel nearly 15,000 miles a year throughout Ohio with a topographic map at hand, while my good friend, the late Charles F. Walker of The University of Michigan, or my brother, John S. Thomas, would drive. I have maps showing prairie remnants stretching for miles along roads in Madison County where I defy you to find a single prairie plant today. The Amish have moved in and, indeed, they are clean farmers. They do not tolerate any "weeds," native or European.

I had the privilege of being in the field with Transeau on a few occasions and I remember very vividly one trip we took into the Madison County prairies. I invited along my good friend, Dr. Clarence H. Kennedy of the Department of Zoology and Entomology, who was a great entomologist and scientist, although a little tempermental. Dr. Kennedy had never had the opportunity to visit the prairies in Ohio. I told him I was sure that he would collect some fine prairie insects. At that time, he was specializing in ants. His technique was to take a trowel and dig out the ant hills down to the bottom until he got the queen. As the day progressed, Dr. Kennedy did not appear to be having any success. So I took him to one side and said, "What's the matter, Dr. Kennedy. Aren't you finding anything?" He replied, "No, I should have known better than to go on a field trip with some blankety-blank botanists." A few minutes later, I pointed out a large ant hill along the road. He got out and started digging, and we moved on to other places. We came back later in the day and he was still digging ants. He had discovered a new Ohio ant species, *Formica cinerea* Mayr var. *neocinerea* Wheeler, which was later found to be common throughout prairies (Amstutz, 1940:18-19).

One of the fine attributes of Transeau was his associates. He had the ability to assemble excellent scientists. One of the first was Paul B. Sears, who was with the Department of Botany only too briefly. John H. Schaffner, who was in the department before Transeau came, was really a great botanist. Homer C. Sampson, director of the general botany program, was the individual who would "clamp down" on those poor freshmen who used teleological or anthropomorphic phrases. He just would not tolerate it; however, he was a very good botanist and instructor. Lewis H. Tiffany, who was also in the department briefly before he went to Northwestern University, collaborated with Transeau and Sampson in writing a superb general botany textbook (Transeau, Sampson, and Tiffany, 1940). Wilmer G. Stover was a very fine specialist in gilled fungi.

A great scholar attracts exceptional students and this list contains some of the fine botanists of this century. Wendell H. Camp was an excellent taxonomist and field man who died too soon. Robert B. Gordon (1966, 1969) published the map of the natural vegetation of Ohio. Richard H. Bohning was formerly the Dean of the College of Biological Sciences. Bernard S. Meyer succeeded Transeau as chairman of the Department of Botany. Clarence E. Taft became an authority on algae. This list contains many others including Lois Lampe Zimmerman, Adolph E. Waller, Clyde Allison, Glen W. Blaydes, Lawrence E. Hicks, Clara G. Weishaupt, Richard A. Popham, Carroll A. Swanson, and John N. Wolfe. Of course, I idolized John Wolfe, with whom I was associated for many hours in the field. Wolfe along with Richard T. Wareham and Herbert T. Scofield (1949) published a monumental study of the microclimates and macroclimate of Neotoma, a small valley in Hocking County, Ohio, which I owned at that time. One of the great experiences of my life was the privilege of going to Point Hope, Alaska, with Wolfe. Fred Norris, Gareth E. Gilbert, Floyd Chapman, Hal DeSelm, Clyde Jones, Gordon Crowl, Janice C. Beatley, Royal Shanks, Jack Sharp, and Robert Sigafoos are some of the other students who were part of the department during the latter years of the Transeau era.

I have often made the statement that when Transeau was chairman of the department, it was the greatest department on The Ohio State University campus. After forty-five years, I still hold that opinion.

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PENINSULA OR ARCHIPELAGO?

Paul B. Sears
Las Milpas
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We are meeting "in the shadow" of not one, but two notable students of prairie plant life, Edgar Nelson Transeau and John Henry Schaffner. The latter had long been at The Ohio State University in 1915 when Transeau joined the Department of Botany as a professor and I began my professional career as an instructor in the same department. I have known most of the active American botanists during the first half of this century. I would rank Schaffner and Transeau among the best of them.

Although they were very different in personality, they shared exceptional intelligence and mutual respect. Schaffner once told me that he had surprised his colleagues by inviting Transeau, a strong individual, into the department. Transeau in turn had a genuine appreciation of Schaffner.

Schaffner had grown up on the prairies of Kansas, where he imbibed from its rich flora the basis for his profound knowledge of the plant kingdom. Modest and learned, he was endlessly patient and generous, informally tutoring me in taxonomy, cytology, and genetics. Independently, he and Charles E. Bessey had developed the currently accepted rationale of vascular plant phylogeny. Previously, the complex inflorescence of the catkin, rather than the spiral flower of the Magnoliaceae, had been thought to be primitive, derived from the cone or strobilus. This belief was held at Chicago, Harvard, and the German School of Engler. Bessey's ideas were presented at a meeting of the Missouri Botanical Garden in 1914 and later published (Bessey, 1915). Schaffner's ideas on the classification of plants and principles of taxonomy are published in 22 papers in the *Ohio Naturalist* and the *Ohio Journal of Science* from 1905 to 1931 and later summarized (Schaffner, 1934).

As a graduate student interested in ecology, Transeau had serenely weathered professorial skepticism. Later, with characteristic humor, he maintained a running dispute, which can be illustrated by an incident involving Professor Bessey. Passing Bessey's office one day, I was invited to share a letter he had received from an eastern colleague. It complained that the "center of botanical influence had shifted to the barbarian schools of the mid-West." The writer felt that Bessey, a student of Asa Gray, should regret this deplorable event. Transeau loved to ridicule this kind of statement.

While we meet here in Columbus, the First International Rangeland Congress is taking place in Denver. Some comment is justified on the importance of grasslands, both subhumid and semiarid, which are giving way to the production of crops by a mechanized agriculture dependent on fossil fuel and products of the petrochemical industry. Besides threatening its own source of energy, this relationship has created grave hazards in the pattern of the plant and animal industry. Farms have become fewer and larger. Their operators, once half of our population, are now about a tenth, not far above the number of unemployed and fewer than the number on public subsidy.

Livestock is increasingly being produced on the range in competition with speculative dry farming and irrigation agriculture drawing upon limited ground water. Often this water is also in demand for urban and industrial use. Animals are brought from the range to be fattened in huge feedlots on grain and forage. Their feed is grown on rich black prairie soil whose farms rarely have livestock. The historically stable agrarian pattern of plants, animals, and farm families on the same land appears to be declining.

In this integrated pattern, animal wastes were returned directly to crop land. Now they accumulate at feed lots where they are economically difficult to return to the soil on which the feed is grown. Such wastes are the source of organic colloids essential to soil structure and plant nutrition. Glue-like, they hold mineral particles in crumbs that permit the movement of air and water. In addition soil colloids adsorb and hold plant nutrients which otherwise would leach away. Then, by the process of base exchange, these nutrients are supplied as needed by plant roots. In places, notably East Anglia (modern Norfolk and Suffolk in England), the loss of this crumb structure in the soil has already led to a drop in production, due to mechanized agriculture without livestock.

Crops produced by the tillage of subhumid grasslands are a major source of the world's breadstuffs, but here the loss of soil by wind and water erosion continues. Rivers that drain prairie farms run turbid after heavy rains, while some, like the Cannon River in Minnesota, may be inky black during spring freshets. Farther west, dust storms have recurred both in the 1950's and in this decade.

Grasslands are vital to long-run human welfare in other ways. Unplowed reserves, even those used for grazing if skillfully managed, form soil while reducing run-off and erosion. Thus, fertility is preserved, production of organic matter maintained, and loss of soil prevented. Aesthetically, the living prairie is a rare combination of beauty with utility, as anyone watching the waving sea of changing colors on the Kansas Flint Hills can testify.

Nevertheless, we continue to sacrifice productive land, either under tillage or in its natural state, to urban and industrial demands. Concurrently, we are pouring into crop land quantities of energy that approach or even exceed the amount recovered in yield. Such policies contain the seeds of their own destruction and of the decimation of the native prairies, one of our precious heritages.

To a lad growing up in northern Ohio, with its woodlots, rail fences, and plenty of clear white pine shipping-boxes, three regions appealed to me in my reading: oceans, mountains, and treeless prairies. Curiosity about the prairie was piqued by my father's stories; he was born in 1860. As a youthful guest of cousins in Nebraska, he took a long covered-wagon trip across the unfenced tallgrass country. Tales of buffalo bones and hides, prairie dogs, and the tiny owls that shared their burrows with less welcome guests, the rattlesnakes, were told. A marksman, he told about shooting long-eared jack rabbits, sighting his rifle between the even larger ears of the mules drawing the wagon.

As my interest in plant life increased, I noticed that the roadside plants south of Bucyrus, Ohio, were very different from those growing north of the Sandusky River. Reading that Colonel William Crawford's troops had been ambushed by Indians hiding in the grass, I learned that the rich farms between Bucyrus and Marion 18 miles (28.8 km) to the southwest had been tallgrass prairie, except for the oak and hickory groves on the knolls. Further, I learned that this prairie had extended northwest from Marion toward Upper Sandusky and had been settled by relatives and friends.

Two years of graduate work that began in 1913 at the University of Nebraska gave me the opportunity to see considerable grassland and, thanks to cytological study, to become interested in pollen. Then, as an instructor at The Ohio State University, I was able to begin a study of the native vegetation of Ohio and to continue with cytological work that was later accepted as a doctoral thesis at Chicago (Sears, 1922 a,b).

In the twenties, there were various theories as to the cause of continental grasslands: fire, soil texture, wind, scant rainfall, and grazing by bison being the most frequently discussed. Henry Allen Gleason (1923), viewing colonies of southwestern plants in Illinois, suggested that prairies farther east might be relicts of a period of postglacial climate warmer and drier than the present. The idea was intriguing; the problem was to test it.

The opportunity came in 1925 or later when the late Professor Charles Olmsted, then an undergraduate at Nebraska, spent a few weeks at the Iowa Lake Laboratory at Okoboji with me. In addition to Dr. Bohumil Shimek's collections and notes, the library there had files of foreign journals. Among them was a review of the work of the Swedish scientist Von Post (1916) who had used pollen preserved in peat and other sediments as an indicator of former vegetation and climate. We began to look for pollen, and we found it in the mud of Lake Okoboji. A quest began; perhaps Gleason's idea could be tested. The first step was to learn to identify the kinds of pollen and the second was to convince granting agencies about the merit of this research.

Bogs and lake sediments of the north-central states proved to hold plenty of preserved pollen. A period of trial and error ensued that included mistaking the pollen of *Picea glauca* (*P. canadensis*), which I had never seen, for that of *Abies*. We found this sequence of vegetation from the pollen record: spruce, pine, hardwoods and hemlock, oak and hickory, and more recent forest types, including beech. From this evidence we inferred that there had been two relatively dry intervals, the pine and the oak—hickory. After becoming familiar with the European literature, I realized that this sequence fitted that of the European palynologists: subarctic, boreal, atlantic, subboreal, and subatlantic (Sears, 1948).

Gleason was glad for the confirmation of his floristic evidence of post-Wisconsinan conditions favorable to the extension of southwestern species, but he had not realized that there might have been two such intervals: the pine (boreal) and the warmer oak—hickory (subboreal). Since grassland flourishes from Texas to southern Alberta, it is obviously less dependent on temperature than on the rainfall-evaporation ratio.

As skill in identifying nontree pollen has increased, it has become clear that the eastward extension of prairie plants has not been a sudden cataclysmic invasion during the oak—hickory (subboreal) stage that Deevey and Flint (1957) called the altithermal rather than the xerothermic. Rather, as pollen profiles from both the Castalia Prairie (Resthaven Wildlife Area, Erie County, northern Ohio) and the Bucyrus Bog (Crawford County, Ohio) show, there has been, from the beginning of the post-Wisconsinan record, a strong representation of plants more characteristic of grassland than of forest (Sears, 1930, 1967). These are the grasses, composites, and chenoams (chenopods and amaranths).

In 1956 we had the privilege of an extended visit (sponsored by Yale University and the Rockefeller Foundation) with the late Dr. Johannes Iversen, the distinguished Danish ecologist and my revered friend. Iversen checked the "other pollen" category (largely herbaceous) in my 1930 analysis of Bucyrus bog and found it to consist mainly of sedges, grasses, composites, and chenoams. Present from the beginning of sedimentation, these showed maxima at 107 inches (2.68 m) and 10-12 inches (25-30 cm), corresponding to spruce—pine and oak—hickory maxima, respectively. Because of drainage, fire, and other disturbances, I am unable to infer more, but this evidence confirms that grassland groups were present from the beginning, increasing and decreasing with environmental changes which were probably climatic and persisting in a variety of edaphically favorable sites as Transeau (1935) and later workers have also noted.

There can be no doubt, in view of Transeau's evidence, that a distinctive climatic extension or peninsula extends eastward from the prairie province between the northern and southern zones that are more favorable to forest communities. Within this climatic peninsula, prairies and related successional communities are essentially islands. These islands can therefore be likened to an edaphic archipelago within a climatic sea. Furthermore, they represent not catastrophic invasion, but a continuum that began with deglaciation and persisited until land use and management practices of European settlement obliterated them.

Thus, a phenomenon prevails throughout the grassland province which is exemplified in reverse farther west. The extensive Cross-Timbers of oak and associated species extending south through eastern Kansas and Oklahoma and into Texas are wooded islands within a sea of subhumid prairie. Farther west are islands, an archipelago, of tallgrass prairie within a sea of short grasses, as are the shinneries of dwarf oaks in western Oklahoma. Such "outliers" have persisted because sandy soils yield their water more generously during dry seasons than do the finer soils around them. Clearly, the vegetation found by the white man in midcontinental America showed superbly that the impact of climate is either damped or amplified by the variety of local conditions.

Transeau, the eminent ecologist, would, I am sure, agree with this simple conclusion. He brought to this university the unique blend of devotion to truth, common sense, and respect for teaching that had characterized the normal schools. His accomplishments were never better expressed than by the late William Crocker, distinguished plant physiologist and first director of the Boyce Thompson Institute for Plant Research. When I remarked to Crocker that Transeau had developed at The Ohio State University one of the best botany departments in the nation, he asked, "Why do you say *one* of the best?"

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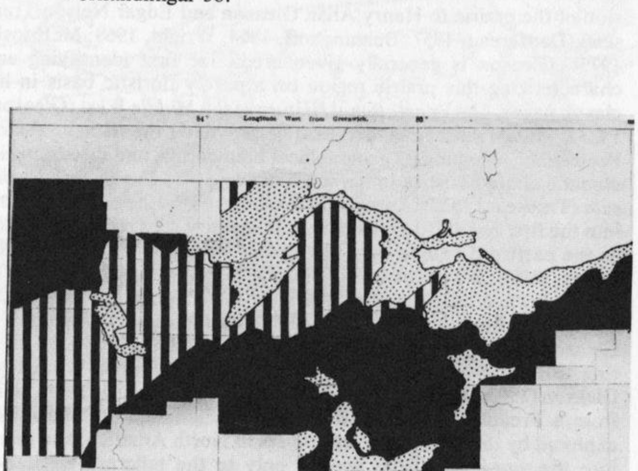

Sears' Map of Original Vegetation of Western Lake Erie Basin in Northwestern Ohio

Believed to be one of Sears' early attempts at mapping original vegetation in Ohio, prepared in 1922, the map is apparently the one cited as having been presented at the annual meeting of the Ohio Academy of Science. (Proc. Ohio Acad. Sci. 7:250. 1923.) Black = beech forests, stippled = prairies and marshlands, stripped = swamp forests. (From a glass lantern slide, collection of E.N. Transeau currently in the possession of R.L. Stuckey).

ORIGIN AND DEVELOPMENT OF THE CONCEPT OF THE PRAIRIE PENINSULA

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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

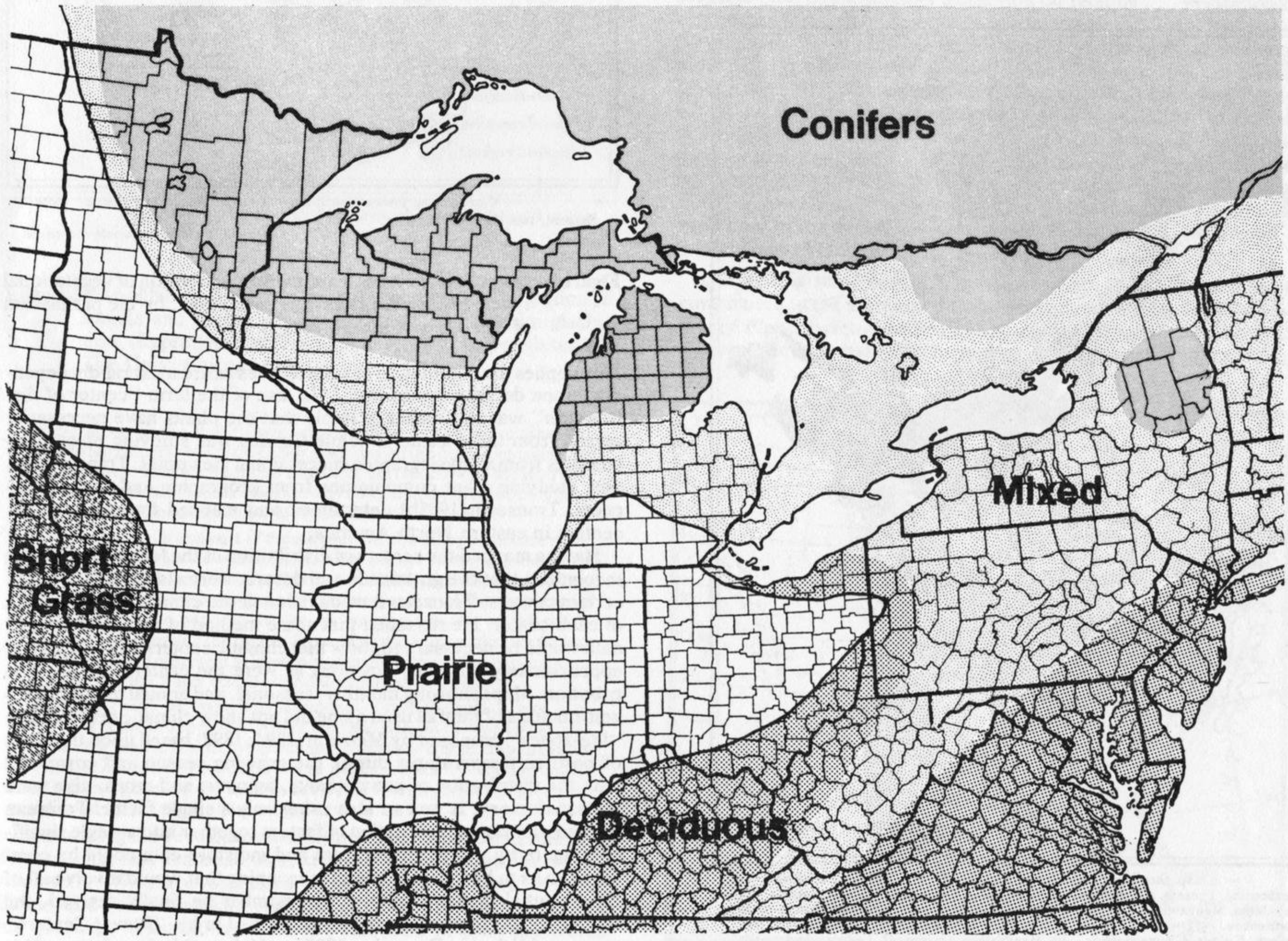


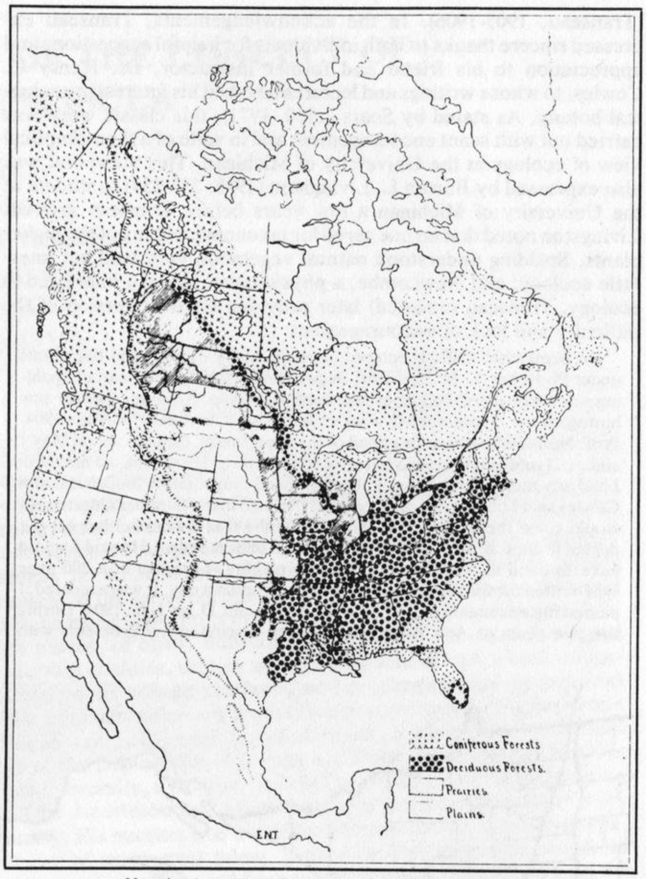
Figure 1. Map of north-central United States showing peninsula-like projection of prairie vegetation between the shortgrass region and the forested areas at the time of the "Xerothermic Period" as viewed by Transeau. (From an original unpublished map prepared by E.N. Transeau and redrawn for this publication 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.)

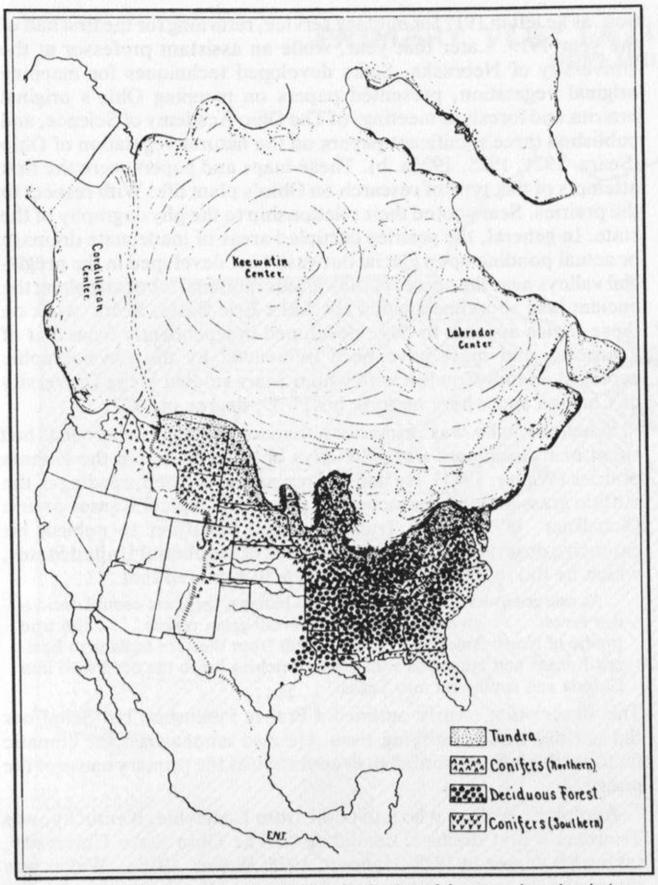


Map showing present distribution of forest, prairie and plains. (After Sargent, 10th Census, Vol. 9.)

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

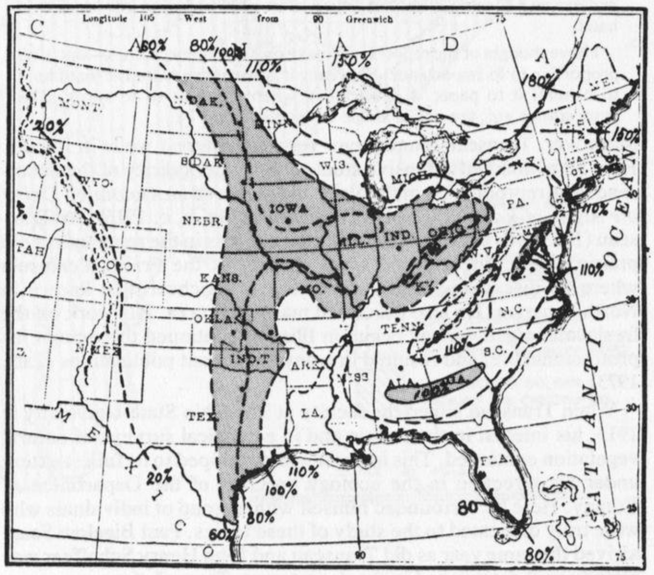


Figure 5. Map of eastern United States showing the ratio of rainfall to evaporation in percentages in different regions; prairie region is the 60 percent to 100 percent ratio. (From Transeau, 1905a, permission granted by Enoch Brater, ed., Mich. Acad. Arts, Sci., and Letters.)

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

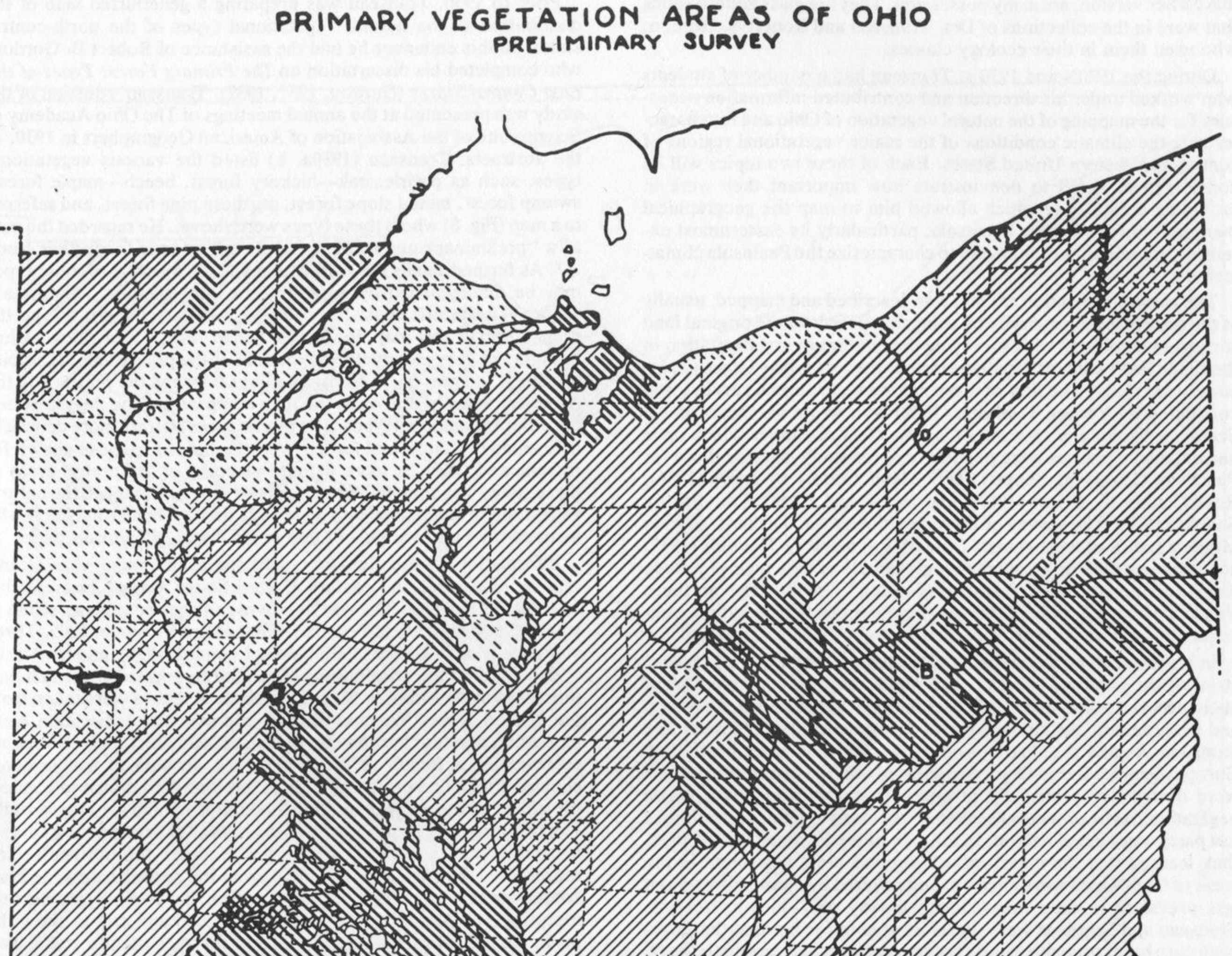


Figure 6. Transeau and Sampson's preliminary map drawn in 1934 showing primary vegetational areas in Ohio. (From Transeau and Sampson, 1935.)

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

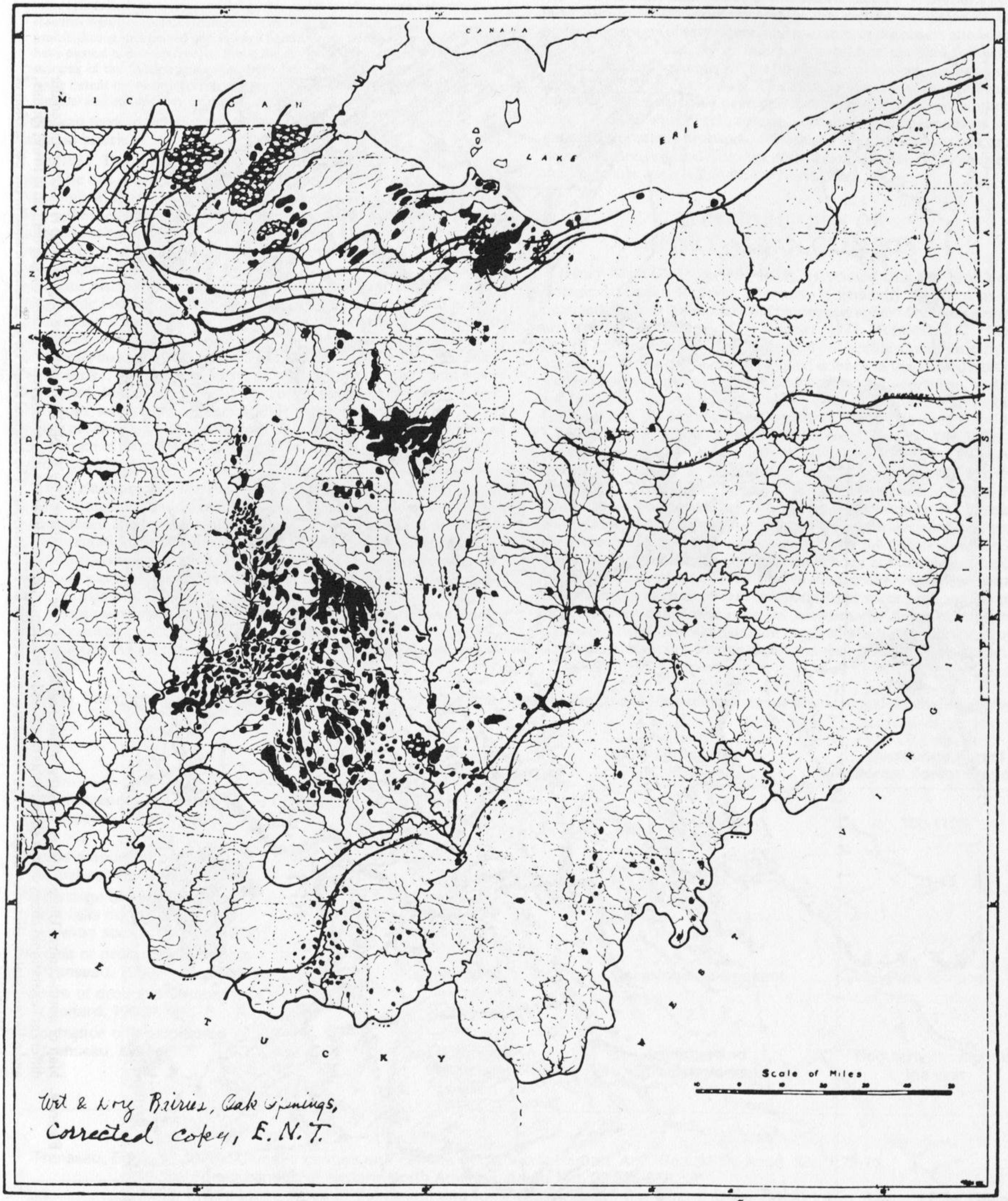


Figure 7. Transeau's unpublished map of "Ohio Vegetation: Prairies" originally printed in 1950. The version published here was one later revised by him showing areas of wet and dry prairies (black) and oak openings (circles). (Original in the office of the Ohio Biological Survey.)

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.

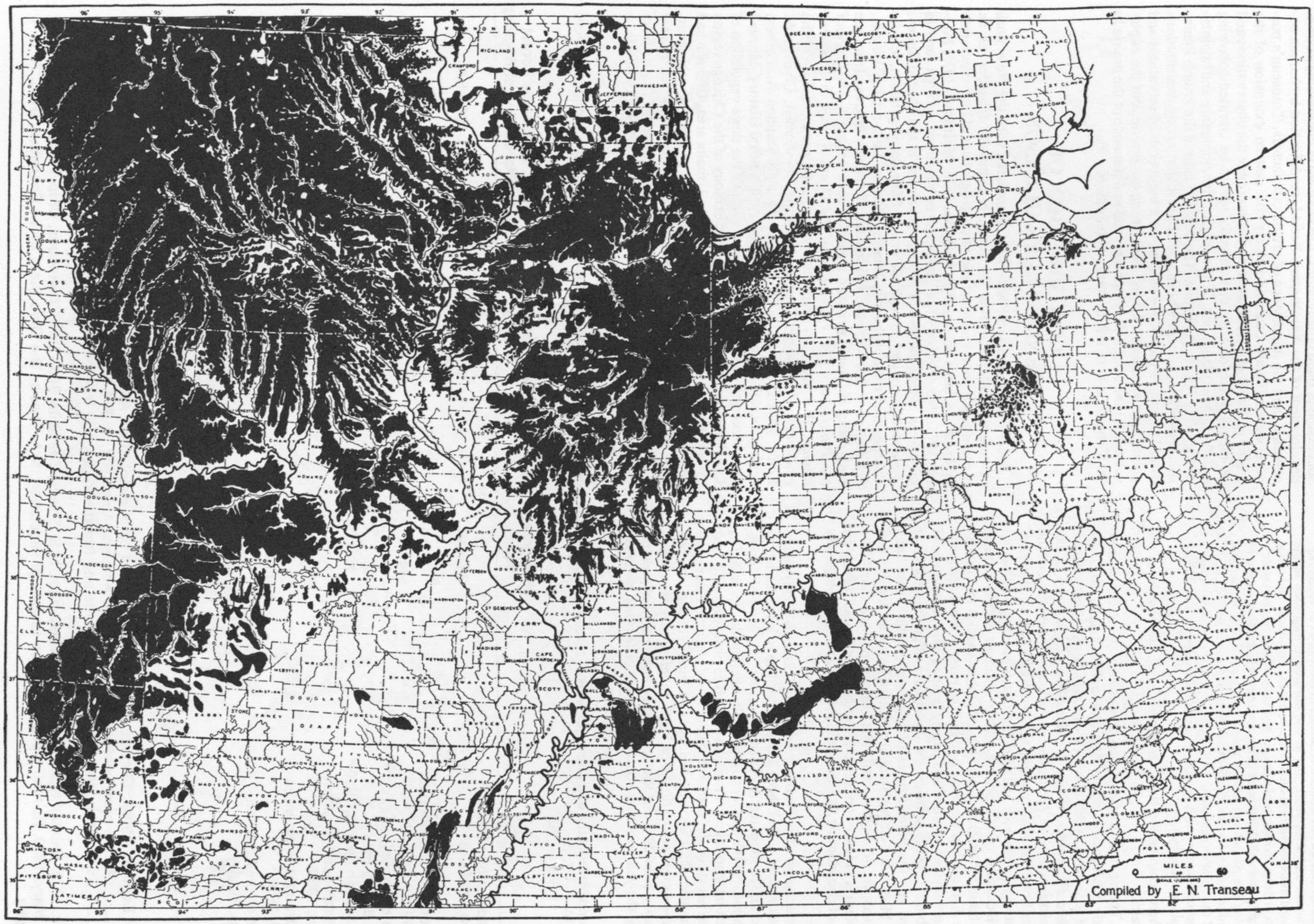
CONTRIBUTION OF HENRY ALLAN GLEASON

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.)

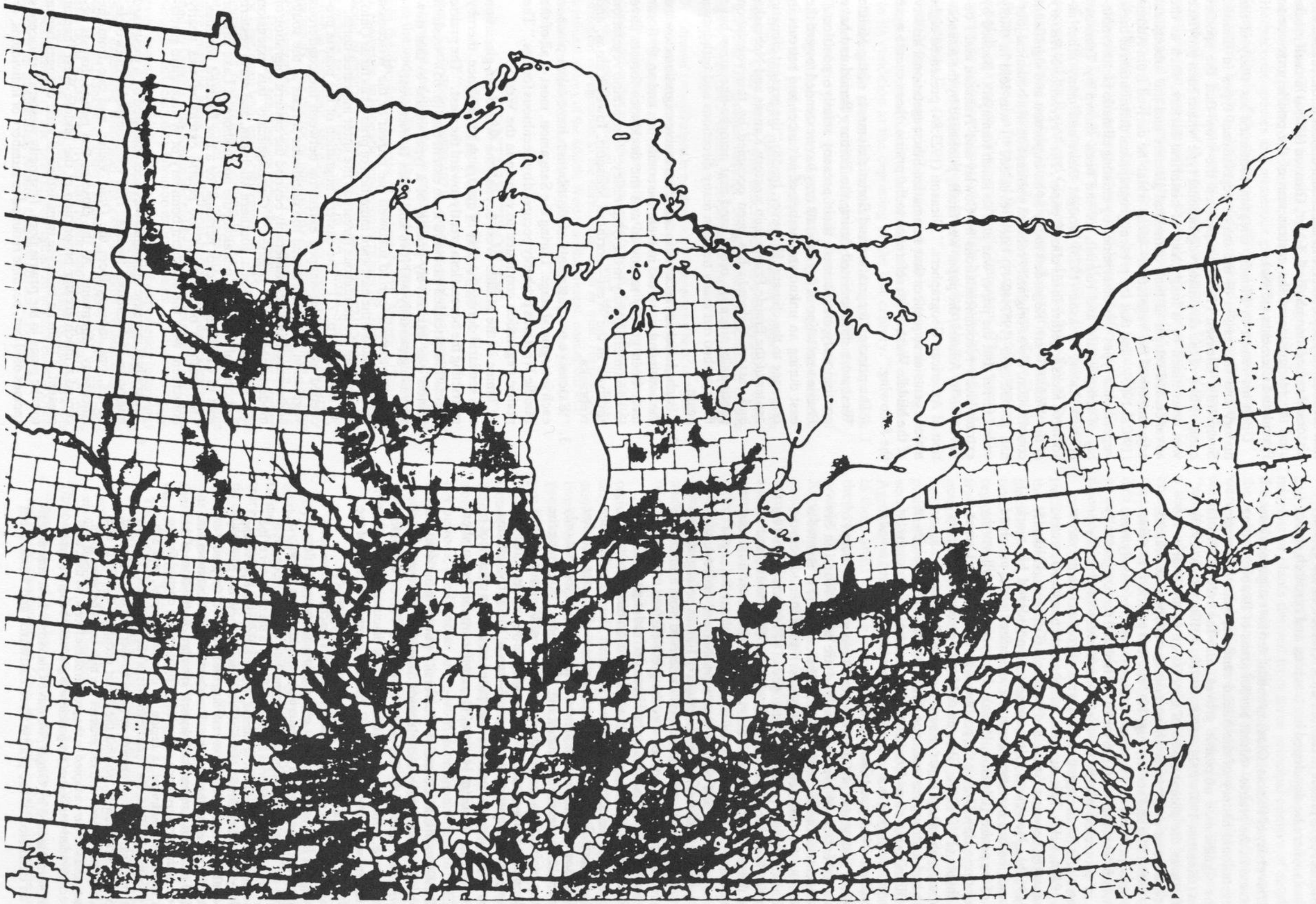


Figure 10. Map of north-central United States showing the prairie-forest border areas as viewed by Transeau. (From an original unpublished map prepared by E.N. Transeau. The original is a glass lantern slide in the possession of R. L. Stuckey.)

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

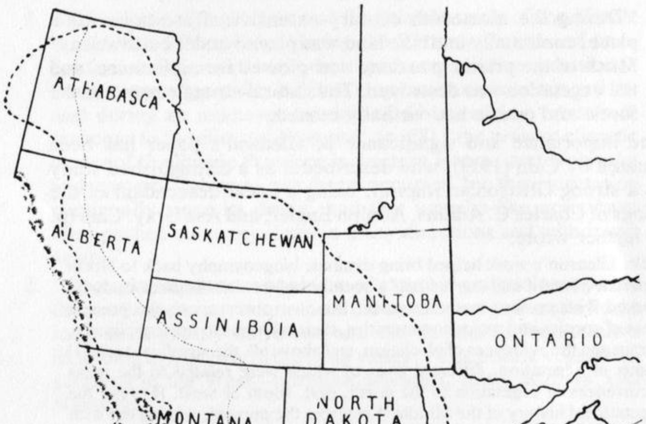


Figure 11. Map of central portion of North America showing vegetational types of the Prairie Province, divided into three regions. I. The prairie region, II. The Sand Hill region, and III. The foothill region. (From Pound and Clements, 1898.)

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.

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CONTRIBUTORS TO THE DEVELOPMENT OF THE PRAIRIE PENINSULA CONCEPT

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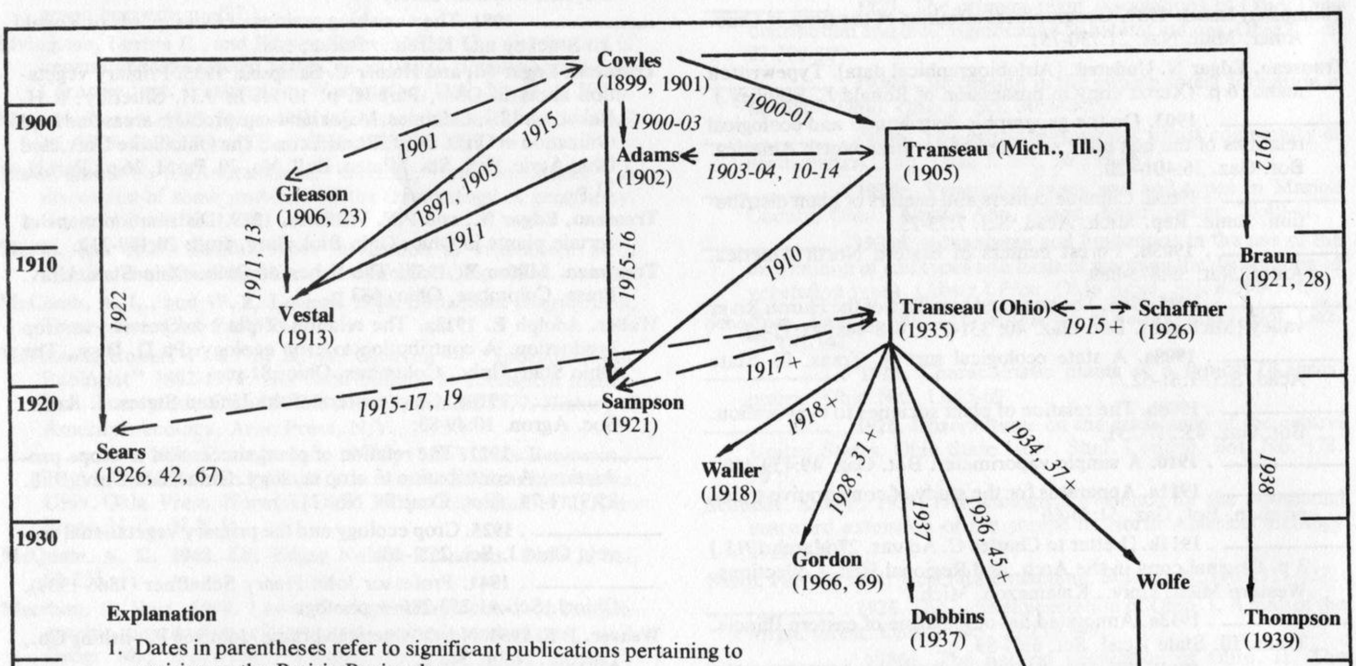
Department of Botany
College of Biological Sciences
The Ohio State University
1735 Neil Avenue
Columbus, Ohio 43210

During my investigations into the development of the concept of the Prairie Peninsula, I obtained photographs of the individuals involved and read all of their relevant published papers. At the Conference, 8 in. x 10 in. photographs of these contributors with accompanying quotations of key passages to the Prairie Peninsula idea were placed on display. In addition, brief biographical notes and citations of their definitive publications on prairies were included. The display was well received with many favorable comments, and therefore, it was decided to reproduce it here.

The arrangement of the individuals is chronological with respect to the quoted passages, beginning with Asa Gray, America's foremost botanist of the nineteenth century. Henry C. Cowles, placed second, begins a long tradition of plant ecological studies in North America. Three of his students, Charles C. Adams, Edgar N. Transeau, and Paul B. Sears promoted many of Cowles' ideas through their students and published papers. Adolph E. Waller, Homer C. Sampson, Raymond A. Dobbins, and Robert B. Gordon, all students of Transeau, taught botany at The Ohio State University and wrote about the prairie. John H. Schaffner, a long-time colleague with Transeau at the university, described the prairie as known to him from boyhood days. Henry A. Gleason and E. Lucy Braun were both influenced by the teaching and writings of Cowles, but their contributions to the concept of the Prairie Peninsula, for the most part, were developed independently. Through his numerous writings beyond the confines of the prairie, Sears has interpreted ecology in a broad perspective to a wide audience. Both Sears and Gordon represent the present-day link between the Transeau era and today's students of the prairie. In the "shadow of Transeau," these photographs and quotations continue to link the past with the present. The development of the concept of the Prairie Peninsula is also depicted in a pedagogical genealogical chart showing the early influence of Cowles and Adams, and the major role of Transeau (Table 1).

Table 1. Pedagogical Genealogical Chart Showing the Development of the Concept of the Prairie Peninsula

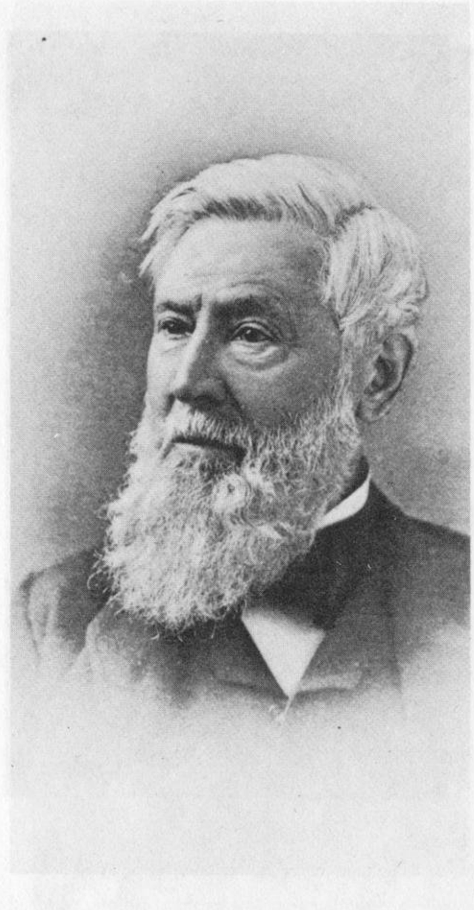


Explanation

1. Dates in parentheses refer to significant publications pertaining to prairies or the Prairie Peninsula.
2. Solid lines with dates: Individuals directly influenced by taking degrees or courses, or being a student at the same institution. Dates are the years individuals received degrees or took courses.
3. Dashed lines with dates: Individuals indirectly influenced through an association, usually as colleagues at the same institution. Arrows at both ends of dashed lines indicate influence was strong in both directions. Dates are the years the individuals were together.
4. Those dates with plus signs (+) signify that the individuals continued at The Ohio State University in association with Transeau.

ASA GRAY

18 November 1810 - 30 January 1888



Born: Sanquoit, New York

Education: College of Physicians and Surgeons of the Western District of the State of New York, Fairfield

Fisher Professor of Natural History: Harvard University, 1842-1873

(photograph, date unknown)

GRAY ACKNOWLEDGED THE PUZZLE OF THE EASTERN PRAIRIES AS OUTLIERS WITHIN THE DECIDUOUS FOREST (1878)

". . . 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, when no physical barrier is interposed between the ground that receives rain enough for forest and that which receives too little, there must be a debatable border, where comparatively slight causes will turn the scale either way. Difference in soil and difference in exposure will here tell decisively. And along this border, annual burnings—for the purpose of increasing and improving Buffalo-feed—practised for hundreds of years by our nomade predecessors, may have had a very marked effect. I suspect that the irregular border line may have in this way been rendered more irregular, and have been carried farther eastward wherever nature of soil or circumstances of exposure predisposed to it." A. Gray. 1878. Am. J. Sci. 116: 93-94.

Photograph reproduced from "Asa Gray" by Walter Deane, 1888, Bull. Torrey Bot. Club 15:59-72, photograph opposite p. 59.

HENRY CHANDLER COWLES

27 February 1869 - 12 September 1939

Born: Kensington, Connecticut

Education: A.B. Oberlin College
Ph.D. University of Chicago

Professor of Botany (from 1911): University of Chicago, 1898-1934

(photograph, date unknown)

COWLES URGED STUDIES IN ECOLOGICAL AND GEOGRAPHIC PLANT ECOLOGY (1901)

". . .ecology is essentially a study of origins and life histories, having two well-marked phases; one phase is concerned. . .with the origin and development of plant societies or formations. . .Examples . . .are tropical evergreen forests, deserts in continental interiors, prairies, deciduous forests, arctic tundras. These formations are widespread because the factors that produce them are widespread. We might call these formations climatic formations. . .and the subject that deals with them geographic ecology or ecological plant geography." H.C. Cowles. 1901. Bot. Gaz. 31: 73-74.

One of Cowles' Pioneering Works in the Development of Ecology:

H.C. Cowles. 1901. 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.

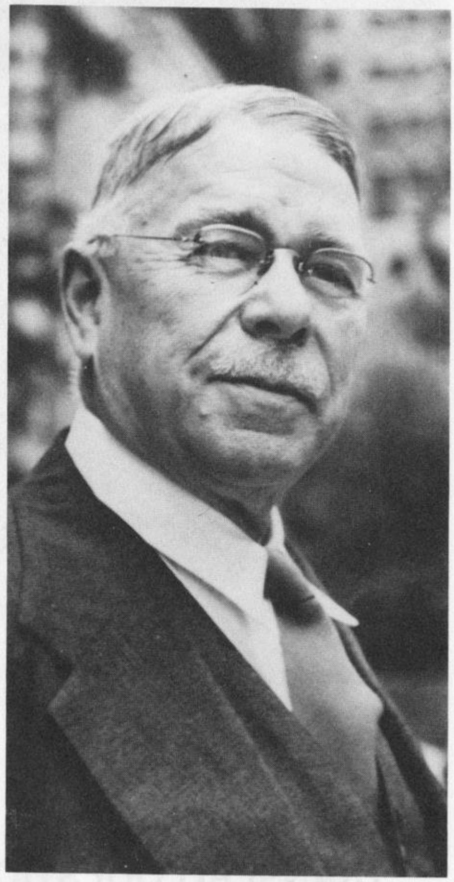
Cowles' Only Known Publication on the Prairie:

H.C. Cowles. 1928. Persistence of prairies. Ecology 9: 380-382.

Photograph reproduced from "Henry Chandler Cowles, physiographic plant ecologist" by Charles C. Adams and George D. Fuller, 1940, Ann. Assoc. Amer. Geographers 30:39-43, photograph opposite p. 40.

CHARLES CHRISTOPHER ADAMS

23 July 1873 - 22 May 1955



(photograph, about 1952)

Born: Clinton, Illinois

Education: B.S. Illinois Wesleyan University
M.S. Harvard University
Ph.D. University of Chicago

Assistant Entomologist: Illinois State Laboratory of Natural History, 1896-1898

Curator, Museum: University of Michigan, 1903-1906

Ecologist: Illinois State Laboratory of Natural History, 1908-1914

Director: New York State Museum, 1926-1943

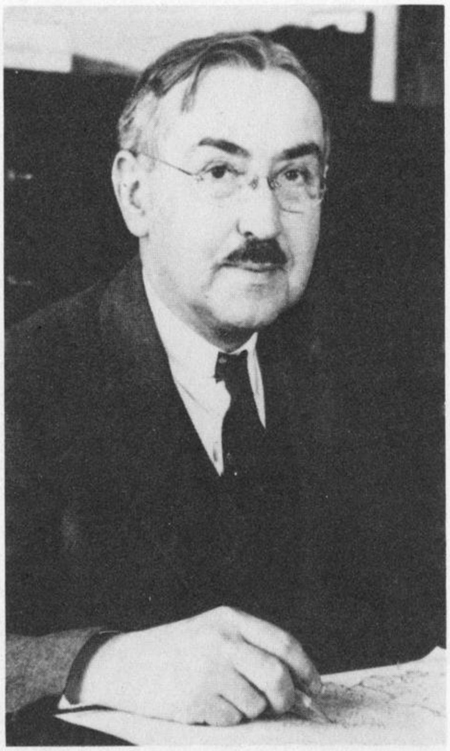
ADAMS FIRST PROPOSED A "PRAIRIE PENINSULA" (1902)

"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." C.C. Adams. 1902. J. Geogr. 1: 355.

First Known Statement of a Prairie Peninsula:

C.C. Adams. 1902. Postglacial origin and migrations of the life of the northeastern United States. J. Geogr. 1: 352-357.

Photograph taken by Dorothy Kehaya. Copy supplied by Harriet Dryer Adams, daughter.



(photograph, 1936)

EDGAR NELSON TRANSEAU

21 October 1875 - 25 January 1960

Born: Williamsport, Pennsylvania

Education: B.S. Franklin and Marshall College
Course work at University of Chicago under H.C. Cowles Ph.D. University of Michigan

Taught Botany: Alma College, 1904-1906
Eastern Illinois Teachers College, 1907-1915

Professor of Plant Physiology and Ecology:
The Ohio State University, 1915-1946

TRANSEAU QUESTIONED THE CLIMATIC CAUSES OF THE "PRAIRIE PENINSULA" (1905)

"The mapping of these centers [of plant distribution] naturally brings up the question of the climatic determinants of each. During glacial times the Northeastern Conifer must have been mixed with the Deciduous forest. Why are they so distinctly separated at the present time? What are the causes of the 'prairie peninsula' in Iowa, Illinois, and Indiana; and the region of open forests adjoining it? Naturally we look for some method of mapping climatic data, which will show climatic centers in approximately the same positions as the centers of plant distribution." E.N. Transeau. 1905. Am. Nat. 39: 883.

Definitive Work:

E.N. Transeau. 1935. The Prairie Peninsula. Ecology 16: 423-437.

Photograph provided by the Department of Botany, The Ohio State University.

HENRY ALLAN GLEASON

2 January 1882 - 21 April 1975

Born: Dalton City, Illinois

Education: B.S., M.A. University of Illinois
The Ohio State University (1905)
Ph.D. Columbia University

Taught Botany: University of Illinois, 1906-1910
University of Michigan, 1910-1919

Curator: New York Botanical Garden, 1919-1950

(photograph, date unknown)

GLEASON RECOGNIZED THE EXTENSION OF THE PRAIRIE FLORA EASTWARD (1906)

"An eastern extension of the great western prairie reaches across Iowa into Illinois 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." H.A. Gleason. 1906. Science N.S. 23: 874.

Definitive Work:

H.A. Gleason. 1923. The vegetational history of the Middle West. Ann. Assoc. Am. Geogr. 12: 39-85.

Photograph provided by the New York Botanical Garden, Bronx, N.Y., courtesy of Charles Long.

(photograph, 1940)

ADOLPH EDWARD WALLER

24 August 1892 - 28 January 1975

Born: Louisville, Kentucky

Education: A.B. University of Kentucky
M.S., Ph.D. The Ohio State University

Taught Botany: The Ohio State University, 1918-1963

WALLER NOTED THE RELATIONSHIP OF CLIMATIC CENTERS AND CROP PLANTS -- CORN AND WINTER WHEAT IN THE PRAIRIE (1918)

"The geographic distribution of our important crop plants appears. . . to be in accord with the well-known centers of natural vegetation. Attention has been called. . . to the separation and restriction of groups of plants to regions where the combination of factors most suited to the development of the group was localized. Transeau was able to show this by a map of the rainfall evaporation ratios. . . His mapped results clearly indicate the desert region, the plains, the prairies and their eastern extension in Illinois, . . . the central deciduous [forest] . . . In detail this means that the corn and winter wheat belts correspond to the deciduous central forest and the prairie climaxes . . ." A.E. Waller. 1918. J. Am. Soc. Agron. 10: 49, 80.

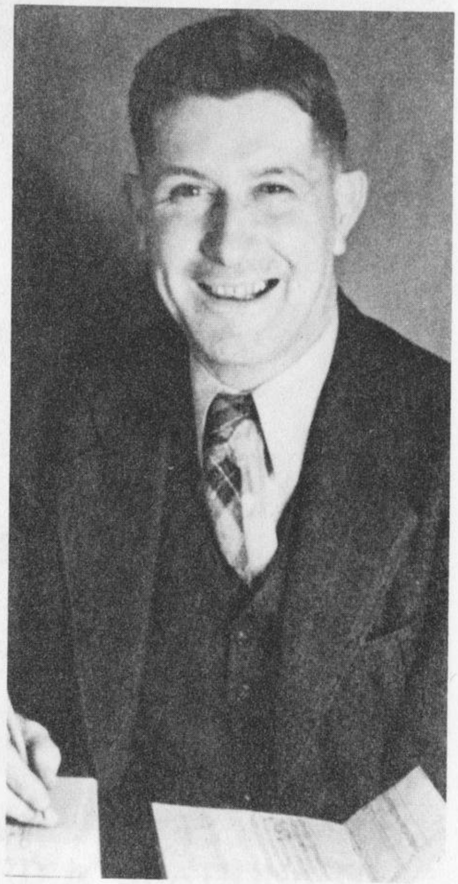
Definitive Work on Crop Ecology:

A.E. Waller, 1921. The relation of plant succession to crop production: A contribution to crop ecology. Ohio State Univ. Bull. 25(9): 1-74. Contributions in Botany, No. 117.

Photograph provided by the Department of Botany, The Ohio State University.

HOMER CLEVELAND SAMPSON

21 January 1885 - 2 July 1963



(photograph, 1938)

Born: Wheeler, Illinois

Education: B.S., Ph.D. University of Chicago

Professor of Botany (from 1922): The Ohio State University, 1917-1955

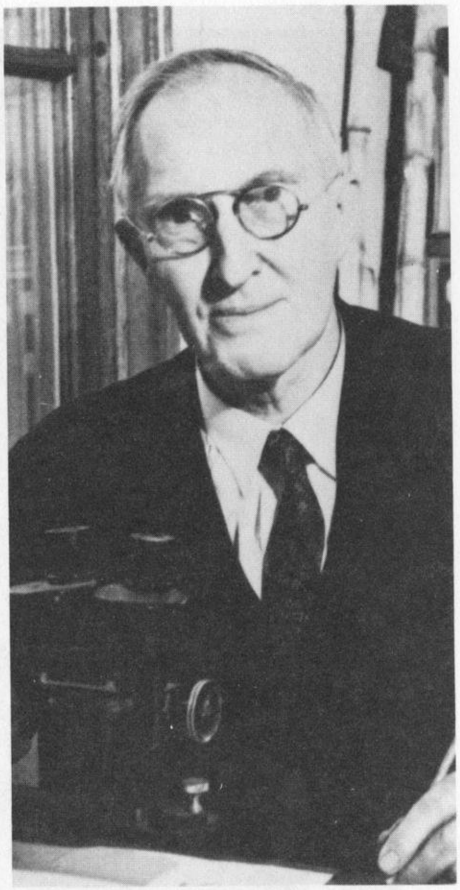
SAMPSON, A DEVOTED STUDENT OF TRANSEAU, STUDIED THE ECOLOGICAL RELATIONSHIPS OF THE PRAIRIE VEGETATION IN ILLINOIS (1921)

"The purpose of this survey was to determine as far as possible the composition and ecological relation of the prairie vegetation of Illinois. The prairie region proper which forms a distinct formation between the grass-lands of the Great Plains on the west and the deciduous hardwood forest on the east. . .The prairie therefore lies in a region in which the ratio of rainfall to evaporation ranges from 60 to 80 per cent. . .[as shown on Transeau's map]. . I. . .express many obligations to Dr. Edgar N. Transeau,. . .who first introduced me to the problems of the prairie in the summer of 1910, and helped me with valuable data and criticisms during the preparation of this report." H.C. Sampson. 1921. Illinois Nat. Hist. Surv. Bull. 13: 523, 527.

Definitive Work:

H.C. Sampson. 1921. An ecological survey of the prairie vegetation of Illinois. Illinois Nat. Hist. Surv. Bull. 13: 519-577 + pls. XLXIII-LXXVII.

Photograph provided by the Department of Botany, The Ohio State University.



(photograph, 1935)

JOHN HENRY SCHAFFNER

8 July 1866 - 27 January 1939

Born: Agosta, Marion County, Ohio;
boyhood spent in Clay County, Kansas

Education: Baker University, Kansas
The University of Michigan
University of Chicago
University of Zurich, Switzerland

Taught Botany: The Ohio State University,
1897-1939

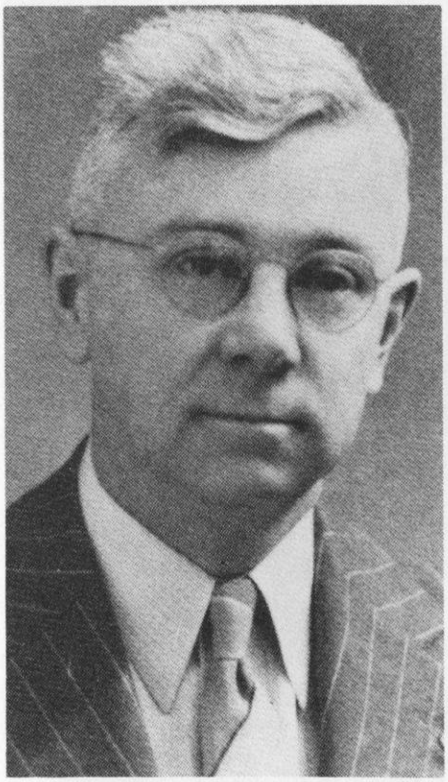
SCHAFFNER DESCRIBED THE GREAT WESTERN PRAIRIE AS KNOWN TO HIM SINCE BOYHOOD (1926)

"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 . . . The eastern boundary of the prairie, as originally determined by Transeau, coincides approximately with the line where the ratio of rainfall to evaporation is 80 per cent, while the western boundary is at about the 60 per cent rainfall evaporation line . . . The primary cause of the prairie and plain is climate . . . all reduced to a single factor -- the ratio of rainfall to evaporation." J.H. Schaffner. 1926. Ohio State Univ. Studies Contrib. Botany 178. pp. 50, 51, 52.

Definitive Work on the Prairie:

J.H. Schaffner. 1926. Observations on the grasslands of the central United States. Ohio State Univ. Studies Contrib. Botany No. 178. 56 pp.

Photograph provided by the Department of Botany, The Ohio State University.



RAYMOND ANSON DOBBINS

31 December 1895 -3 November 1950

Born: Kokomo, Indiana

Education: B.S. Ohio Northern University
B.A., M.S., Ph.D. The Ohio State University

Taught Biological Sciences: Ohio Northern University, 1926-1945

Professor of Botany: Albany College of Pharmacy of Union University, Albany, New York, 1948-1950

(photograph, date unknown)

DOBBINS MAPPED THE ORIGINAL PRAIRIE VEGETATION AREAS OF WEST-CENTRAL OHIO (1937)

". . . The Ohio prairies were fragmentary, island-like outliers of the eastward, peninsula-like extension of the great climatic prairies of Illinois, Iowa, and adjacent states. They were composed of typical prairie plants, with the same associations, dominants and successions as in the more extensive prairies farther west . . . Such prairies occupy habitats which are wet or even inundated in the spring but subject to drought and low water table in summer." R.A. Dobbins. 1937. Ph.D. Dissertation, The Ohio State University, Columbus. p. 149.

Definitive Work:

Raymond Anson Dobbins. 1937. Vegetation of the Northern "Virginia Military Lands" of Ohio. Ph.D. Dissertation, The Ohio State University, Columbus. 161 pp.

Photograph reproduced from "Raymond Anson Dobbins, 1895-1950" by C. L. Newcombe, W. D. Billings, and E. S. Hathaway, 1951, Bull. Ecol. Soc. Amer. 32(3):73.

EMMA LUCY BRAUN

19 April 1889 - 5 March 1971

(photograph, about 1950)

Born: Cincinnati, Ohio

Education: B.A., M.A., Ph.D., University of Cincinnati

Taught Botany: University of Cincinnati, 1914-1948

Professor of Plant Ecology (from 1946)

BRAUN PROPOSED AT LEAST TWO EASTWARD MIGRATIONS OF PRAIRIE (1928)

"The placing of prairie occupancy at such an early date [pre-Illinoian time] seems to be the only possible interpretation of the observed evidence. It means then, that there were at least two xerothermic periods, the first pre-Illinoian [during which time the xerophytic prairie developed in the unglaciated area of Adams County, Ohio], the last, Wisconsin and early post-Wisconsin [during which time the mesophytic prairie developed in the Wisconsin glaciated area of Western Ohio.]. It means that there were at least two eastward migrations of prairie, remnants of both of which are still preserved in relic colonies." E.L. Braun. 1928. Ecology 9: 296.

Definitive Work on the Prairies of Adams County, Ohio:

E.L. Braun. 1928. The vegetation of the Mineral Springs region of Adams County, Ohio. Ohio Biol. Surv. Bull. 15: 375-517.

Photograph reproduced from "E. Lucy Braun (1889-1971) outstanding botanist and conservationist: A biographical sketch, with bibliography" by Ronald L. Stuckey, 1973, Mich. Bot. 12:83-106, photograph on p. 85.

PAUL BIGELOW SEARS

17 December 1891 -

(photograph about 1963)

Born: Bucyrus, Ohio

Education: B.S. Ohio Wesleyan University
M.A. University of Nebraska
Ph.D. University of Chicago

Taught Botany: The Ohio State University, 1915-1919
University of Nebraska, 1919-1927

Professor of Botany: University of Oklahoma, 1927-1938
Oberlin College, 1938-1950
Yale University, 1950-1960

SEARS REVIEWED THE CONCEPT OF XEROTHERMIC THEORY AND ITS RELATION TO THE EXTENSION OF PRAIRIE EASTWARD IN NORTH AMERICA (1942)

". . . in North America [there] are. . . numerous instances of warm and continental plants beyond their usual limits. Most striking, however, were the islands of prairie in the deciduous forest region east of the prairies proper. With [the distinction between grassland and forest]. . . based primarily upon a difference in available moisture. . . the likelihood of an earlier, more continental climate than the present, during which prairies came farther east than now, was certainly increased." P.B. Sears. 1942. Bot. Rev. 8: 733.

Selected Works:

P.B. Sears. 1926. The natural vegetation of Ohio II. The prairies. Ohio J. Sci. 26: 128-146.

P.B. Sears. 1942. Xerothermic theory. Bot. Rev. 8: 708-736.

P.B. Sears. 1967. The Castalia Prairie. Ohio J. Sci. 67: 78-88.

Photograph supplied by Paul B. Sears.

(photograph, 1955)

ROBERT BENSON GORDON

23 July 1901 - 11 February 1981

Born: Erie, Pennsylvania

Education: B.S., M.S., Ph.D., The Ohio State University

Taught Botany: The Ohio State University, 1930-1938
Pennsylvania State Teachers College at West Chester, 1938-1964

GORDON MAPPED THE "ORIGINAL VEGETATION OF OHIO" (1966)

". . . during the past fifty years, there has been a growing body of evidence that natural vegetation, if it can be correctly ascertained, provides the best possible means of judging the potentiality of the environment which has existed locally for the past thousand years. It appears basic to the environmental sciences which loom large in importance to the requirements of modern civilization and in planning for future land use. Techniques are yet to be developed in making adequate use of such data that already have accumulated." R. B. Gordon. 1969. Ohio Biol. Surv. Bull. N.S. 3(2): 2.

Definitive Work on the Natural Vegetation of Ohio:

R.B. Gordon. 1966. Natural vegetation of Ohio at the time of the earliest land surveys. Ohio Biol. Surv. Map (35" x 38") in eight colors; scale 1:500,000.

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

Photograph supplied by Robert B. Gordon.

MEMORIES OF E. LUCY BRAUN

Lucile Durrell
2340 Raeburn Terrace
Cincinnati, Ohio 45223

In the mid-1930's, Richard, my husband, and I were geology students at the University of Cincinnati where we took three botany courses from a marvelous teacher, E. Lucy Braun. The first course was world botany in which we roamed the world from pole to equator. Next was geographic botany in which we studied the vegetational types in the United States. The third course was plant succession, using the communities in the Cincinnati region, together with their changes as our laboratory. Lucy illustrated many of her lectures with superior slides of her own taking.

These courses have added immeasurably to our appreciation of the earth. An important part of our travel experience is our awareness of the vegetation. Facts learned so long ago jump into our minds, for example, the drip tips of leaves in tropical rain forests, the wide spacing of desert plants, and the vivid blue of alpine plants. After all that Lucy had taught us, what a thrill it was to see our first baobab tree, the flat top acacias of the African savanna, or the myriad species of eucalyptus in Australia. Although there was little talk about land conservation in those early years, Lucy planted the seeds of awareness and concern in her students. Her interest and knowledge inspired the creation of the nature preserve system in Adams County, Ohio, beginning in 1959 with 42 acres (16.8 ha) for Lynx Prairie, a system that has now grown to over 3000 acres (1200 ha).

Lucy's teaching continued long after her early retirement. Professional scientists, such as Jane L. Forsyth at Bowling Green State University, came to her for help and advice. Jane told me that Lucy wanted to shift the glacial boundary slightly in southwestern Ohio on the basis of her knowledge of the distribution of plants. Amateurs who wished to know something about species and where to find them came to her. One of those individuals is a well-known Cincinnatian who has given generously to help The Nature Conservancy with land acquisition in Adams County. This person said, "She introduced me to all the plants. She showed me how to use a hand lens; she opened up a whole new world for me. From her I learned so many things about nature." This same admirable woman has recently deeded her estate overlooking the Ohio River to the Hamilton County Parks and her wonderful woods will become a nature preserve.

In 1969 at the age of 80, Lucy assisted the Woman's Committee of the Cincinnati Museum of Natural History plan a short-term adult course. She gave two of the lectures, and assisted by Richard, led a field trip to Roosevelt Lake in Scioto County, Ohio, for over 80 people.

Another active conservationist, a learning companion on field trips with Lucy in her latter years, described Dr. Braun as a very lively lady. On one excursion in search of trailing arbutus, they scurried up a steep slope in the Shawnee State Forest. However, both Lucy and her sister, Annette, said nothing when they found the arbutus, allowing this friend to have the delight of her own discovery of the plant.

Lucy was born in 1889, five years later than her sister, Annette. Their parents were exceedingly strict and protective. Her mother, a retired teacher, taught Lucy at home for the first three years.

Annette by her 30's had already established a reputation as a microlepidopterist, but parental supervision continued. One time a staid and well-respected colleague came from out-of-town to consult with Annette. Her father, a school principal, said, "You may have one hour with my daughter." During that whole time he sat on a chair outside the open door.

Their parents took the two girls by horse-drawn street car to the woods in Rose Hill, now a part of Avondale, and Lucy began collecting and pressing plants during her high school years. Throughout her life she made an extensive herbarium, which now resides at the National Museum in Washington, D. C.

As the neighborhood changed following their parents' death, the two little old maids were mocked and teased by young boys. Life became unbearable and it was necessary to leave their old-fashioned, narrow house in Walnut Hills and find a new home.

In 1943 Lucy purchased two acres (0.8 ha) with a spacious and beautiful limestone house on Salem Road, a drive that winds up from the Ohio valley to Mt. Washington. A wonderful large-paned window in the dining room looks out to the majestic trees which surround the house. Into this woods with a rich herbaceous flora, Lucy introduced numerous native plants, many from the Appalachians. Luckily, her land lay on leached Illinoian glacial deposits so the acid-loving plants flourished.

Richard and I would receive a call from Lucy, "Come, you must come; the red azalea of the Cumberlands is in bloom." It was a summons and dutifully we would go. She took great pride in the *Magnolia ashei* that she had started from seed collected in western Florida.

In this tranquil setting the two sisters lived serenely, surrounded by their Victorian furniture which took on beauty in their new home. Befriended and helped by their neighbors, the Brauns became a source of pride to Mt. Washington, where they were known as the two lady doctors.

Their social life was limited. Occasionally they entertained with a slide show, always with an intermission for lemonade and cookies. For visiting scientific peers, I only recently learned, to my surprise, that they had the simplest of suppers.

Both ladies enjoyed their many western motor trips. Lucy, the photographer, took hundreds of slides, labeled by date, place, time, and direction. Her only relaxation at home was her plants and her mystery stories. When a friend expressed surprise, she retorted, "Why, all scientists read mysteries."

Annette, who had assisted Lucy in all phases of her life, bloomed after Lucy's death. For the first time in 87 years, she made the decisions. One day she proudly proclaimed, "I made a coffee cake this morning." Annette, although missing her sister dreadfully, lived in their home for five more years. In 1976 it was necessary to move her to a nursing home, and she sold the house to DeVere Burt, Director of the Cincinnati Museum of Natural History. Annette died 27 November 1978 at 94. She was a remarkable lady in her own right.

At Iowa State University, DeVere had been fully exposed to Lucy's book, *The Deciduous Forests of Eastern North America*, and to her studies in ecology. When he came to Cincinnati, he found it a thrill to rub elbows with E. Lucy Braun. He still experiences nostalgia when walking through the garden where she nurtured so many plants. With Annette's help from her nursing home, he kept a log of the blooming dates of the plants. DeVere still tends the coleus and the begonia plants, some of which are over 100 years old, continuing the sisters' ritual of taking slips in the fall. A forsythia planted by their mother in 1850 on May Street and moved to Mt. Washington in 1943 still blooms beneath the kitchen window. Her mother's primroses still flower at the edge of the woods which border the front yard.

DeVere considers it the greatest honor to live in her house. Guests in the natural science field who come to visit are honored to know that they are sleeping in the home of E. Lucy Braun. For her they hold a reverential feeling.

Field trips were very much a part of Lucy's and Annette's lives; Annette was usually her companion. They first went to Adams County on the Norfolk and Western Railroad and stayed at an old-fashioned spa in Mineral Springs. In her early studies she took her students with her for a week to make transects and plot studies.

One of these early students tells that the scheduled entertainment one evening was a fungi watch. Lucy and the students climbed the hill behind the hotel and waited for darkness to fall. It became perfectly dark, but to Lucy's dismay, the species down slope identified earlier as phosphorescent did not glow as she had predicted. When she went down the hill to investigate, she found, to her chagrin, that the fungus was glowing only on the underside.

Lucy could not be fooled about the many native plants, for her knowledge was encyclopedic. She also had total recall of all her trips, their dates, what plants she had seen and where. On request she could give you the exact directions for the location of a certain species in such detail as "40 feet [12 m] southwest from the big beech."

After 1930 when Lucy bought her first car, she and Annette made many trips to the Kentucky mountains. While walking in the hills during prohibition, moonshiners posed a serious problem. It was hill protocol never to approach a still. Luckily the ladies never had a direct confrontation. Local residents warned them of locations; sometimes the calls of the moonshiners alerted them to danger or even the lookout men directed them away from the stills.

The Braun sisters got along well with the suspicious mountain people because they heeded the local customs. They made friends and they never tattled on the moonshiners. They often rode the logging trains to remote areas. One day, while attempting to climb Big Black Mountain in Kentucky, they approached a mountain cabin where they had been told a trail started. When Lucy asked the woman where the trail took off, the woman replied, "There's no trail up Big Black Mountain. It's too overgrown, too steep; you would never make it from here." The two sisters stayed a little longer, chatting. Suddenly the light in the woman's eyes turned friendly, "Oh, you're the plant ladies living with the Mullins family. You're the ladies that take pictures of trees. Come along, I'll show you the trail."

One day in the Natural Bridge area in Kentucky, Annette and Lucy were returning to the lodge late in the day by a different way then they had gone. They suddenly sensed they were approaching a still, so they retreated over the divide into another valley where Lucy remembered ten years before she had used a wooden ladder to climb up over the steep sandstone rim. The ladder was gone. It was necessary to make a wide detour and they did not reach the lodge until 9:30 pm, well after dark, much to the relief of the management. It would be interesting to know how many miles these sisters walked in pursuit of Lucy's plants. Annette said they walked 24 miles (38.4 km) on one long day.

Lucy's field trips continued almost to her death. Her last long excursion was to Carter Caves, Kentucky, in 1970; she died a year later. In the last year or so, her vigor was gone. She walked slowly stopping often. I remember she told Richard, "I can't go with everybody now, but you are willing to go slowly enough."

Thanks did not come easily to Lucy's lips; instead, she could be blunt and ungracious. A delicious soup brought during her illness prompted, "I don't like it, take it back." A lovely pink blanket initialed by a friend especially for her fared equally, "I don't need it, take it back." Only now do I realize that Lucy did sometimes show appreciation, although not often. Despite her idiosyncrasies, she had a wide circle of friends: notable scientists from the University of Cincinnati, her students, and nonprofessionals. Known and admired by botanists in her field, she carried on an active correspondence often feuding with them if they opposed her views. These letters are all on file at the Cincinnati Museum of Natural History, where DeVere Burt hopes to research them for a future paper. Elizabeth Brockschlager, a retired school teacher and proficient botanist of Cincinnati, has kept a collection of personal letters written about Lucy's trips.

She was admired and respected by her students, a number of whom went on to develop careers in botany. Many were faithful to the end. However, one noted botanist commented, "She treated me like a sophomore until she died." In the early 1920's, Dr. Braun sparked the university botany club, The Blue Hydra, to raise money to purchase the botanical preserve of Hazelwood for the university. The students organized money-making projects and asked for donations. They sold homemade candy on Tuesdays and Thursdays to the engineers. How different from today; now someone would ask for a grant.

Lucy might be characterized by four D's and an F: *dedication, determination, domination, demanding,* and *frugal*. She was *dedicated* to plant science, to her department to which she brought renown, and to land preservation. It was she who brought the attention of The Nature Conservancy to Adams County. How well I remember Lucy in April of 1967 leading a group of Cincinnatians over the shoulder of Whip-poor-will Hill to an elbow of capture and on to the one of two stations for *Pachystima canbyi* in Ohio. All of this land is now part of The Wilderness Preserve and four of that original group have been generous contributors.

The second D is for *determination*. A former student tells this story. Moving into a new office in Old Tech Building, Dr. Braun found the room on the ground floor unbearably hot. A call to the maintenance department brought no results. It then became her policy each morning when she arrived to take a temperature reading and call maintenance. "This morning my room is 100 degrees," The next day another call, "My office is 98 degrees." This pattern continued for several weeks and finally the head of maintenance replied, "All right, all right," but then she heard him say, "Go up and wrap those steam pipes in Old Tech and shut that blankety-blank woman up."

A story is told of how she intimidated a member of the Ohio Flora Committee when some changes were suggested for *The Woody Plants of Ohio*. She was determined that her way was the only way, and she set up such a tantrum that the member retreated saying. "What can I do?"

Her strong will appeared on field trips even with adults. One would eat where Lucy wanted to eat, one would rest where Lucy wanted to rest, and she was always in complete charge. She was determined that no fire should ever touch the prairie patches in Adams County. She believed the rocky soil was too shallow to withstand burning. Dr. Warren A. Wistendahl of Ohio University innocently asked what she thought about the management of preserves. She launched into a heated attack on the practice of burning for Adams County. It was indeed a scorching reply.

The third D is for *domination*. Lucy, the bread-winner, was particularly dominating towards her sister who served as housekeeper. Annette was a renowned authority in entomology, but she did her research at home. Lucy was in complete command. She would say, "Annette, get me that book" or "Annette, go find the map." It was hard sometimes not to rebuff Lucy's treatment of her sister, but I always held my tongue. Dr. Milton B. Trautman commented, "She was the only person in the world with whom I usually kept my mouth shut."

As for the last D, she was *demanding* of her students, requiring a complete report after every field trip, and of her illustrator, Bettina Dalvé. Having never done any botanical drawings when Lucy approached her to do the drawings for *The Woody Plants of Ohio*, Bettina started with the low price of $1.50 an hour. Evidently, Dr. Braun was satisfied with her work since Bettina illustrated the whole book. When Dr. Braun asked Bettina to do *The Monocotyledoneae: Cat-tails to Orchids*, Bettina replied, "I can't possibly do them at that price." Lucy answered, "I wondered when you would ask."

It was Dr. Braun's practice to bring a fresh plant and written instructions concerning the essential details to be sketched. Bettina marveled at the clarity of these words, particularly in how effectively they communicated to her, a nonbotanist. She could easily follow Lucy's instructions. Lucy spoke glowingly of the drawings to others, but Bettina waited eight and one-half years hoping for some sign of appreciation, but none ever came even after the wide public acclaim accorded the two books.

Bettina commented that "She was a very difficult woman to work for. The manner of disdain with which she treated my mother who did all the layouts was especially hard for me. Mother was a talented artist and Dr. Braun behaved like an intellectual snob." Bettina recounts how she and her husband returned from a long western trip hot, tired, and dirty. Lucy Braun was waiting on the porch steps, plant in hand, demanding an immediate sketch. Bettina complied.

The F is for *frugal*. The two sisters were exceptionally frugal. One day in the field I admired a black-and-white wool coat that Annette was wearing. "Oh, yes," she said, "I bought it in 1913." I gasped in amazement; that was before I was born. The coat was then already well over 50 years old.

When time came for friends to break up the house, their saving ways came into even sharper focus. Many packages from their May Street moving, about 30 years before, still remained wrapped: three coat hangers labeled "3 rusty hangers" and a package labeled "2 good empty boxes." Numerous small gifts still remained in their boxes.

Lucy was free to give criticism, but she did not take it with grace. The Kenneth Casters of the University of Cincinnati tell about an incident when a micropaleontologist came to lecture in the Geology Department. Because this lecture was after Lucy's retirement, the newer students in attendance knew nothing of E. Lucy Braun. To them the two white-haired sisters appeared like two characters out of "Alice in Wonderland." As the lecture continued, challenging Dr. Braun's origins of the mixed mesophytic forest, Lucy's lips grew tighter and tighter. When the speaker sat down she rose to battle and made a ferocious attack upon him which was followed by a vast silence that filled the room. Finally, the speaker arose and said, "Thank you, Dr. Braun, I wanted to hear your opinion."

Lucy was the master of the "put-down." To me, when I mentioned a new and delicious cookie recipe, "Oh, I couldn't waste my time on that sort of thing." Or to Marion Becker, author of *The Joy of Cooking*, a creative person who led several exciting lives in conservation, promoting the arts, and creating a wonderful wildflower garden, "How can you fritter away your time on all those different things?" To her sister who might want to show a friend some new drawings of her moths, "Oh, they don't want to see pictures of your old bugs."

Many years ago Dr. Milton B. Trautman observed the peculiarity of the skunk cabbage in which the pistillate portion of the flower is mature before the pollen is ready. Excited that he had found something rare in nature, he told Lucy of his discovery. Lucy very quickly pricked his balloon of elation by a terse comment, "Not at all, not at all uncommon."

Lucy had a strong self image. In 1956 she was included in the 50 most outstanding botanists by the Botanical Society of America. When I asked Annette for Lucy's reaction she answered, "Why she didn't say anything. She knew she deserved it." Annette also commented that her sister considered *The Deciduous Forests of Eastern North America* her crowning achievement.

Kenneth Hunt, former Professor of Botany at Antioch College, gave me this thumbnail sketch: "a mild-mannered, gentle person, confident and sure, a woman of steel, a master of her craft, quiet, absolute." I can agree with all, except perhaps the "gentle."

Annette spoke of her sister only with admiration and affection. Lucy respected her opinion and Annette played an important role in the writing of Lucy's books. The cooperation appears one-sided; Lucy's contribution to Annette's research was the identification of the food plants of her moths. When they carried on a joint conversation, one sister would start a sentence and the other would finish it.

We visited Lucy several times in her last three months as she grew weaker. As she lay wan upon her bed, Richard and I sat beside her while she plotted strategy to help save the Red River Gorge in Kentucky. Her mind was clear.

Lucy was born a Victorian, and she died a Victorian in 1971 at 82 years of age. Times change, but she did not change. We marvel now at a life so full of significant scientific achievement. Our lives and those of many others are richer and fuller because of E. Lucy Braun.

E. Lucy Braun is still generating stories. She was known to a number of garden clubs in Cincinnati, many of whom contributed money to the projects in Adams County. After her death the ladies were accustomed to calling her the late E. Lucy Braun. One young woman inquired, "Who is this Lady Braun, is she from England or somewhere?" Say it fast, the late E. Lucy Braun. I know Emma Lucy Braun is pleased that she has entered into the nobility.

ACKNOWLEDGEMENTS

I express thanks to all who have shared with me their memories of E. Lucy Braun.

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The Braun Sisters in the Field

E. Lucy Braun (right) and her sister, Annette Braun, at Lynx Prairie, Adams County, Ohio. Annette is wearing the black-and-white coat mentioned on p. 38. (Photograph courtesy of The Nature Conservancy. Originally printed in the 1973 fall issue of The Nature Conservancy News.)

SOME VERTEBRATES OF THE PRAIRIE PENINSULA

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When asked if I would present a paper for this conference relative to some vertebrates associated with the Prairie Peninsula, I accepted gladly, partly because of my friendship with the late Dr. Edgar Nelson Transeau and partly for an opportunity to express my admiration for his many accomplishments. I first became acquainted with Dr. Transeau in 1925; thereafter, I occasionally visited him and always brought along a list of questions relative to the Ohio flora, prairies, or topography. He had an intense curiosity concerning the natural world. Although a busy faculty member he willingly gave of his time to answer intelligent questions, asked by anyone, whether his student or not.

Throughout the 1925 to 1934 period Dr. Transeau (1935) was interested in developing his concept of the Prairie Peninsula. During that time I was actively engaged in a survey of Ohio vertebrates, especially fishes and birds. As my research progressed, it was evident that most of the 148 species of fishes could be relegated to fewer than a dozen distributional patterns. One of these was similar to the general outline of the Prairie Peninsula in Ohio. Professor Transeau requested and was given maps showing the Ohio distribution of two species of fishes, blackstripe topminnow *(Fundulus notatus)* and western creek chubsucker *(Erimyzon oblongus claviformis)*, which illustrated the similiarities between the original prairies and the corn-producing areas of the state. Of the various groups of vertebrates inhabiting the original prairies of Ohio, only fishes and birds are discussed here. Thomas (1951) and Smith (1957) have reported on species of amphibians, reptiles, and mammals in relation to the Prairie Peninsula. Scientific nomenclature of vascular plants is that of Weishaupt (1971); of fishes, Trautman (1957); of birds, American Ornithologists' Union (1957, 1973); and of mammals, Burt and Grossenheider (1976). The scientific name of an organism is given following the first appearance of its common name.

THE FISHES

After plotting stream gradients, it was apparent that those streams draining the largest prairies in Ohio had low gradients (Trautman, 1942). Many gradients were only a foot or less per mile. These original prairie streams were usually sluggish, meandered between low banks, and when in flood overflowed their banks and sometimes became more than one-half mile (0.8 km) wide. Even in flood, the waters remained relatively clear. For example, the Maumee River system of northwestern Ohio originally contained waters of marked clarity with substrates of sand, gravel, bedrock, and organic debris. Frequently mentioned in the literature was the great abundance of submersed aquatic plants, also an indication of water clarity. Scott (1793-1794) stated that the Maumee River was "near 600 yards [540 m] wide and near the head of the [Grand] Rapids it resembles a Meadow flooded over with long grass entirely across."

Authentic records of fishes collected before 1900 include those species which normally inhabit waters of extreme clarity and are intolerant to turbidity. Among them are the spotted gar *Lepisosteus oculatus)*, harelip sucker *(Lagochila lacera)*, popeye shiner *(Notropis ariommus)*, northern madtom *(Noturus stigmosus)*, and gilt darter *(Percina evides)*. None of these have been collected in the Maumee River system since. Another group, somewhat more tolerant to turbidity and silt-covered substrates, has become endangered or has not been recorded since 1950. In this group are the greater redhorse *(Moxostoma valenciennesi)*, pugnose minnow *(Notropis emiliae)*, bigeye shiner *(Notropis boops)*, blacknose shiner *(Notropis heterolepis)*, channel darter *(Percina copelandi)*, and sand darter *(Ammocrypta pellucida)* (Trautman, 1957).

Plowing of friable soils adjacent to prairie streams usually resulted in sheet erosion during severe storms, which caused the formerly clear waters to become turbid and the substrate to become silt-covered. Naturally, substrates of low-gradient streams became silted more readily than did those of higher gradients. The late Professor James S. Hine and I obtained striking proof of the rapid covering of substrates with silts following plowing. On 8 August 1893, Kirsch (1895) captured many harelip suckers in the Blanchard River, a tributary of the Maumee River system. He reported whitish clay outcrops, sands, and gravels as composing the substrate. The stream was remarkably clear of rubbish; water willow *(Justicia americana)* and dartweed, presumably the water smartweed *(Polygonum coccineum)*, were common then. Kirsch described the locality so accurately that on 7 July 1929, Hine and I located the exact spot. We found no rooted aquatic plants, the water was turbid, and the substrate consisted of silt. Digging with shovels through 12 to 18 inches [30-45 cm] of silt, we found the clean sand, gravel, and whitish clay described by Kirsch. These substrates were sharply separated from the superimposed silt, indicating that silting occurred abruptly, presumably following the first plowing. In the sand, the blackened roots of the former aquatic plants were remarkably well preserved. Obviously the habitat of the harelip sucker, including its food, had been eliminated. The harelip sucker has not been reported from Ohio since 1893. Outside of Ohio, the harelip sucker was numerous in similar prairie-type streams of the Prairie Peninsula and adjacent areas. However, it has not been captured anywhere since 1900 and the species is now considered to be extinct.

The bigeye shiner *(Notropis boops)*, another species intolerant to turbid waters, was collected from several localities before 1900 in the Maumee River and its tributaries. Today, the species remains present in the unglaciated south-central section of Ohio, and in a northern extension of the upland prairies of Kentucky, where, above the 600-foot [180-m] contour, there are normally clear streams having substrates of clean gravel, sand, and limestone bedrock. Prior to 1928 two adjacent tributaries of Morgan's Fork in Pike County, Ohio, contained large populations of bigeye shiners. During the spring of 1928, a farmer removed trees and brush; then he plowed a steep hillside adjacent to one of the tributaries. The soils rapidly eroded from the hillside during rains, entered the tributary, and caused the formerly clear waters to become turbid and the substrate to be deposited with silt. This situation resulted in nearly complete extirpation of the bigeye shiner from this tributary. The hillside, not having been plowed again, became clothed with saplings and herbs, consequently, the erosion was arrested. The waters returned to their former clarity; the sand, gravel, and bedrock were again exposed; and this shiner reestablished its numbers either through a local relict population existing in the tributary or from an invasion of individuals from the adjacent tributary.

Since 1900 there has been an invasion, or increase in numbers, of several species of fishes that are tolerant to turbid waters. Before 1900 the range of the suckermouth minnow *(Phenacobius mirabilis)*, a species tolerant to turbidity, was almost entirely west of the Mississippi River. It was first recorded for Illinois and Indiana in 1876. By 1922 it had invaded Ohio, becoming well distributed in the Maumee drainage as well as elsewhere in western Ohio.

The orangespotted sunfish *(Lepomis humilis)* is another western invader which is also considerably tolerant to turbidity and siltation. This species appears to have been first recorded for Indiana in 1888, but it was not recorded for Ohio until 1920 when specimens were captured from the Wabash River system. By 1929 it had become established in the Maumee River system, either by its own efforts during floods, or by man. It likewise invaded eastward in the Ohio River. This sunfish became established in the former prairie areas of the upper Great Miami River system by 1930, and in former prairie areas in the Scioto River system by 1945.

THE BIRDS

The literature contains abundant, but widely scattered, references to those species of birds associated with prairies during one or more seasons of the year. Unfortunately many references are vague as to what prairie type is indicated, while other references are very specific, stating in what manner the prairie differs from a marsh, fen, bog, brushy field, or swamp. For example, prairies include such diverse types as "barrens," with or without a sparse growth of "scrub" oaks; "bowling greens," usually grasslands containing scattered black walnuts *(Juglans nigra);* hawthorn thickets *(Crataegus* spp.), interspersed with grasses and other herbs; and dry prairies, usually rocky, overly drained hillsides with sparse vegetation.

Some authors define prairie types by the species of birds most frequently occurring in the area and during what season of the year they are present. Several authors consider only those species of birds to be prairie indices if they remain mostly in treeless, herbaceous areas during some season of the year. Birds in this group include the bobolink *(Dolichonyx oryzivorus),* dickcissel *(Spiza americana),* Henslow's sparrow *(Ammodramus henslowii),* and grasshopper sparrow *(Ammodramus savannarum).* Before the advent of telephone lines and fences these birds proclaimed their territory by singing from the tops of large "weeds," or singing in flight as did the horned lark *(Eremophila alpestris).*

Some authors described "prairie edge" species of birds. They inhabited herbaceous vegetation, shrubs, and prairie border areas of brush and trees. Among them were the bobwhite *(Colinus virginianus),* indigo bunting *(Passerina cyanea),* and field sparrow *(Spizella pusilla).* Species inhabiting or nesting in the usually hilly "dry prairies" that were bordered with brush and scattered trees included the eastern kingbird *(Tyrannus tyrannus),* mockingbird *(Mimus polyglottus),* gray catbird *(Dumetella carolinensis),* brown thrasher *(Toxostoma rufum),* loggerhead shrike *(Lanius ludovicianus),* yellow warbler *(Dendroica petechia),* common yellowthroat *(Geothlypis trichas),* yellow-breasted chat *(Icteria virens),* and Bachman's sparrow *(Aimophila aestivalis).*

The Oak Openings of northwestern Ohio contained a rather distinctive avifauna. Conspicuous species were the common flicker *(Colaptes auratus)* and redheaded woodpecker *(Melanerpes erythrocephalus);* although primarily woodland inhabitants, they spent much time fly-catching over the prairies. Throughout winter the common flicker habitually foraged for ants among the many ant hills scattered about the prairies. Savanna sparrow *(Passerculus sandwichensis),* vesper sparrow *(Pooecetes gramineus),* and lark sparrow *(Chondestes grammacus)* nested on the sandy beach ridges or former post-Wisconsinan lakes and among the "blowouts" with sparse vegetation.

Several species of water birds nested in the vegetation surrounding pothole lakes. These species were the mallard *(Anas platyrhynchos),* blue-winged teal *(Anas discors),* king rail *(Rallus elegans),* Virginia rail *(Rallus limicola),* and sora *(Porzana carolina).* Nesting about the larger lakes were the pied-billed grebe *(Podilymbus podiceps),* American bittern *(Botaurus lentiginosus),* least bittern *(Ixobrychus exilis),* and common gallinule *(Gallinula chloropus).*

Formerly the greater prairie chicken *(Tympanuchus cupido)* nested in the Ohio prairies or invaded the state from a northerly direction during winter. Kirtland (1838:184) wrote that "The prairie hen is found in considerable numbers in the northwestern parts of our State." About 1835 Judge Emery D. Potter saw "thousands together on the open lands within six miles [9.6 km] of Toledo," according to Waggoner (1888:29). Presumably they were winter visitants from outside Ohio. Wheaton (1882:446) wrote that " 'A male Pinnated Grouse was killed by a gunner, seven miles [11.2 km] west of Columbus, November 16, 1878' " in a former extensive prairie, a locality now within the Columbus city limits. Wheaton (1882:450) noted that in 1802 the prairie-brush inhabiting bobwhite was seen and heard in the "High-bank Prairie" near Chillicothe.

Although no nesting records of the swallow-tailed kite *(Elanoides forficatus)* are known for Ohio, it was formerly an abundant summer resident, according to many authors (Kirtland, 1838; Kirkpatrick, 1859; Wheaton, 1879, 1882; Jones, 1903; Wilson, 1935). These hawks migrated northward from their southern nesting grounds, especially during the latter half of summer, feeding upon the then abundant invertebrate and vertebrate fauna, especially grasshoppers. I recall as a boy, more than 50 years ago, walking across the former prairie remnants of central Ohio, flushing hundreds of grasshoppers, the favored food of the swallow-tailed kites.

At times huge swarms of other insects perched on vegetation or flew over the prairies. These invertebrates were preyed upon by diverse species of birds, such as kingbirds, other smaller flycatchers (Family Tyrannidae), common nighthawks *(Chordeiles minor),* and several species of swallows (Family Hirundinidae), especially during their southward migrations in late August and September. At dusk, hundreds of nighthawks and large concentrations of thousands of swallows could be seen coursing over the prairies. Lightningbugs were also conspicuous. Before 1920, my parents and I, following a rain shower, sometimes took an evening drive through the Pickaway-Big Darby Plains to observe the thousands of lightningbugs, a truly spectacular sight.

Many species of migrant waterfowl and shorebirds nesting to the north, utilized the prairies during migrations before the prairies were modified by draining, ditching, plowing, or cultivating. Only those of us sufficiently antiquated and having an affection for the natural world remember these huge concentrations of avian migrants. Before 1930 I spent many fascinating hours listening to the late Oliver H. Niemeyer reminisce about waterfowl and shorebird migrations that occurred about 1900 on the extensive prairies north of Columbus. Walking over these former prairies, he pointed out landmarks which made me visualize former prairie conditions. Throughout spring the untiled, undrained, rather level prairies were water-covered, except for a few slightly higher elevations. In a light boat Ollie and his father, a market hunter, traversed the flooded prairie for miles, dragging the boat over elevations and shooting waterfowl and shorebirds. The day's hunt sometimes totaled many dozens of ducks and shorebirds. Among the shorebirds they shot were the American golden plover *(Pluvialis dominica),* pectoral sandpiper *(Calidris melanotos),* greater yellowlegs *(Tringa melanoleuca),* and lesser yellowlegs *(Tringa flavipes),* all of which were particularly abundant. During late summer when much of the prairie was dry and ablaze with flowers, the upland sandpiper *(Bartramia longicauda)* appeared in loose flocks, some containing dozens of birds. By 1940 virtually all of these prairies had been tiled, drained, and were under cultivation.

During the colder months the broad-winged, high soaring red-tailed hawk *(Buteo jamaicensis)* and rough-legged hawk *(Buteo lagopus)* and the low quartering marsh hawk *(Circus cyaneus)* were conspicuous. They were present in large numbers wherever small rodents were concentrated. The short-eared owl *(Asio flammeus),* known to farmers as "prairie owls," also congregated in these areas. Over 50 years ago, I saw 34 short-eared owls, each one perched on a fence post, the fence enclosing about 20 acres (8 ha) of prairie. Walking back and forth across this prairie, I saw over 300 mice, mostly meadow voles *(Microtus pennsylvanicus).* With the widespread use of insecticides and herbicides, such concentrations of owls, hawks, and mice are rarely seen today.

In spring, the slight depressions within a prairie were filled with water, and later a sedge, *Carex* (mostly *C. lacustris),* grew in these places, called "prairie sloughs." Marsh hawks and short-eared owls roosted in these sloughs, occasionally in groups of 5 to 50 birds. Later these sloughs became escape cover for ring-necked pheasants *(Phasianus colchicus)* during the hunting season.

Small land birds generally avoided the wind-swept treeless prairies in winter, especially when snow-covered. The most conspicuous small winter birds were horned larks, lapland longspurs *(Calcarius lapponicus),* and snow buntings *(Plectrophenax nivalis).*

Outside Ohio one of the most authentic accounts concerning the original prairies in spring and summer was written by Ridgway (1889: 13-16). On 8 June 1871 he and his companions visited Fox and Sugar Creek prairies, situated a few kilometers west of Olney in southeastern Illinois. Ridgway wrote that "the prairie itself was free from tree or brush." On the prairie the dickcissel was very numerous; less plentiful were the horned lark, eastern meadowlark *(Sturnella magna),* Henslow's sparrow, and grasshopper sparrow. The men were fascinated by the "Swallow-tailed Kites floating about on buoyant wing" and the "many Mississippi Kites [*Ictinia mississippensis*]." Resting beside the brushy, woody prairie edge, they heard and saw a large number of birds that were presumably nesting. Among these species were the bobwhite, red-headed woodpecker, mockingbird, brown thrasher, white-eyed vireo *(Vireo griseus),* Bell's vireo *(V. bellii),* red-eyed vireo *(V. olivaceus),* warbling vireo *(V. gilvus),* yellow-breasted chat, summer tanager *(Piranga rubra),* cardinal *(Cardinalis cardinalis),* towhee *(Pipilo erythrophthalmus),* and field sparrow.

A second visit took place in August of 1871 when many of the species recorded on the previous visit were observed again. The total number of species seen "within the bounds of the prairie itself, numbered about ninety-five on each occasion; while the surrounding woodlands, cultivated grounds and river bottoms" recorded an additional forty-five species which probably "breed upon an area five miles [8 km] square, having as its centre the portion of the prairie where we made our investigations." Of the total only "twenty-five were water-birds."

A third visit was made 12 years later in 1883. Ridgway found the changes "almost beyond belief." Instead of the original prairie "*there remained only 160 acres* [64 ha] *not under fence*." The remainder contained homes, barns, outhouses, "fields of corn and wheat," and extensive orchards. "As a consequence, we searched in vain for the characteristic prairie birds," absent except on the 160 acres (64 ha); "but shades of Audubon! - equally numerous were the detestable House Sparrow [*Passer domesticus*]." Ridgway concluded, "We left our [former] beautiful prairie with sad heart, disgusted with the change [however beneficient to humanity] which civilization had wrought"; adding "it will probably not be many years before a prairie in its primitive conditions will be found in Illinois." Here is another illustration of how quickly and with comparative ease a prairie ecosystem can be eliminated.

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Field Trip Participants at Daughmer Bur Oak Savanna, Crawford County, Ohio
Some ecologists who attended the Sixth North American Prairie Conference, 12-17 August 1978 (left to right): Milton B. Trautman, Paul B. Sears, Frank Preston, Edward S. Thomas, Robert B. Gordon, and Walter A. Tucker. (Photograph by Kim Heller, Division of Wildlife, Ohio Department of Natural Resources.)

THE BIG BARRENS OF KENTUCKY NOT A PART OF TRANSEAU'S PRAIRIE PENINSULA

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According to Dicken (1935a) the term "barrens" was applied by the 18th century settlers in Kentucky, Tennessee, and adjacent states to treeless areas with tall grasses and a few shrubs. However, in some areas there was a sparse growth of post oaks and other stunted trees (Dicken, 1935a). According to Sauer (1927), the first settlers in Kentucky did not know the word "prairie" and thus used the word "barrens" to denote the grasslands they found on the Pennyroyal Plateau. After carefully analyzing statements of early writers, Sauer (1927) concluded that the Kentucky Barrens were so called because of the absence of forest cover, and not because the early settlers thought the land infertile and unproductive as suggested by Shaler (1885), Miller (1919), and McInteer (1942, 1946).

When Transeau (1935) published his map of the Prairie Peninsula, he included the Big Barrens of Kentucky. Since then, the Big Barrens generally have been accepted as part of the Prairie Peninsula (Benninghoff, 1963; Kuchler, 1964; Malin, 1967; Geis and Boggess, 1968); however, many students of the North American prairie are not familiar with this once-extensive grassland in Kentucky (Fig. 1). Thus, the purposes of this paper are to (1) describe the region where the Big Barrens occurred, (2) examine the historical evidence for the existence of extensive grasslands in this region of Kentucky, (3) review the theories on the origin of the Kentucky grasslands, (4) describe the present status of the vegetation of the area, and (5) end with a conclusion on the validity of including the Big Barrens of Kentucky as part of the Prairie Peninsula.

DESCRIPTION OF THE BIG BARRENS REGION OF KENTUCKY

According to the classification scheme of Fenneman (1938) pertaining to the physical divisions of the United States, the Big Barrens Region is in the Interior Low Plateaus Province on what is commonly known as the Mississippian Plateaus (McFarlan, 1943). In Kentucky the Mississippian Plateaus Section is known as the Pennyroyal. Sauer (1927) in his study of the regional geography of the area divided the Pennyroyal into eight subsections according to the landscape forms which have resulted from weathering of the different types of Mississippian limestone bedrock. The Big Barrens occurred in the Pennyroyal Plain and the Elizabethtown Area subdivisions of the Pennyroyal. Both of these subdivisions are developed over the cavernous Mammoth Cave limestone. The Pennyroyal Plain is mostly smooth and rock outcrops are rare. Only one major stream, the Barren River, crosses the area, but the area is well-drained due to fissures in the limestone which allow surface water to enter subterranean streams. Sinks occur in the area, but many of them are quite shallow (Sauer, 1927). In contrast to the Pennyroyal Plain, the Elizabethtown Area has fewer stretches of conspicuously smooth land, and the landscape is generally rolling. This area is drained by surface streams which have carved valleys, even though numerous sinks are in the area (Sauer, 1927). The karst landscape of the Pennyroyal Plain and the Elizabethtown Area and the associated problems of soil erosion have been described in detail by Dicken (1935b) and Dicken and Brown (1938).

The important soil series of the Pennyroyal Plain and the Elizabethtown Area are Pembroke, Crider, and Russellville. These red-yellow podzolic soils were developed under forest cover in limestone residuum with a very thin loess mantle, and agriculturally they are highly productive. The A horizons are dark reddish brown to dark brown silt loams and are medium to strongly acid. The B horizons are reddish brown to dark red silty clay loams and are strongly to very strongly acid (Bailey and Winsor, 1964).

Thornthwaite (1931) classified the climate of the Pennyroyal as a type BB'r, a humid mesothermal climate in which there is little or no water deficiency for plant growth at any season. According to the system of using bioclimatic data to classify vegetation by Holdridge (1947), the potential natural vegetation of the Big Barrens Region is a warm temperate moist forest (Sawyer and Lindsey, 1963).

With one exception, the general vegetation maps depicting the vegetation of Kentucky do not show any grasslands. Sargent (1884), Shreve (1917), Livingston and Shreve (1921), Shantz and Zon (1924), and Braun (1950) all show the climax vegetation of the state, including all of the Big Barrens Region, as deciduous forests. On the other hand, Kuchler (1964), following the outline of the Barrens on Transeau's (1935) map, shows the potential vegetation of the Big Barrens Region of Kentucky as a mosaic of oak—hickory forests and bluestem prairie. There are no maps dealing specifically with the vegetation of Kentucky.

HISTORICAL EVIDENCE FOR GRASSLANDS IN THE BIG BARRENS REGION OF KENTUCKY

As might be expected, no extensive prairies exist in Kentucky today. Only a few small areas are left which support colonies of prairie species, and all of these have been moderately to severely disturbed. The historical records indicate that the grasslands disappeared in the early part of the 19th century, and no accounts are in the scientific literature on the species composition and structure of the "original" barrens vegetation. General Land Office Surveys were not made for this portion of Kentucky. Thus, the only evidence for the existence of extensive grasslands in Kentucky are references on early maps and descriptions in the writings of early travelers in the area.

The first complete map of Kentucky was published by Filson (1784). On this map between the Salt and Green Rivers the following statement is printed. "Here is an extensive tract, call'd Green River Plains, which produces no timber, and but little water; mostly Fertile, and cover'd with excellent Grass and Herbage." A map of the state of Kentucky, from an actual survey by Elihu Barker, was published in 1795 and was included in a topographical description of the western territory of North America (Imlay, 1797). On this map a large area between the Green and Great Barren Rivers, in the eastern portion of the Pennroyal Plain, is encircled by a dotted line and the word "Barrens" printed in the center of the area. In the northern portion of the Elizabethtown Area of the Pennyroyal the phrase "Naked Land or Barrens" is written. On Munsell's map (1818) the term "barrens" is written several times on the Pennyroyal.

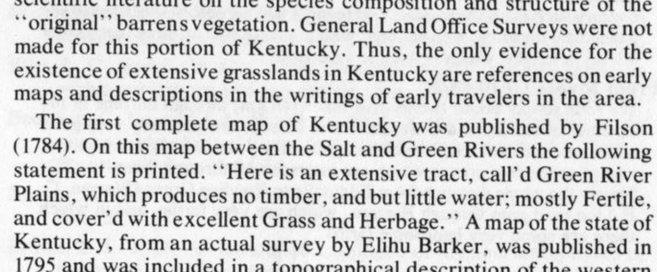

Figure 1. The Big Barrens Region of Kentucky. (Redrawn from Dicken, 1935a.)

Many statements verifying the existence of barrens in the Pennyroyal of Kentucky appear in the writings of early travelers. A selection of quotations from these early authors gives some impression of what the Barrens were like in the late 18th and early 19th centuries:

From Filson (1784:20):

> Below a creek, called Sinking Creek, on this river [Green River], within fifty miles [80 km] of Ohio, towards Salt River, a great territory begins, called Green River Barrens, extending to the Ohio. Most of this is very good land, and level. It has no timber, and little water, but affords excellent pasturage for cattle.

From André Michaux's journal of 1796 in Thwaites (1904:92):

> The 12th passed through a Country covered with grass and Oaks which no longer exist as forests, having been burned every year. These lands are called Barrens lands although not really sterile. The grasses predominate. . . . The 13th of February traveled 37 Miles [59.2 km] without seeing a House through the lands called Barren lands. The *Salix pumila* that grows there in abundance is the same as that which is very common in the Illinois prairies as one leaves Vincennes Post to go to Kaskaskia.

From Louis-Phillippe (1797:110-111) in Becker's translation:

> It [the Barrens] is a high and dry plateau, where trees are sparse and grass and shrubs plentiful. One sees only small, stunted trees, most of them oaks and hickories, and everywhere lush grass dotted with charming flowers. So these Barrens struck us as exceedingly pleasant, and were a happy change from the forests we were so weary of. There are some stands of tall timber, but very few and only along the river banks.

From F. A. Michaux (1805:178):

> From this river [Little Barren, 10 miles or 16 km from the Green River] begin the Barrens, or meadows of Kentucky. [p. 186] On the 27th of August, I set off early in the morning, and thirteen miles [20.8 km] from Kesley's crossed the line which separates the state of Tennessee from that of Kentucky. The Barrens also end there, and, to my great satisfaction, I re-entered the woods; for nothing is more wearisome than the dull uniformity of these immense meadows. [p. 183] The Barrens, or meadows of Kentucky comprize an extent of sixty or seventy miles [96 or 112 km] in length, by fifty or sixty [80 or 96 km] in breadth. Instead of finding a country such as had been described to me, I was agreeably surprized to see a beautiful meadow, well covered with grass, of two or three feet [0.6 or 0.9 m] in height, which is used to feed cattle.

From Joynes (1810:157):

> We rode to-day about twenty-five miles [40 km] through barrens in the counties of Hardin and Grayson. These barrens are generally very good soil, and are covered with excellent grass. They are entirely uninhabited, except at the few groves which are interspersed through them. [p. 223] Nearly the whole distance from Eddyville to Bowling Green (Warren, C. H.) the road goes through Barrens, which are very fertile, and in which there are some very handsome farms.

THEORIES ON THE ORIGIN OF THE BIG BARRENS

Atwater (1819) wrote that prairies and barrens occurred on level land along streams and that trees were excluded from them because the soil was too wet for tree growth. He stated that prairies and barrens occurred on alluvial soil and that the barrens along the Green River in Kentucky occupied soil which the water had made and formerly covered. Wells (1819) quickly responded to Atwater's theory by saying that the Barrens of Kentucky were not on alluvial soil and that he believed fire was the most likely cause of their origin. Many writers including F. A. Michaux (1805), Bourne (1820), Flint (1820), Owen (1856), Shaler (1876, 1885), and Sauer (1927) believed that the Big Barrens were the result of frequent fires set by the Indians. The fires destroyed the original forest vegetation and prevented the regrowth of trees; therefore, grasses and forbes became the dominant vegetation.

Since the Big Barrens were nearly coextensive with the cavernous Mammoth Cave limestone (Davidson, 1840; Miller, 1919; and Dicken, 1935a), Dicken (1935a) and McInteer (1946) thought that there might be some causal relationship between the karstic topography and the grassland vegetation. Sauer (1927) attributed the correlation to the smoothness of the Pennyroyal surface (over which fires could readily spread) rather than to the karstic topography *per se*. McInteer (1942, 1946) thought that the severe drought conditions in the karstic landscape had originally killed the trees and then prairie species invaded. Grasslands then were maintained by the karstic topography which caused the soil to be subjected to more severe droughts than soils in nonkarstic adjacent areas, certain climatic conditions as described by Transeau (1935), and frequent fires. Miller (1927) and Dicken (1935a) also attributed the Barrens to a combination of factors: namely karstic topography; grazing by vast herds of buffalo, deer, and elk; and fires. Finally, Garman (1925) did not believe that fires caused the grasslands in Kentucky. Instead, he thought that the grasslands were an indirect result of glaciation. That is, although the Big Barrens Region of Kentucky was not glaciated, the soil was boggy and cool immediately after the glaciers started to retreat from Ohio, Indiana, and Illinois. These cool, moist soils prevented the growth of trees and favored the growth of sedges. In time as the land became higher and drier, a climax vegetation of tall grasses and composites appeared. Garman considered the Kentucky grasslands to be merely an outlier of the midwestern prairies and their origin and species composition the same.

PRESENT STATUS OF THE VEGETATION

When the Pennyroyal was settled in the late 18th century, "the regular hunting expeditions of the Indians into Kentucky were arrested, as they were in about 1790, this region, relieved from further firing, began to spring up in forest again" (Shaler, 1885:30). According to Shaler (1885:29), "the swift return of the forests after the Indian fires were stopped caused a large part of this prairie country to be rewooded before it could be subjected to the plough." Writings of early observers contain statements regarding the reforestation of the Big Barrens Region. Dana (1819:90) observed that the Barrens which "a few years since exhibited the appearance of a beautiful praira, destitute of timber" now had a "growth of various kinds of trees . . . ." Reverend Robert Davidson (1840 :31-32) on an excursion to the Mammoth Cave and Barrens of Kentucky wrote, "With the advancing settlement of the country, the prairie fires were gradually extinguished, and young timber had liberty to grow. The consequence is, that tracts which were destitute of shade ten or twenty years since, are now covered with extensive forests of Black Jack or scrub oak . . . ." Short (1845:187) wrote that the Kentucky Barrens are "tracts of country which seem to be in a state of transition from open prairies to densely timbered forests." In his study of the botany of Barren County, Hussey (1876) commented on the small size of the oaks which he attributed to the recent reintroduction of forests into the Barrens.

Although little information is available on the composition and structure of the forests of the Big Barrens Region, several authors who published after the mid-1800's have noted the kinds of trees that grew in them. Owen (1856:83) recorded "varieties of oak, black Hickory, and occasionally Butternut, *juglans cathartica;* Black Walnut, *juglans nigra;* Dogwood, *cornus florida;* Sugar-tree, *acer saccharinum* . . . ." Hussey (1876:34) commented on the forests of the former Barrens in Barren County that "The most of the oaks are of the following species: *Quercus, coccinea, rubra, nigra*—the latter species very numerous. *Alba* is found, but not abundant; also *imbricaria* and *obtusiloba*, about the numerous sinkholes. I saw no tulip trees, linn, beech, black walnut, or butternut." Sargent (1884) mentioned the abundance of black oaks of various species, but said that there were not very many white oaks; and that walnuts, yellow poplar, and beech were missing from the young forests. Recently, Bougher and Winstead (1974) studied the structure and composition of a 5.9 ha old-growth climax forest on a nearly level section of land within the Big Barrens Region at Bonayer in Barren County. This forest had 24 species in the tree size class (> 5 cm dbh) and had not been disturbed since about 1790. It was characterized as an oak forest, and the dominant species was *Quercus alba* with an Importance Value of 61.3 out of 300. Other canopy species with an Importance Value of 20 or more were *Nyssa sylvatica, Carya ovata, Liquidambar styraciflua,* and *Liriodendron tulipifera*. Bougher and Winstead (1974:54) concluded that the ". . . Bonayer Forest is typical of what the vegetational composition would be in south central Kentucky if this area were left undisturbed by man."

The vegetation of the Big Barrens Region today consists primarily of agricultural crops (corn, soybeans, winter wheat, tobacco, and hay), pastures, secondary oak forests, and abandoned pastures and old fields in various stages of secondary succession. A few societies of prairie and cedar glade plants have been located in small areas where the soil is too shallow, rocky and/or steep to cultivate. However, even these areas have been moderately to severely disturbed by pasturing.

We have prepared floristic lists for several areas in the former Big Barrens Region in Hart, Logan, and Simpson Counties where a number of species characteristic of prairies and/or cedar glades occur (Baskin and Baskin, 1978). An unpublished floristic list of a rocky prairie area in Hardin County has been prepared by Ray Cranfill of the University of Kentucky. A composite list from the five sites (two in Logan County and one each in Hart, Hardin, and Simpson Counties) has been compared with the species lists in 23 articles published on prairie sites throughout much of Transeau's Prairie Peninsula. Table 1 is a list of the species collected from the five sites in Kentucky which also occurred on three or more species lists from the Prairie Peninsula north and west of Kentucky. In preparing the list we made an effort to exclude both native and alien species that occur as "weeds" in prairies. Unless authorities are given for the species listed in Table 1 or mentioned in the remainder of the paper, nomenclature follows Fernald (1950).

The characteristic prairie grasses that occur at the Kentucky sites are *Andropogon gerardii*, *A. scoparius*, and *Sorghastrum nutans*. Principal prairie species (Weaver, 1954) that are conspicuously absent include *Bouteloua curtipendula*, *Calamagrostis canadensis*, *Elymus canadensis*, *Koeleria cristata*, *Panicum virgatum*, *Spartina pectinata*, *Sporobolus heterolepis*, and *Stipa spartea*. However, *Bouteloua curtipendula*, *Elymus canadensis*, *Panicum virgatum*, *Spartina pectinata* (Braun, 1943), and *Koeleria cristata* (Browne and Athey, 1976) have been collected elsewhere in Kentucky. The characteristic prairie forbs listed by Weaver (1954) that also occur at the Kentucky sites are *Antennaria plantaginifolia*, *Asclepias verticillata*, *Aster azureus*, *Cicuta maculata*, *Echinacea pallida*, *Eryngium yuccifolium*, *Euphorbia corollata*, *Fragaria virginiana*, *Helenium autumnale*, *Heliopsis helianthoides*, *Hypoxis hirsuta*, *Kuhnia eupatorioides*, *Lespedeza capitata*, *Liatris squarrosa*, *Linum sulcatum*, *Lobelia spicata*, *Oxalis violacea*, *Petalostemon candidum*, *P. purpureum*, *Phlox pilosa*, *Physalis heterophylla*, *Pycnanthemum flexuosum*, *Ratibida pinnata*, *Rudbeckia hirta*, and *Senecio plattensis*. Many species of forbs that Weaver (1954) considered to be characteristic of true, undisturbed prairies were not present on the Big Barrens sites.

A number of forbs characteristic of prairies in the Prairie Peninsula (Table 1) were present at our sites in the Big Barrens Region, but they were not listed as principal prairie species by Weaver (1954). Included in this list are these species: *Allium cernuum*, *Apocynum cannabinum*, *Asclepias tuberosa*, *A. viridiflora*, *Aster novae-angliae*, *A. oblongifolius*, *A. sericeus*, *Cirsium discolor*, *Coreopsis tripteris*, *Liatris aspera*, *Lithospermum canescens*, *Monarda fistulosa*, *Parthenium integrifolium*, *Scutellaria parvula*, *Silphium terebinthinaceum*, *Solidago nemoralis*, *Spiranthes cernua*, and *Viola pedata*.

ARE THE BIG BARRENS A PART OF THE PRAIRIE PENINSULA?

We believe that the Big Barrens of Kentucky should not be considered a part of the Prairie Peninsula. No evidence is known to indicate that grassland vegetation was ever the climatic climax or even the subclimax (edaphic climax) vegetation of the Big Barrens Region of Kentucky. The quick reinvasion by trees of the fire-maintained grasslands after cessation of burning by the Indians argues against grasses as being climax or subclimax. To the contrary, the following evidence indicates that the climax vegetation is deciduous forest: (1) the only virgin tract of vegetation (the Bonayer Forest) in the Big Barrens Region today is a deciduous forest, (2) the soils were developed under forest and not under prairie vegetation, (3) after the Indians stopped burning the area, tree seedlings quickly became established and when left undisturbed the trees grew to maturity, (4) when agricultural land is abandoned or when road and railroad rights-of-way are left untended, secondary succession is toward forest vegetation, and (5) the climate is optimal for growth of deciduous forests.

In Kentucky today, plant species characteristic of the prairie north and west of Kentucky are restricted to regularly mowed roadsides and corners of fields, railroad rights-of-way (mowed or burned), badly eroded sites in old fields, and to soils too shallow and rocky for development of forests. Since prairie plants in Kentucky are not restricted to areas formerly thought to be a part of the Barrens, their indicator value of presettlement prairie vegetation is limited. In fact, one of the best colonies of prairie species, in terms of number of species, that we have located in Kentucky is on a railroad rights-of-way in Grayson County outside the Barrens.

SUMMARY

Historical evidence indicates that much of the Pennyroyal Plateau in Kentucky was grassland when the area was settled in the late 18th century, and thus Transeau (1935) considered the Big Barrens to be part of the Prairie Peninsula. These grasslands were not a climatic or edaphic climax but were maintained by fires set by the Indians. When burning of the area ceased, land that was not used for agricultural purposes quickly returned to deciduous forests, which is the climatic climax of the area. A few colonies of plant species characteristic of the Prairie Peninsula still exist in small areas of the former Big Barrens Region where the soil is too shallow for the establishment of trees and in other places where man's activities have slowed or stopped secondary succession. However, since (1) deciduous forest is climatic climax over the entire former Big Barrens Region, (2) grasslands are not even subclimax (or edaphic climax, except possibly in small "islands" or shallow, rocky soils), and (3) the soil was developed under a forest cover, we conclude that the Big Barrens of Kentucky should not be considered as a part of the Prairie Peninsula.

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Table 1. Names of herbaceous plant species collected from prairie—cedar glade sites in the Big Barrens Region of Kentucky that occur on at least three floristic lists from prairies within the Prairie Peninsula. Complete references are provided in the "literature cited" section.

	Illinois				Indiana	Iowa			Michigan					Missouri		Ohio			Wisconsin				
	Sampson, 1921	Paintin, 1929	Vestal, 1914	Gates, 1912	Bliss & Cox, 1964	Shimek, 1911	Conard, 1952	Shimek, 1925	Thompson, 1968	Haynes, 1964	Thompson, 1975	Gleason, 1917	Brewer, 1965	Hurd & Christisen, 1975	Drew, 1947	Sears, 1926	Jones, 1944	Hurst, 1971	Curtis, 1956	Curtis & Green, 1949	Thomson, 1940	Green, 1950	Curtis, 1959
Allium cernuum	x	x	x	x	x	x					x					x		x					x
Andropogon gerardii	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
A. scoparius	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Antennaria plantaginifolia	x		x			x	x	x			x						x						
Apocynum cannabinum	x	x	x	x		x	x	x	x	x	x		x		x	x	x		x			x	x
Asclepias tuberosa	x		x	x		x	x	x			x					x	x	x			x		x
A. verticillata	x		x			x	x	x			x				x	x			x	x		x	x
A. viridiflora	x			x		x	x	x			x				x		x					x	x
Aster azureus		x		x			x	x			x		x	x			x	x	x	x			x
A. oblongifolius		x				x	x	x									x		x				x
A. novae-angliae	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x			x
A. sagittifolius							x						x				x						
A. sericeus	x		x			x	x	x			x								x	x	x	x	x
Cassia fasciculata					x		x								x								x
Cicuta maculata	x	x	x			x	x	x	x	x	x		x						x	x			x
Cirsium discolor	x		x			x		x	x	x	x					x	x	x	x	x		x	x
Coreopsis tripteris	x					x	x	x	x		x	x	x			x	x	x					
Cypripedium candidum							x				x	x						x					
Delphinium virescens						x	x							x									x
Echinacea angustifolia						x	x			x													
E. pallida	x					x	x	x							x	x						x	x
Elymus virginicus							x	x															
Eryngium yuccifolium	x	x	x	x	x	x	x	x			x		x	x	x		x		x	x		x	x
Eupatorium altissimum						x	x				x							x				x	x
Euphorbia corollata	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fragaria virginiana	x	x	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x		x	x
Gerardia tenuifolia				x		x					x					x							
Helenium autumnale	x			x			x	x	x	x	x												x
Helianthus hirsutus						x									x		x				x		
H. mollis	x										x			x	x								
Heliopsis helianthoides	x		x			x	x		x		x	x					x	x	x			x	x
Hypoxis hirsuta	x	x	x	x		x	x	x		x	x		x	x	x		x		x	x			x
Krigia biflora	x	x	x			x	x													x			
Kuhnia eupatorioides	x	x				x	x	x			x					x	x		x	x	x	x	x
Lespedeza capitata	x		x	x		x	x	x	x		x				x	x	x		x	x	x	x	x
Liatris aspera							x		x		x			x				x	x	x			x
L. spicata	x	x	x	x							x	x	x			x	x	x					
L. squarrosa	x					x	x	x								x	x						
Linum sulcatum	x					x	x								x		x		x		x		x
Lithospermum canescens	x	x	x	x		x	x	x			x			x			x		x	x		x	x
Lobelia spicata	x	x	x	x		x	x	x	x	x	x		x	x	x	x	x	x	x			x	
Monarda fistulosa	x					x	x	x	x		x		x				x	x	x	x		x	x
Oxalis violacea	x	x				x	x	x							x		x					x	x
Parthenium integrifolium	x	x	x			x		x							x								x
Penstemon hirsutus	x					x	x			x	x							x					
Petalostemum candidum	x	x		x		x	x	x						x	x				x		x	x	x
P. purpureum	x	x	x	x		x	x	x						x	x				x	x	x	x	x
Phlox pilosa	x	x	x	x	x	x	x	x	x		x			x					x	x		x	x

Table 1. (cont.) Names of herbaceous plant species collected from prairie—cedar glade sites in the Big Barrens Region of Kentucky that occur on at least three floristic lists from prairies within the Prairie Peninsula. Complete references are provided in the "literature cited" section.

	Illinois				Indiana	Iowa				Michigan				Missouri		Ohio			Wisconsin				
	Sampson, 1921	Paintin, 1929	Vestal, 1914	Gates, 1912	Bliss & Cox, 1964	Shimek, 1911	Conard, 1952	Shimek, 1925	Thompson, 1968	Haynes, 1964	Thompson, 1975	Gleason, 1917	Brewer, 1965	Hurd & Christisen, 1975	Drew, 1947	Sears, 1926	Jones, 1944	Hurst, 1971	Curtis, 1956	Curtis & Green, 1949	Thomson, 1940	Green, 1950	Curtis, 1959
Physalis heterophylla	x						x				x						x					x	x
Physostegia virginiana	x		x													x							
Polygala senega		x					x	x			x												
Pycnanthemum flexuosum	x				x	x		x							x	x	x						
Ratibida pinnata	x	x	x	x		x	x	x	x		x		x		x	x		x	x	x	x	x	x
Rosa carolina	x				x					x	x												
Rudbeckia hirta	x	x	x	x		x	x	x	x	x	x		x			x	x	x	x	x			x
Scutellaria parvula	x					x	x	x							x		x		x	x	x		
Senecio plattensis		x				x	x	x									x						
Silphium terebinthinaceum	x	x	x	x	x				x		x	x				x	x	x	x			x	x
S. trifoliatum		x														x	x						
Sisyrinchium albidum											x				x			x					
Solidago nemoralis	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x		x	x		x	x
Sorghastrum nutans	x	x	x	x		x	x	x	x		x	x		x	x	x	x	x	x	x	x	x	x
Spiranthes cernua	x	x	x			x	x			x	x			x	x			x					
Viola pedata	x					x	x	x			x			x					x			x	x

THE LIVING PRAIRIE

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Dr. Durward L. Allen presented his paper after the banquet of the Sixth North American Prairie Conference on 15 August 1978. His talk was based on two of his publications:

Allen, Durward L. 1967. The life of the prairies and plains. Our Living World of Nature Series. McGraw-Hill Book Company, N.Y., N.Y. 232 p.

__________ . **1976.** The hole in the system: A great plains national park, p. 5-8. *In* Robert M. Linn. Proceedings of the First Conference on Scientific Research in the National Parks. Vol. 1. 680 p.

PERSONAL RECOLLECTIONS OF THE OHIO NATURAL VEGETATION SURVEY

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In 1921 I began to study the flora of Ohio when I made the acquaintance of a group of central-Ohio naturalists who belonged to the Wheaton Club. This organization, named in honor of James M. Wheaton, M.D., a distinguished lecturer in the Starling Medical College and early writer on the birds of Ohio, promoted the study of natural history. Like John James Audubon, Wheaton collected birds and preserved the specimens as "skins." Two of this symposium's speakers, Edward S. Thomas and Milton B. Trautman, have been among the most active and long-lived members of the Wheaton Club. Another active member was the late Arthur R. Harper, then an auditor for the Ohio State Life Insurance Company. He conducted weekend hikes for Boy Scout leaders. While an upperclassman at The Ohio State University, I took advantage of those trips in 1921 and 1922. Art Harper was equally informed regarding native trees, shrubs, wildflowers, and ferns. As that was my first introduction to botany, I learned a great deal from him. Between 1921 and 1926, I kept field notebooks on the plants and birds of central Ohio. During any one year, I observed no more than 140 kinds of birds and about 600 species of seedbearing plants and ferns that occurred in the counties of south-central Ohio.

In 1926 I became an instructor in the Department of Botany at The Ohio State University, where Dr. Edgar N. Transeau, my mentor, was chairman of the department. That same year Paul B. Sears (1926a, b) published the second and third parts of his paper, *The Natural Vegetation of Ohio*, which dealt specifically with the prairies and plant succession. Simultaneously a plague of the European corn borer *(Ostrinia nubilalis)* posed a threat to the corn *(Zea mays)* production in east-central United States. The Congress of the United States appropriated ten million dollars to fight the plague. This money was used to establish quarantine stations on the main highways that led from areas of heavy infestation and to pay supervisors, field inspectors, and common laborers to monitor the corn harvest in the prairie states, including southeastern Michigan and Ohio. The laborers handpicked the stover and stubble that might contain larval insects and then burned them. "Flame throwers" that had served as offensive weaponry during World War I were used to sear the stubble in larger fields. Thus, millions of dollars were funneled into a quasi-military type of control with no appropriations for research. The problem of researching other phases in the life history and behavior of the European corn borer was adopted by the Bureau of Entomology and Plant Quarantine in the United States Department of Agriculture. In Ohio, the Department of Entomology at the Ohio Agricultural Experiment Station, Wooster, undertook a study of habitat preferences, food plants other than corn, life history, and environmental influences of the corn borer. This research was directed by J. S. Houser, L. L. Huber, and C. R. Neiswander who employed a staff of trained entomologists, soil scientists, and botanists. Among the botanists were Professors Homer C. Sampson and Edgar N. Transeau.

The study of the habitat preferences of the corn borer in Ohio was assigned to Homer C. Sampson and I was his field assistant. We cooperated with entomologists at the field laboratory near Oak Harbor, Ottawa County, where a large acreage of corn had been severely infested. The results of the studies on the corn borer in relationship to its environment in Ohio were published with Sampson contributing as a coauthor of a section on the correlation of the corn borer with vegetational types (Neiswander, Sampson, and Kelsheimer, 1928). One of the study's conclusions was never published probably due to political considerations. Huber asserted that comparative counts showed the corn borer population in selected sample plots to be actually higher the year after the ten million dollars of federal funds had been expended for the "control" program already described. The female corn borer produces about 200 eggs from a single mating. Quarantine officers did not realize that during one summer night the moths could extend their range by about 35 miles beyond the boundaries of any heavily infested area.

Transeau was commissioned in the summer of 1927 to travel in Europe to observe the habitats where corn borer damage was most extensive, and others where little or no damage to the corn crop had been observed. I can still recall an article reporting on his findings in central Europe which was credited to Transeau (1928). Published in *Science News-Letter*, it carried the title, "Prairies may stop borer." The article caused much chagrin to Transeau. No one could appreciate the distinct floristic and edaphic differences between the European steppes and the American tallgrass prairies than could Transeau.

From 1926 to 1930 I was a graduate assistant in the Department of Botany at The Ohio State University. I profited greatly from courses conducted by John H. Schaffner and Transeau. I accompanied Schaffner on field trips to the northeastern counties and assisted him in his studies of *Equisetum* and other pteridophytes of interest to him. In those days graduate students and younger members of the Wheaton Club visited nearby localities of great botanical interest, such as Sugar Grove in the Hocking Hills, south of Lancaster; Buckeye Lake, east of Columbus; the Red Hills, east of Westerville; and the Dallas Arborvitae Bog (now called Cedar Bog), south of Urbana. Transeau accepted my enthusiasm for field botany, and together we studied plants in shallow ponds and prairie sloughs. During the spring months he made a special effort to obtain representatives of the algal genera of the Zygnematales when their remarkable conjugating filaments could be found. I attended Transeau's classes in plant ecology and plant physiology, and in spite of his tutelage I never quite comprehended the distinction between plant zonation, which we observed, and plant succession, which we inferred. Transeau had studied plant ecology under the influential teaching of Henry C. Cowles at the University of Chicago, and I understood that Frederick E. Clements was a classmate. But Transeau had little respect for Clements' ecological concepts and even less respect for his terminology which caused much dispair for students beginning a study of ecology. Based on the distributional data with the plants in the state herbarium, I completed my M.S. thesis on *The Floristic Regions of Ohio* (Gordon, 1928). The Ph.D. degree came later (Gordon, 1931). From 1930 to 1937 I taught courses in general botany and local flora, and conducted many field trips for Transeau's plant ecology class.

At the same time I was teaching in the department and completing the requirements for my degrees, Transeau and Sampson were preparing a reconnaisance map of the natural vegetation of Ohio which included all of the extensive plant associations as nearly as could be determined (Sampson, 1927). They later published a preliminary black and white version of the map (Transeau and Sampson, 1935). After the mid-1930's Transeau and Sampson did little work on the Ohio Vegetation Survey. Transeau continued to advise graduate students who conducted studies on the natural vegetation as part of their thesis or dissertation requirements. Among the students were Gordon S. Crowl, Raymond A. Dobbins, Lawrence E. Hicks, Clyde H. Jones, and John N. Wolfe. Following Transeau's retirement, Wolfe succeeded him as the professor of ecology in the department until he took a position with the Atomic Energy Commission in 1955.

In 1937 I joined the faculty at West Chester State Teachers College, West Chester, Pennsylvania, and through the years I taught a number of basic science courses plus general botany and ecology until retirement. During the spring of 1964, while I was recovering very slowly from major surgery, a letter arrived from John N. Wolfe carrying the surprising news that the Ohio Vegetation Survey was to be "resuscitated." Although weak, I accepted the challenge and began work on the project that summer in the plant ecology laboratory at The Ohio State University. The late Charles A. Dambach, then director of the Natural Resources Institute at the university and also the executive secretary of the Ohio Biological Survey, secured the necessary funds to support me during this first summer. Over the years Wolfe and

[1]Robert B. Gordon died on 11 February 1981.

Bernard S. Meyer, who succeeded Transeau as chairman of the department in 1946, preserved Transeau's large file of reprints, field records, indexed topographic sheets with notations, and his students' theses and dissertations. Dr. Wolfe had maintained a bibliographic card file on Ohio vegetational and floristic studies. These materials aided me considerably in my efforts toward final preparation of the map of the natural vegetation of Ohio. Dr. Dambach offered dynamic leadership in every aspect of the project. In 1965, when it became necessary to fill gaps in the information to complete the map, he secured the assistance of Robert G. Stephenson, executive director of the Research Foundation at The Ohio State University, and together with Dr. Gareth E. Gilbert, we prepared a research proposal to the Environmental Biology Section of the National Science Foundation. The project was funded for a two-year period with the employment of six technical assistants beginning work in July 1965. As described by Gordon (1969:5), these assistants located old survey records extant for many of the counties which had not been studied by Transeau and his students. The information was transcribed onto existing county maps which was later interpreted and incorporated into the preliminary draft.

The final map of the natural vegetation of Ohio (Gordon, 1966) was printed in eight colors in Columbus during the summer of 1966. Hal Flint, cartographer extraordinaire, for the Ohio Geological Survey, assured me that it was the most nearly perfect printing job that he had ever supervised. The bulletin describing the natural vegetation of Ohio in pioneer days was subsequently published (Gordon, 1969).

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GEOGRAPHICAL SETTING OF OHIO PRAIRIES

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Thirty years ago when I was a student at The Ohio State University, Sears (1926) and Jones (1944) had already written on Ohio prairies, and Transeau (1935; Stuckey, 1981: 14) published his map of the Prairie Peninsula. A later map by Transeau (1950; Stuckey, 1981: 11) showed only the areas of prairies in Ohio. It was more than a decade later before Gordon (1966) published his map of the natural vegetation showing locations of original prairie in Ohio. With the appearance of that publication and the companion bulletin, *The Natural Vegetation of Ohio in Pioneer Days* (Gordon, 1969), more individuals began to look seriously at Ohio prairies and to study what remained. Geographically, the prairie remnants in Ohio are located in the area near Toledo, Erie County, Marion County, the west-central portion of glaciated Ohio, Adams County, and three noteworthy very local sites in the southeastern counties of unglaciated Ohio. The prairies mentioned below are located on an Ohio map (Fig. 1) and most of them are described and located with maps in *Prairies of Ohio* (Denny, 1978) or are listed with representative species in *The Prairie Survey Project* (Cusick and Troutman, 1978). The numbers following the name of a prairie refer to Fig. 1.

In the Toledo area of Lucas County remnants include Irwin Prairie State Nature Preserve (1), Schwamberger Preserve (2), Oak Openings Metropolitan Park (3), Crissey Railroad Prairie (4), and Wildwood Estate (5). For example, Irwin Prairie is an Ohio Department of Natural Resources State Nature Preserve acquired with the help of The Nature Conservancy (Lindsay, 1965). A boardwalk makes exploration in this wet prairie convenient. The plant communities have been studied by Tryon and Easterly (1975). Irwin Prairie State Nature Preserve and Schwamberger Preserve have been discussed by Easterly (1981). The area west of Toledo has extensive postglacial fossil sand dunes and beaches, and the prairie plants on the high sand dunes are worthy of exploration in the Oak Openings Metropolitan Park (Forsyth, 1968). In this part of the state, prairie remnants are frequent along many railroad rights-of-way and township roads (Anderson, 1971).

In the Sandusky Bay area of Erie County, is the Castalia Prairie (6; Dachnowski, 1912; Hurst, 1971; Sears, 1967). Part of this once vast prairie still can be seen at Resthaven Wildlife Area (Chapman, 1949). Marl was quarried here for cement production, and the marl pits have now been converted into public fishing ponds and waterfowl production. A portion of the area is tallgrass prairie, of which a part is managed with fire. In a wetter tract a tremendous population of prairie dock (*Siphium terebinthinaceum*) exists. The Castalia Prairie is one of the three known localities in Ohio for the small white-flowered lady's-slipper orchid (*Cypripedium candidum*).

Three prairies are especially outstanding in the Marion County area, although prairie plants grow along railroad and highway rights-of-way in many places (Troutman, 1981). Claridon Prairie or Marion Conrail Prairie (7), formerly called Caledonia Prairie, is located on the Conrail line east of Marion. The Route 95 Railroad Prairie (8) is just west of the Marion city limits and contains Sullivant's milkweed (*Asclepias sullivantii*) and many other prairie species. The largest wet prairie is the Killdeer Plains Wildlife Area (9) northwest of Marion in Wyandot County. It has poorly drained soils caused by the existence of a hardpan formed by an earlier proglacial lake. At the time of settlement, it was virtually all wet prairie. Now owned by the Division of Wildlife, Ohio Department of Natural Resources, the area contains extensive dikes, shallow reservoirs, sizeable remnants of native tallgrass prairie (Ohio Division of Wildlife, 1970a, b), and Ohio's only known population of the prairie garter snake or eastern plains garter snake (*Thamnophis r. radix*) (Conant et al., 1945; Dalrymple and Reichenbach, 1981).

The prairies of the west-central part of Ohio are most familiar to me. Most of these prairies are original, but at least three of them have

1. Irwin Prairie State Nature Preserve
2. Schwamberger Preserve
3. Oak Openings Metropolitan Park
4. Crissey Railroad Prairie
5. Wildwood Estate
6. Castalia Prairie
7. Clarendon Prairie
8. Route 95 Railroad Prairie
9. Killdeer Plains Wildlife Area
10. Glen Helen
11. Aullwood Audubon Center
12. Milford Center Prairie
13. Bigelow Cemetery State Nature Preserve
14. South Charleston
15. Zimmerman Prairie
16. Buck Creek Fen
17. Cedar Bog State Memorial
18. Stillwater Prairie
19. Davis State Memorial
20. Lynx Prairie Preserve
21. The Wilderness
22. Buzzardroost Rock
23. Red Rock
24. Abner Hollow
25. Adams Lake Prairie State Nature Preserve
26. Buffalo Beats
27. Limestone Bank Prairie
28. O.E. Anderson Compass Plant Prairie

Figure 1. Geographical location of some Ohio prairies in relation to the glacial boundary.

been planted since 1960. Two of these are at Glen Helen (10), a nature preserve of Antioch College, Yellow Springs, Greene County, and the third is at Aullwood Audubon Center (11), Montgomery County (Moeller, 1973). The prairies at Glen Helen consist of 2.8 ha (7 acres) in two plots planted on terrain that was hardwood forest at the time of settlement, but they are now managed by burning and maintained as prairie. The prairies were planted by Antioch students in 1965.

Natural prairies are near Milford Center, Chuckery, South Charleston, Selma, and Zimmerman; at Buck Creek Fen and Cedar Bog; and along the Stillwater River. The Milford Center Prairie (12) is located in western Union County along an abandoned railroad right-of-way now occupied by power lines owned by Dayton Power and Light Company. As noted by King (1981 a, b), about 50 species of prairie plants have been recorded from approximately a mile of the right-of-way, the most significant being a large population of royal catchfly (*Silene regia*). Bigelow Cemetery State Nature Preserve (13), is an old cemetery of less than 0.4 ha (1 acre) in northern Madison County (Overton, 1981). Formerly called Chuckery Cemetery, it was the first Ohio prairie I ever visited. This visit was during a plant ecology class field trip in October 1948. For many years, this cemetery was mowed, but now the plants are allowed to come into bloom. Special prairie plants at this site are the royal catchfly, purple coneflower (*Echinacea purpurea*), a gray-headed coneflower (*Ratibida pinnata*), Indian grass (*Sorghastrum nutans*), and big bluestem (*Andropogon gerardii*). A list of the vascular plants in this cemetery prairie has been prepared by Carr (1981).

The prairie near South Charleston (14) extends south past Selma along a 8 km (5 mile) stretch of railroad parallel to U.S. Route 42 in Clark and Greene Counties. Significant here is a stand of the cut-leaved form of the prairie dock. Zimmerman Prairie (15) is along Route 35, west of Xenia, Greene County. In private ownership, it is a prairie-fen association which lies under high voltage power transmission lines and is bounded by two mainline railroads and a four-lane highway (Ramey, 1978). Black-eyed susan (*Rudbeckia hirta*) and prairie dock are dominant members of the prairie element. In northern Clark County, Buckcreek Fen (16), consisting of less than 0.4 ha (1 acre) is located at the base of an esker and supports a great diversity of fen and prairie species. Cedar Bog State Memorial (17), southern Champaign County, is a fen with a distinct prairie element. It is one of the most floristically diverse areas in the state, and has been extensively studied (Frederick, 1974; King and Frederick, 1974). Queen of the prairie (*Filipendula rubra*), one of many of the plants associated with wet and/or mesic prairies, grows there. The Stillwater Prairie (18), located along the Stillwater River, Miami County, was recently acquired by the Miami County Park District. The flora of this prairie remnant is discussed by Huston (1981).

In unglaciated Ohio in the Adams County area, the major preserved prairie sites are the Davis State Memorial, owned by the Ohio Historical Society; Lynx Prairie, The Wilderness, Buzzardroost Rock, Red Rock, and Abner Hollow. All of these sites, except Davis State Memorial, were acquired by The Nature Conservancy, and are now owned and managed by the Cincinnati Museum of Natural History. Adams Lake Prairie State Nature Preserve (25) is a site belonging to the Division of Natural Areas and Preserves, Ohio Department of Natural Resources. The prairie vegetation in this area of the state has been discussed by Braun (1915) and Cusick (1981).

Davis State Memorial (19) is mostly woodland, although a few small prairie openings are present (Stein, Undated). It is the unsprayed and unmowed roadsides nearby that are really striking, where the purple coneflower and the false aloe (*Agave virginica*) can be seen on the berm and in the adjoining abandoned fields.

Lynx Prairie (20), known also as the E. Lucy Braun Preserve, is probably the best known prairie site in Adams County (Braun, 1967) and probably the most difficult to locate. It is reached by a trail through a stand of pine at the rear of the East Liberty Church and Cemetery, just south of the village at Lynx. At that location the soils are derived from the Ohio Black Shale, but the prairie openings, or cedar glades, are down slope on the contour that is above the massive Peebles Dolomite. The first opening is known as the North Prairie. It has a marvelous progression of prairie plants that bloom from early spring until frost, for example, shooting-star (*Dodecatheon meadia*), rattlesnake master (*Eryngium yuccifolium*), blazing-star (*Liatris squarosa*), and rigid goldenrod (*Solidago rigida*). Other openings connected by trails have equally spectacular prairie plants.

Nearby are two prairies perched on the top of cliffs which are quite sensitive and, consequently, are no longer open to the general public. The best known of these is Buzzardroost Rock (Durrell, 1974), described 50 years ago by Braun (1928). It has a very delicate ecosystem which cannot withstand the abuse of hundreds of sightseers, and therefore, should be visited only for scientific purposes. Nearby, Red Rock is also a fragile area that requires protection. The cylindric blazing-star (*Liatris cylindracea*) grows here at the interface of the Ohio Black Shale and the Peebles Dolomite above the red-stained cliffs. On the slope of the upper valley behind Red Rock, wood lily (*Lilium philadelphicum*) occurs. Abner Hollow, a few kilometers to the south, is another lovely preserve with prairie openings and second growth hardwood forest.

Adams Lake Prairie State Nature Preserve (25) is about 1.6 km (1 mile) north of West Union off State Route 41. When I was with the Division of Parks and Recreation, Ohio Department of Natural Resources, ten years ago, I received a short letter from the late Dr. E. Lucy Braun which in effect said, "Do you know there is a prairie right over your fence at Adams Lake State Park?" Everyone in the office said, "Huh? Prairie? Where?" We went to the park and climbed over the fence, and sure enough, there was a prairie on a highly eroded calcareous shale slope. This site was one of the first preserves acquired by the new Division of Natural Areas and Preserves after its creation in 1970. Especially striking at this prairie is the abundance of prairie dock and mounds of the Allegheny mound ant (*Formica exsectoides*). Many other unprotected remnant prairies are in the area just north of West Union.

Three small areas of prairie openings in unglaciated southeastern Ohio are noteworthy. Buffalo Beats (26) in the Wayne National Forest near Athens, Athens County, is an unusual small prairie opening surrounded by mixed oak forest (Wistendahl, 1975, 1981). Limestone Bank Prairie (27), near Barnesville, Belmont County, is the easternmost relict prairie known in Ohio. The third site, O.E. Anderson Compass Plant Prairie (28), is among mixed oaks and pines on a west-facing hillside near the crossroad town of Wilgus in the southernmost part of the state in Lawrence County. Here the compass plant (*Silphium laciniatum*), disjunct by many kilometers to the west in Indiana and Kentucky (Cusick, 1978), grows in association with other prairie plants.

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E. Lucy Braun at Lynx Prairie

E. Lucy Braun at Lynx Prairie, E. Lucy Braun Preserve in Adams County, Ohio. (From a color slide taken by John H. Melvin, Oct. 1967. Print in the possession of R. L. Stuckey.)

GEOLOGICAL SETTING OF OHIO PRAIRIES

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For prairies, or for any kind of plants or animals, the geologic setting is fundamental. Geology involves (1) materials, such as rocks, minerals, and soils, which translate into biology as substrates; (2) processes, such as erosion and deposition by streams, glaciers, and waves, and also mountain-building activities, which translate into biology as natural disturbance and creators of landscape and aspect; and (3) history, the record of past landscapes and life, which reveals past distributions, migrations, and evolution of species, which in turn determines which organisms will be available to populate any area.

Prairies are usually thought of as being associated with dry climates, a concept difficult to argue against when the great expanse of prairies on the relatively dry Great Plains of western United States is considered. In Ohio, however, deep in the mesic deciduous forest of eastern North America, the climate is not dry, but is characterized by considerable amounts of rainfall. Actually, it is not the amount of rainfall that makes the difference, but the amount of soil moisture available to the plants. The amount of this soil moisture depends on how much rainwater actually penetrates into the ground, which is related both to the permeability of the geologic materials forming the substrate and to the slopes. Steeper slopes and slopes with south-facing aspects, both a result of geologic erosion, help to reduce soil moisture. Thus in Ohio, despite the moist climate, excessively well-drained substrates, especially on higher, well-drained, south-facing sites, may support dry prairies, the critical dry conditions being created by the local geologic conditions. In contrast, such permeable substrates at lower elevations tend to hold water and thus to be very wet. In addition, of course, prairies occur only where past geologic history has made the seeds of prairie plants available. A brief survey of Ohio's bedrock, regolith, and topography may help to identify the nature of such geologic controls in this state.

Ohio's bedrock is all sedimentary rock of Paleozoic age — mainly limestone (oldest), shale, and sandstone (youngest). These rock layers lie almost flat, being bent into a very broad low arch, with dips of less than one degree on each side (Figure 1). The crest of this arch extends generally north-south through western Ohio, passing almost through the city of Cincinnati, hence its name, the Cincinnati Arch. Subsequent erosion has cut deepest where the arch stood highest, along its crest in western Ohio, exposing the oldest bedrock, the limestone, there. In eastern Ohio, on the eastern flank of the arch (the western flank lies outside Ohio), erosion has not cut as deep, removing less of the overlying rock and exposing only the youngest, sandstone bedrock; the oldest rock, the limestone, remains deeply buried here (Figure 1). The shale, which occupies a position intermediate in position and age relative to the limestone and sandstone, is exposed along a north-south belt through central Ohio.

The erosion that removed so much of this bedrock, especially in western Ohio, was done by a preglacial stream system, the Teays River system. This stream headed in the Appalachian Mountains (the present New River) and flowed northwestward into Ohio and then westward across Indiana and Illinois, probably joining the preglacial Mississippi River. It lasted about 200 million years (all of the Mesozoic and most of Cenozoic time) and was only destroyed when its northward-going course in Ohio was blocked by the first (Kansan?) of the southward-advancing glaciers of the Pleistocene Ice Age, somewhat less than a million years ago.

These Ice Age glaciers extended southward across Ohio as far as Cincinnati, but they did not cover all the state. The limestone bedrock of western Ohio, on the deeply eroded crest of the Cincinnati Arch, is not very resistant to erosion and so had been worn down almost flat during preglacial times by the Teays River and its tributaries. Thus the flat surface on this limestone bedrock offered no deterrent to the advancing ice. In contrast, the sandstone bedrock of eastern Ohio is quite resistant to erosion and thus had been dissected by the Teays River and its tributaries into hills which subsequently blocked the flow of the glacier, preventing it from advancing very far southward in eastern Ohio.

These different kinds of bedrock formed substrates that are very different, although all are dry. The limestone is solid, but contains small cave-like openings, made by solution, that allow water to drain quickly down through the rock, so that it makes a very xeric substrate. The sandstone is also very permeable, and in addition it characteristically occurs as steep hillslopes, intensifying the dryness of the substrate it forms. Shale is not permeable, but also typically forms low hills from which rainwater quickly drains away. Thus, if Ohio's different bedrocks were the only substrates, prairies would presumably have been much more extensive in the state. That Ohio's substrates are not all so dry is due largely to the overlying regolith, composed dominantly of the deposits left by the Ice Age glaciers.

Wherever the glacial ice covered Ohio, it left impermeable till, composed of clay with an unsorted admixture of silt, sand, pebbles, and boulders that represented the glacier's non-ice contents. Where the ice melted, these rock materials were dumped, forming the regolith called till. Preglacial valleys were filled with till, leveling the preglacial landscape by deposition. Thus, the flatness characteristic of most of western Ohio is due to till deposition and *not* to glacial erosion. As a result, new, flat, poorly drained substrates of impermeable till were substituted for the old, preglacial, excessively well-drained bedrock substrates now buried by the till.

Locally gravel deposits were created by glacial meltwater washing and reworking the till. Gravel washed into crevasses (cracks) in the glacier, forming hills called kames, or washed into narrow tunnels in the ice, forming eskers. Gravel also washed down valleys leading away from the glacier, partially filling these valleys with a deposit called outwash, which now, due to recent stream dissection, generally occurs in terraces. Where any of these gravel deposits now stand at low elevations, they are generally saturated by ground water, creating very wet substrates, but where they stand higher, in the form of kames, or eskers, or hill-shaped erosional remnants of outwash, potential dry prairie sites are created, especially on high south-facing slopes. In addition, wherever the underlying bedrock of sandstone or limestone is exposed locally, for some reason lacking a cover of till even though the glacier did cover it, additional possible dry prairie sites are provided.

Adams County in the southern part of the state is especially well known for its prairies because this area contains the one region in Ohio where dolomite (magnesium-bearing limestone) bedrock was never covered by the glacier because it lay so far south. As a result, an array of especially unusual prairie plants occurs, as reported in many publications by Dr. E. Lucy Braun. Notable among the prairies in this area are Lynx Prairie, where dry dolomite is abundantly exposed, and Buzzardroost Rock, a high dry rocky promontory of dolomite.

Dry prairie also occurs locally elsewhere in Ohio on sandstone hills, kames or eskers, or eroded outwash remnants. Most of these, however, are too small to be individually named or mapped, or to appear in the published list of the state's prairies (Cusick and Troutman, 1978).

Strangely, most of Ohio's prairies are not dry prairies, but *wet* prairies. Indeed, it has been estimated that 70-80 percent of the state's prairies are wet or mesic. Some of the wettest ones are really marshes. Though some might question calling marshes prairies, some of the prairies mapped on Ohio's vegetation map (Gordon, 1966) are indeed marshes, because the earliest land surveys, from which much of the data for the map were taken, called them "prairies" or "treeless." Other areas are less wet and even today contain truly dramatic remnants of the more extensive mesic prairies.

These wet or mesic prairies typically occur on flat, poorly drained, clayey till plains; on old lake plains; or in wet spring-fed sites. The extensive areas of prairies west of Columbus, including Selma Prairie, Zimmerman Prairie, and Bigelow (Chuckery) Cemetery State Nature Preserve, are all on poorly drained till plain. Lake-plain prairies include the Killdeer Plains, occurring on lake clays, and Irwin

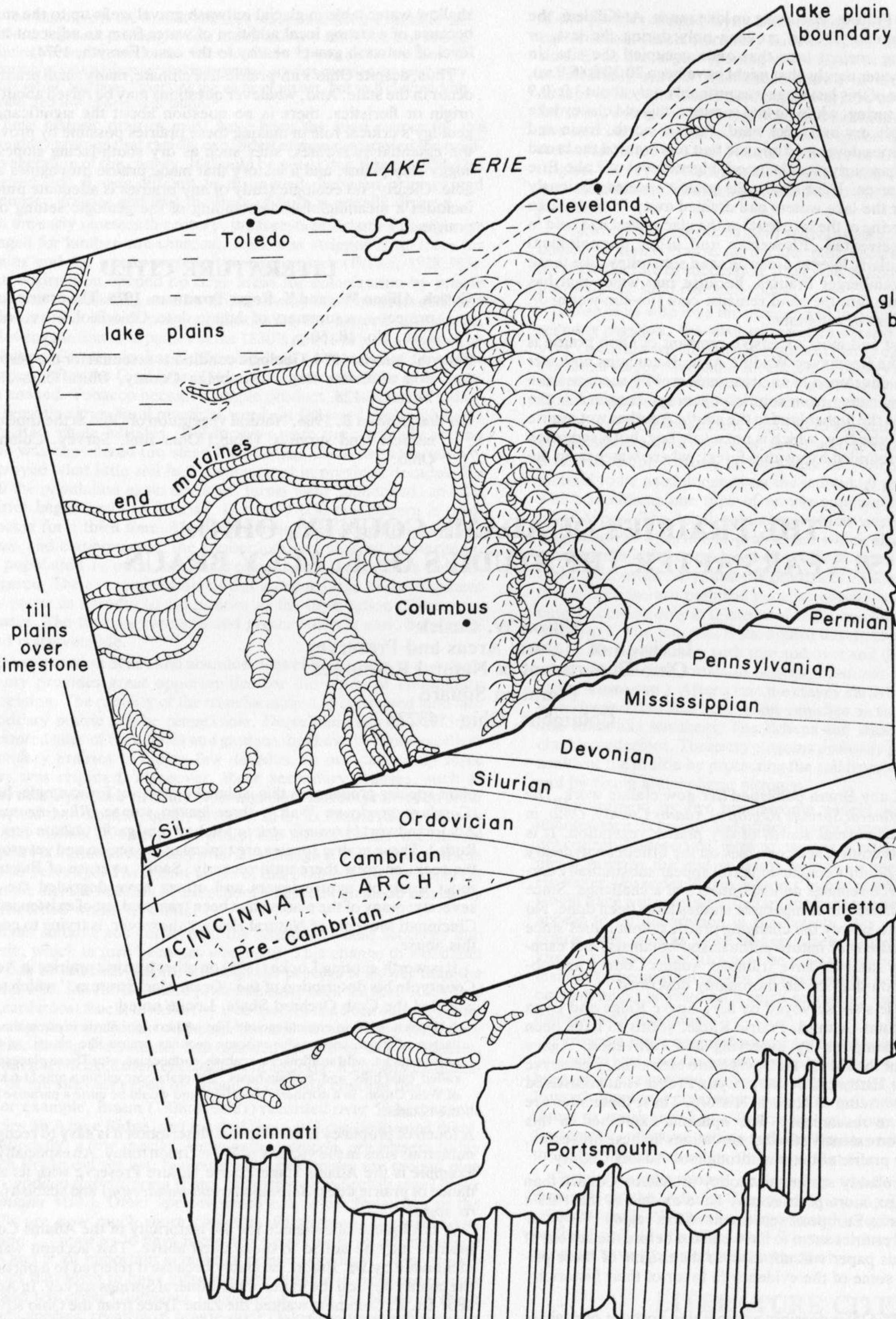

Figure 1. Geological setting of Ohio. (Drafting by Diann Lind.)

and Schwamberger Prairies, occurring on lake sands. At Killdeer, the prairie plants presumably began growing only during the last, or lowest, stage of the ancient lake that once occupied the site. In contrast to earlier water depths that might have been 20-30 ft (6-9 m), the water at the time of this last stage was probably only about 3 ft (0.9 m) deep during the spring, while, in late summer, this old clayey lake bottom was probably dry and brick-hard. Farther north, Irwin and Schwamberger Prairies developed on sand that represented the broad offshore deposit of an early, ice-dammed, higher level of Lake Erie known as Lake Warren. Here again, the prairie species obviously appeared only after the lake waters had drained away from the area because of the lowering of the lake level as the glacier that had held in the lake waters retreated. Flowering and other phenological phenomena are regularly later at areas on sand substrates, like those at Irwin and Schwamberger Prairies, because rain water that has soaked quickly down into the sand remains cool (un-sun-warmed), retarding related plant development.

Probably the best and most extensive remnant of Ohio prairie is that at Castalia in the Resthaven Wildlife Area. It contains both wet and mesic prairies, developed in an area made wet by seepage from springs of water emanating from solution openings dissolved in the limestone that forms the higher land to the south. Another wet prairie in Ohio occurs at Cedar Bog, which is not a true bog, but a sedge fen and wet prairie surrounded by swamp forest, where water from the shallow water table in glacial outwash gravel wells up to the surface because of a strong local addition of water from an adjacent higher level of outwash gravel nearby to the east (Forsyth, 1974).

Thus, despite Ohio's un-prairie-like climate, many small prairies do occur in the state. And, whatever questions may be raised about their origin or floristics, there is no question about the significance of geology's critical role in making these prairies possible by providing the essential substrates, sites such as dry south-facing slopes and soggy clay plains, and a history that made prairie propagules available. Clearly, no ecologic study of any prairies is adequate unless it includes a meaningful understanding of the geologic setting of the prairies.

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THE PRAIRIES OF ADAMS COUNTY, OHIO: 50 YEARS AFTER THE STUDIES OF E. LUCY BRAUN

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In 1928 Dr. E. Lucy Braun published her now classic work, *The Vegetation of the Mineral Springs Region of Adams County, Ohio*, in which she described several stands of dry prairie vegetation. It is appropriate that this conference convenes on the fiftieth anniversary of her publication. Braun's conclusions still appear substantially correct, and her research remains an inspiration and a challenge. Since this work was published, no comparable studies have been done. No one has attempted to survey the changing prairie communities since 1928, although hundreds of nature enthusiasts, botanists, and especially Braun's own students have tramped Adams County and observed the vegetation that she so thoroughly described.

Two of the prairie sites surveyed by her, Agave Ridge and Lynx Prairie, are still extant. A third, Prairie Ridge, seems to have been altered beyond redemption by quarrying and cultivation. Agave Ridge is a portion of the Edwin H. Davis State Memorial, a preserve owned by the Ohio Historical Society; Lynx Prairie is administered by the Cincinnati Museum of Natural History. Thus, these sites are readily accessible to researchers. The opinions expressed in this paper are based upon extensive field observations in these preserves, as well as in other prairie situations throughout Adams County.

More prairies probably are present today in Adams County than existed 50 years ago; more prairies may have existed in the 1920's than occurred prior to European settlement of this region. Very few primary or historic prairies seem to have existed before the advent of the Europeans. This paper will not discuss the origins of these primary prairies, but some of the evidence in favor of their historicity will be recounted.

Braun cited (1928:425) a possibly exaggerated account of prairies from a pioneer's recollections. However, the best source is Dr. John Locke (1838), a geologist who in 1837 surveyed a broad portion of southwestern Ohio for the Ohio Geological Survey and who also noted prairie vegetation. He referred to Adams County as "terra incognita" even to Ohioans. His observations were detailed and accurate, and his prose remains eminently readable. Locke ascended Buzzardsroost Rock, which he termed "Split Rock," and listed the plant species growing on this isolated exposure; for example, hazel, (*Corylus americana* Walt.), three-leaved sumac (*Rhus aromatica* Ait.), sandwort (*Arenaria stricta* Michx.), and garlic (*Allium cernuum* Roth.). These prairie species are typical of the region and yet grow on the rock, or grew there until recently. Sadly, overuse of Buzzardsroost Rock by nature lovers and others have degraded the area severely; many of the plants have been trampled out of existence. The Cincinnati Museum of Natural History, however, is trying to correct this abuse.

It is worth quoting Locke (1838) on other historic prairies in Adams County. In his description of the "Great Marl Stratum," which today is called the Crab Orchard Shale, Locke noted:

> When it is left in conical mound-like outliers, the marle is often almost barren of trees, and produces some peculiar prairie like plants, as the prairie docks, wild sunflowers, scabish, rudbeckias, etc. These places are called 'bald hills' and 'buffalo beats'. Several occur within a mile [1.6 km] of West Union, in a northerly direction, and would be quite a paradise for the botanist.

A touch of prophecy is here! In this description it is easy to recognize numerous sites in the vicinity of West Union today. An especially fine example is the Adams Lake Prairie Nature Preserve with its abundance of prairie dock *(Silphium terebinthinaceum)* and scabish *(Liatris spp.)*

A third piece of evidence for the historicity of the Adams County prairies may be added to those cited above. This account was not mentioned by Dr. Braun, probably because it referred to a portion of the county beyond the limits of her Mineral Springs survey. In August 1807 Dr. F. Cumming walked the Zane Trace from the Ohio River at Aberdeen to Sinking Spring at the Adams-Highland County line. His recollections are quoted in Evans and Stivers (1900:127-131). Cumming's most significant observations refer to the land about present-day Locust Grove in Franklin Township in northeastern Adams County. The property owner's names in the quote below can be identified in Evans and Stivers as being in that area along the Trace, approximately the modern State Route 41.

> The land here is the worst I had seen since I had left the banks of the Ohio: it had been gradually worse from about two miles [3.2 km] behind Squire Leedom's, and for the last two miles [3.2 km] before we came to Marashon's it had degenerated into natural prairies or savannas, with very little wood, and none deserving the name of timber, but well clothed with brush and low coarse vegetation.

These historic prairies must have been the seed source for the secondary prairies that rapidly expanded as man devastated the original vegetation of the county. It should be noted that Braun (1928:426) believed that it was difficult to distinquish between primary and secondary prairies and that the flora of both is equally diverse.

In the early nineteenth century, the forests of Adams County were ravaged for lumber and charcoal. Bark was stripped from trees for tanning and the trunks were left to rot in place (Braun, 1928:383). Such destruction opened up large areas for colonization by prairie species as the resulting erosion stripped away the thin forest soils and re-created the xeric, rocky conditions of the historic grasslands. Following the financial panics of the 1830's and 1840's, the population of Adams County declined, allowing land to revegetate for a few decades. After the Civil War (1861-1865), a second wave of destruction ensued. Tobacco became a staple product, as it remains today, but sensible agricultural practices were not followed. Tobacco fields blanketed whole hillsides. The furrows were run vertically and no slope was considered too steep for planting. Such methods quickly destroyed what little soil had accumulated in previous decades. By 1920 the population again declined, farms were abandoned, and the prairies began again to flourish. In the 1970's, this pattern is commencing for a third time. The land is being developed for vacation homes and campgrounds, the lumber industry is small but thriving, the population is once more increasing, and the prairies are endangered. The eventual results of this current surge of development may prove as harmful to the prairies as the destruction of previous decades. The time for research and preservation is *now*, before the trend is irreversible.

The alternation of use and abandonment of these prairies in Adams County provides great opportunities for the study of community succession. The rapidity of the transformation of cultivated land into secondary prairie can be remarkable. Durrell and Durrell (1975:23) recounted tales of corn fields and gardens that have become excellent secondary prairies in only a few decades. In one case, only three years was required. Moreover, these secondary prairies, such as those near Lynx, are virtually indistinguishable from prairies on older sites, and their flora is equally diverse. In Lynx Prairie itself, furrows are still visible. In Green Township, the former Cedarville School property is a grassy secondary prairie, although it was abandoned less than 50 years ago. The recent origin of this prairie is readily apparent from the air; the outlines of the school's baseball diamond can easily be discerned within its limits.

Given suitable soil conditions, the abandoned land succeeds into prairie, which in turn becomes woodland. This change to woodland also can be relatively rapid, although the process is slower than the former one. On the dolomite promontories, such as, Red Rock and Buzzardsroost Rock, invasion by tree species has been slowed by the dry, exposed conditions. Although the arid nature of the secondary prairies during the summer has retarded growth of woody species, this has not checked their encroachment entirely. A cursory examination of the sites surveyed by Braun (1928) will confirm this.

For example, Braun (1928:419-421) recorded over 50 herbaceous species on Agave Ridge, and most of these still can be located there. Additionally, a few species, some quite common, are present today which Braun did not list; two outstanding examples are ground pine (*Lycopodium flabelliforme* (Fern.) Blanchard) and scrub pine (*Pinus virginiana* Mill.). Other species which had a low frequency in the 1920's are now much more common. Persimmon (*Diospyros virginiana* L.) appears to have increased significantly on all sites since 1928 and is an important invader of prairie openings. Other woody species that seem to have increased are red-bud (*Cercis canadensis* L.) and red cedar (*Juniperus virginiana* L.). In the shade of these woody species, rosettes of prairie-dock (*Silphium terebinthinaceum* Jacq.) bear leaves which are much less robust than similar specimens growing in full sun. This seems to indicate that the woody species have invaded the prairie openings recently and that their growth is detrimental to the shade-intolerant prairie plants.

Any doubts as to the continuing diminution of the Adams County prairies are eliminated by Braun's photographs of the Lynx Prairie 1928:423-424) which showed extensive openings where only small, narrow prairie patches now exist. Although much of the destruction of the prairies around Lynx has resulted from pasturing and home construction, much more may have been lost due to natural succession. Even the largest opening in the Lynx Prairie Preserve today is considerably smaller than those shown in the photographs. This change is likewise confirmed by co-workers of Braun and by those fortunate enough to have accompanied her in the field. For instance, she told one companion with whom I spoke that scrub pine, now well-established in Lynx Prairie, was rare or nonexistent during her original survey. Without management, Lynx Prairie probably will become a series of shrinking prairie islands amid the sea of pines and junipers.

Unfortunately, no substantive vegetational studies have been conducted in Lynx Prairie during the past decades against which to measure the rate of succession. This void of knowledge reaffirms the necessity for such research today.

Those of us who love the prairies and their beauty are faced with a seeming paradox. We wish to maintain natural conditions; yet, the very condition we treasure is transient. How can one preserve successional stages? We must accept the necessity and the obligation of management. To preserve assemblages of species in various successional stages, one must disrupt the dynamic flow of nature.

The type of management required to maintain prairies is a controversial subject. In some cases, fire is used to reduce woody competition, but simple cutting of trees also may be successful. The best method to be used depends on the individual prairie site. A method which maintains one type of prairie community may not preserve other types. The local conditions which were present during the origination of a particular prairie and which also have maintained it must carefully be considered. Four basic types of prairies occur in Ohio: wet, mesic, dry, and the prairies of Adams County. Unique in this latter case are both the peculiar condition of unglaciated dolomite, occurring only in this area of Ohio, and the prairie communities native to it. Unique, too, is the almost desert-like environment of this region during summer, with thin sod over soil that is nearly bare and often cloaked with crusts of lichens (*Cladonia* spp.) and blue-green algae (*Nostoc* sp.). After a rain the clayey earth becomes slippery and waterlogged, but this state soon vanishes as the sun bakes the clay into brick-like hardness. The lichens and algae become brittle and crackle underfoot. These cryptogams probably play a vital role in the health of the prairie by protecting the soil from wind and rain erosion and by fixing atmospheric nitrogen.

Management by fire has become widely accepted as a prairie maintenance technique and prairie lovers have acquired a reputation, not entirely undeserved, as pyromaniacs. Certainly in more hydric or mesic prairies the sod is thick enough to recover from burning. However, the sod is thin in Adams County prairies, and fire probably would have a disastrous effect on the lichens and algae. Natural fires appear to be uncommon in the county. No reports of large-scale prairie fires, such as those that occurred in the tallgrass prairies, are known to the author. It would be rash to use burning uncritically to manage these unusual sites in Adams County; however, experimental burning might be tried on a small secondary prairie as a test of this management technique.

Perhaps a more straightforward approach would be the use of that ecological tool, the chainsaw. Indeed, desultory efforts already have been made to cut down cedars and pines in the Lynx Prairie. Dr. Jane Forsyth (personal communication) can well remember Dr. Braun's threat to sneak into Lynx Prairie and cut down the invading trees. Systematic, selective cutting on Lynx Prairie probably would provide the safest management on this important site.

Certainly some control on invading woody species is urgently required on the Adams County prairies. As Durrell and Durrell (1975:23) said, "Without management the secondary prairies stand on the threshold of extinction." We must not only save the prairies, we must save the prairies from themselves.

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1820 Ohio Map by Alexander Bourne and J. Kilbourne

One of the earliest maps of Ohio showing natural features, including those areas with extensive prairie vegetation (From Amos Bourne, 1820, Archaeologia Americana 1: opposite p. 104.)

Members of the Department of Botany, The Ohio State University, about 1922-23
In the preceding papers by Thomas, Sears, Stuckey, and Gordon, reference was made to the quality Department of Botany developed by Professor Transeau. First row, left to right: Edgar N. Transeau, Lewis H. Tiffany, Ruth White, Wilmer G. Stover, Adolph E. Waller, Jasper D. Sayre. Second row: Lois Lampe, John H. Schaffner, Homer C. Sampson, Ernest L. Stover, Sylvester S. Humphrey, Harmon A. Runnels, Mary E. Wurdack. Third row: Donald B. Anderson, Bernard S. Meyer, Raymond A. Dobbins. (From the Department of Botany, The Ohio State Univ.)

Transeau's Plant Ecology Class, 1935
The field trips were conducted by Robert B. Gordon, who is standing and has his left hand on a large sycamore tree located north of Highbanks along the Olentangy River, Delaware County, Ohio (From a glass lantern slide, collection of R.B. Gordon and currently in the possession of R.L. Stuckey. Photograph by Luther L. Baumgartner, 26 Oct. 1935.)

Professor E. N. Transeau in an Ohio Prairie

The following note written by John Wolfe appears on the reverse side of the original copy in the Department of Botany, The Ohio State University, Columbus, Ohio: "We were on the prairie remnants preserved along the railroad right of way just outside Marion [Marion County] on the road to Agosta. The time was August 1941. As I recall Fred Norris took the Photo. J[ohn] W[olfe]."

THE VANISHING PRAIRIES OF OHIO

Edgar Nelson Transeau

In the course of assembling materials related to the theme of this Prairie Conference, an unpublished manuscript on the vanishing prairies of Ohio by E. N. Transeau was kindly provided from the files of Dr. Gareth E. Gilbert, Department of Botany, The Ohio State University. It is here published as Dr. Transeau originally wrote it, with the exception of minor editorial modifications and the addition of references whence the quotations were obtained. For many years this paper was read in the plant ecology classes at The Ohio State University. *Editors.*

Although the prairies were among the last areas in Ohio to be broken by the plow, they have been almost completely eradicated from the landscape. The pioneers who entered Ohio by way of the Ohio River and Lake Erie established their settlements in forested lands that closely resembled the lands in New England, Pennsylvania, and Virginia from where they came. By 1810 scattered settlements had been established throughout eastern and southern Ohio along the larger streams. Ease of transportation was a major factor in the selection of home sites, but water supply and timber for building houses and fences were also important. But it was not until 1830 that the settlers began to invade the lands where trees were scattered or entirely absent. Trees afforded protection from heat in summer and from winds in winter. To be sure, it required much labor to cut down the trees and remove the stumps. Since there was no timber market, for the most part the trees had to be rolled into great piles and burned.

Military scouts and travelers had long before written of the "barrens," the "oak openings," the meadows, and "prairies" where tall grasses were predominant in late summer. They knew of the deep brown loam that underlay the grasslands, but settlers still preferred forest and stream margins.

Christopher Gist (1750:47) reported the "beautiful natural Meadows, covered with wild Rye, blue Grass and Clover, and abounds with Turkeys, Deer, Elks and Most Sorts of Game particularly Buffaloes thirty or forty of which are frequently seen in one meadow. . . ." The Pickaway Plains were described by Cyrus P. Bradley (1835:235) as "A natural plain of from three to seven miles [4.8-11-2 km] in extent, covered with a low, wild plum producing a luscious fruit, and without a single tree in its whole extent to obstruct the view." If he had traveled through this area later in the summer, he would have been impressed by the tall bluestem grass that prevailed there.

Bradley (1835:246, 251) later went from Marion to Sandusky and made these remarks:

> It is to be understood that prairie land is not necessarily low or wet—but signifies only a level or perhaps undulating plain destitute of timber and covered with a sweet grass. Such land is often dry and capable of every variety of cultivation. But the prairies we passed over today are what we might call meadows, very low and wet, incapable of being drained, in a state of nature, unsusceptible of improvement. They are used for grazing and, are exceedingly profitable . . . I shall never forget my ride across those gloomy, unhealthy prairies, which produce nothing but long grass, horned cattle, disease, mosquitoes and rattlesnakes.

An historian of Madison County (Brown, 1883:341) wrote the following observations:

> The prairies consisted of level stretches of country covered with sedge-grass, and dotted here and there with patches of shrubby burr-oak growing on the highest points of land. The sedge-grass grew to an enormous height, sometimes sufficient to hide man and horse when travelling through it; it proved a blessing to the first settlers being very nutritious food for stock, which had extensive ranges where now stands some of the finest producing farms in Madison County. The pioneers would cut this grass in June and July, and upon it the stock were fed throughout the winter months. Nearly every autumn prairie fires swept over the county, destroying everything in their path, endangering the lives and property of the pioneers, as well as the existence of the denizens of the forest that fled before the devouring elements to places of safety; but with the gradual settlement of the country these fires grew less frequent, until at last they became a thing of the past. We have been told that the timber in the east bank of the streams was always the largest, as these fires generally ran from west to east, and being checked by the intervening water ways, the trees on the east bank were generally spared the withering destruction that befell those upon the opposite side of the stream. The growth of the burr-oak on the prairies was impeded by these periodical fires, and the greater amount of the present timber of Madison has grown up since the first settlement of the county.

These quotations indicate three reasons why settlers avoided these lands: (1) poor drainage in winter and spring, (2) mosquitoes and malaria in summer, and (3) the autumn fires set by Indians and settlers to improve the pastures the following year. A fourth reason for retarded settlement was the difficulty of plowing the prairie. The wooden plows and the early iron plows were quite unsuited to turn the prairie sod, and even when better plows were available, it required four to six oxen to break the turf. An early writer said that it was just as much labor to prepare prairie land for farming as it was to prepare the forest land.

The most famous extensive prairies were the "Pickaway Plains" and the "Barrens" directly west beyond the Scioto River at Circleville; the "Darby Plains" centering in Madison County but having outliers extending into all the adjoining counties and down the Miami Valley from Urbana to Dayton; and the "Killdeer Plains" between Marion, Upper Sandusky, and Bucyrus. The "Bowling Green" prairies covered the central part of Wood County and adjoined the "Great Black Swamp" while the region of Sandusky Bay had many large areas of both wet and dry prairie.

Briefly, the prairies were of two types, very different in appearance. The Upland Dry Prairies on the sand ridges of the old lake shores and on the outwash gravel hills common west of Bellefontaine and extending from Urbana southeastward to Laurelville. The predominant grasses were little bluestem and, less frequently, the big bluestem, Indian grass, dropseed grass, and tall smooth panic-grass. With the grasses were a number of flowering herbs: sunflowers, asters, blazing-stars, flowering spurge, purple and yellow coneflowers, Sullivant's milkweed, purple ironweeds, and prairie docks. During June and July these prairies were a riot of color, ending in the autumn with goldenrods, sunflowers, and prairie docks, more or less hidden among the 3-5 ft [0.9-1.5m] grasses. The dry prairies in Ohio were usually small areas surrounded by hazel and plum thickets and scrub growths of post, bur, black, and scarlet oaks. Sometimes they occupied ridges or mounds within the wet prairie lands.

The Wet Prairies occupied level or rolling, poorly drained areas in the glaciated portions of Ohio. In spring these lands were partly or entirely under water. As summer approached, the water disappeared except in the sloughs and a meadow of lush grasses took its place. In the smaller prairie openings and on the borders of the larger ones, veritable flower gardens produced a succession of color from the purple violets, yellow buttercups, and zizias of spring through the pink and rose-colored milkweeds and purple coneflowers to the brilliant and profuse yellows of goldenrods, sunflowers, rudbeckias, rosinweeds, and the red or purple ironweeds.

By September the grasses attained heights of 6-10 ft [1.8-3m] and with the coming of frost the grasses and taller flowering herbs were soon killed, dried, and bent over on the ground. This mass of highly inflammable material was at once a menace if a fire was started either by lightning or by man. If there were no fires the mass of dead herbs formed a spongy layer several inches in thickness that impeded drainage during wet periods of winter and spring. It was the disintegration of this material that added the dark brown humus to the surface of the soil.

The question most frequently asked is why trees were absent from these areas when the settlers came into Ohio although many prairie areas support trees and wood lots today. The answer to this question is not simple, but involves a number of factors, some of which belong to prehistoric times, some to the historic period, and some involve our present-day climatic conditions.

At the outset, let us emphasize the fact that an explanation of the prairies must account not only for the absence of trees but also for the occurrence in these areas of an unique community of grasses and flowering herbs entirely absent from the forested regions of this state. These same plants do occur even more abundantly and cover still larger areas in Indiana, Illinois, and Iowa. Central Ohio, in fact, forms the eastern end of what ecologists have called the prairie grassland peninsula. This extension of the central grasslands was probably far larger and more continuous 2,000 to 3,000 years ago, when a prolonged dry period of perhaps several hundred years led to the destruction of much of the upland forest in the corn belt states as far east as western Pennsylvania. As the forest trees died out, the grasses took their place.

Grasslands are easily set on fire. There can be no doubt that the hot prairie fires eliminated tree seedlings on their borders and helped to maintain or enlarge the grassland areas for the prairie species have extensive underground roots and stems and are not easily exterminated by fire. Prairies were here before prairie fires, but prairie fires helped to exclude the trees after prairies became established. Fires did not start prairies.

Another reason why trees invaded prairie areas so slowly is that prairie grasses and other herbs formed so dense a growth that even when tree seedlings started they were shaded out and starved before the end of the year. In the wet prairies, if tree seedlings survived the fall and winter they were likely to be drowned the following spring.

Trees now grow on many prairies because since the time of settlement artificial drainage has lowered the water table so that the lands are now well-drained throughout the year. Moreover, the prairie farmers carried hundreds of bushels of acorns, walnuts, and hickory nuts from the forests eastward and planted them in fence rows and wood lots so as to make more timber available for fencing and farming buildings. With the land no longer covered by water in the spring, tree seeds germinated. Grazing and plowing destroyed the tallgrasses and they no longer shaded out the seedlings. Consequently, one may now find artificially planted wood lots in the Darby Plains where once there was scarcely a tree on the horizon.

A factor that helped to preserve the scattered remnants of prairie along roadsides and railroad rights-of-way in Ohio, Indiana, and Illinois, and not in states north and south of us is the irregularity of rainfall in these states. The average annual precipitation is not greater either north or south of us, but the rains are more evenly distributed. The Prairie Peninsula, however, has more frequent and more prolonged droughts. These conditions are unfavorable to the growth of trees, but are not destructive to grasses. When droughts occur in several successive years, as in the years from 1930 to 1935, under natural conditions the prairie areas would have been enlarged and the upland forests decreased.

The greatest factor in the disappearance of the prairie has been the easy and profitable cultivation of the prairie after drainage was established. Today, relict patches of prairie are exceedingly rare and our only sure method of locating many of the ancient prairie areas is by means of the dark soil that formed beneath them.

Prairies, then, are remnants of vegetation that came into Ohio from the grasslands of Iowa and Illinois during a prehistoric dry period. Trees invaded them very slowly because they were often covered with water during the spring months and tree seedlings were drowned. Tree seedlings were shaded out by the tallgrasses and burned up by prairie fires. Likewise, prairie grasses in competition with tree seedlings have been favored by the prolonged periodic droughts so characteristic of the corn belt states from Iowa to Ohio.

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Prairie in Marion County, Ohio

Nine-foot [2.7-m] tall prairie grasses hide a man (just to the right of the center) in a prairie northeast of Marion, Ohio. (Undated photograph from a glass lantern slide collection of E. N. Transeau and currently in the possession of R. L. Stuckey.)

GUIDE TO OHIO PRAIRIE PLACE NAMES

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In many instances names are given to places that reflect the conditions of the time when the place is originally named. Throughout Ohio, examination of local maps reveals that some place names pertain to prairies, such as, Prairie Run, Prairie Road, Prairie School, Big Prairie, Prairieview Cemetery, and these names are indicative that non-forested areas and prairies may have been present in the vicinity at some time in the past. A knowledge of locations of these place names may be useful in locating remnant prairies that may still exist in the state.

In an effort to capture these names and record their locations, the topographic maps of the Ohio Geological Survey were scanned for those place names involving the words "prairie" and "plain." The entire series of 15′ quadrangle maps were reviewed. Based on this obtained information and a general knowledge of the distribution of prairies in Ohio, only the key counties (Adams, Clark, Clinton, Darke, Delaware, Erie, Fairfield, Fayette, Franklin, Greene, Huron, Lucas, Mercer, Miami, Ottawa, Paulding, Pickaway, Ross, Sandusky, Seneca, Wood, and Wyandot) were scanned from the more recent 7½′ quandrangle maps. Two place names directories by Fitak (1976, 1980) were consulted (Table 1.)

Later, the scope of the project and sources of information about Ohio's prairie place names broadened, and additional words, such as, Big Island, Buffalo Fork, Burr Oak, Chaparral Road, and Glade Run were added. Figure 1, an index map of Ohio townships, accompanies the map of Ohio prairie place names (Fig. 2). For each place name in Table 1, the county, township, quadrangle map, and general location given by township and range numbers and/or latitude and longitude is provided. Creeks and rivers are also identified by their larger drainage basin (Ohio Div. Water, 1960). Many historical references to prairie place names in Ohio are contained as annotations in a *Guide to the Literature of Ohio Prairies: A Selected Bibliography* by Stuckey and Reese (1981). No effort, however, has been made to include recent prairie place names, but many of them can be located in *The [Ohio] Prairie Survey Project* by Cusick and Troutman (1978) and *Prairies of Ohio* by Denny (1978).

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We thank Dr. Charles C. King who contributed and collected information on prairie place names from many sources, Karen J. Reese who examined the *Gazetteer of Ohio Streams* and provided Figure 2, Dale Soltis who verified most of the latitude and longitude data, and Rosemary Kullman who typed the manuscript.

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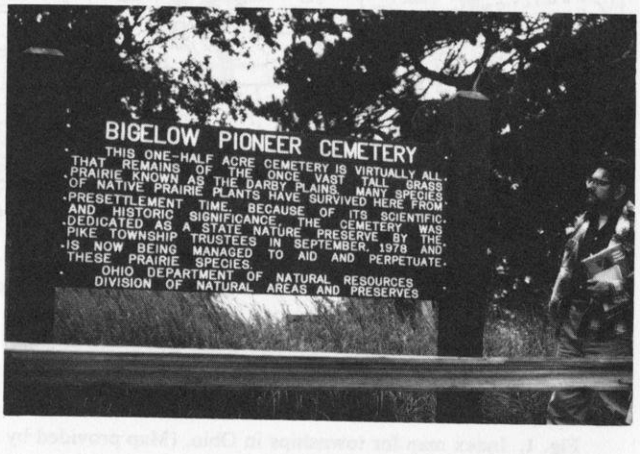
Prairie Road Sign
Prairie Road sign at the intersection of Ohio Route 4 and Prairie Road, Clark County, Ohio. (Photograph by Ralph E. Ramey, 1981.)



Bigelow State Nature Preserve
Charles C. King at the dedication of this superb example of a pioneer prairie cemetery in Madison County, Ohio. (Photograph by K. Roger Troutman, 1979.)

Fig. 1. Index map for townships in Ohio. (Map provided by the Ohio Geological Survey, Ohio Department of Natural Resources.)

Fig. 2. Location of Ohio prairie place names.

Table 1. Ohio Prairie place names. Quadrangles without footnotes are 15′ maps.

County— Township	Quadrangle	Place Name	Township, Range	Location Latitude	Longitude
Adams Liberty	Seaman	**Chaparral School**		38°50′	83°36′
Adams Liberty	West Union[1]	**Chaparral Cemetery**		38°50′	83°36′
Adams Liberty	West Union[1]	**Chaparral Road**[2,3] (Twp. Rd. 22)		38°50′	83°34′ to 83°37′
Allen *(see VanWert)*		**Prairie Ditch**			
Athens Trimble	Corning[1]	**Burr Oak** (town of)		39°33′	82°4′
Athens Trimble & Morgan Homer Union & Perry Monroe	Corning[1]	**Burr Oak Lake** (Hocking River Drainage Basin)	T8N, R13W T7N, R13W T11N, R14W	39°34′ to 39°31′	82°1′ to 82°3′
Athens Dover	Nelsonville[1]	**Buffalo Beats Prairie**	T10N, R14W	39°27′	82°9′
Athens Athens Dover	Nelsonville[1] The Plains[1]	**The Plains** (area west of Hocking River)	T9N, R14W T10N, R14W	39°2′ to 39°23′	82°7′ to 82°9′
Ashland Clear Creek	Ashland North[1]	**Savannah** (town of)	T25N, R20W	40°57′	82°21′ to 82°22′
Auglaize Wayne	Alger	**Prairie Fork School**	T5S, R8E	40°35′	83°56′
Carroll East	Kensington[1]	**Glade Run Church**	T15N, R4W	40°40′	80°58′
Champaign Urbana	Mechanicsburg Urbana East[1]	**Pretty Prairie School**	T5, R11	40°3′	83°43′
Champaign Urbana & Clark Moorefield	Urbana East[1]	**Prairie Road**	T5, R10	40°1′ to 40°4′	83°43′
Clinton Union Wilson	Bowersville[1] Port William[1] Wilmington[1]	**Prairie Road**		39°26′ to 39°30′	83°44′ to 83°48′
Coshocton Linton	Cambridge Plainfield[1]	**Plainfield** (town of)	T4N, R5W	40°12′	81°43′
Coshocton Linton	Plainfield[1]	**Plainfield Cemetery**	T4W, R5W	40°13′	81°44′
Coshocton Layfayette Oxford	Fresno[1]	**The Plains** (area south of Tuscarawas River)	T5W, R4W T5N, R5W	40°15′ to 40°17′	81°37′ to 81°45′
Darke Neave	Greenville	**Prairie Outlet** (Stillwater River Drainage Basin)	T11, R2E	40°0′ to 40°3′	84°38′ to 84°40′
Darke Harrison	New Paris	**Sunbeam Prairie**	T9N, R1E	39°56′	84°47′
Delaware Radnor	Delaware	**Prairie Run** (Scioto River Drainage Basin)	T5N, R20W	40°20′	83°10′
Delaware Berkshire	Marengo Westerville	**Prairie Run** (Big Walnut Creek Drainage Basin)	T4N, R16W	40°15′	82°52′
Fairfield Amanda	Amanda[1]	**Muddy Prairie** (area surrounding Muddy Prairie Creek)	T14N, R20W	39°40′	82°38′
Fairfield Amanda	Amanda[1]	**Muddy Prairie Road**[2,3] (now Sand Hill Road)	T13N, R20W T14N, R20W	39°38′ to 39°45′	82°44′
Fairfield Hocking Madison Amanda	Lancaster Amanda[1] Clearport[1]	**Muddy Prairie Run** (Hocking River Drainage Basin)	T13N, R20W T12N, R19W	39°36′ to 39°40′	82°40′ to 82°43′
Fairfield Amanda	Circleville East Ringgold[1]	**Muddy Prairie Creek** (Hocking River Drainage Basin)	T13N, R20W	39°40′	82°38′ to 82°46′
Fayette Perry	Greenfield	**Plainview School**		39°25′	84°20′

Table 1. (cont.) Ohio prairie place names. Quadrangles without footnotes are 15′ maps.

County— Township	Location Quadrangle	Place Name	Township, Range	Location Latitude	Longitude
Fayette Paint Jefferson Union	Washington Courthouse[1] Midway[1] Jeffersonville[1]	**Prairie Road**		39°34′ to 39°42′	83°28′ to 83°30′
Franklin Prairie	Galloway[1]	**Prairie Township**		39°56′	83°11′
Franklin Prairie	Galloway[1]	**Prairie-Norton School**		39°57′	83°8′
Franklin Prairie	Galloway[1]	**Prairie-Lincoln School**[2,5]		39°57′	83°8′
Franklin Prairie	Galloway[1] Southwest Columbus[1]	**Prairie Township**		39°53′ to 40°0′	83°8′ to 83°15′
Franklin Prairie	Galloway[1]	**Prairie Street** [2,6]		39°57′	83°8′
Franklin Plain	New Albany[1] Sunbury[1]	**Plain Township**	T2N, R17W T2N, R16W	40°3′ to 40°8′	82°45′ to 82°53′
Fulton Gorham	Wauseon	**Prairie School**	T9S, R1E	41°39′	84°15′
Gallia *(see Lawrence)*		**Little Buffalo Creek**			
Guernsey Spencer Valley	Byesville[1] Caldwell North[1] Cumberland[1]	**Buffalo Fork** (Wills Creek Drainage Basin)	T9N, R10W T8N, R9W	39°51′ to 39°54′	81°32′ to 81°39′
Guernsey Valley & Noble Buffalo Center Enoch	Byesville[1] Caldwell North[1] Sarahsville[1]	**Buffalo Creek** (Wills Creek Drainage Basin)	T8N, R9W T7N, R8W	39°45′ to 39°54′	81°27′ to 81°32′
Guernsey Valley	Byesville[1]	**Buffalo** (town of)	T8N, R2W	40°55′	81°30′
Hamilton Anderson	East Cincinnati	**Plainview School**		39°6′	84°20′
Harrison German	Amsterdam[1]	**Buffalo Hill Cemetery**	T11N, R4W	40°23′	80°53′
Highland Penn	Sabina	**Plainview School**		39°16′	83°37′
Holmes Prairie	Holmesville[1] Millersburg[1]	**Prairie Township**	T14N, R13W T13N, R13W T10N, R6W T10N, R7W	40°36′ to 40°40′	81°52′ to 81°59′
Holmes Ripley	Shreve[1]	**Big Prairie** (town of)	T18N, R14W	40°40′	82°6′
Holmes Killbuck Monroe	Glenmont[1]	**Buffalo Ridge**	T8N, R8W T9N, R8W	40°31′ to 40°33′	82°0′ to 82°2′
Holmes Berlin Salt Creek	Millersburg Berlin[1]	**The Plains** (area surrounding both sides of Doughty Creek)	T10N, R5W T9N, R5W	40°34′ to 40°36′	81°48′ to 81°49′
Holmes Prairie	Holmesville[1]	**Prairie Cemetery**	T18N, R13W	40°38′	81°56′
Huron Lyme	Flat Rock[1]	**Prairie Road**	T4N, R24W	41°13′ to 41°15′	82°49′
Jackson Coal	Jackson[1]	**Buffalo** (town of)	T7N, R18W	39°6′	82°37′
Jackson Coal Washington	Byer[1]	**Glade Run** (Salt Creek Drainage Basin)		39°8′ to 39°9′	82°37′ to 82°38′
Jackson *(see Scioto)*		**Glades Road**			
Jackson *(see Scioto)*		**Glade Run**			

Table 1. (cont.) Ohio prairie place names. Quadrangles without footnotes are 15′ maps.

County—Township	Quadrangle	Place Name	Township, Range	Location Latitude	Longitude
Lawrence Symmes	Waterloo[1] Sherritts[1]	**Buffalo Creek** (Symmes Creek Drainage Basin)	T5N, R17W	38°44′	82°29′ to 82°31′
Lawrence Symmes & Gallia Greenfield	Patriot[1] Waterloo[1]	**Little Buffalo Creek** (Symmes Creek Drainage Basin)	T5N, R17W T6N, R17W	38°44′ to 38°46′	82°29′
Lucas Richfield	Swanton	**Prairie School**	T9S, R5E	41°41′	83°47′
Lucas Richfield Spencer Harding	Swanton	**Prairie Ditch** (Ottawa River Drainage Basin)	T9S, R5E T10S, R5E	41°37′ to 41°41′	83°46′ to 83°49′
Madison Fairfield	Big Plain[1]	**Big Plain-Circleville Road**		39°50′	83°15′
Madison Fairfield	Big Plain[1]	**The Plains School**		39°51′	83°17′
Madison Fairfield	London	**Big Plain** (town of)		39°50′	83°17′
Madison Darby & Union Jerome	Milford Center	**Plain City**		40°6′	83°15′
Madison Stokes	Octa Jeffersonville[1]	**Grassy Plain School** (now called Grassy Point School[2])		39°44′	83°31′
Madison Canaan	Plain City[1]	**Plainview Christian Day School**		40°3′	83°20′
Madison Oak Run Union Deer Creek	London Big Plain[1] Jefferson[1]	**Glade Run** (Deer Creek Drainage Basin)		39°51′ to 39°57′	83°21′ to 83°22′
Madison Deer Creek	London	**Glade School**		39°55′	83°21′
Madison Deer Creek	London	**Glade Run Pike**		39°51′ to 39°56′	83°21′
Madison Pleasant	Mount Sterling[1]	**Burr Oak Heights**		39°42′	83°16′
Madison Deer Creek	West Jefferson[1]	**Lower Glade Cemetery**		39°53′	83°21′
Madison Range	Jeffersonville[1] Midway[1]	**Prairie Pike**		39°42′ to 39°44′	83°29′ to 83°30′
Madison Paint	London[1]	**Buffenbarger Prairie** [2,7]		39°50′	83°29′
Marion Grand Salt Rock Big Island	La Rue	**Prairie Run** (Sandusky River Drainage Basin)	T4S, R13E T4S, R14E T5S, R14E	40°37′ to 40°40′	83°15′ to 83°20′
Marion Big Island	Marion West[1]	**Big Island** (town of)	T5S, R14E	40°37′	83°13′
Marion Big Island	La Rue	**Big Island School**	T5S, R13E	40°34′	83°17′
Marion Grand Prairie	Morral[1]	**Grand Prairie Cemetery**	T4S, R15E	40°41′	83°9′
Marion Big Island	New Bloomington[1]	**Big Island Wildlife Area**	T5S, R14E	40°34′ to 40°38′	83°15′ to 83°18′
Marion Big Island	Meeker[1] Morral[1] Marion West[1]	**Big Island Township**	T5S, R14E	40°35′ to 40°38′	83°11′ to 83°18′
Marion Grand Prairie	Morral[1] Monett[1]	**Grand Prairie Township**	T4S, R14E T4S, R15E	40°38′ to 40°42′	83°4′ to 83°11′
Meigs Orange	Keno Cooville[1]	**Tuppers Plains** (town of)		39°10′	81°51′
Meigs Olive	Colvlille[1]	**Flatwood Cemetery**	T4N, R11W	39°8′	81°47′

Table 1. (cont.) Ohio prairie place names. Quadrangles without footnotes are 15' maps.

County—Township	Quadrangle	Place Name	Township, Range	Location Latitude	Longitude
Meigs Chester	Chester[1]	**Flatwoods Church**	T2N, R13W	39°4′	81°58′
Meigs Chester	Chester[1]	**Flatwoods Road**	T2N, R13W	39°3′ to 39°5′	81°57′ to 81°59′
Mercer Union & Van Wert York	Celina	**Kyle Prairie Ditch** (Auglaize River Drainage Basin)	T3S, R2E	40°44′	84°30′ to 84°34′
Mercer Dublin	Celina	**Prairie School**	T4S, R2E	40°40′	84°36′
Mercer Liberty Hopewell	Erastus[1]	**Prairie Creek** (Wabash River Drainage Basin)	T5S, R1E	40°33′ to 40°36′	84°40′ to 84°44′
Mercer Franklin	Montezuma[1] Celina[1]	**Prairie Creek** (flows into Grand Lake St. Marys; Wabash River Drainage Basin, in part)	T6S, R3E	40°27′ to 40°30′	84°31′
Mercer Granville	St. Henry Montezuma[1]	**Cranberry Prairie**	T7S, R2E	40°24′	84°35′
Monroe Perry	New Matamoras Antioch[1]	**Plainview** (town of)	T3N, R5W	39°41′	81°36′
Morgan *(see Athens)*		**Burr Oak Lake**			
Muskingum Salt Creek Rich Hill	Norwich[1] Ruraldale[1]	**Buffalo Fork** (Muskingum River Drainage Basin)	T13N, R12W T13N, R11W T12N, R11W	39°50′ to 39°54′	81°45′ to 81°52′
Muskingum Salem	Conesville Otsego[1]	**Prairie Fork** (Muskingum River Drainage Basin)	T2N, R6W	40°2′ to 40°4′	81°50′ to 81°53′
Noble Buffalo	Byesville[1] Sarahsville[1] Caldwell North[1]	**Buffalo Township**	T8N, R9W T8N, R10W	39°50′ to 39°53′	81°27′ to 81°34′
Noble Seneca	Sarahsville[1]	**Little Buffalo Creek** (Wills Creek Drainage Basin)	T8N, R8W T7N, R8W	39°47′ to 39°51′	81°25′ to 81°27′
Noble Buffalo	Caldwell North[1]	**Buffalo School**	T8N, R9W	39°51′	81°32′
Noble Jefferson Enoch	Macksburg[1]	**Buffalo Run** (Duck Creek Drainage Basin)	T5N, R8W T6N, R8W	39°39′ to 39°41′	81°25′ to 81°27′
Noble Buffalo Seneca	Caldwell North[1] Sarahsville[1]	**North Fork Buffalo Creek** (Wills Creek Drainage Basin)	T8N, R8W T8N, R9W	39°50′ to 39°52′	81°27′ to 81°30′
Noble *(see Guernsey)*		**Buffalo Creek**			
Paulding Brown & Putnam Monroe Perry	Continental[1]	**Prairie Creek** (Auglaize River Drainage Basin)	T1N, R4E	41°5′ to 41°7′	84°20′ to 84°23′
Paulding Latty Washington Blue Creek & Van Wert Union	Continental[1]	**Prairie Creek** (Auglaize River Drainage Basin)	T1N, R3E T1N, R2E	41°0′ to 41°7′	84°25′ to 84°35′
Paulding Brown	Continental[1]	**Prairie Chapel**	T2N, R4E	41°6′	84°21′
Paulding *(see Van Wert)*		**Upper Prairie Creek**			
Perry *(see Athens)*		**Burr Oak Lake**			
Pickaway Pickaway	Williamsport[1]	**Pickaway Plains**	T3N, R22W	39°31′ to 39°33′	83°0′ to 83°1′
Pickaway Salt Creek	Hallsville	**Prairieview Cemetery**	T11N, R20W	39°29′	82°50′

Table 1. (cont.) Ohio prairie place names. Quadrangles without footnotes are 15′ maps.

County—Township	Quadrangle	Place Name	Township, Range	Location Latitude	Longitude
Pickaway *(see Ross)*		**The Prairie**			
Pike Pee Pee	Piketon[1] Waverly South[1]	**Prairie Road**[2,8] (Twp. Rd. 432)	T5N, R21W	39°5′ to 39°6′	83°0′
Pike *(see Scioto)*		**Glade Run**			
Putnam *(see Paulding)*		**Prairie Creek**			
Ross Colerain & Pickaway Salt Creek	Hallsville[1]	**The Prairie**	T10N, R20W	39°27′ to 39°29′	82°46′ to 82°50′
Sandusky Rice	Wightmans Grove[1]	**Stony Prairie**[2,9]	T6N, R15E T5N, R15E	41°24′ to 41°26′	83°3′ to 83°7′
Scioto Madison & Jackson Harrison	Minford[1]	**Glades Road**	T3N, R20W T4N, R20W T5N, R19W	38°50′ to 38°52′	82°48′ to 82°50′
Scioto Madison & Pike Marion & Jackson Scioto	Stockdale[1]	**Glade Run** (Little Scioto River Drainage Basin)	T5N, R20W T4N, R20W	38°55′ to 38°57′	82°47′ to 82°50′
Stark Plain	North Canton[1] Hartville[1] Canton East[1] Canton West[1]	**Plain Township**	T11N, R8W T10N, R8W	40°47′ to 40°54′	81°18′ to 81°25′
Wood Montgomery	Elmore	**Prairie Depot** (now the town of Wayne)	T4N, R12E	41°18′	83°28′
Union Union	Milford Center	**Prairie Run** (Darby Creek Drainage Basin)		40°9′	83°25′
Union *(see Madison)*		**Plain City**			
Van Wert Jennings & Allen Spencer	Delphos Spencerville	**Prairie Ditch** (Auglaize River Drainage Basin)	T3S, R4E T3S, R3E	40°44′ to 40°46′	84°23′ to 84°27′
Van Wert Jennings	Delphos	**Prairie School**	T3S, R4E	40°46′	84°25′
Van Wert Union Tully & Paulding Blue Creek	Van Wert	**Upper Prairie Creek** (Auglaize River Drainage Basin)	T1S, R1E T1S, R2E T1N, R2E	40°55′ to 41°0′	84°40′ to 84°47′
Van Wert Willshire	Van Wert	**Prairie Creek** (St. Marys Drainage Basin)	T2S, R1E T3S, R1E	40°47′ to 40°49′	84°42′ to 84°48′
Van Wert Liberty York	Van Wert	**Prairie Ditch** (Auglaize River Drainage Basin)	T2S, R2E T2S, R3E	40°45′ to 40°48′	84°30′ to 84°38′
Van Wert *(see Paulding)*		**Prairie Creek**			
Van Wert *(see Mercer)*		**Kyle Prairie Ditch**			
Warren Harlan	Morrow	**Pleasant Plain** (town of)		39°17′	84°7′
Washington Barlow	Fleming[1] Little Hocking[1] Parkersburg[1]	**Buffalo Run** (Little Hocking River Drainage Basin)	T3N, R10W	39°22′ to 39°23′	81°36′ to 81°39′
Wayne Plain	West Salem	**Plain Church**	T19N, R14W	40°46′	82°2′

Table 1. (cont.) Ohio prairie place names. Quadrangles without footnotes are 15′ maps.

County—Township	Quadrangle	Place Name	Township, Range	Location Latitude	Longitude
Wayne Plain	Wooster[1] New Pittsburg[1] Jeromesville[1] Shreve[1]	**Plain Township**	T11N, R8W T21N, R15W T19N, R14W	40°43′ to 40°48′	81°59′ to 82°7′
Wayne Wooster	Wooster[1] Homesville[1]	**Prairie Lane**	T19N, R13W	40°44′ to 40°47′	82°56′
Wood Plain	Bowling Green North[1] Bowling Green South[1]	**Plain Township**	T5N, R10E T4N, R10E	41°18′ to 41°25′	83°39′ to 83°45′
Wood Middleton	Bowling Green	**Hull Prairie**	T6N, R10E	41°28′	83°42′
Wood Plain	Bowling Green North[1]	**Plain Church**	T5N, R10E	41°23′	83°42′
Wood Middleton Plain	Maumee	**Hull Prairie Road**		41°31′	83°40′
Wyandot Marseilles Pitt	Morral[1]	**Killdeer Plains Wildlife Area**	T4S, R14E	40°42′	83°14′

[1] Quadrangles are 7½′ maps.

[2] Place name not actually printed on a quadrangle.

[3] Allison W. Cusick and K. Roger Troutman, 1978, The Prairie Survey Project—a summary of data to date, Ohio Biol. Inform. Circ. No. 10, p. 5.

[4] Muddy Prairie Road is the road going north through the town of Amanda and around Sand Hill. (Charles R. Goslin, 1980, Crossroads and fence corners, historical lore of Fairfield County, Vol. 2, Fairfield Heritage Association, [Lancaster, Ohio], p. 146-147.)

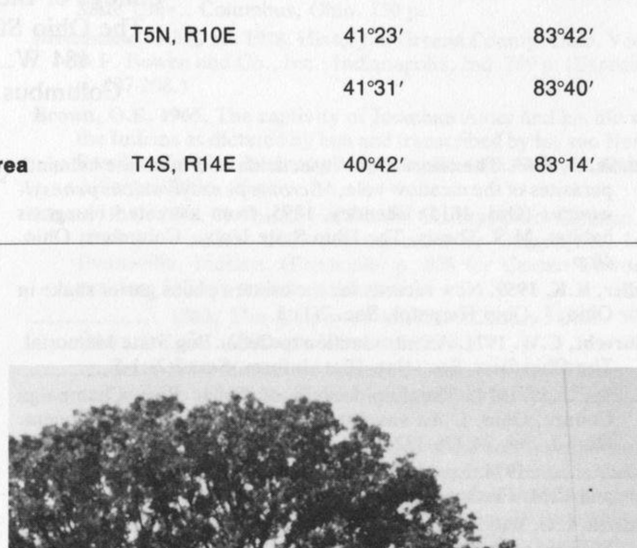
[5] Prairie-Lincoln School is located in town of New Rome, north of U.S. Rt. 40 on Amesbury Way.

[6] Prairie Street is in the town of New Rome.

[7] Charles C. King, 1981, personal communication. This Buffenbarger Prairie should not be confused with Buck Creek Prairie Fen which is owned by Mrs. Blanch Buffenbarger, Clark County. (Guy Denny, personal communication, 1981.)

[8] Prairie Road crosses U.S. Rt. 23 at three intersections south of Waverly. (Pike County Highway Map, Ohio Department of Transportation.)

[9] Stony Prairie is north of U.S. Rt. 80 and U.S. Rt. 90, and south of Co. Rt. 523. (State of Ohio Road Map, Standard Oil of Ohio.)



Ohio Historical Marker for the Sandusky Plains

The marker for the Sandusky Plains is located at the edge of Daughmer Bur Oak Savanna, Crawford County, Ohio. This outstanding savanna is listed by the Soil Conservation Society of America as a significant natural area. (Photograph by K. Roger Troutman, 1978.)

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1944, 9 Jul. Exploring black land prairies [Marion and Wyandot Counties]. p. 6F.

1944, 17 Sep. Ohio has few poisonous snakes. p. 6F.

1945, 25 Feb. Birds on Ohio's snowy prairie [Madison County]. p. 7F.

1945, 1 Apr. A visit to Ohio's wet prairies [Marion and Wyandot Counties]. p. 7F.

1945, 20 May. Birds of our black land prairie [Marion and Wyandot Counties]. p. 7F.

1945, 22 Jul. Milkweeds are attractive plants.

1945, 2 Sep. A visit to Ohio's wet prairie [Marion and Wyandot Counties].

1946, 7 Apr. The horned lark—an early nester. Mag.

1946, 8 Dec. Dry prairie ["high banks" along Deer Creek near Williamsport]. Mag.

1946, 16 Jun. Ohio's swamp rattler [massasauga]. Mag.

1947, 5 Jan. Ohio's showiest wildflowers [several prairie species]. Mag.

1947, 28 Sep. Wild sunflowers. Mag.

1947, 2 Nov. Beauty in the barrens [Adams County]. Mag.

1948, 25 Jul. A word for the milkweed [Florida milkweed in Ross County's wet prairie]. Mag.

1949, 26 Jun. Rare, vanishing plants are found in Cedar Swamp.

1949, 3 Jul. Prairies [Marion and Wyandot Counties] are in flower.

1950, 19 Feb. Tour of prairie lands [Marion and Wyandot Counties].

1950, 7 May. Golden plover sighted on trip [Marion and Wyandot Counties].

1950, 4 Jun. Strange plants at Cedar Swamp.

1950, 2 Jul. Wildlife lush on Castalia Prairie. 80(2):1F.

1950, 27 Aug. Rock Run [Jackson County] magnolias date back to preglacial days [with species listed for a dry prairie].

1950, 10 Sep. Ecologists to inspect Ohio hills and prairies [Adams County].

1950, 24 Sep. Field trip attracts scientists [" 'prairie loop' road, just east of Revenge . . . At Peebles . . . prairie 'oak opening' . . . Adams County.].

1950, 1 Oct. Gentian is aristocrat of our wild flowers.

1951, 3 Jun. 'Shaking Prairie' in bloom [east of Troy].

1951, 15 Jul. July offers a host of pretty wild flowers [butterfly-weed, orange-fringed orchid].

1951, 22 Jul. Awakening of prairies bring unusual blooms [Marion and Wyandot Counties].

1951, 12 Aug. Flowers flourish at Cedar Swamp.

1951, 16 Dec. Big drought brought us prairies.

1952, 16 Mar. Larches and longspurs are found near Toledo [Oak Openings Metropolitan Park].

1952, 23 Mar. Squeaky horned larks heard in wet prairies [Marion and Wyandot Counties].

1952, 14 Sep. Plants, wildlife abound on prairie [Castalia]. 82(76):21F.

1952, 21 Sep. Rare frostweed found on Wood County's sand dunes.

1952, 26 Oct. Compass plant found on Wilgus Prairie [Lawrence County].

1953, 4 Jan. Few remnants of prairie vegetation still found.

1953, 8 Feb. Early horn larks sighted [Marion and Wyandot Counties] on field trip.

1953, 29 Mar. Wildlife division will restore prairie vegetation [Killdeer Plains, Marion and Wyandot Counties].

1953, 7 Jun. Carnivorous plants thrive at state nature sanctuary. [Cedar Swamp].

1953, 11 Oct. Rare [sand-haunting] grasshoppers found in Ohio's northwestern corner [Williams County].

1953, 25 Oct. 'Butcher bird' among sights seen on tour of prairie [Killdeer Plains].

1954, 10 Jan. Hawks and owls are plentiful in Killdeer Plains.

1954, 7 Mar. Prairie horned larks stake their claims [Marion County].

1954, 21 Mar. Prairie horned larks entertain watchers.

1955, 20 Feb. Many horned larks seen at Delaware Reservoir.

1955, 20 Mar. Mallards seem quite tame at Castalia refuge.

1955, 29 May. Naturalists study Ohio's last arbor vitae [Cedar] bog.

1955, 26 Jun. Dickcissel seen on tour of Killdeer Refuge.

1955, 10 Jul. New species of grasshopper found for museum [prairies in Adams County and Fort Hill].

1955, 17 Jul. Canada prairie lilies found with same leaves [Vinton County].

1955, 2 Oct. Reed used by Indians found in trip to [Killdeer] Plains.

1961, 24 Sep. Article on the Wilderness [Adams County].

1962-1964. Rare plants in West Union area [Adams County].

1962-1964. [Prairie] horned lark seen in Big Island [Wildlife] Area [near Marion].

1962-1964. Shrike and [short-eared or "prairie"] owl seen on [Pickaway-Ross] county line tour.

1962-1964. Horned larks return to nesting territory [Killdeer Plains Wildlife Area].

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1962-1964. Ohio boasts of 15 kinds of sunflower.

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Higby Prairie

Sorghastrum nutans community which existed at Higby Prairie on 1 September 1931. Allison Cusick inspected the site in 1976 and 1977, and has reported that the original prairie has been destroyed. Higby Prairie and other prairies in Ross County, Ohio, are mapped and discussed on pages 49 and 65, respectively, by G. S. Crowl (1937. A vegetation survey of Ross County. M.S. Thesis, The Ohio State Univ., Columbus, Ohio.176 p.) (Photograph from the Department of Botany, The Ohio State Univ.)

PART II. CONTRIBUTED PAPERS

RECONSTRUCTION OF PRAIRIE PENINSULA VEGETATION AND ITS CHARACTERISTICS FROM DESCRIPTIONS BEFORE 1860

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During the two centuries preceding 1860, numerous travelers entered the Prairie Peninsula and recorded their impressions in letters and journals. These records are not scientific investigations; rather they are the images that form a generalized concept of the vegetation and the natural conditions which existed before the arrival of European man.

These itinerants identified five basic vegetational types in and adjoining the Prairie Peninsula: prairie, barrens, oak openings, deciduous forests, and evergreen forests. They also mentioned three major environmental factors: fire, moisture relationships, and soil characteristics. Analysis of these descriptions lead to the conclusion that the prairies occurring east and north of the Mississippi and Ohio Rivers exhibited far closer physiognomic affinities to tropical grasslands than to the grasslands of western interior North America.

SOURCES OF DATA

> There are likewise considerable openings in the western regions especially between the Wabash and the Mississippi, on the banks of Lake Erie, and those of St. Laurence [Lawrence], in Tennessee and Kentucky [which] bear no resemblance to the arid plains of Arabia and Syria, but remind us rather of the *steps* or grassy wastes of Tartary and Russia.

Thus, Volney (1804:7) opened his general discussion of the region now known as the Prairie Peninsula, a region about which Croghan (1765:145) had stated that "It is surprising what false information we have had . . . These meadows bear fine wild grass, and wild hemp ten or twelve feet [3 to 3.6m] high . . . ."

Only a few remnants of Croghan's meadows now remain. These fragments command attention from those studying pre-European environmental conditions and ecological processes, as well as those who wish to preserve the natural heritage of the North American continent. Unfortunately, the profound effects of European modification of Prairie Peninsula vegetation were being reported as early as 1815 (Drake, 1815; Flint, 1822). Speaking of English Prairie in Illinois, Woods (1822:292) stated that "feeding or mowing [prairie grass] soon destroys it" and "yard-grass comes on land that has been much trodden." His observations were affirmed by Thomas (1819), Welby (1821), Shirreff (1835), Buckingham (1847), Ferguson (1856), and Bryant (1850) in other parts of the region. The latter (p. 262) observed:

> In my journey the next day, I was struck by the difference which five years had made in the aspect of the country . . . The broad prairie . . . was spotted here and there with young orchards, or little groves, and clumps of bright-green locust-trees, and where the prairie remained open, it was now depastured by large herds of cattle, its herbage shortened, and its flowers less numerous.

Caird (1859) concluded that most ranchers found it best to hasten the process by plowing the prairie and planting bluegrass.

In view of these modifications, if consideration of extant prairie fragments is to be meaningful, it appears necessary to establish the relationship between these remnants and the vegetation which existed at the time of European settlement. Regrettably, one must agree with Atwater (1831:216) that "It appears to me, that our botanists have neglected our prairies . . ." an oversight which was not recognized until the modifications had become evident. Therefore, it is necessary to use existing sources in an effort to establish a reconstruction of original Prairie Peninsula vegetation.

In the period between 1671 and the mid-1800's, a large number of Europeans journeyed through or settled in the Prairie Peninsula. Many of these individuals recorded their observations in journals and letters which provide a body of data that have been analyzed according to the methods of Jakle (1977). To use these data sources effectively, it is necessary to understand certain of their characteristics. With very rare exceptions, these accounts are not the result of scientific studies but are expressions of the images perceived by travelers. These recorded images are tempered by five factors: (1) season and year of observation, and any pecularities of that season or year, (2) mode of transportation, (3) prior knowledge of the observer gained either by education or experience, (4) reason for the journey, such as seeking a homesite or vacationing, and (5) reason for writing about the area visited. For example, a book by an English gentleman farmer trying to induce English immigration to Illinois will contain different images than a book written about a New York lady's western holiday which was intended to entertain her peers.

The frequency and detail with which various images appear are strongly affected by the above factors. For example, nearly all travelers who visited the prairie in the fall described fires. For wayfarers of poetic or romantic bent, fires were almost the only feature of the prairie deserving eloquence. On the other hand, pragmatic writers discussed fire because of its real threat to life and property. In contrast to fire, the density of the prairie sod, vitally important to farmers, escaped unnoticed by romanticists and hasty itinerants. Nevertheless, the principal features of prairie vegetation are evident from this literature and only a small fraction is cited here.

RECONSTRUCTION OF PRAIRIE VEGETATION

Travelers observed five vegetational formation groups (*sensu* UNESCO, 1973) in and adjoining the Prairie Peninsula: prairie, barrens, oak openings, and deciduous and evergreen forests. The forests which virtually enclosed the Prairie Peninsula were extensively described and subdivided, but these details are outside the scope of this paper. Prairies occupied a core area, the Grand Prairie of Illinois, and they became smaller and more isolated to the north, east, and south. Barrens were shrub savannas located chiefly south of the principal northeasterly axis of prairie distribution, whereas oak openings, or tree savannas, occurred primarily north of this axis. However, the distribution of prairies, barrens, and oak openings was perceived as extremely complex. "Prairies of a few yards' extent are found in the midst of dense and extensive forests, and rows of trees jutting miles into the open country, without visible agency to account for their preservation" (Shirreff, 1835:243).

Prairies were "immense meadows, interspersed with small copses of wood, which seem to have been placed by the hand; the grass is so very high that a man is lost among it . . ." (Charlevoix, 1761, 2:200). Although Charlevoix's description was universally endorsed (Dablon, 1674; Hennepin, 1683; St. Cosme, 1699; Hulme, 1818; Woods,

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1822; Schoolcraft, 1825) and a popular phrase of the nineteenth century described prairies as "like an English park," prairies on sandy or rocky ridges could be composed of open stands of grass less than half a meter tall (Thomas, 1819; Atwater, 1831). These sites, however, were normally occupied by groves or oak openings (Gilman, 1836; Flint, 1822).

The prairie consisted "chiefly of three or four tall growing [grass] species, the creeping roots of which escape destruction [by fire], and continue to exist without renewal from seed" (Shirreff, 1835:245). But a wide variety of forbs and flowering shrubs, such as roses, were also present (Filson, 1784; Woods, 1822; Parsons, 1840; Steele, 1841; Buckingham, 1847) and diversity was so great that a companion of Ellet (1853:39) "counted eighty different species of plants in flower . . . besides a number of sedges and grasses . . ." on one July morning at Cherry Valley, Illinois.

This abundance of forbs and shrubs in no way detracted from the density of the sod. "Six horses are necessary for the first ploughing, as the grass and shrub roots are deep down and uncommonly tough, having been growing for ages . . ." (Faux, 1823:273). Multiple teams of horses could not break the sod in the Grand Prairie as Steele (1841:134) related, "The ground is very hard to break, generally requiring several yoke of oxen . . . ."

Most travelers clearly differentiated prairies from barrens and oak openings because (1) the number and distribution of woody plants varied and (2) barrens and oak openings owed their existence exclusively to fire and were rapidly replaced by forest in its absence (Flint, 1822; Flagg, 1838). Whereas prairies contained very few woody plants other than in the groves, barrens were "land nearly destitute of timber, but much overrun with scrubby underwood . . ." (Woods, 1822:260). Although the largest and best known barrens lay south of the Ohio River, barrens occupied substantial parts of Ohio and Indiana (Hutchins, 1778; Drake, 1815; Welby, 1821). Birkbeck (1818:94) described his route into Vicennes, Indiana, from the east as "partly across 'barrens,' that is land of middling quality, thinly set with timber, or covered with long grass and shrubby underwood; generally level and dry, and gaudy with...brilliant flowers...." The woods between Corydon, Indiana, and the Ohio River were interspersed with barrens which were "covered over with small copsewood, also with grasses, and an immense variety of forbs . . ." (Flint, 1822:280-281). These shrub savannas frequently formed narrow transitional zones between prairie and forest (Flint, 1822; Woods, 1822; Shirreff, 1835).

In many localities, the principal woody stratum was composed of trees rather than shrubs and produced oak openings rather than barrens. The oaks at Pontiac, Michigan, were "noble trees [which] stand like apple trees in an orchard, from one to three rods [4 to 15 m] asunder . . ." (Bradley, 1835:259). While the image of an orchard was frequently invoked, most authors regarded the oaks and other trees as stunted, "about thirty feet [9m] in height" (Shirreff, 1835:218). Often, there was "not a twig of underwood" (Hoffman, 1835:142, Ellet, 1853) and the grass grew "to a height of five or six feet [1.5 or 1.8 m]" (Schoolcraft, 1825:7), but at some sites the undergrowth was "a sort of scrub oak" (Bradley, 1835:259).

ENVIRONMENTAL FACTORS

The travelers not only described the vegetation but also discussed a number of environmental factors which commanded attention, such as fire, moisture relationships, and soil characteristics. Some indications of biotic impacts were also provided (Hennepin, 1683; Croghan, 1765; Ferguson, 1856).

For reasons noted earlier, fire was the most universally recognized element of the environment. Although fires were believed to arise occasionally from natural causes, most were set by humans. Hennepin (1683:143) reported that the Miami Indians near the Kankakee River hunted bison in the following way: "When they see a herd, they gather in great numbers, and set fire to the grass every where around these animals, except some passage which they leave on purpose, and where they take post with their bows and arrows. The buffalo, seeking to escape the fire, are thus compelled to pass near these Indians . . . ." Carver (1778), Schoolcraft (1821), and Blane (1824) described similar hunting practices, the results of which were, that by late October, so much of the prairie had been burned that Hennepin's party found game difficult to procure.

Severity of fires varied greatly with dryness of the season (Woods, 1822; Flower, 1822), but some burning occurred every year. Almost all fires occurred in the fall; Hoffman (1835) and Cobden (1859) described exceptions. The fall was "called the *Indian summer* [and] is caused by millions of acres for thousands of miles round, being in a wide-spreading, flaming, blazing, smoking fire, rising up through wood and prairie, hill and dale, to the tops of low shrubs and high trees, which are kindled by the coarse, thick, long, prairie grass, and dying leaves . . ." (Faux, 1823:232).

Prairie fires frequently "reached the forests, and rushed like torrents through. Some of the trees fell immediately, others stood like pillars of fire, casting forth sparkles of light. Their branches are strewed in smoking ruins about them" (Fordham, 1818:234). Hoffman (1835) evoked a similar image of fire in the oak openings of Michigan. In evaluating the role of fire in the prairies, however, it must be recognized that forest fires were also commonly reported by Cuming (1810), Thomas (1819), Harris (1821), Schoolcraft (1821), Welby (1821), Flint (1822), Woods 1822), and Ferrall (1832). These authors provided no evidence to suggest that such fires led to the creation of prairie.

Similar to fire, wetness was a powerful and frequently recurring image of the prairie. "We rode off on our way to Princeton, Indiana, through a cold, wet, marshy prairie, over which hang dense fogs, and on which lies water knee-deep in summer" (Faux, 1823:301). The mud was occasionally so deep that "Once my horse sunk in the plain up to his chest, and rolled over" (Fordham, 1818:151). These wet prairies were commonly inhabited by crayfish (Faux, 1823).

These images of southern Illinois were similar to central Illinois where "the soil is a very rich black mud almost impassable in wet weather" (Cobden, 1859:151) and a rain shower "covered the roads four or five inches [10 or 12.5cm] deep with water . . ." (Shirreff, 1835:251). In northern Indiana and Illinois, Charlevoix (1761, 2:184) "walked a league farther in the meadows, having my feet almost always in the water" and "boats of eighteen tons [16.2 tonnes] have actually passed over the intervening prairie [between the Chicago and Des Plaines Rivers] at high water" (Hoffman, 1835:244). In northern Ohio, Bradley (1835:246) "turned from the road and waded through the long grass of the prairie for miles, prefering a foot of unadulterated water, for it stood to that depth on the surface of the ground, to a great or greater depth of mud [in the road]." The concensus was that the prairie would have been called a swamp in New England (Ogden, 1823) and a marsh in England (Faux, 1823).

Prairies were nevertheless divided into two classes, wet and dry, meaning permanently wet versus seasonally wet. Many prairies became dry in the late summer or during droughts. For example, Flint (1822) described the prairie south of Sandusky, Ohio, in the fall of a drought year, as dry; yet, Bradley (1835) described the same prairie, seen in early summer, as very wet. When the prairie was dry, it was intensely dry, with the soil cracking and creating dust which was a great inconvenience to travelers (Flint, 1822; Flagg, 1838; Ellet, 1853).

Cultivation resulted in immediate improvement of drainage (Birkbeck, 1818). Drake (1850:316) explained that "The rigid grasses of the prairie retard the escape of rains and melted snows, while their long wiry roots bind the soil, and prevent the waters from excavating trenches through which they might flow off." Construction of roads (Bryant, 1850), drainage ditches, and planting of live hedges (Fuax, 1823) also greatly reduced the wetness of the prairie.

A third image of the prairie was the richness of its soil (Dablon, 1674; Hennepin, 1683). One term, "black vegetable mold," defined the soils of the prairie (Thomas, 1819; Ferguson, 1856; Steele, 1841). Both Flint (1822) and Woods (1822) equated prairie soils to the peat soils of England. Atwater (1831:212) observed the ditching of the wet prairie at the northern edge of Circleville, Ohio, and "ascertained that this prairie contained a great abundance of peat. I have specimens of it in my possession, which burn brisky . . . ." Atwater also listed many other Ohio prairies as being herbaceous peat bogs.

In 1858 Caird, the British agriculturist, collected soil samples in Illinois. Voelcker (1859:127) performed the chemical analyses and reported to Caird that "*Indeed, I have never analysed before soils which contained so much nitrogen, nor do I find any records of soils richer in nitrogen than yours.*" Voelcker also noted that the phosphorus and lime contents of these samples were unusually low, in contrast to the nitrogen levels, which were "nearly twice as much as the most fertile soils of Britain" (Caird, 1859:77).

CONCLUSION

This reconstruction of Prairie Peninsula vegetation before 1860 is based on a modest sample of the extant travel literature and, therefore, details are subject to elaboration. Each point presented, however, has been derived from two or more sources. Agreement among the sources is sufficiently complete to permit one fundamental conclusion to be drawn. The eastern North American prairie was composed of dense sods of frequently burned tallgrasses, accompanied by many different forbs. They occupied seasonally or permanently wet soils which were often peat-like in their characteristics. In these aspects of physiognomy and ecology, the prairies lying east and north of the Mississippi and Ohio Rivers exhibited far closer affinities to tropical grasslands, such as those in Colombia and Venezuela, than to the grasslands of western interior North America.

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CHARACTERIZATION OF SOME SOUTHEASTERN BARRENS, WITH SPECIAL REFERENCE TO TENNESSEE

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The barrens of southeastern United States refer to vegetation resembling tallgrass prairie, but in the central southeast, as in Tennessee and Kentucky, the term may include scrub forest, woodland and savanna with grass-dominated openings (open barrens or prairie), and low density forest with grass understory. Usage follows André Michaux as cited by Williams (1928), Safford (1869), Killebrew and Safford (1874), and Dicken (1935). It is recognized that areas called barrens in the eighteenth and nineteenth century include some rather stable forest, grassland, and a large number of communities of considerable extent which were successional, i.e., reacting to or recovering from environmental modification as timber cutting, fire, and climatic shifts (Vestal, 1936; DeSelm et al., 1973).

Excluded here are the pine barrens of the Coastal Plain (Schwarz, 1907), the shale barrens of the Ridge and Valley Province (Platt, 1951), the serpentine barrens of Pennsylvania and West Virginia (Wherry, 1963), and other openings, such as, the grassy balds (Mark, 1958), the granite outcrops (McVaugh, 1943), sand dunes and salt marshes (Godfrey and Godfrey, 1976), grass-sedge marshes and bogs (Wells and Shunk, 1928), and moss-ericad bogs (Barclay, 1957). The barrens are related floristically and successionally to, and may be contiguous with, rock glades over sandstone, cedar and cedar-pine glades over limestone or dolomite, and freshwater marshes. Probably some areas described in early accounts and seen today are old fields. Indian fields were noted early in various places in the Southeast according to Hawkins as reported by Williams (1928). The relationship between twentieth century old fields and barrens was noted by DeSelm et al. (1969).

EXTENSIVE SOUTHEASTERN PRAIRIE

Extensive grassland, excluding marshes and swamp openings which are often called prairie in Florida by Davis (1967) and elsewhere on the Coastal Plain by Hilgard (1860), are well known in the Southeast. Prairies inland from the coastal marshes of Texas and Louisiana (Chabreck, 1972) were described briefly in Texas by Tharp (1926), and mapped by Allred and Mitchell (1954) and Newton (1972). Similarly, wet prairie occurred on the Mississippi River alluvial plain of Missouri and Arkansas (Shantz and Zon, 1924; Allred and Mitchell, 1954). The quick conversion of this land for agriculture, especially rice culture, left little for scientific study.

The Black Belt of Alabama and Mississippi is more or less confined to the Dermopolis chalk; recent studies are Jones and Patton (1966), Rankin and Davis (1971), and Rankin (1974). The Jackson Prairie of Mississippi occurs on the Tertiary Jackson Group, Forest Hills Formation, and Red Bluff clays, sands, and limestones (Bicker, 1969; Lowe, 1921).

The barrens of Kentucky occur both in the central part of the state and in the Jackson Purchase area of western Kentucky. Garman (1925) and McInteer (1942, 1946) commented on barrens vegetation in Kentucky, and they were mapped by Dicken (1935).

SMALL BARRENS OPENINGS

Early travelers in the Southeast saw numerous openings in the forest matrix (Harper, 1958). They were especially numerous on the Coastal Plain where Indian populations were high (Denevan, 1976). Many were doubtlessly old fields or recent burns (Stewart, 1956). Interior of the Coastal Plain and south of the limits of Wisconsinan glaciation, hundreds, perhaps thousands, of small openings occurred in addition to the large or extensive but discontinuous ones mentioned previously. Here, Indian populations were generally lower (Denevan, 1976) and old fields explanations are less likely. In Tennessee openings occurred in several physiographic regions excluding only the Blue Ridge Province and Mississippi River alluvial plain. The map by Transeau (1935) indicated prairie in western Tennessee (Mississippi Embayment, Coastal Plain) and the northern Highland Rim (Interior Low Plateau). Dicken (1935:Fig. 1) also indicated barrens on the western and eastern Highland Rim. Shanks (1958), in a more accurate portrayal, drew inclusive boundaries wherein barrens occurred on the northern, eastern, and southeastern Rim. DeSelm et al. (1969) examined a series of sites from the Ridge and Valley, and described the consequences of understory burn in barrens on the eastern Rim (DeSelm et al., 1973).

SITES AND METHODS

In 1954 the author began searching for remnants of barrens in Tennessee. By 1960, 24 sites had been located, and floristic lists from each opening and adjacent forest border, savanna, or scrub were obtained by repeated visits. For one-third of these sites, University of Tennessee Herbarium specimens, chiefly those of A.J. Sharp and R.E. Shanks, were used to supplement personal collections. The search was intensified in 1973, and in 1977 herbarium records were added from other sites.

A total of seventy-seven sites are reported here and nine additonal ones are currently under study. They are located in the Ridge and Valley (43 sites), Cumberland Plateau (11), eastern Highland Rim (7), northern Rim (1), western and southwestern Rim (4), Central Basin (3), western Tennessee River Valley (4), and western Tennessee (4). Sites vary in size from about 0.1 to 100 ha. Valley and Ridge sites are mostly over Chickamauga limestone on shallow soils. Cumberland Plateau sites are on shallow, stony, sandy soils of gently sloping

Table 1. Percentages of 931 native taxa among certain life forms and intraneous and extraneous floristic elements.

	Intraneous			Extraneous			
	Southern	Northern	Endemic	Southern	Northern	Western	CP[1]
Phanerophytes	10.6	4.7	0	1.3	1.3	< 0.1	0
Hemicryptophytes	23.1	19.7	1.0	2.7	5.2	1.2	0.7
Cryptophytes	5.9	4.3	0.1	1.4	0.4	0.4	0.6
Total	47.5	33.9	1.1	6.0	7.8	2.3	1.3

[1]Long disjunct Coastal Plain taxa.

upland. Highland Rim sites are on flat to gently sloping loess derived soils with shallow fragipans. Most western Tennessee River Valley sites are on shallow soils over limestone; the western Tennessee sites are on loess over Tertiary sands and clays. Included among the sites are a few suspected old fields (DeSelm et al., 1969), and at least one cedar-pine glade (Finn, 1968) in the Valley and Ridge and rock outcrop borders on the Plateau.

SOME CHARACTERISTICS OF THE TENNESSEE BARRENS FLORA

Based upon data through 1977, 1022 vascular plant taxa occur in the barrens of Tennessee, representing about 37 percent of the state's flora. Native plants total 931, of which 772 are herbaceous. When a comparison of the list of native taxa in the barrens of Tennessee is made with that of Gibson (1962), which contains a large sample of the Kentucky flora, Raunkiaerian life form distribution is very similar. However, the hemicryptophyte percent here is 42.9, 8.3 percent lower than in Kentucky. Perhaps the more southerly climate is operating (Cain, 1950).

When the sites are arranged longitudinally, certain trends occur which may be significant: (1) the nanophanerophyte (shrub) percentages peak on the Plateau and decline elsewhere, (2) the woody vine percentage peaks in the three limestone regions (Ridge and Valley, Central Basin, and western Tennessee River Valley), (3) pteridophytes occur chiefly in eastern and eastern middle Tennessee, peaking on the flat, poorly drained eastern Rim, and (4) hemicryptophyte and cryptophyte percentages rise irregularly east to west into areas of less certain precipitation during the growing season (Vaiksnoras and Palmer, 1973).

Fernald (1950) provided his opinion of the taxonomic-geographic relationships of the northeastern flora, and based upon his opinion, expressed as manual range, the flora of the barrens is composed of 81.4 percent intraneous and 18.6 percent extraneous (peripheral) elements. Western and long disjunct Coastal Plain elements are minimal. Among intraneous taxa, the most common life forms are southern (Table 1). Among extraneous taxa, the northern to southern ratios are varied, but it seems possible that dispersal mechanisms or some other yet unevaluated characteristic may be operating instead of life-form.

SOME REMAINING PROBLEMS

The foregoing represents only a brief first look at the long accumulated data that has just been computerized. Many other analyses are planned, and the author welcomes suggestions for analytical avenues and techniques. For example, the cryptogam flora is relatively uncollected.

Intriguing problems such as those of the timing of evolution of the flora, the age of the barrens, and the consequences of Pleistocene vegetation displacement and of Holocene climatic changes should be examined. The vegetation in terms of its plant communities and its edaphic physical and chemical interactions are parts of another set of unexplored matters.

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PRAIRIES ON KANSAN OUTWASH DEPOSITS IN NORTHERN KENTUCKY

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Previous studies of prairie vegetation in Kentucky have been concerned with the Prairie Peninsula of the west and west-central sections (Garman, 1925; Sauer, 1927; Dicken, 1935; McInteer, 1942, 1946; Braun, 1950; and Bryant, 1977), although small patches of prairie are known from the Knobs and the south-central sections of that state (Braun, 1950). All of those areas were not exposed to Pleistocene glaciations. To date no reports of prairie vegetation are known for the extreme northern counties of Kentucky where Ray (1974) identified deposits of Nebraskan, Kansan, and Illinoian till and outwash; however, in adjacent southwestern Ohio, prairies were described for glaciated areas of Illinoian (Braun, 1928a, b; Irwin, 1929). Braun (1928a) pointed out that other glacial advances, though not represented in the glacial deposits of southern Ohio, may have influenced its vegetation.

At Bald Point, an area of Kansan outwash deposits in Boone County, Kentucky, two small prairie inclusions were discovered within an old growth mixed mesophytic forest. No thorough descriptions of prairie vegetation on Kansan deposits east of the Mississippi River are known although Evers (1955), and Voigt and Mohlenbrock (1964) mentioned their presence in southern Illinois. The Principia Prairie which was studied by Kilburn and Warren (1963) was probably near the southern edge of the Kansan in Illinois.

This paper describes two prairies on Kansan outwash in northern Kentucky and makes comparisons with other prairies in particular those of southern Ohio and southern Illinois. The phytogeographical significance of prairies on pre-Illinoian deposits south of the Illinoian glacial boundary is considered.

STUDY AREA

The prairies on the Kansan outwash deposit are approximately 10 km west of Union, in western Boone County, Kentucky, and approximately 9 km east of the Ohio River (Fig. 1). The area is extremely dissected with elevations ranging from 159 to 245 m above mean sea level. Conglomerate cliffs outcrop throughout the area especially along the small tributaries to Gunpowder Creek. Ray (1974) reported that along the outer margins of the Kansan ice sheet, outwash and till were deposited in valleys intermediate between the upland surface and the bottoms of the present stream valleys. He found these deposits present in the vicinity of Gunpowder Creek. Ray stated that the silty sand filling the channel was well exposed and the lower part of the deposit contained large and abundant calcareous nodules which indicated a long period of weathering and an abundant source of calcite. Soils of the area included Cynthiana, Eden, Rossmoyne, and Jessup (Weisenberger et al., 1973).

Both prairies occur on slumps which appear to be common in the area. For convenience these two prairies are referred to as Bald Point 1 and Bald Point 2. Bald Point 1, approximately 0.07 ha, occupies an exposed point on a southwest-facing ridge line. This turtleback slump slopes gently on either side to the forest. A large conglomerate outcrop is present near the upper edge of the prairie. Bald Point 2, approximately 0.05 ha, is south-facing and is situated on an upper ridge adjacent to an area in the thicket stage of secondary succession.

The old growth forest which surrounds the prairies has as its dominants the following species: *Acer saccharum, Liriodendron tulipifera, Fraxinus americana, Quercus rubra, Fagus grandifolia, Quercus muhlenbergii, Tilia americana,* and *Quercus alba.* Braun (1950) suggested that a forest of similar composition originally occupied the more rolling topography of the outer periphery of the Outer Bluegrass of Kentucky.

The climate of northern Kentucky is temperate and humid. The average temperature is 12.2° C and the average rainfall is 101.6 cm (Weisenberger et al., 1973).

METHODS AND MATERIALS

The prairies were visited two to three times per month during the growing seasons of 1976 and 1977, and monthly visitations have continued to the present. The prairies were sampled by 1 m x 1 m quadrats. Quadrats were established at 5-m interals along a series of line transects across each prairie. Twenty-five quadrats were sampled in Bald Point 1 and sixteen in Bald Point 2. The frequency was calculated for each species. Curtis (1959) suggested that frequency alone was an adequate expression of data for species in grassland vegetation.

Soil samples were collected from the prairies, prairie-forest borders, and surrounding forest, and were sent to the Soil Testing Laboratory, University of Kentucky, for analysis of pH, calcium, phosphorus, magnesium, and potassium. Soil texture was determined by the hydrometer method. All samples were made to a depth of 25 cm with a soil auger and placed in plastic bags for transport. In addition, soil samples were placed in sealed vials containing small amounts of distilled water and allowed to incubate in sunlight for a period of up to six weeks. After that time the samples were analyzed for the presence or absence of soil algae. Nomenclature for vascular plants follows Fernald (1950) and for algae Smith (1950).

RESULTS

Bald Point 1

The dominant grasses were *Bouteloua curtipendula, Andropogon scoparius,* and *Sorgastrum nutans* with frequencies of 60, 44, and 16 percent, respectively (Table 1). The dominant forbs and their frequencies, expressed as percentages, were *Galactia volubilis,* 72; *Opuntia humifusa,* 52; *Euphorbia corollata,* 48; *Monarda fistulosa,* 40; *Equisetum hyemale,* 28; and *Rudbeckia hirta,* 20. Other forbs present, but not included in quadrats, were *Allium stellatum, Pellaea atropurpurea,* and *Solidago caesia* while *Physostegia virginiana* and *Cacalia atriplicifolia* were most abundant on the conglomerate outcrop near the upper edge of the prairie. Woody species included *Rhus radicans, Celastrus scandens,* and seedlings of *Cercis canadensis,* with frequencies of 48, 44, and 20 percent, respectively. Several dead seedlings of *C. canadensis* and *Juniperus virginiana* were observed in the prairie.

The change from prairie to tree cover was quite abrupt. Forbs at the prairie-forest border were *Erigeron pulchellum*, *Senecio obovatus*, and *Penstemon hirsutus*. Shrubs and small trees included *Viburnum rufidulum*, *Cornus florida*, and *C. canadensis;* trees present were *Fraxinus americana*, *Quercus muhlenbergii*, *Q. rubra*, *Tilia americana*, *Acer saccharum*, and *Ostrya virginiana*.

Soils were predominantly sand, but due to the abundance of calcite the pH was 7.9 (Table 2). The high sand content is the result of weathering of the conglomerate. Water rapidly percolates through the sand and is funneled off to the forest slopes along a clay fracture which lies from 0.5 to 1.5 m below the surface. It was along the lower prairie edge where water seepage was evident that *Equisetum hyemale* occurred in greatest abundance.

Bald Point 2

This prairie was dominated by *Andropogon scoparius* with a frequency of 81.25 percent (Table 1). *Bouteloua curtipendula* was absent from this prairie. Forbs included *Hieracium venosum*, *Solidago caesia*, and *Lycopodium flabelliforme* in addition to a number of "weedy" species. Shrubs included *Hypericum spathulatum* and *Symphoricarpos orbiculatus*. Seedlings of *Robinia pseudo-acadia* were abundant at the upper edge of the prairie. Trees at the prairie-forest border were *Nyssa sylvatica*, *Liriodendron tulipifera*, *Fraxinus americana*, *Acer saccharum*, and *Quercus muhlenbergii*.

Soils were composed of clay and silt with only a trace of sand. The pH was 5, and the amount of phosphorus was exceedingly low. The soil resembled that of the adjoining ridge woods more closely than any other, suggesting that this prairie site was formerly forested.

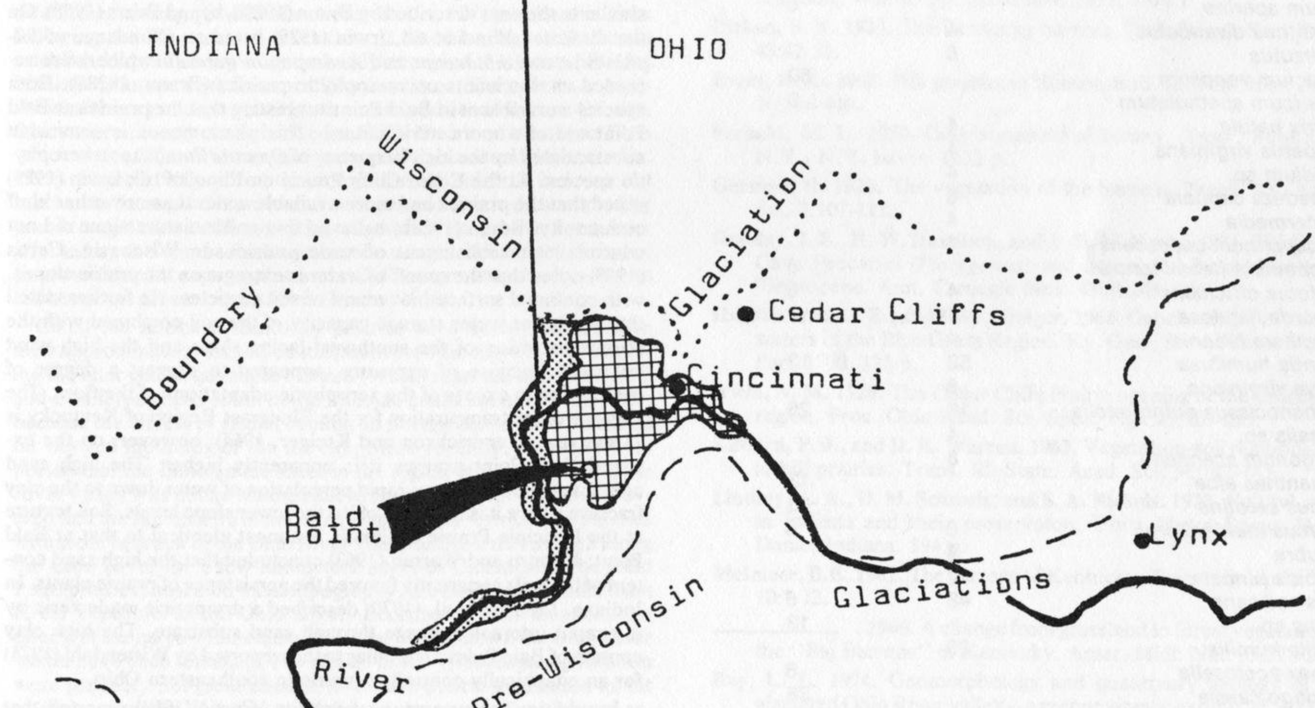

Figure 1. Map of the glaciated tristate area of Kentucky, Ohio, and Indiana with the Kansan and Illinoian deposits in the vicinity of the Bald Point Prairies indicated. Other prairies are marked by a solid dot. (Modified from Ray, 1974.)

Table 1. Frequency (percent) of plant species at Bald Point 1 and 2, two prairie sites on a Kansan outwash deposit, Boone County, Kentucky.

	Bald Point 1	Bald Point 2
Achillea millefolium		31
Ambrosia artemisiifolia	8	
Andropogon scoparius	44	81
Anemone virginiana		6
Arabis laevigata		6
Asclepias verticillata	12	
A. viridiflora	4	
Blephilia ciliata	16	
Bouteloua curtipendula	60	
Carex sp.		13
Celastrus scandens	44	13
Cercis canadensis	20	13
Chenopodium sp.	4	
Crataegus sp.		6
Desmodium sp.	4	
Equisetum hyemale	28	
Euonymus atropurpureus	8	
Euphorbia corollata	48	6
Galactia volubilis	72	
Galium sp.		6
Galium aparine		6
Helianthus divaricatus	4	
H. hirsutus	8	
Hieracium venosum		50
Hypericum spathulatum		6
Hystrix patula	4	
Juniperus virginiana	4	
Lepidium sp.	4	
Lespedeza capitata	8	
L. intermedia	4	
Lithospermum canescens	4	
Lycopodium flabelliforme		6
Melilotus officinalis	4	6
Monarda fistulosa	40	
Oenothera biennis	4	
Opuntia humifusa	52	13
Ostrya virginiana	8	
Parthenocissus quinquefolia	16	25
Physalis sp.	4	
Polygonum scandens	8	
Prenanthes alba		13
Prunus serotina		13
Quercus muhlenbergii	8	6
Q. rubra	8	
Ratibida pinnata	12	
Rhus radicans	48	6
Rubus sp.		13
Ruellia humilis	20	
Rumex acetosella		6
Solidago caesia		38
Sorgastrum nutans	16	
Symphoricarpos orbiculatus		13
Tradescantia ohiensis	4	
Triodia flava	4	
Verbascum thapsus	4	
Vitis sp.		6

DISCUSSION

Numerous reports of scattered prairie communites have been reported from within the eastern deciduous forest region. In Illinois Evers (1955), and Voigt and Mohlenbrock (1964) referred to these prairie relicts as hill prairies. Almost invariably, prairie openings occur on exposed locations where evaporation and exposure are great (Irwin, 1929). Those locations are primarily on steep hillsides, usually sloping toward the southwest (Evers, 1955; Curtis, 1959). On Illinoian till, Irwin (1929) noted prairie openings on exposed, slumped, steep, southwest-facing slopes. All of these descriptions including slumps are similar to the location of the prairies on Kansan outwash in northern Kentucky.

Unless stated otherwise the majority of the following discussion is concerned with Bald Point 1. The two dominant grasses, *Bouteloua curtipendula* and *Andropogon scoparius,* were also the dominants of the Illinois hill prairies (Evers, 1955; Kilburn and Warren, 1963; Voigt and Mohlenbrock, 1964), the xeric prairies of southern Ohio (Braun, 1928b), and the xeric prairies of Wisconsin (Curtis, 1959). *Sorgastrum nutans,* which was third highest in frequency among the grasses, was also reported (Braun, 1928b; Evers, 1955; Voigt and Mohlenbrock, 1964), but it was less abundant than *Bouteloua curtipendula* and *Andropogon scoparius*.

The presence of prairie forbs gave those prairies an appearance similar to the ones described by Braun (1928a, b) and Evers (1955). On the dissected Illinoian till, Irwin (1929) listed an abundance of *Silphium terebinthinaceum* and *Andropogon gerardii* which were recorded as dominants on mesophytic prairies (Braun, 1928a). Both species were absent at Bald Point suggesting that the prairies at Bald Point are of a more xeric nature. This phenomenon is somewhat substantiated by the high frequency of *Opuntia humifusa,* a xerophytic species. At the Cedar Cliffs Prairie on Illinoian till, Irwin (1929) noted that the prairies had more available water than any other bluff community. Braun (1928b) believed that soil moisture alone did not control the establishment of xeric prairies. In Wisconsin, Curtis (1959) noted that the runoff of water is extreme on the prairie slopes, with continual surface movement of soil particles. He further stated that the lower water storage capacity of the soil combined with the strong insolation of the southwest-facing slope and the high wind velocities because of exposure, appeared to suggest a degree of desiccation in excess of the xerophytic adaptations of the flora. The average evapotranspiration for the Bluegrass Region of Kentucky is 71 cm/year (Hendrickson and Kreiger, 1964); however, on the exposed Bald Point prairies it is apparently higher. The high sand content of the soil allows rapid percolation of water down to the clay fracture where it is funneled off to the lower slope levels. Soil texture at the Principia Prairie in Illinois is almost identical to that at Bald Point; Kilburn and Warren (1963) concluded that the high sand content of the soils apparently favored the persistence of prairie plants. In Indiana, Lindsey et al. (1970) described a dry prairie made xeric by the rapid internal drainage through sand substrate. The high clay content of Bald Point 2 is similar to that reported by Wistendahl (1975) for an edaphically controlled prairie in southeastern Ohio.

In addition to low water availability, Curtis (1959) reported that nutrients were severely limited and that great uniformity existed in many of the chemical properties of prairie soils, particularly pH and calcium content. Evers (1955) and Curtis (1959) recorded a pH range of 7-8.3. A pH of 7.9 at Bald Point 1 falls within this range; however, calcium, potassium, and phosphorus were lower than reported by Curtis (1959) for the xeric prairies of Wisconsin. The low pH of 5 for Bald Point 2 suggests that this site was formerly forested.

Table 2. Soil texture (percentages of clay, silt, and sand), pH, and nutrients (ppm of phosphorus, potassium, calcium, and magnesium) at sampling sites in the Bald Point prairie—forest complex, Boone County, Kentucky.

	Clay	Silt	Sand	pH	P	K	Ca	Mg
Mesic Woods	3.18	24.62	72.31	7.30	93.00	36.50	1300	46.00
Mesic Woods—Prairie Border	2.68	35.71	61.61	7.70	64.50	76.00	1825	44.50
Bald Point 1 Prairie	2.83	17.08	80.10	7.90	44.38	58.38	2010	48.38
Oak Woods—Prairie Border	3.70	22.22	74.07	8.00	21.00	51.50	2185	58.00
Oak Woods	2.16	37.41	60.41	8.00	25.50	60.50	1945	43.00
Equisetum—Woods Border	2.99	10.45	86.57	7.85	43.00	66.50	2020	45.00
Ridge Woods	99.00	trace	trace	5.50	21.50	86.00	325	43.50
Bald Point 2 Prairie	52.40	47.50	trace	5.00	7.00	179.00		

The invasion of Bald Point 1 by forest species appears not to be occurring. The lower sand and higher silt content in the forest and prairie-forest border soils may account for the abrupt change from prairie to forest. Irwin (1929) suggested that slumping is unfavorable for tree growth yet does not adversely affect prairie grasses. The movement of forest species onto Bald Point 2 is occurring, although slowly. One additional difference noted in the soil is that *Chlorococcum,* a green alga, was present in all but the prairie soils; however, *Oedocladium,* another green alga, was present in the soil of Bald Point 2. The absence of these green algae suggests a high degree of desiccation for Bald Point 1.

The significance of the Bald Point prairies is that they are on Kansan outwash immediately south of the Illinoian and Wisconsinan glaciations. This geographical position allows for speculation on the origin of these prairies, particularly since Braun (1928a) suggested that the absence of prairie south of the glacial boundary in Ohio, Kentucky, Indiana, and Illinois, and from the adjacent Illinoian drift plains of Ohio pointed to a pre-Illinoian prairie extension from the west. She believed that it was plausible that the prairies of Adams County, Ohio, were the southeastern limit of a prairie arm extending down from the northwest; all evidence of which was obliterated by the Illinoian glacial advance.

The Bald Point prairies on Kansan deposits support Braun's hypothesis assuming that these prairies are remnants of a seed source established during pre-Illinoian times and not of xerothermic time following the Wisconsinan glaciation. It could be argued that once established, prairies have continuously occupied the slump hillsides of the Kansan outwash from pre-Illinoian times. The species composition of these prairies resembles the xeric prairies of Adams County, Ohio, more closely than the Cedar Cliffs Prairie of southern Ohio which dates from Wisconsinan or post-Wisconsinan times (Irwin, 1929). Braun (1950) stated that exposures of old drift in areas not reached by later galciations may have been continuously occupied by prairie vegetation. Although this vegetation may have been later affected by the approach of another ice margin, the longer period of time available for topographic and soil development, also has had an influence on present vegetation (Braun, 1950).

Could the northern Kentucky prairies have been maintained in their approximate present locations from pre-Illinoian times considering the later glacial advances? Braun (1928a) reported that the Arctic and Coniferous belts south of the Illinoian could not have been wide, because the effects of glacial cooling do not appear to have extended far beyond the limits of the ice cap. More recently, Ray (1974) reported that the Illinoian ice sheet in the region of the glaciated Ohio River valley was not as widespread as formerly believed. He discovered that the Illinoian till in northern Kentucky is restricted to patches within the bedrock of the Ohio River valley and to a narrow belt along the Ohio River for a few kilometers north of Cincinnati. The Bald Point prairies, based on local topography, are sheltered by hills from direct exposure to the Ohio River. Because of their location, the effects of the narrow Illinoian tongue that passed down the Ohio River would have been lessened. The effects of the Wisconsinan glaciation were probably not great enough to disturb prairie vegetation as far south as northern Kentucky. Based on the types of vertebrate remains from Welsh Cave in Woodford County, Kentucky, Guilday et al. (1971) concluded that 13,000 years ago the vegetation of central Kentucky was prairie, semiprairie, open prairie parkland, boreal woodland, and open country. This evidence is consistent with the presence of xeric prairies in northern Kentucky. In fact, Anderson (1954) postulated that the dry lime prairies in the Driftless Area of Wisconsin persisted throughout the Pleistocene period of glaciation even though they were within a few kilometers of the glacial border.

In conclusion, if Braun's hypothesis is correct, the Bald Point prairies may represent the remnants of that pre-Illinoian prairie extension. Those prairies on the Kansan outwash were probably more extensive in former times. It is probable that prairie species in northern Kentucky could have survived the more recent glaciations and climatic changes. Small prairie communities could have been maintained in areas where exposure, soils, and slumping favor their persistence. In fact, where slumping occurs within the forest, prairie plants are able to invade those slumps and maintain themselves for a period of time. This phenomenon has occurred at Bald Point 2 and could be a possible factor allowing prairie plants to persist within the mesophytic forest. Moreover, Braun (1928b) stated that it is not among existing conditions that a complete explanation of a vegetational type is sought; rather the vegetational type may represent the summation of past conditions, and be modified by more recent conditions.

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BUFFALO BEATS, A PRAIRIE REMNANT IN UNGLACIATED SOUTHEASTERN OHIO, SUPPORTS TRANSEAU'S PRAIRIE PENINSULA CONCEPT

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The well known map of the Prairie Peninsula by Transeau (1935), later reproduced in part by Weaver (1955), shows the extent of prairie vegetation in the Midwest and its range eastward into Ohio. Buffalo Beats, a prairie of 0.4 ha, is significant because it is an easternmost remnant of the Prairie Peninsula surrounded by forest vegetation within the Wayne National Forest, Athens County, Ohio. Floristic evidence and soil characteristics are summarized here and suggest that Buffalo Beats is a prairie relict which supports Transeau's concept of a Prairie Peninsula. Extensive documentation has been presented by Wistendahl (1975).

DESCRIPTION

Perhaps one of the most significant facts of the Buffalo Beats prairie is that it is located on unglaciated terrain. The Wisconsinan glacial border lies approximately 40 km (25 miles) to the northwest (Ohio Div. Geol. Surv., 1965). The hilly topography of southeastern Ohio is strikingly apparent (Bier, 1956) with maximum elevation of approximately 335 m (1100 ft) and a relief of approximately 60 m (200 ft). The effect of nonglaciation on plant distribution has been discussed, for example, by Braun (1928), Gordon (1969), and Forsyth (1970). Kingsley and Mayer (1970) published a map with Athens County having greater than 50 percent forest cover. Their tabulated data reveal that 68 percent of the county is in commercial and private forest. The original forests of the region prior to settlement by European man, as indicated from the records of the original surveyors, were primarily dominated by a mixture of oaks (Gordon, 1966, 1969), but the secondary forest in the vicinity of Buffalo Beats is now commonly referred to as an oak—hickory forest climax or cover type. The existence of a small, 0.4 ha (1 acre), prairie surrounded by forest is, indeed, extremely unusual and raises numerous ecological and phytogeographical questions. The prairie, extant at this writing, appears much like a photograph in Jones (1944). Although no known photograph exists of the Buffalo Beats prairie at the time of Transeau, the prairie probably has changed very little in the intervening 40 or more years since Transeau first saw it.

FLORISTIC COMPOSITION

The floristic composition of the Buffalo Beats prairie is a true prairie and not merely an old field with some prairie species present. *Andropogon gerardii* (big bluestem) is the dominant and seasonally most conspicuous grass. Other species typical of true prairies in Ohio are *A. scoparius* (little bluestem), *Coreopsis tripteris* (tall tickseed), *Eryngium yuccifolium* (rattlesnake-master), *Euphorbia corollata* (flowering spurge), *Liatris aspera* (rough blazing-star), *L. cylindracea* (cylindric blazing-star), *Phlox subulata* (moss phlox), *Quercus stellata* (post oak), *Silphium trifoliatum* (whorled rosinweed), *Solidago rigida* (rough-leaved goldenrod), and *Sorghastrum nutans* (Indian grass). A few small, but relatively old, trees occur on the prairie; these are *Quercus stellata* (post oak) and *Q. alba* (white oak). The former is uncommon in the region, but the latter is a codominant with other oaks in the adjacent forest. Although *Crataegus* spp. (hawthorns), *Sassafras albidum* (sassafras), *Cercis canadensis* (redbud), *Cornus florida* (flowering dogwood), *Fraxinus* spp. (ash), and other species which invade open areas in the forests of southeastern Ohio (Barcus, McConnell, and Wistendahl, 1978) are present in the immediate vicinity of the prairie, they do not occur on the opening. The invasion of forest species is occurring slowly.

An attempt was made to determine if there were viable seeds of prairie species buried in the upper 10 cm (3.9 inches) of soil in three areas: prairie, transition, and forest. Although some differences were noted in the species composition of the seedlings which emerged, no evidence of residual prairie seed appeared in the forest adjacent to the prairie. Such negative results might be expected because of the slow rate of invasion of the prairie by the forest; however, the results of this preliminary study are inconclusive.

SOIL AND PLANT RELATIONSHIPS

Soil data from intervals along an 80-m transect line illustrates graphically that the prairie soil has a pH of 7.5, whereas the forest soil has a pH of 4.5 with the transitional soils intermediate (Wistendahl, 1975). The prairie species end abruptly at the prairie-transition. On the other hand, a continuous cover of forest occurs from the transition zone into the adjacent forest. Quadrat data reveal that the transition zone and the forest are 91 percent similar in species composition, but that they are only 39 percent similar if density values for tree stems per species are included in the calculations. The difference is because of the presence of a large number of individuals of *Quercus alba* (white oak) in the transition zone. Presumably, the prairie had extended to the limits of the calcareous soil including that portion now occupied by the trees in the transition zone. The locations, sizes, and ages of selected trees were determined on and adjacent to the prairie.

An example specimen, *Quercus alba* with a diameter of 51.8 cm (20.1 inches) and a height of 17 m (55.8 ft) located 2.4 m (7.9 ft) from the edge of the prairie, had 277 growth rings at breast height in 1960. Other trees were similarly old for their sizes. Resampling 17 trees for diametrical and vertical size after an interim of ten years revealed growth rates considerably less than 0.5 cm/yr (0.2 inch/yr) in diameter and 0.25 m/yr (0.82 ft/yr) in height. These data compare favorably with those of Geis and Boggess (1970) who estimated that it took 400-600 years for a grove to develop on an Illinois prairie.

The existence of the Buffalo Beats prairie appears to be strongly correlated with the characteristics of the soils. The results of soil analyses reveal that the prairie and transitional soils are similar in clay content (ca 60 percent) and calcium levels (18.8 meq/100 g) which result in higher water-holding capacities and pH values than soil of the surrounding forest (Wistendahl, 1975). A feature of the calcareous soils is the presence of calcareous nodules in the B horizon, similar in appearance to those illustrated by Evers (1955). The prairie soils are dark reddish brown in color in contrast to the light buff color of those derived from shale under the adjacent forest. Soils of the transitional area are variable and appear to be modified in color to that between those of the prairie and the forest. Severson and Arneman (1973) report similar changes in soil in a forest-prairie transition in Minnesota.

SUMMARY

The eastern location of Buffalo Beats prairie appears to support Transeau's concept from several viewpoints. Floristically, Buffalo Beats is a prairie and not merely an old field. The duration of this prairie, perhaps since preglacial times and at least over the past 200-300 years, indicates a relatively stable vegetation with an abrupt transition from prairie to forest. Additionally, the soil has features characteristic of those of mature prairie soils such as the presence of calcareous nodules. Although small in area, Buffalo Beats may best be considered to be an "outlier" of Transeau's Prairie Peninsula rather than a component of the eastern deciduous forest or a distinct vegetational type itself.

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STARK-CASE PRAIRIE, A SIGNIFICANT REMNANT IN NORTHEASTERN OHIO

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In July 1977, Freda Case, an active amateur botanist, brought attention to this site with an inquiry about prairie-dock *(Silphium terebinthinaceum)*. Several observing and collecting excursions to the site resulted in the recognition of a large number of prairie species. This site, 3.25 ha (8.1 acres), is in the SW¼, NW¼, Section 15 and the SE¼, NE¼, Section 16 of Perry Township, T10N, R9W, Stark County, Ohio longitude 81°29′ and latitude 40°47′14″, being about 81 km (50 miles) south of the east side of Cleveland. This paper is a preliminary floristic study of this prairie remnant.

CLIMATE

The climate of Stark County is influenced by the presence of Lake Erie to the north. Lake Erie moderates cold air masses during the late fall and winter, contributes to brief, heavy snow squalls in autumn, and delays the arrival of spring. The average date of the first frost is 22 October and the last freeze is 30 April. The growing season varies in duration from 120 to 211 days with an average of 160 days. The average high temperature for June, July, and August is 27.3°C (81.1°F). The average low temperature for December, January, and February is -6.6°C (20.1°F). The normal precipitation in May, June, and July is 28.4 cm (11.17 inches) or about 32 percent of the average precipitation of 89.3 cm (35.13 inches) for the year. Normally no month receives less than 5 cm (2 inches) of precipitation. About 13.5 percent of total precipitation is snow (U.S. Dept. Commerce, Natl. Weather Serv. Office, Akron-Canton Airport, Akron, Ohio, 1978, personal communication).

HISTORY

Most of Stark County has been glaciated several times. About 20 m (66 ft) of Navarre Till lies under the remnant. The Navarre Till is composed of ground and end moraines from the Killbuck Lobe of late Wisconsinan Age. The till is calcareous, sandy, and moderately pebbly with numerous cobbles and boulders. The composition of the matrix averages 47 percent sand, 37 percent silt, and 16 percent clay.

Several historical sources confirm the existence of natural openings in western Stark County. "In the spring of 1807 two young men, with a horse and a cart loaded with provisions, blankets and rifles followed the Indian trail over the plains west of Canton to the Tuscarawas River . . ." (Everts, 1875). Thomas Rotch, a founder of Massilon, in a letter to his brother described the area as "A handsome plaine about a mile from the Tuskarawa branch of the Muskingum River . . ." (Kane, 1976). Sears (1926) noted "there seem to have been no less than five regions [in Ohio] in which the prairies were of considerable size in the aggregate . . . third, the sandy region of oak openings in Wayne and Stark counties."

The remnant has undoubtedly been pastured in recent times, but presently it is ungrazed. The small Wetmore Creek near the south side of the remnant has been channelized in an area mapped as being floodplain and kettlehole (DeLong and White, 1963). Evidence of old ditches persist in the remnant. The single most important event was the construction of the railroad through the area. The original railroad was constructed sometime between 1847 and before the arrival of the first train in Massillon on 11 March 1852 (Kane, 1976). Before the railroad converted to diesel locomotives the area burned frequently (Mary Perry, 1978, personal communication).

METHODS

Seven distinct plant communities are apparent at the site (Fig. 1). These communities are described individually in the discussion. The remnant was visited several times in the fall of 1977 to map and assemble a list of the prairie species (Table 1). The prairie species selected were determined from the studies of Curtis (1955), Sears (1926), Scharrer (1971, Table 9), and Schulenberg (1970). An approximate abundance value for each species was estimated for the entire area covered by each community. The abundance is designated as rare (R) for one plant, uncommon (U) for two to five plants, common (C) for six to twenty-five plants, or abundant (A) for more than twenty-five plants in an area of 3 m × 3 m.

Voucher specimens of distinctive species were collected for this site. These vouchers are in the herbarium of The Wilderness Center, Inc. In some cases, the numbers of these plants were too small to justify their collection, for example, prairie coneflower *(Ratibida pinnata)* and grass-of-Parnassus *(Parnassia glauca)*. Photographic vouchers were obtained for these species.

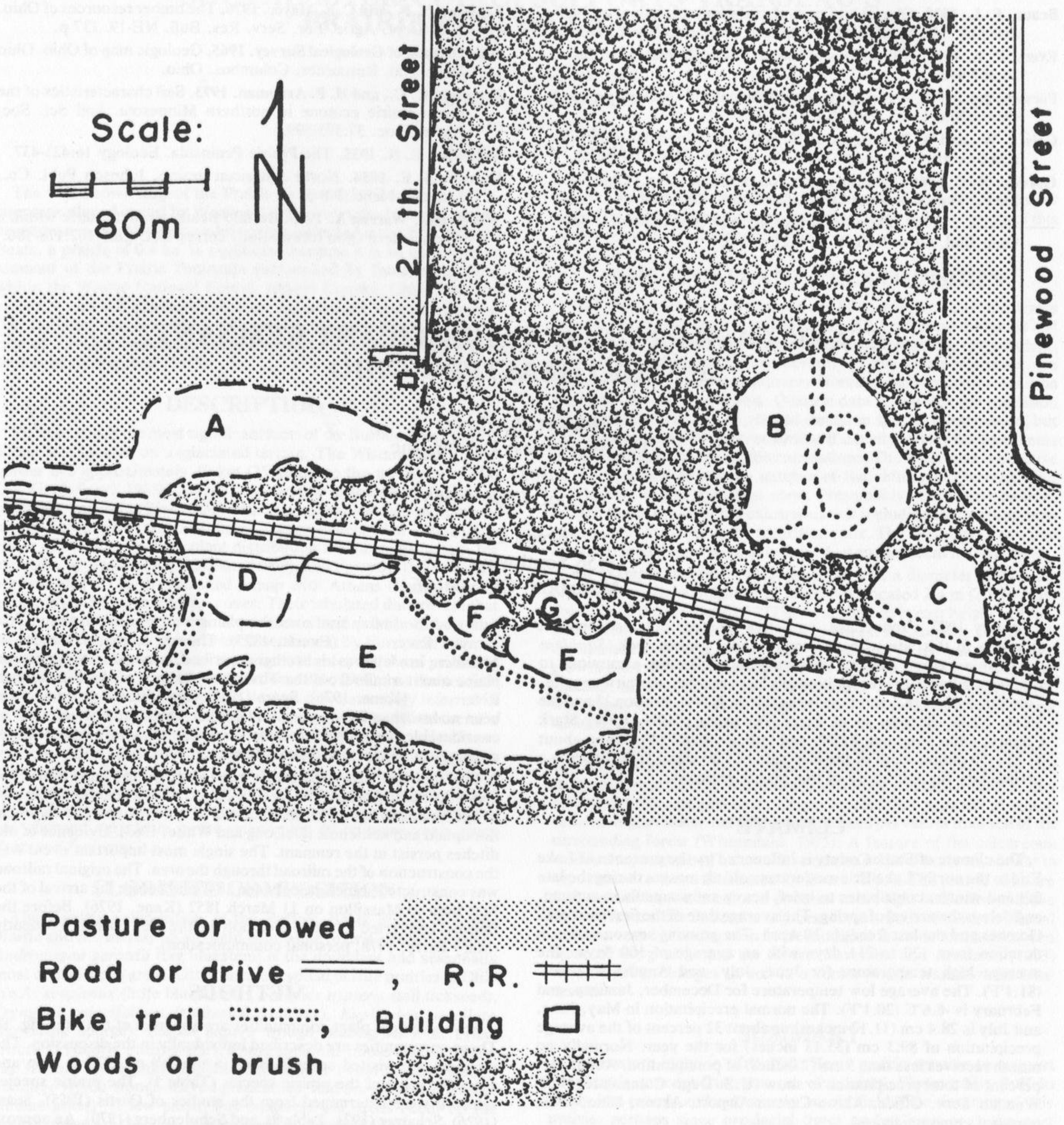

Figure 1. Stark-Case prairie remnant plant association map for 1977.

DISCUSSION

This remnant of a larger presettlement prairie now exists as seven distinct plant communities. The top of the railroad grade was not included as part of the remnant. The only plant species of interest on the top of the grade that does not appear in any of the seven communities is butterfly weed *(Asclepias tuberosa)*.

Secondary succession is proceeding through the encroachment of typical woody species: brambles (*Rubus* spp.), hawthorns (*Crataegus* spp.), American hazelnut *(Corylus americana)*, smooth sumac *(Rhus glabra)*, large-toothed aspen *(Populus grandidentata)*, and wild black cherry *(Prunus serotina)*.

Big Bluestem—Indian Grass Community

This community occurs in the corner of a lightly pastured field and the sides of the railroad ditch. It is about 0.72 ha (1.8 acres) in size. The soil type is Canfield which is a light-colored, moderately well-drained soil with a thin, compact fragipan between 6 dm (24 inches) and 1 m (39.5 inches) (Christman, et al., 1971). It is formed on moderately coarse-textured glacial till on slopes ranging from 2 to 20 percent. Seep spots occur in some areas. The plant cover is primarily big bluestem *(Andropogon gerardii)* and Indian grass *(Sorghastrum nutans)* with a number of other prairie and alien species. For each community, a more complete listing of the prairie species present is in Table 1.

Gray Goldenrod—Broom-sedge—Poverty-oat Grass Community

Hardhack *(Spiraea tomentosa)*, gray goldenrod *(Solidago nemoralis)*, broom-sedge *(Andropogon virginicus)*, and poverty-oat grass *(Danthonia spicata)* typify this community. The site, about 0.72 ha (1.8 acres), appears to be an old field that is unofficially being used as a motorcycle race track. The soils are mapped as Loudenville and Wooster (Christman, et al., 1971). These soils are light-colored and well-drained. Loudenville develops on 2-35 percent slopes in shallow deposits of silty and loamy glacial till. Wooster soil has a thin, compact fragipan between 5 dm (20 inches) and 1 m. Wooster soil forms in moderately coarse-textured glacial till. Flat-topped white aster *(Aster umbellatus)* has not been located elsewhere in the Stark-Case prairie remnant.

Grass-leaved Goldenrod—New England Aster Community

The building of the railroad grade in effect created a kettle hole, where one may already have existed. The Wooster soil under this locale has been described above. No two or three species dominate. It can be best described as a grass-leaved goldenrod *(Solidago graminifolia)*, New England aster *(Aster novae-angliae)*, jewelweed *(Impatiens pallida)*, and virgin's bower *(Clematis virginiana)* community. Prairie-dock and Virginia spiderwort *(Tradescantia virginiana)* are unique to this site. A housing development to the east has already destroyed a large patch of prairie-dock. A count of the prairie-dock revealed 50 plants of which half were nonflowering juveniles.

Indian Grass Community

Indian grass dominates this community. It is the only place where thimbleweed *(Anemone cylindrica)* and prairie coneflower *(Ratibida pinnata)* are represented. The soil is Wooster (Christman, et al., 1971). The flatness of the site, dominance of Indian grass, presence of many alien species, and light-colored soil indicate that fill dirt must have been removed from this site. The size is 0.24 ha (0.6 acre).

Joe-pye-weed—Canada Burnet—New England Aster Community

This is the largest community with 1.12 ha (2.8 acres). The soil is Papakating which is a dark-colored, poorly drained alluvium with a medium texture, and a high water table (Christman, et al., 1971). The dominant plants are joe-pye-weed *(Eupatorium maculatum)*, Canada burnet *(Sanguisorbia canadensis)*, and New England aster. This is the only locale with nodding wild onion *(Allium cernuum)*, Canada wild-rye *(Elymus canadensis)*, cowbane *(Oxypolis rigidior)*, Culver's-root *(Veronicastrum virginicum)*, and golden alexanders *(Zizia aurea)*.

Ohio Goldenrod—Mountain Mint—Whorled Rosinweed Community

This community, divided by an expanding strip of smooth sumac and American hazelnut, is 0.24 ha (0.6 acres) and underlain by Wooster soil. A ditch has been cut on the uphill, north side of the eastern portion. The topsoil exposed by the ditch is dark and thick giving the impression of little disturbance and erosion. The species dominating this site are Ohio goldenrod *(Solidago ohioensis)*, Indian grass, mountain mint *(Pycnanthemum virginianum)*, whorled rosinweed *(Silphium trifoliatum)*, and little bluestem *(Andropogon scoparius)*.

Between the previous two communities is an area of a few square meters that is of interest because it contains shrubby cinquefoil *(Potentilla fruticosa)* and grass-of-Parnassus *(Parnassia glauca)*. These characteristic fen species may reflect the influence of a seep.

Little Bluestem—Gray Goldenrod Community

This smallest community is dominated by little bluestem, gray goldenrod, and flowering spurge *(Euphorbia corollata)* with big bluestem, Indian grass, and whorled rosinweed. New Jersey tea *(Ceanothus americanus)* is unique to this location. The size is 0.04 ha (0.1 acre) and it is on Wooster soil.

SUMMARY

Stark-Case prairie is a remnant of a more extensive prairie which can be documented by reference to historical sources and the biological literature. The site contains over 75 characteristic prairie species which can be divided into seven different communities. Preservation of this prairie remnant is justified by the species composition of the site and its eastern location. Human development and natural succession threaten the continued existence of the communities at this locale.

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Table 1. Relative abundance (R=rare, U=uncommon, C=common, and A=abundant) of herbaceous prairie species represented in the following communities at the Stark-Case prairie remnant: Big Bluestem—Indian Grass (A), Gray Goldenrod—Broom Sedge—Poverty-oat Grass (B), Grass-leaved Goldenrod—New England Aster (C), Indian Grass (D), Joe-pye-weed—Canada Burnet—New England Aster (E), Ohio Goldenrod—Mountain Mint—Whorled Rosinweed (F), and Little Bluestem—Gray Goldenrod (G).

	Communities						
	A	**B**	**C**	**D**	**E**	**F**	**G**
Allium cernuum Roth (nodding wild onion)					R		
Ambrosia artemisiifolia L. (common ragweed)	R	U	R	R	R		
A. trifida L. (giant ragweed)	R		U		R		
Amphicarpa bracteata (L.) Fern. (hog peanut)		R			R		
Anaphalis margaritacea (L.) Clarke (pearly everlasting)		R		R			R
Andropogon gerardii Vitman (big bluestem)	C			U	R	U	U
A. scoparius Michx. (little bluestem)				R		U	A
A.virginicus L. (broom-sedge)	R	U	A		R		
Anemone cylindrica Gray (thimbleweed)				R			
Angelica atropurpurea L. (purple angelica)					R		
Apios americana Medic. (wild bean)	R		R		R		
Apocynum cannabinum L. (Indian hemp)			R		R		
Asclepias incarnata L. (swamp milkweed)					R		
A. syriaca L. (common milkweed)			U		R		
Aster ericoides L. (heath aster)	R	R	U	R	R	R	
A. lateriflorus (L.) Britt. (white wood aster)					R		
A. lucidulus (Gray) Wieg. (glossy-leaved aster)					U		
A. novae-angliae L. (New England aster)	R	R	U	R	C	U	
A. sagittifolius Wedemeyer (arrow-leaved aster)					R		
A. umbellatus Mill. (flat-topped white aster)		R					
Bromus ciliatus L. (fringed brome)					R		
Ceanothus americanus L. (New Jersey tea)							R
Chelone glabra L. (turtlehead)					R		
Cicuta maculata L. (water hemlock)					R		
Cirsium muticum Michx. (swamp thistle)			R		R	R	
Convolvulus sepium L. (hedge bindweed)	R		R		R		
Conyza canadensis (L.) Cron. (horseweed)		R			R		
Coreopsis tripteris L. (tall coreopsis)	R	U	R	R	R	U	R
Danthonia spicata (L.) Beauv. (poverty-oat grass)		U		C			
Desmodium canadense (L.) DC. (showy tick-trefoil)					R		
Elymus canadensis L. (Canada wild rye)					R		
E. virginicus L. (Virginia wild rye)					R		
Equisetum arvense L. (common horsetail)			R				
Eupatorium maculatum L. (spotted joe-pye-weed)		R	R	R	A	R	
E. perfoliatum L. (boneset)		R	R		R		
Euphorbia corollata L. (flowering spurge)						R	U
Geum laciniatum Murr. (rough avens)			R		R		R
Helenium autumnale L. (sneezeweed)					R	U	
Helianthus giganteus L. (tall sunflower)	R	R	R	R	U	R	R
H. tuberosus L. (Jerusalem-artichoke)					R		
Heliopsis helianthoides (L.) Sweet (ox-eye)	R			R	R		
Lactuca biennis (Moench) Fern. (tall blue lettuce)		R			R		
Lobelia siphilitica L. (great blue lobelia)					R		
Lysimachia quadrifolia L. (whorled loosestrife)				R	R		
Monarda fistulosa L. (bergamot)			U	R	R	C	
Muhlenbergia mexicana (L.) Trin. (muhly grass)					R		
M. racemosa (Michx.) BSP. (muhly grass)						R	
Oenothera biennis L. (evening primrose)		R	R		R		
Onoclea sensibilis L. (sensitive fern)					R		
Oxypolis rigidior (L.) C. & R. (cowbane)					R		
Panicum capillare L. (old-witch grass)					R		
P. clandestinum L. (panic grass)					R		
Parnassia glauca Raf. (grass-of-Parnassus)						R	
Phalaris arundinacea L. (reed canary grass)					R		
Phlox maculata L. (wild sweet william)					R		
Physalis heterophylla Nees (common ground cherry)					R		
Polygonum sagittatum L. (arrow-leaved tearthumb)		R	R		R		
Potentilla fruticosa L. (shrubby cinquefoil)						U	
P. simplex Michx. (old-field cinquefoil)	R	R			R		
Prunella vulgaris L. (self-heal)			R		R		
Pycnanthemum virginianum (L.) Durand & Jackson (Virginia mountain mint)					R	A	
Ratibida pinnata (Vent.) Barnh. (prairie coneflower)				R			
Rudbeckia hirta L. (black-eyed susan)	R	R	R	R	R	U	R
R. triloba L. (brown-eyed susan)	R						
Sanguisorba canadensis L. (Canada burnet)					C	C	
Silphium terebinthinaceum Jacq. (prairie-dock)			50[1]				
S. trifoliatum L. (whorled rosinweed)				R	R	A	R
Solidago graminifolia (L.) Salisb. (grass-leaved goldenrod)		U	C	U	R	U	R

Table 1. (cont.) Relative abundance (R=rare, U=uncommon, C=common, and A=abundant) of herbaceous prairie species represented in the following communities at the Stark-Case prairie remnant: Big Bluestem—Indian Grass (A), Gray Goldenrod—Broom Sedge—Poverty-oat Grass (B), Grass-leaved Goldenrod—New England Aster (C), Indian Grass (D), Joe-pye-weed—Canada Burnet—New England Aster (E), Ohio Goldenrod—Mountain Mint—Whorled Rosinweed (F), and Little Bluestem—Gray Goldenrod (G).

	Communities						
	A	B	C	D	E	F	G
S. nemoralis Ait. (gray goldenrod)	R	U		U		R	R
S. ohioensis Riddell (Ohio goldenrod)					R	A	
S. patula Muhl. (swamp goldenrod)	R	R	R		R	U	
Sorghastrum nutans (L.) Nash (Indian grass)	U			C	R	A	U
Spiraea alba Du Roi (meadow-sweet)		R	R		R		
S. tomentosa L. (hardhack)		U		R			
Steironema quadriflorum (Sims) Hitchc. (narrow-leaved loosestrife)					R		
Thalictrum revolutum DC. (skunk meadow-rue)					U		
Thelypteris palustris Schott. (marsh fern)			R		R		
Tradescantia virginiana L. (Virginia spiderwort)			R				
Triosteum perfoliatum L. (horse-gentian)					R		
Verbena hastata L. (blue vervain)			R		R		
V. urticifolia L. (white vervain)			R		R		
Vernonia altissima Nutt. (ironweed)		R	R	R	R		
Veronicastrum virginicum (L.) Farw. (Culver's-root)					R		
Zizia aurea (L.) Koch (golden alexanders)					R		

[1] A count of the prairie-dock revealed 50 plants of which half were nonflowering juveniles in community C.

PRAIRIE REMNANTS OF MARION, CRAWFORD, AND WYANDOT COUNTIES IN NORTH-CENTRAL OHIO

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Marion, Crawford, and Wyandot Counties in north-central Ohio contain one of the largest and easternmost groups of "islands" in Transeau's Prairie Peninsula. Regrettably, much of this land was grazed or plowed soon after settlement, thus obliterating much of the presettlement vegetation. This area has considerable botanical interest, but it has not been intensively studied. Nearly all earlier field work has been done in conjunction with much larger projects. This preliminary study is an attempt to map accurately the past and present prairie vegetation, and to correlate plant distribution with other environmental factors.

STUDY AREA

The study area includes portions of three counties located in north-central Ohio about 65-100 km (40-60 miles) north of Columbus (Fig. 1). Geographically this area of 1625 km^2 (625 mi^2) is centered at 83°10′W and 40°40′N. The largest and most interesting prairie "islands" are located mostly in the central portion of the three counties. About 20 percent of this area was prairie or prairie-like at the time of European settlement (Dobbins, 1937; Gordon, 1966; Sampson, 1930 a, b; and Shaw and Kopf, 1965). The map by Transeau (1935) was too general to be useful in this project.

The general terrain of this area is flat to gently rolling and ranges from 240 to 300 m (800 to 1000 ft) above MSL. It is underlaid by limestone and dolomite bedrock of Devonian and Silurian ages. Bedrock exposures are not evident except in several commercial limestone quarries. This region was completely covered by the Wisconsinan glacier. The till plains are cut in east-west directions by three, roughly parallel, end moraines: the Ft. Wayne, Wabash, and St. John's. These moraines more or less converge east of Bucyrus northeast of the area. Between these moraines temporary postglacial lakes formed as the glacier receded. These lakes eventually drained and left behind flat, poorly drained areas bordered by gently rising moraines which were transected by slow-flowing streams. In this setting the prairies probably replaced former woody vegetation during the Xerothermic Period some 3500 years ago.

The lowland soils are primarily Paulding, Toledo, Pewamo, and Blount. These soils, which are quite high in clay, were formed from high lime drift and lake sediments during the post-Wisconsinan period. The soils of the Killdeer Plains Wildlife Area often exceed 60 percent for very fine clays. Most of this area has been drained either by tile in the silty areas or surface ditches in areas of high clay content. Unlike the preagriculture days when hundreds, if not thousands of acres were flooded after heavy rains, floods now occur in few locations and last only a few days. Climatically, the area receives about 0.91 m (36 inches) of precipitation a year with more than half the amount occurring during the growing season of 150-165 days.

EARLY ACCOUNTS

One of the earliest accounts of the "Sandusky Plains," as the area was called, was by Colonel James Smith (1799). As an Indian captive from 1755-1759, he traveled the glades (prairies) of Wyandot and Marion Counties. He (p. 100) made the following comment concerning a ring-hunt on the prairie:

> We waited until we expected rain was near falling to extinguish the fire, and then we kindled a large circle in the prairie. At this time, or before the bucks began to run a great number of deer lay concealed in the grass, in the day, and moved about in the night; but as the fire burned in toward the centre of the circle, the deer fled before the fire: the Indians [Wyandot] were scattered also at some distance before the fire, and shot them down at every opportunity, which was very frequent, especially as the circle became small . . . The rain did not come on that night to put out the outside circle of the fire, and as the wind arose it extended thro the whole prairie . . . .

Deer were extirpated in Marion County during the 1860's, probably 30-40 years before the last native prairie chicken was killed (Jacoby,

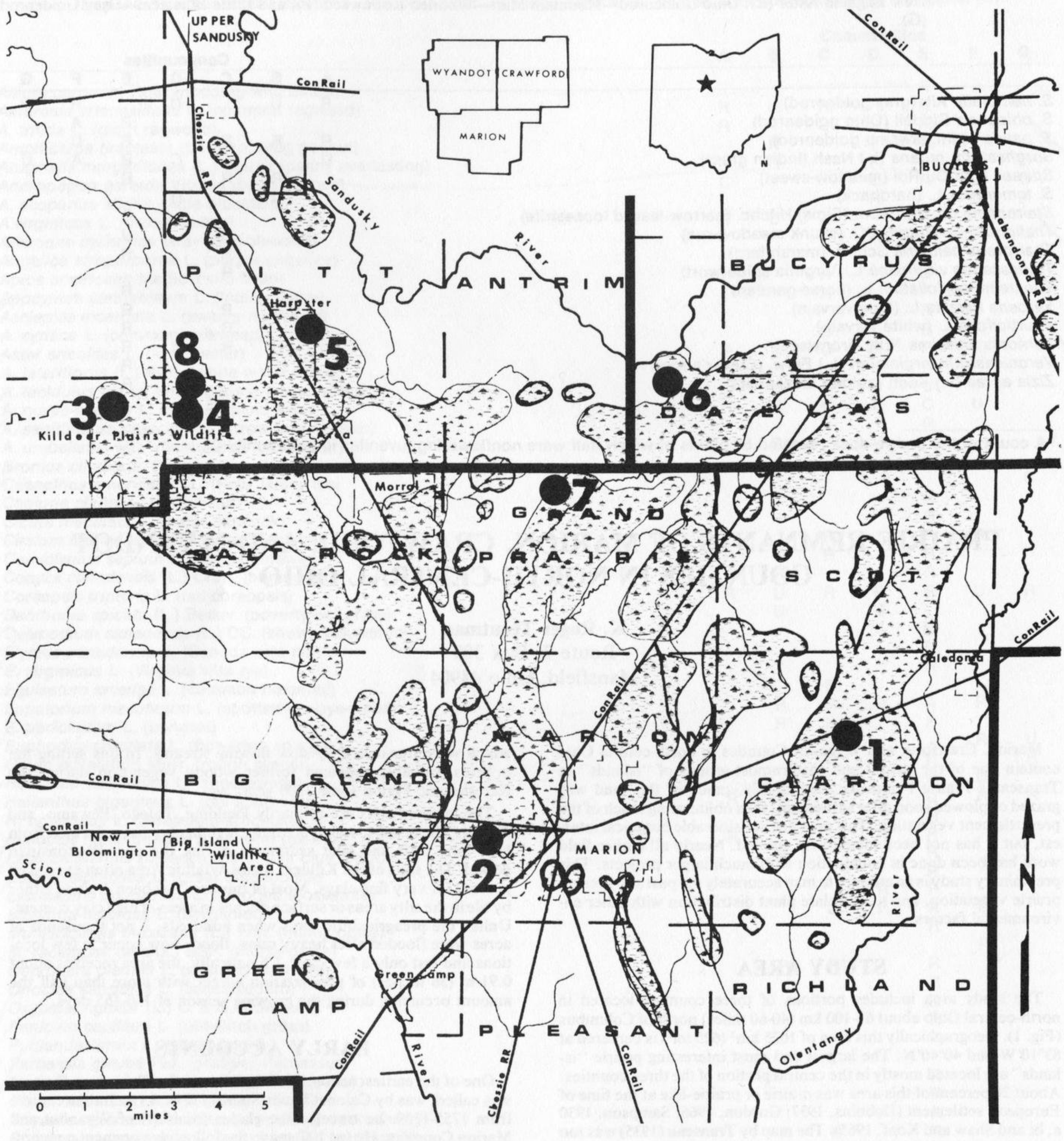

Figure 1. Presettlement prairies as indicated by tone pattern in Crawford, Marion, and Wyandot Counties, Ohio. Partially adapted from Dobbins, 1937; Gordon, 1966; Sampson, 1930b; and Shaw and Kopf, ca 1965. Numbers indicate extant prairies as follows: 1) Claridon, 2) Marion West, 3) Sullivant's Milkweed, 4) Killdeer Restoration, 5) Harpster, 6) Daughmer Savannah, 7) Bretz Cemetery, and 8) Bowshersville Cemetery.

1907).

Atwater (1818) in an account of the Sandusky Plains, mentioned the tallness of the grasses, the vastness of the view, and the level, low-lying ground too wet to grow trees surrounded by slight rises that supported open groves of woody plants. Bourne and Kilbourne (1820) mapped the Sandusky Plains as barrens, i.e., prairies interspersed with isolated trees or groves. Riddell (1837) gave an excellent account of this region. For the duration of the 19th century, little was apparently published about the Sandusky Plains flora. Botanical interest in the area, however, was rekindled after Sears (1926) published a map and account of the original vegetation of Ohio. During the 1930's Sampson (1930b), Dobbins (1937), and Transeau (1935) created vegetation maps that included all or part of this region. Gordon (1966) published a map of the original vegetation of Ohio based on early land survey records.

METHODS

A base map of the area was prepared. Known presettlement or field maps of prairie vegetation by Dobbins (1937), Gordon (1966), Sampson (1930b), and Shaw and Kopf (1965) were transferred to individual base maps and clear transparencies for use as overlays during field work. Herbarium specimens of previous workers were studied; most locality data were useless because they lacked detail.

During the 1976-1978 growing seasons an effort was made to investigate all roadsides or other potential prairie areas for prairie plants and animals. The presettlement prairie "islands" mapped by previous workers served as a guide. In addition, during the summer of 1978 all roadsides within 8 km (5 miles) of any presettlement prairies were searched. Thirty cemeteries within the mapped presettlement prairies and many cemeteries outside them were investigated. Most railroad rights-of-way were either driven or walked and other railroad rights-of-way showing less potential were visually examined from all intersecting highways. Data were gathered on the fauna, but observations were included only where they directly related to the prairie.

The species that this study considered are listed in Appendix Table II of Cusick and Troutman (1978:49-51). All prairie plants identified were spot-mapped on individual taxa maps to within a 60 m (200 ft) accuracy level in most cases. Specimens were collected only where identification was questionable by field observation. Many roadsides were mowed annually, making some species quite difficult to locate. These sites should be investigated before mowing in the future.

RESULTS

Fauna

No studies are known on the nonarthropod invertebrate fauna with prairie affinities in the area except formicids (Amstutz, 1943). Insects and spiders are abundant in the prairie areas. Mound-building ants occur throughout and are good indicators of relatively undisturbed prairies. Their mounds often exceed 45 cm (18 inches) in height or about 1 m (3 ft) in diameter. All known reptiles in the area are typical central Ohio species except for the prairie garter snake or eastern plains garter snake, *Thamnophis radix* (Conant, 1951; Dalrymple and Reichenbach, 1981).

Bird species found included good numbers of horned larks, grasshopper sparrows and vesper sparrows. Dickcissels are seen occasionally in summer and short-eared owls winter at Killdeer Plains. Prairie chickens disappeared around the turn of the century and a reintroduction attempt in the mid-1930's failed (Milton B. Trautman, 1978, personal communication). Red-headed woodpeckers and fox squirrels are fairly common in the extant bur oak *(Quercus macrocarpa)* openings.

Thirteen-lined ground squirrels are fairly common but are usually in the morainal areas rather than the lowlying lake plains. No historical records of bison were located although they undoubtedly occurred in the area previous to European settlement. The last wolf was killed in the 1860's (Jacoby, 1967).

Flora

Although approximately 20 percent of the study area was covered with prairie or prairie-like vegetation, excluding the still numerous oak savanna remnants at the time of European settlement, nearly all the intact prairie communities have been detrimentally affected by human activities over the past 150 years. Less than 40 ha (100 acres) of the original 300 km² (or about 75,000 acres) of prairie communities are still extant. Even this acreage is being invaded by woody plants and alien species. Prairie vegetation along roadsides and in other "waste" areas is, however, fairly common. They usually contain one or two species, but occasionally a community of ten or more species is present. However, these areas are degraded to some degree by alien "weeds" and woody plants, and by spraying, mowing, grazing, drainage, cultivation, and urbanization. These prairie remnants could be destroyed by the landowners or by lack of prairie management.

Nearly all the prairies here are wet to mesic and most are probably flooded annually. These prairies are similar to the prairies immediately west of Columbus but differ considerably from the dry prairies or glades of southern Ohio, the gravel morainal prairies of western Ohio, and the sand prairies of northwestern Ohio. Drier upland sites in the area were covered formerly by oak or oak—hickory forests.

Nearly all the wet sites have been drained and cropped or allowed to convert to woodlands, primarily consisting of soft maple, elm, ash, and willow. Prairie plants on these wet sites are now limited to ditch bottoms; shores of ponds, lakes, or marshes; or other sites that accumulate and hold water for rather extended periods of time. The mesic prairies have survived somewhat better, occurring primarily along railroad and highway rights-of-way and on the formerly very wet sites in the Killdeer Plains area that have been partially drained but are not being farmed.

Probably the most diverse prairie community in the study area is Claridon Prairie or Marion Conrail Prairie, formerly Caledonia Prairie, located about 4.8 km (3 miles) east of Marion. This prairie extends along railroad tracks for more than 3.2 km (2 miles) east and west of State Route 98. The most diverse, least "weedy" portion is a strip about 23-30m (75-100 ft) wide on both sides of the tracks and extending for about 1.6 km (1 mile) east of State Route 98. To date about 61 prairie species have been identified. It is one of the most diverse prairie sites in the state and is now being considered for designation as a state nature preserve. Local landowners, Conrail, and the county highway department are aware of its significance and have agreed to minimize mowing, spraying, and grading practices. A sign marking the area was erected by the Marion County Historical Society during the prairie conference.

A diverse but now very "weedy" prairie is located on a strip of railroad right-of-way that is 6.4 km (4 miles) west of Marion along State Route 95. Ironically none of the 56 recently known species were completely lost following landscaping and bulldozing in 1976. Prairie dock *(Silphium terebinthinaceum)* and most prairie grasses *(Andropogon gerardii, A. scoparius, Sorghastrum nutans,* and *Spartina pectinata)* were nearly eliminated. Closed gentian *(Gentiana andrewsii)*, downy phlox *(Phlox pilosa)*, wild hyacinth *(Camassia scilloides)*, and golden alexanders *(Zizia aurea)* are at least temporarily much more abundant. Royal catchfly *(Silene regia)*, rattlesnake-master *(Eryngium yuccifolium)*, and hoary puccoon *(Lithospermum canscens)* formerly here have not been seen for more than 25 years. Only the latter species is still known to exist anywhere in the study area.

Killdeer Plains Wildlife Area has several scattered remnants of diverse prairie, but "weeds" have degraded most of them. The rearing and hunting of waterfowl, especially Canada geese, is the primary "purpose" for this area. Consequently, some of the prairies may have been destroyed to improve goose-rearing habitat. When the prairie areas are managed, it is usually by mowing. Although previously the areas have been burned, area personnel believe that burning is detrimental to prairie because of the supposed increase of teasel *(Dipsacus sylvestris)* following spring burns. No burning is now known to be taking place, although it should be instituted in several areas on at least an experimental basis. The soils on much of the wildlife area are quite high in clay. They may not favor prairie grasses and where prairie grasses occur they tend to form clumps rather than sod. This phenomenon may be partially due to the soil's high shrink-swell characteristics, its winter heaving, the structural shear surfaces which are readily apparent in soil cores or profiles, and the high water retension capabilities of the clay particles. A study of the soil and their potential vegetation under different management plans would be interesting and valuable. Of interest also is a 40-acre (16-ha) field of former bluegrass *(Poa* spp.) sod. This field, which was planted circa

1915 (Ohio Div. Wildl., 1970), now contains one of the largest stands of Sullivant's milkweed *(Asclepias sullivantii)* in the state. Past management has included mowing, burning, and probably grazing. Several other prairie species such as prairie dock, stiff goldenrod *(Solidago rigida)*, and gray-headed coneflower *(Ratibida pinnata)* occur on the roadside perimeter of the field. Long-term ecological or management studies of this field should be started. Soon after the Killdeer Plains area was obtained by the Division of Wildlife, Ohio Department of Natural Resources, in the mid-1950's, a prairie was restored near the north boundary. Unfortunately, several species were undoubtedly imported from Illinois or Missouri such as *Bidens polylepis, Eryngium yuccifolium, Helianthus mollis, Liatris pycnostachya*, and *Veronia crinita* even though the first two species probably were native to the area.

Although in presettlement times prairie vegetation undoubtedly occurred in close association with bur oak openings, very few openings were found that contained more than a few species of prairie grasses or forbs. Most of these openings were either mowed or grazed annually. Only two areas of significant interest were observed. Daughmer Bur Oak Savanna in southwestern Crawford County is a tract of 16 ha (40 acres) that has never been plowed and contains many 0.6 -1.2 m (2-4 ft) dbh oaks. Although it is a recognized natural area by the Soil Conservation Society of America, the area has been greatly degraded by the annual late summer grazing of several dozen sheep. The second area is an oak opening of 8-16 ha (20-40 acre), about 1 km (1.5 miles) northeast of Harpster, Wyandot County. It is ungrazed, but shrubs and young bur oak are invading to the extent of shading the prairie plants. It contains about a 0.2 ha (0.5 acre) of relatively undisturbed prairie along its south border. Unfortunately, the undisturbed prairie was destroyed in late 1979.

DISCUSSION AND CONCLUSIONS

Within the past three years, about 80 species of grasses and forbs that could be considered "prairie" species (Table 1) have been located in the study area. This list does not include the woody shrubs or trees often associated with prairie borders. It also excludes the sedges *(Carex)*, sedge-like plants, and asters *(Aster)*, of uncertain identification.

Nodding wild onion *(Allium cernuum)*, whorled milkweed (*Asclepias verticillata*), and golden alexanders (*Zizia aurea*) probably occurred historically, but they were never recorded before this study. One or two species of "broad-leaved" *Liatris* occur in the study area. Herbarium records indicate the occurrence of *L. scabra*, but only one site of the Series Scariosae of *Liatris* was discovered and the specimens were identified as *L. scariosa*. An extremely pin-

Table 1. Remnant prairie plant taxa of Marion, Crawford, and Wyandot Counties in north-central Ohio seen in 1974-1978. Letters in parentheses indicate relative occurrence: rare (R), 1-5 stations; infrequent (I), 6-10 stations; uncommon (U), 11-20 stations; common (C), 21 or more stations. This list does not include the following: woody plants, sedges or sedge-like plants, alien species, native species not included in Appendix Table II of Cusick and Troutman (1978)[1], species of uncertain identification, species not located to date, and unknown species extirpated from the area before being collected or observed.

Allium cernuum (R)
Andropogon gerardii (C)
A. scoparius (U)
Anemone virginiana (R)
Asclepias purpurascens (R)
A. sullivantii (C)
A. tuberosa (C)
A. verticillata (R)
Aster novae-angliae (U)
Baptisia leucantha (I)
Calamagrostis canadensis (C)
Camassia scilloides (R)
Cassia fasciculata (I)
Ceanothus americanus (R)
Cicuta maculata (I)
Cirsium discolor (I)
Comandra umbellata (R)
Coreopsis tripteris (I)
Desmodium canescens (C)
D. canadense (I)
Elymus canadensis (I)
Equisetum laevigatum (R)
Eryngium yuccifolium (R, extirpated?)
Erythronium albidum (R)
Eupatorium altissimum (I)
Euphorbia corollata (C)
Gaura biennis (I)
Gentiana andrewsii (R)
Gerardia tenuifolia (R)
Helianthus giganteus (I)
H. grosseserratus (C)
H. hirsutus (U)
H. strumosus (R)
Heliopsis helianthoides (C)
Hierochloe odorata (R)
Hypoxis hirsuta (I)
Ipomoea pandurata (R)
Iris shrevei (U)
Lathyrus palustris (R)
Lespedeza capitata (R)
Liatris scabra (R, extirpated?)
L. scariosa (R)
L. spicata (I)
Lilium michiganense (R)
Lithospermum canescens (R)
Lobelia spicata (R)
Lysimachia ciliata (R)
L. lanceolata (R)
L. quadriflora (R)
Lythrum alatum (C)
Mirabilis nyctaginea (R)
Monarda fistulosa (C)
Oxypolis rigidior (R)
Panicum virgatum (C)
Penstemon digitalis (R)
Phlox pilosa (R)
Physostegia virginiana (R)
Polygala senega (R)
Polygonatum commutatum (U)
Prenanthes racemosa (R)
Psoralea onobrychis (R)
Pycnanthemum virginianum (C)
Ratibida pinnata (C)
Rosa carolina (C)
Rudbeckia hirta (C)
Silene regia (R, extirpated?)
Silphium t. var. *terebinthinaceum* (C)
S. terebinthinaceum x S. laciniatum (R)
S. trifoliatum (C)
Sisyrinchium albidum (I)
Solidago riddellii (I)
S. rigida (C)
Sorghastrum nutans (U)
Spartina pectinata (C)
Teucrium canadense (C)
Thaspium barbinode var. *pinnatifidum* (R)
Tradescantia ohiensis (C)
Vernonia fasciculata (R)
Veronicastrum virginicum (I)
Zizia aurea (R)

[1]Cusick, Allison W., and K. Roger Troutman. 1978. The prairie survey project, a summary of data to date. Ohio Biol. Surv. Inform. Circ. 10. p. 49-51.

natified form of *Silphium* occurs at several stations. This taxon has been identified by different authorities as both *S. terebinthinaceum* var. *pinnatifidum* and as introgression products of *S. terebinthinaceum* x *S. laciniatum* (Fisher, 1966).

Only two of approximately 30 cemeteries investigated had more than five species of prairie plants growing therein. Neither of those cemeteries has been used for burials during the present century. Most cemeteries during pioneer times were built on the moraines and not actually in the wet or mesic prairie areas. Consequently, most cemeteries probably never contained many prairie plants. Moreover, most cemeteries, including very old ones, are either completely overrun by woody plants or are very well manicured by either individuals or governmental entities.

Considerable disagreement exists between mappers about the extent of the original prairie. When a composite map is made using all known sources, published and unpublished, about 30 percent of the study area is mapped as prairie which is 10 percent more than that area mapped by each individual worker. To complicate matters more, the northwestern section of the study area is indicated as forested during the time of settlement. Recent intensive soil studies of this area by Joseph R. Steiger (1978, personal communication), however, have indicated that the soils in this area were derived primarily from a grassland and not a forest type environment.

Therefore, the former extent of the prairies in the three-county area is unknown. Considerable study is needed before a definite conclusion, if any, can be made. Fortunately, the early land survey records still exist and will be reexamined. Accurate soils maps or field surveys are now being prepared by the U.S. Soil Conservation Service. These efforts, along with the author's efforts to inventory more accurately and map the present vegetation, will further clarify the past and present vegetation of this area and significantly add to our knowledge of the eastern edge of the tallgrass prairie.

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SOILS OF THE PRAIRIES IN WESTERN OHIO

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Many soils in Ohio retain indications of prairie influence even though the plant species that characterize the grasslands have mostly disappeared. Using some of the well-established principles of soil development in prairie and forest environments, this study provides a view of the extent and character of prairies in western Ohio before settlement and their interaction with the surrounding forests. This study encompasses a 49-county area in western Ohio that extends north to Lake Erie, south to the Ohio River, and westward from a line between Sandusky and Portsmouth to the Ohio-Indiana line (Fig. 1). All references used are included in the literature cited section. Data are available in the Soil Conservation Service office for counties not published as yet.

The northern part of the area contains flat, poorly drained lake plains, bounded on the south by a broad belt of nearly level to rolling glacial ground and end moraines, which extend south to the Wisconsinan glacial boundary. Farther south are Illinoian till plains, with a mantle of silt in most areas, bounded still farther to the southeast by unglaciated bedrock hills. Throughout this area are smaller deposits of sandy or gravelly ridges, glacial outwash, alluvial sediments, organic deposits, and local occurrences of shallow limestone or shale.

Figure 1. Counties of western Ohio in the study area.

Based on soils data, some evidence of prairie influence appears to be present in all of these materials.

Soil surveys are now completed and published in 31 of these western Ohio counties. These surveys provide detailed maps of the location and extent of the different soils on an aerial photobase; soil descriptions, interpretations, and classification; estimates of engineering properties for all soils; and physical and chemical data for selected soils. The total extent of each soil type for each county is presented in Tables 1 and 2.

Six of the ten soil orders currently recognized (Soil Survey Staff, 1975) are present in the study area: Alfisols, Entisols, Histosols, Inceptisols, Ultisols, and Mollisols. The most extensive order is the Alfisols, mineral soils which have a light-colored surface layer and an accumulation of clay in the subsoil. Deciduous hardwood forest was the predominant vegetation of these soils at the time of settlement (Gordon, 1966).

Entisols are mineral soils with a light-colored surface layer and show little or no evidence of soil development. These soils usually have stratified alluvial sediments in the subsoil and occur on flood plains. Bottomland forest was the native vegetation.

Histosols are organic soils which occur in very poorly drained bogs where native vegetation was mostly aquatic herbs and shrubs. Nine different soils in the 49-county area are classified as Histosols; all are Saprists, a suborder which consist mainly of well-decomposed plant remains of variable depth. Carlisle muck is the most extensive organic soil in this area.

Inceptisols are soils with altered horizons due to leaching of bases, iron, or aluminum but without evidence of strong weathering. These soils occur mainly on poorly drained sites on lake plains or till plains. Native vegetation was deciduous swamp forest.

Ultisols are soils that have been highly leached of bases and in which clay has accumulated in the subsoil. Most of these soils occur on deeply weathered unglaciated landscapes where deciduous forest vegetation is dominant.

Mollisols are soils which are very dark-colored and base-rich throughout the solum. They are the main soils associated with prairies. Most of these soils were formed under conditions that contributed plentiful supplies of calcium and magnesium to the surface either by percolating soil water or from the prairie vegetation.

Aquolls and Udolls are the most extensive suborders of Mollisols occurring in western Ohio. The Aquolls or Humic Gley soils (U.S. Dept. Agric., 1975) are very dark-colored soils with gray or mottled gray and brown subsoils. They are saturated for part of the growing season. Twenty-five different soils are classified as Aquolls in the published soil surveys of western Ohio, the most extensive of which are Brookston, Pewamo, and Kokomo. The Udolls, formerly called Brunizems or Prairie Soils, are more freely drained soils of humid areas; they formed in the areas of the tallgrass prairie. Twenty-seven different soils classified as Udolls occur in the area; the most extensive ones are Dana, Warsaw, and Ross.

One soil series, Castalia, is classed as a Rendoll. This suborder of Mollisols was formerly known as Rendzina soils in the older classification system. They have very dark-colored surface soils like Udolls, and are highly calcareous and shallow over limestone bedrock. In Ohio they are located only near Lake Erie.

In Table 2, the soils identified as having organic surface horizons or very dark-colored mineral surface horizons have been grouped into five communities based on their properties and classification:

1. Soils formed in Ohio bogs that have organic layers more than 40 cm thick classify as Saprists.
2. Mineral soils of the swampy uplands are mainly Aquolls. The water table is near the soil surface during part of the growing season, but it is in the lower subsoil and substratum during midsummer and fall.

Table 1. Occurrence of Mollisols and Histosols in five communities in 31 surveyed counties (3,640,241 ha) of western Ohio. See soil surveys in "literature cited" for complete data on acreage and extent of soils in each county studied. Names of soil series which are followed by an asterisk (*) may also occur on terraces.

	Hectares	Percent		Hectares	Percent
Bogs	15,113	2.2	**Swampy uplands**	549,642	80.4
Adrian	650		Abington*	3,240	
Carlisle	6,935		Bono	2,698	
Edwards	522		Bonpas	2,440	
Linwood	1,855		Brookston	159,023	
Martisco	321		Cohoctah*	4,699	
Muskego	180		Colwood	7,149	
Olentangy	298		Gilford	2,003	
Rifle	3,044		Granby	2,579	
Warners	1,527		Joliet	534	
Moist uplands	40,149	5.8	Kings	90	
Brenton*	287		Kokomo	38,970	
Crane*	309		Lippincott*	10,547	
Corwin*	4,082		Luray	7,963	
Dana	6,777		Mahalasville*	1,093	
Darroch	1,547		Marengo	7,044	
Elliott	2,698		Millgrove	18,939	
Kane*	192		Millsdale	9,129	
Lawshe	587		Montgomery	20,882	
Nineveh*	103		Needham	688	
Odell	2,425		Patton	9,633	
Parr	375		Pewamo	197,923	
Plattville	342		Ragsdale	18,151	
Raub	2,242		Westland*	24,225	
Tippecanoe*	2,140		**Droughty uplands**	8,577	1.3
Warsaw*	10,036		Castalia	773	
Wea*	5,534		Channahon	121	
Wilmer	473		Fairmount	2,047	
Bottomlands	70,034	10.3	Gasconade	547	
Huntington	818		Lorenzo	263	
Lanier	2,414		Rodman	2,829	
Medway	6,518		Romeo (Var.)	1,997	
Ross	26,713		Total	683,497	100.0
Sloan	33,571				

3. Soils of moist uplands with moderate to very high available water capacity are mainly Udolls which remain moist throughout the growing season.
4. Soils of droughty uplands are also Udolls which generally occur on sites so shallow to bedrock or sand and gravel that they have very low or low available water capacity and are droughty for part of most growing seasons.
5. Soils of alluvial bottomlands are not only moist but receive frequent to occasional streambank overflow. They range from well to poorly drained and include both Aquolls and Udolls.

Of these communities, the very dark-colored prairie soils in western Ohio are most frequently associated with swampy uplands. The distribution of these prairie soils with their associated communities in the study area is as follows: 80.4 percent for swampy uplands; 10.3, alluvial bottomlands; 5.8, moist uplands; 2.2, bogs; and 1.3, droughty uplands. The Mollisols and Histosols comprise about 18.8 percent of the total area surveyed in 31 counties. The occurrence of these soils by county varied from about 2 percent in Paulding and Clermont Counties to more than 40 percent in Fayette County.

Table 3 gives data from laboratory analyses of 12 soil profiles sampled during the soil surveys in western Ohio. All but two of the soils appear in pairs; each very dark-colored soil formed under prairie is compared with a lighter-colored soil formed under deciduous forest on similar topography.

Bono and Toledo are both very poorly drained soils. Bono is an Aquoll and Toledo is an Aquept, a suborder of Inceptisols. Bono soils generally occur in local depressions on lake plains whereas Toledo soils are present on flats. The Bono soil was sampled in Crawford County in a section known locally as the Sandusky Plains, a former grassland—oak savanna (Troutman, 1981). It shows a less pronounced increase in clay content in the subsoil over that in the surface layer than does the Toledo soil. Compared to the Toledo soil, organic matter content in the surface layer of the Bono pedon is about one-third higher and the surface layer is thicker. Organic matter is distributed throughout the subsoil. In the Toledo soil organic matter is present only in the upper part of the subsoil. No significant differences are noted in reaction (pH) or base saturation. Base saturation is the percentage of total cation exchange capacity occupied by cations of calcium, magnesium, and potassium. Accumulation of basic cations is usually higher under sites of prairies than forests.

Odell and Crosby soils are both somewhat poorly drained associates of Brookston soils on the nearly level till plains in west-central Ohio. Odell is an Udoll and Crosby is an Aqualf, a suborder of Alfisols. In the Odell sample from Preble County, the upper two horizons (Ap and B1) are very dark-colored whereas the clay accumulation in the subsoil layers is not quite as pronounced as in Crosby. Reaction and base saturation are lower in the surface and subsoil layers of the dark-colored Odell soil, perhaps indicating a mixed influence on this site by both forest and grassland.

Elliott, an Udoll, and Blount, an Aqualf, are somewhat poorly drained soils developed on glacial till plains in north-central and northwestern Ohio. Elliott soils are much less extensive than Blount soils. The Elliott soil sampled in Erie County has very dark-colored horizons extending to a depth of 30 cm which contain 2.6 percent organic matter. In contrast, the surface layer of Blount soil sampled in Allen County has an organic matter content that decreases to nearly 1 percent below the surface layer. In the subsoil of the Blount, reaction decreases more sharply and clay content increases more than in the Elliott.

Corwin and Celina are moderately well-drained soils developed on the till plains of west-central Ohio. Corwin is an Udoll and Celina is an Udalf, a suborder of Alfisols. Corwin soils sampled in Montgomery County have very dark-colored horizons (Ap and A1) that extend to greater depths than the Celina. In contrast to the Corwin soils, the Celina pedon sampled in Montgomery County has a lighter-colored surface, lower organic matter levels, and a more pronounced increase in clay content of the B horizon over the A horizon. Reaction and base saturation also are lower in the Celina.

Warsaw, an Udoll, and Fox, an Udalf, are well-drained soils developed on glacial outwash terraces along stream valleys in south-

Table 2. Distribution (in percentages) of very dark-colored soils in five communities of surveyed counties in western Ohio. See soil surveys in "literature cited" for complete data on acreage and extent of soils in each county studied.

	Bogs	Swampy Uplands	Moist Uplands	Droughty Uplands	Bottom Lands	Total
Allen	< 0.1	26.8	0	0	3.1	30.0
Butler	0	3.1	5.6	0	3.3	12.0
Champaign	1.7	19.9	1.9	0.5	1.7	25.7
Clark	1.8	22.6	0.7	0.6	2.5	28.2
Clermont	0	< 0.1	0	0.8	1.3	2.2
Clinton	0	19.4	< 0.1	0	1.5	21.0
Crawford	0.2	19.7	1.2	0	0.5	21.6
Delaware	< 0.1	22.1	0	0	1.3	23.5
Erie	1.5	14.9	3.1	2.1	1.2	22.8
Fayette	0	40.0	0.5	0	0.7	41.2
Franklin	< 0.1	15.1	0.8	0	2.9	18.9
Greene	0.4	19.8	2.2	0.2	5.2	27.8
Hancock	0.3	25.3	0	0	2.8	28.4
Henry	< 0.1	10.0	0	0	1.1	11.2
Highland	0	2.9	0.8	0.4	1.3	5.4
Huron	2.4	9.4	0	0	0	11.8
Logan	1.9	8.4	0.5	0.4	0.3	11.5
Mercer	0.1	33.1	1.0	0	1.3	35.5
Miami	0.2	16.8	2.1	0.2	1.8	21.1
Montgomery	< 0.1	15.5	1.9	0.6	6.4	24.5
Paulding	0	0.3	0	0	1.7	2.0
Pickaway	0.2	20.8	6.0	0.2	3.0	30.2
Preble	0	17.7	1.3	0.1	5.1	24.2
Putnam	< 0.1	4.0	0	0	1.8	5.9
Ross	0	4.6	0.7	0.2	1.9	7.4
Shelby	< 0.1	21.3	0.7	0	0.1	22.2
Union	< 0.1	17.2	< 0.1	0	0.3	17.7
Van Wert	0	32.1	0.2	0	0.5	32.8
Warren	0	6.2	3.6	1.1	1.5	12.4
Williams	2.1	12.0	0	0	2.6	16.7
Wood	0.2	5.8	0	0	1.1	7.1

central and west-central Ohio. The Warsaw pedon sampled in Franklin County is very dark-colored to a depth of 38 cm and has organic matter levels that are consistently higher than the Fox soil sampled in Montgomery County which has a lighter-colored surface. Reaction and base saturation are also higher in both the surface layer and subsoil in the Warsaw.

The well-drained Ross soil, an Udoll, was formed in recent alluvial sediments along major streams in western Ohio. A pedon sampled in Montgomery County has horizons that are very dark-colored and contain about five percent organic matter to a depth of 56 cm. It also has free lime present throughout the profile.

SUMMARY

Several conclusions can be made about Mollisols, the soils of the prairies in western Ohio. A positive correlation exists between the occurrence of these very dark-colored soils and the location of prairies at time of settlement. Some Mollisols occur where the current natural vegetation is deciduous hardwoods but which was probably former prairie. They are not limited to any specific geologic material or formation. These prairie soils are not restricted to any one moisture regime. The occurrence of Mollisols appears to be dependent on a plentiful supply of basic cations in the surface layer. Swampy upland is the native community in which Mollisols are most frequently located in western Ohio.

Table 3. Physical and chemical data for selected soils. The sequence of categories in the "taxonomic classification" column is as follows: order, suborder, subgroup, family, and soil series.

Taxonomic Classification	Horizon	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Reaction (pH)	Organic Matter Content (%)	Base Saturation (%)
Histosols	Oa1	0-18				5.4	62.4	39
Saprists	Oa2	18-53				5.5	63.0	42
Typic Medisaprist	Oa3	53-86				5.3	79.2	42
Euic, mesic	Oa4	86-135				5.7	76.5	52
Carlisle	IILco1	135-178				5.7	72.4	55
	IILco4	244-274	23.5	66.5	10.0	7.2	25.9	73
Mollisols	Ap	0-28	12.0	51.1	36.9	6.5	6.5	74
Aquolls	B1g	28-46	11.6	46.6	41.8	6.8	1.5	84
Typic Haplaquoll	B21g	46-76	8.8	50.5	40.7	7.0	1.3	86
Fine, illitic, mesic	B22g	76-100	10.9	53.2	35.9	7.6	1.2	86
Bono	B31g	100-127	11.4	52.5	36.1	7.3	1.3	82
	IIIB32g	127-137	37.1	37.3	25.6	7.8	1.7	81
	IIIC1	137-178	22.2	51.5	26.3	7.8		
Inceptisols	Ap	0-20	2.3	43.7	54.0	6.2	4.3	76
Aquepts	B1g	20-34	2.6	41.4	56.0	6.6	1.8	82
Mollic Haplaquept	B2g	34-69	2.7	37.3	60.0	7.0	1.0	88
Fine, illitic, nonacid, mesic	B31g	69-100	2.0	34.1	63.9	7.4		93
Toledo	B32g	100-137	2.4	34.1	63.5	7.8		
	C1	137-168	1.6	57.2	41.2	8.1		
Mollisols	Ap	0-18	24.3	56.5	19.2	5.4	3.9	54
Udolls	B1	18-30	24.8	48.4	26.8	6.0	1.0	70
Aquic Arguidoll	B21t	30-48	21.2	45.3	33.5	6.2	0.8	80
Fine-loamy, mixed, mesic	B22t	48-69	17.5	44.1	38.4	6.5	0.6	82
Odell	B3t	69-91	20.3	43.2	36.5	7.1	0.4	89
	C1	91-117	31.4	43.3	25.3	7.7		
	C2	117-152	9.0	28.8	30.0	7.7		
Alfisols	Ap	0-18	26.6	56.1	17.3	7.1	2.6	79
Aqualfs	B1	18-25	22.2	50.9	26.9	6.9	1.1	75
Aeric Orchraqualf	B21tg	25-36	19.2	47.2	33.6	6.8	1.0	80
Fine, mixed, mesic	B22tg	36-43	18.3	47.3	34.4	7.1	0.8	84
Crosby	B23tg	43-51	15.1	42.3	42.6	7.2	0.8	88
	B3g	51-61	35.4	41.3	23.3	7.8		
	C1	61-74	44.6	40.1	15.3	8.0		
	C2	74-86	42.2	41.5	16.3	8.1		
	C3	86-99	49.6	38.0	12.4	8.1		

Table 3 (cont.) Physical and chemical data for selected soils. The sequence of categories in the "taxonomic classification" column is as follows: order, suborder, subgroup, family, and soil series.

Taxonomic Classification	Horizon	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Reaction (pH)	Organic Matter Content (%)	Base Saturation (%)
Mollisols	Ap	0-20	20.4	42.6	37.0	6.1	2.6	72
Udolls	A1	20-30	18.6	43.5	37.9	6.3	2.6	74
Aquic Argiudoll	B21t	30-56	16.0	44.7	39.3	6.6	0.5	79
Fine, illitic, mesic	B22t	56-76	10.6	49.4	40.0	6.8	0.4	83
Elliott	B3	76-104	15.9	51.5	32.6	7.1		83
	C1	104-122	34.9	38.8	26.3	7.3		
	C2	122-152	23.6	48.2	28.2	7.7		
Alfisols	Ap	0-25	23.8	56.7	19.5	6.6	2.9	
Aqualfs	A2	25-28	24.0	48.9	27.1	5.2	1.0	
Aeric Ochraqualf	B21t	28-43	27.4	35.1	37.5	4.9	0.7	
Fine, illitic, mesic	B22t	43-64	17.4	35.8	46.8	6.2	1.1	
Blount	C1	64-97	18.1	43.1	38.8	7.9		
	C2	97-122	25.4	40.9	33.7	7.9		
Alfisols	Ap	0-15	20.2	63.0	16.8	6.0	2.3	62.0
Udolls	A1	15-23	17.9	56.2	25.9	6.3	1.9	68.2
Typic Argiudoll	B21t	23-33	18.3	52.7	29.0	6.3	1.0	70.6
Fine-loamy, mixed, mesic	B22t	33-43	20.4	45.8	33.8	6.5	0.5	79.0
Corwin	B23t	43-61	27.6	43.7	28.7	6.8	0.3	81.5
	B24t	61-76	27.1	41.1	31.8	7.3	0.4	88.6
	B25t	76-91	39.3	29.7	31.0	7.5	0.7	
	B3	91-109	29.9	40.0	30.1	7.9	0.5	
	C	109-140	30.2	45.9	23.9	8.0	0.5	
Alfisols	Ap	0-15	24.6	63.2	12.2	6.6	1.9	72.5
Udalfs	B&A	15-20	24.3	57.7	18.0	6.9	0.4	73.3
Aquic Hapludalf	B21t	20-25	10.8	62.4	26.8	6.0	0.5	70.2
Fine, mixed, mesic	B22t	25-36	7.8	54.3	37.9	5.1	0.4	62.7
Celina	B23t	36-48	8.8	48.1	43.1	5.3	0.4	69.6
	B3	48-61	14.5	48.3	37.2	6.5	0.4	80.5
	C1	61-76	31.5	42.1	26.4	7.7	0.3	
	C2	76-104	37.9	43.1	19.0	8.0	0.3	
Mollisols	Ap	0-23	39.5	41.1	19.4	7.3	3.1	87
Udolls	A3	23-38	38.9	40.6	20.5	7.4	2.9	85
Typic Argiudoll	B21t	38-48	38.4	34.6	27.0	7.3	1.6	74
Fine-loamy over sandy-skeletal, mixed, mesic	B22t	48-58	34.6	26.1	39.3	7.1	1.6	82
	B23t	58-69	41.9	20.4	37.7	7.2	1.6	84
Warsaw	B3	69-86	52.0	33.5	14.5	7.7		
	C1	86-104	80.1	14.7	5.2	8.0		
	C2	104-122	80.6	14.6	4.8	7.9		
Alfisols	Ap	0-20	37.4	49.1	13.5	5.7	1.2	50
Udalfs	B1	20-30	30.8	44.6	24.6	5.5	0.7	52
Typic Hapludalf	B21t	30-35	34.2	34.8	31.0	4.9	0.7	51
Fine-loamy over sandy-skeletal, mixed, mesic	B22t	35-51	49.7	17.8	32.5	4.7	0.4	49
	B23t	51-66	65.8	12.7	21.5	4.9	0.3	38
Fox	IIB3t	66-74	62.3	19.0	18.7	7.0	1.8	80
	IIC	74-152	77.7	16.9	5.4			
Mollisols	Ap	0-20	35.3	48.8	15.9	7.6	5.2	
Udolls	A12	20-33	33.4	49.1	17.5	7.7	4.3	
Cumulic Hapludoll	A13	33-56	38.4	39.4	22.2	7.6	5.6	
Fine-loamy, mixed, mesic	C1	56-71	51.4	34.3	14.3	7.7	3.1	
Ross	C2	71-86	52.6	33.7	13.7	7.7		
	C3	86-102	36.1	46.5	17.4	7.7		
	C4	102-114	32.5	50.9	16.6	7.7		
	C5	114-142	44.3	40.0	15.7	7.8		
	C6	142-168	81.3	11.8	6.9	7.9		

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PRAIRIES OF THE DARBY PLAINS IN WEST-CENTRAL OHIO

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The early nineteenth century settlers of the Darby Plains in west-central Ohio were well acquainted with the numerous prairies in the area. These open grasslands provided striking contrast to the surrounding closed forests which covered most of the Ohio country. Because of the very flat terrain and slow drainage, most of the prairies were covered with water for extended periods each year. At other times the prairies became very dry, and wild fire was almost an annual event. These prairies, and accompanying soils, had developed over thousands of years since the continental glaciers had retreated from the area. However, as settlers and their progeny learned how to drain and cultivate the prairie lands, the face of the landscape became changed so thoroughly that within a century almost all vestiges of the original wet prairies were obliterated. A recent survey has located several significant small remnants of prairie vegetation. These valuable remnants provide unique opportunities and genetic material not only for restoration of wet prairie communities and ecosystems in the area, but also for restoration of human awareness of the natural heritage of the Darby Plains.

GEOGRAPHICAL DESCRIPTION

The Darby Plains, with an area of approximately 1000 sq km (385 sq miles), lie entirely within the glaciated Till Plains Section of the Central Lowland Province (Fenneman, 1938:455). These upland plains are about 16 to 48 km (10 to 30 miles) west and northwest of downtown Columbus, Ohio, primarily within the northern portion of the drainage basin of Big Darby Creek. Elevation generally ranges between 290 and 305 m (950 and 1000 ft) above mean sea level. The highest elevation of about 330 m (1080 ft) occurs near Mechanicsburg in the western section, whereas the lowest of about 232 m (760 ft) is located at the southeastern boundary near Orient along Big Darby Creek.

Big Darby Creek was originally called "Ollentangy" by the Indians according to W. M. Darlington (Smith, 1799, reprinted 1978:102). Prior to settlement, an old Wyandot Indian chief by the name of Darby (Converse, 1968:1) was living along this stream when United States surveyors were working in the area. Jonathan Alder stated that the surveyors named the stream in Darby's honor (O. E. Brown, 1965:71), and soon the surrounding region became popularly known as the Darby Plains.

Because of its popular origin and general use, the term "Darby Plains" has frequently been utilized to describe an area of imprecise dimensions. In the restricted sense, the name refers only to the interfluve between Big Darby and Little Darby Creeks (Orton, 1878a: 421). In other accounts, however, much of the gently rolling country between the Scioto, and the Great and Little Miami Rivers has been referred to as the Darby Plains (Sears, 1926:135; Transeau, 1981). As used in this paper, the Darby Plains are delineated in the following manner. The northern boundary is clearly defined by the generally distinct southern limits of the Powell Moraine in southern Union County. The western boundary is somewhat less well defined by the gradual slopes of the eastern limits of the Cable Moraine in extreme eastern Champaign County. The southern boundary is weakly defined by the northern limits of the low hummocky London Moraine across central Madison County, while the eastern boundary in western Franklin County is also weakly defined by the obscure drainage divide between the Scioto River and Big Darby Creek (Figs. 1 and 2).

GEOLOGICAL DEVELOPMENT

The Darby Plains are a nearly level to gently undulating glacial till plain which has been only slightly dissected by the major streams of the area: Big Darby Creek, Little Darby Creek, Spring Fork, Barron Creek, Treacle Creek, Deer Creek, and Glade Run. Most relief other than that adjacent to these streams is gentle, between 1 to 4m/km (5 to 20 ft/mile). The area in the vicinity of Plain City is one of the flattest in central Ohio (Norris, 1959:34). Indeed, the town's name, which was changed in 1877 from Pleasant Valley (Converse, 1968:8), is derived from this flat landscape.

Bedrock underlying most of the Darby Plains consists primarily of Upper Silurian dolomites of the Bass Islands Group with the Devonian Columbus Limestone on the eastern margins (Stauffer, et al., 1911; Foley, 1973: 13-25). Bedrock is exposed in the Darby Plains at only a few localities: along both Big Darby and Little Darby Creeks near West Jefferson and Georgesville and along Barron Creek about 3 km (2 mi) east of Rosedale (Orton, 1878a:421, 1878b:600; Norris, 1959:26).

Generally, the bedrock is buried by glacial deposits of calcareous till interspersed with lenses of sand and gravel. These deposits range in thickness from about a meter to over 60 m (a few feet to over 200 ft) (Norris, 1959:34), but typical thicknesses over much of the area are 18 to 30 m (60 to 100 ft) (Jonathan C. Gerken, 1980, personal communication). Orton (1878a:422) early recognized this situation in his discussion of the geology of Madison County:

> There is no region of the State in which the basement rock makes a more insignificant show or exerts less influence upon the present surface of the country. Even the details of the topography are seen to depend very largely on the modification of the drift surfaces and these details can, in many cases, be very well explained without any recourse to the underlying beds. All of the questions that concern the county, whether relating to its topography, its soils or its water-supply, connect themselves with the origin and history of the deep drift-deposits, by which its entire surface is now covered.

Most of the surficial glacial drift in the Darby Plains is Darby Till (Goldthwait, 1969), a Pleistocene ground moraine deposit of the Scioto Sublobe of the Erie Lobe of the Late Wisconsinan Glacier. This drift sheet, the Darby Till Plain, occupies a sizeable area of central Ohio extending considerably beyond the limits of the Darby Plains (Dreimanis and Goldthwait, 1973:92-93; see my Fig. 2).

Darby Till was produced during late Wisconsinan time or Woodfordian (Frye and Willman, 1960) in conjunction with a significant ice readvance in the Scioto Sublobe which, about 17,300 years ago, moved to the position of the Reesville Moraine (Teller, 1964:72-73; Dreimanis and Goldthwait, 1973). Goldthwait (1958, 1959) indicated that the till sheet was deposited primarily *under* advancing ice rather than by retreating ice. After development of the Reesville Moraine, relatively rapid retreat of the ice uncovered the Darby Till Plain. During this period of general ablation, minor halts or readvances constructed the Glendon, Esboro, Bloomingburg, and London Moraines and their corresponding elements within the Cable Moraine (Rosengreen, 1970:135; Quinn, 1972:29-30; see my Fig. 2). A few local shallow ponds developed on the deglaciated till plain surface (Goldthwait, 1952; La Rocque 1952), but evidence does not support the concept of a general postglacial "submergence" of the area as postulated by Orton (1878a: 423-424) and interpreted by Sears (1926: 133) as a "former extensive shallow lake upon the region occupied by the Darby Plains . . . ." Rather, the characteristics of the sediments, the very flat topography of much of the Darby Plains, and radiocarbon dates from central Ohio indicate that retreat of the ice in that area of the Darby Till Plain was quite rapid, and that the glacial ice there during ablation was relatively clean and not heavily charged with sediments (Richard P. Goldthwait, 1980, personal communication).

This recession of the ice front occurred during the Erie Interstade (Dreimanis, 1958:81) and continued north of the Darby Plains into northern Ohio across the present Ohio River-Lake Erie drainage divide and well into the Erie Basin. There, large proglacial lakes were

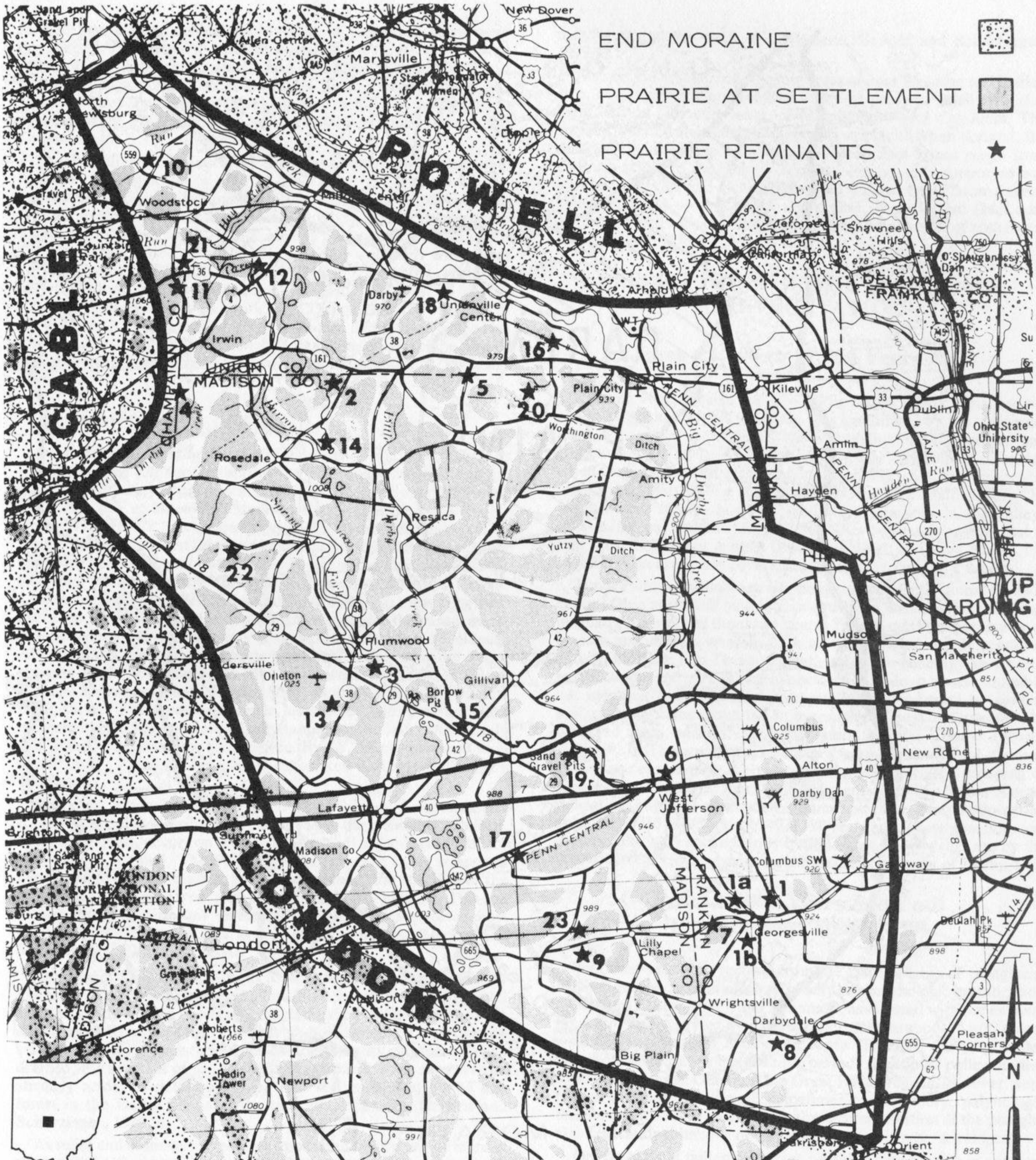

Fig. 1. Map of the Darby Plains in west-central Ohio indicating bordering end moraines, original prairies, and existing prairie remnants as identified in Table 3. (Adapted from Goldthwait et al., 1967; and Dobbins, 1937:113-114. Base map from U.S. Army Corps of Engineers, Army Map Service, Map NJ 17-1, Columbus, Ohio, and NK 17-10, Marion, Ohio.)

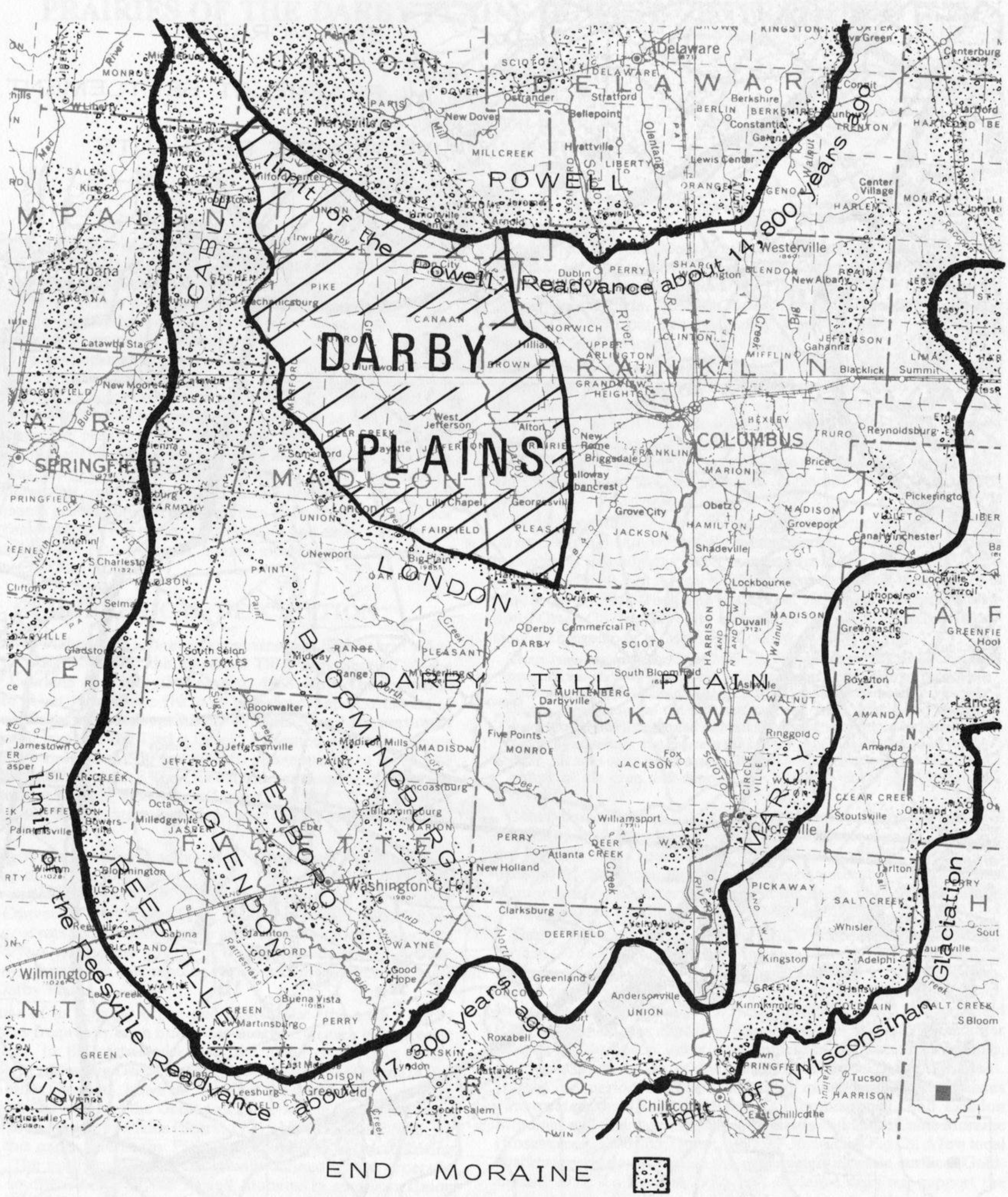

Fig. 2. Map showing relation of the Darby Plains in west-central Ohio to the Darby Till Plain and the end moraines of the Scioto Sublobe of the Erie Lobe of the Late Wisconsinan Glacier. (Adapted from Teller, 1964:72-73; Goldthwait et al., 1967; Dreimanis and Goldthwait, 1973:88-95; and Mörner and Dreimanis, 1973:120).

formed into which considerable amount of lacustrine clays were deposited. A subsequent readvance of the ice front incorporated much of this lacustrine material and deposited it southward as a distinctive clay-rich till sheet (Forsyth, 1965; Goldthwait, et al., 1965:88). The termination of this readvance resulted in the formation of much of the Powell Moraine about 14,800 years ago (Mörner and Dreimanis, 1973:120; see my Fig. 2).

The Powell Moraine not only provides a distinctly topographic boundary at the northern edge of the Darby Till Plain, but also, because of its different geologic history, displays a distinctly different type of surficial till than the Darby Till which occurs immediately south in the Darby Plains. As indicated by Steiger and Holowaychuk (1971), the till of the Darby Plains is generally a strongly calcareous silt loam with a $CaCO_3$ equivalent of 37.6 ± 7.1 percent, while the clay-rich till of the Powell Moraine, especially that west of Marysville, is a calcareous silty clay with a $CaCO_3$ equivalent of only 28.8 ± 2.8 percent. A comparison of the particle-size distribution in the two tills demonstrates clearly the enriched clay composition of the Powell Moraine west of Marysville (Steiger and Holowaychuk, 1971; see my Table 1).

SOILS

Substantial information regarding the soils of the Darby Plains is provided in the soil survey reports and photomaps as published for Champaign County (Ritchie et al., 1971), Franklin County (McLoda, 1977; McLoda et al., 1980), Madison County (Gerken and Scherzinger, 1979, 1981), and Union County (Waters and Matango, 1975). Darby Till has provided the parent material in which have developed since deglaciation, most of the upland soils of the Darby Plains, for example, Kokomo (here formerly Brookston), Crosby, Celina, Lewisburg, Miamian, Hennepin, and Odell series. In a few very local locations, shallow lacustrine deposits have provided the parent materials in which the Montgomery and Patton soils have developed. Alluvium and outwash-terrace deposits associated with the major streams of the area have provided the parent materials of Sloan, Eldean, Medway, Genessee, Fox, Lippincott, Warsaw, and several other series. These soils, however, associated with riparian plant communities in the area, are of only tangential interest to this study and will not be considered further here. By far, the predominant soils of the Darby Plains are the closely associated Kokomo and Crosby series.

The most extensive soil in the Darby Plains is Kokomo (here formerly Brookston) silty clay loam. This dark-colored Mollisol, suborder Aquoll, occurs on level to nearly level upland areas that are very poorly drained. The very dark gray surface layer possesses considerable organic matter, and when drained, the reaction of the deep root zone ranges from slightly acidic to mildly alkaline. This soil is the primary "prairie soil" of the Darby Plains for it supported most of the wet prairies in the area at the time of settlement (Gerken and Scherzinger, 1979:9).

Crosby silt loam is the second most extensive soil in the Darby Plains. It is an Alfisol, suborder Aqualf, and occurs on nearly level areas to gently sloping knolls that are drained only slightly more than are areas of Kokomo soils. The grayish-brown surface layer is considerably lighter in color than is that of Kokomo silty clay loam. When drained, the reaction of the moderately deep root zone ranges from strongly acidic to mildly alkaline. This soil supported mixed oak forest in the Darby Plains at the time of settlement (Gerken and Scherzinger, 1979:9).

As relief and drainage increase on knolls and ridges, one or more of three other Alfisols may be present: Celina silt loam, Lewisburg silt loam, and Miamian silt loam. The surface layer of these soils is generally brown, quiet in contrast to the darker, more poorly drained soils. Root zones are of varying depth, and reactions range from strongly acidic to mildly alkaline. These soils also supported mixed oak forests at the time of settlement (Gerken and Scherzinger, 1979:9).

Also on the upland, in some low areas of poor drainage and limited size, one of three other Mollisols may be present: Odell silty clay loam, Patton silty clay loam, or Montgomery silty clay loam. The surface layer of these soils is dark gray or black. When drained, the reactions of the deep or moderately deep root zones range from medium acidic to moderately alkaline. Patton soils supported wet prairies (Gerken and Scherzinger, 1979:9), whereas Montgomery soils supported swamp forest at the time of settlement (McLoda, 1977:12). Odell soils developed under a mixed influence of both forest and grassland (Steiger, 1981).

DESCRIPTIONS OF THE LANDSCAPE AND VEGETATION

From 23,000 to 17,000 Years Ago

Existing vegetation in the area of the Darby Plains sometime between 23,000 and 17,000 years ago was annihilated by the advancing Late Wisconsian ice sheet of the Scioto Sublobe (Dreimanis and Goldthwait, 1973:90). As indicated primarily by samples of buried wood from elsewhere in Ohio, numerous living trees, mostly spruce, were overridden by the ice (Burns, 1958; Goldthwait, 1958). The forests were spotty, however, and were primarily in the valleys (Dreimanis and Goldthwait, 1973:90). This evidence suggests that at that time throughout central Ohio, including the Darby Plains, the vegetation in areas not covered by glacial ice was park tundra.

Tundra and park tundra were the periglacial vegetational types in central Ohio as the ice margin near the outer Wisconsinan drift limit oscillated for several thousand years. Tundra consisted primarily of grasses and sedges, whereas park tundra included widely scattered spruce and fir trees. These vegetational types generally resembled extant tundra and park tundra in northern latitudes but were probably not identical to them. This interpretation is suggested by several pollen assemblages extracted from samples of peat and organic silts obtained from borings in northwestern Fayette County (Moos, 1970:19-23). These pollen assemblages were evaluated by J. Gordon Ogden as representing the most striking "high arctic" grouping of plants that he had seen from Ohio sediments. The two layers of peat, indicating bog and tundra environments, have been radiocarbon dated at 19,735 ± 475 and 17,340 ± 390 years ago. These peat bogs and organic silts were subsequently buried about 17,300 years ago by the Reesville readvance and the accompanying deposits of Darby Till.

From 17,000 Years Ago Until Presettlement Time (1750)

Published scientific records from the Darby Plains of postglacial vegetational patterns are limited to only one palynologic investigation (Sears and Clisby, 1952), and this study, associated with the excavation of the bones of the Orleton mastodon at a site about 3 km (2 miles) west of Plumwood in Madison County (Thomas, 1952), provides information for only a limited time period. Additional pollen studies from other sites in Ohio and the Great Lakes region, however, support a substantial, although sometimes contradictory, palynologic literature but from which a generalized interpretation of the postglacial vegetational history of the Darby Plains can be developed.

On the basis of pollen data from postglacial sediments in northern Ohio and elsewhere, Sears (1948) identified a sequence of five generalized phases which typify the region's postglacial vegetational history: cold humid conifer, xerophytic conifer, mesophytic deciduous and conifer, xerophytic deciduous, and mesophytic deciduous. Re-

Table 1. Comparison of particle size distribution in Darby Till in the Darby Plains and Powell Moraine Till west of Marysville, Ohio (Steiger and Holowaychuk, 1971).

	Sand (%)	Silt (%)	Clay (%)
Darby Till from the Darby Plains and London Moraine	33.5 ± 5.9	46.0 ± 4.0	20.5 ± 3.1
Till from the Powell Moraine west of Marysville	16.6 ± 5.9	40.7 ± 7.3	42.7 ± 4.8

searchers in Ohio have generally corroborated Sears' sequence (Williams, 1957, 1962; Burns, 1958; Goldthwait, 1958; Kapp and Gooding, 1964; Ogden, 1966; Garrison, 1967; Shane, 1975). Pollen samples from basal sections of postglacial sediments from lakes and bogs in Ohio regularly possess spruce and fir as the dominant pollen types. The presence of these pollens has generally been interpreted as indicating that these tree species initially invaded the recently deglaciated landscape and established boreal forests as the primary plant communities. Ogden (1966:398), however, reported "open ground initially in the vicinity" of Silver Lake, Logan County, and Shane (1976:3-16) using refined analytical procedures on samples from two sites in Darke County demonstrated the existence of an initial tundra and park tundra phase in the sequence. This revised sequence is in general agreement with the postglacial vegetational history reported for eastern North America (Davis, 1965, 1967; Wright 1971; Kapp, 1977; Delcourt and Delcourt, 1979), and an adaptation fitted to the Darby Plains is presented in Table 2.

By 16,000 years ago during the Erie Interstade, most, if not all the ice of the Reesville readvance had melted out of the Darby Plains. The local climate, however, remained quite severe for the next 2,000 years during which time the glacial readvance that constructed the Powell Moraine brought the ice front once again to the northern border of the Darby Plains. Open ground, arctic tundra, and park tundra with spruce and fir trees in the more protected sites typified the region (Shane, 1976:107-115). As the climate became somewhat less severe and the ice receded to the north for the final time, areas of spruce and fir became more numerous and extensive at the expense of the tundra communities.

By 14,000 years ago, glacial ice had permanently left Ohio (Forsyth, 1965:226), and spruce and fir forests were well established in the mid-Ohio latitudes (Kapp and Gooding, 1964; Ogden, 1966; Shane, 1976:108-109). These boreal forests, or variations of them, dominated the Darby Plains for several thousand years.

About 11,000 years ago, as the climate continued to become less severe, pines became the dominant species (Shane, 1976:118-122). This forest type survived in the area for about a thousand years as indicated by the pollen record obtained from the Orleton Mastodon site near Plumwood. Sears and Clisby (1952) inferred from a 20 cm-section of sediments from just beneath and within the bone-bearing stratum that the vegetation of the area had undergone "a shift from fir-spruce forest with some pine to a forest predominantly pine, with no fir, some spruce and some deciduous trees—principally oak and hickory." This shift was interpreted to indicate a change from a cool climate to one that was somewhat warmer and drier. Material from the bone-bearing stratum has subsequently been radiocarbon dated at 9,600 ± 500 years ago (Goldthwait, 1958).

About 10,000 years ago as the climate continued to become warmer and more humid on the Darby Plains, spruce and fir were eliminated and pine nearly so, while a number of deciduous tree species were favored, especially oak, elm, and hickory. By approximately 8,000 years ago (Shane, 1976:123-125), the climate had become sufficiently warm and dry that many of the deciduous trees could not survive. For the next 4,000 years (Wright, 1968), these conditions prevailed or intensified. As discussed by Sears (1942b), this is the Xerothermic Period and it also represents the late postglacial prehistoric dry period described by Transeau (1935:435) when the Prairie Peninsula extended eastward into Ohio.[1] Although some of the species currently considered to be prairie species were probably present previously, prairie as a dominant plant community and those prairie species with western affinities most likely reached their maximum extent in the Darby Plains at this time.

Over the past 4,000 years since the Xerothermic Period, a cooler and more humid climate returned. These conditions generally favored the survival of deciduous tree species and certain herbaceous species and grasses with southeastern affinities (Gleason, 1923:84-85; Stuckey, 1981). Mixed oak forests gradually expanded into the prairies of the Darby Plains. Some western species were eliminated and some southeastern species invaded the prairies which survived the significant fluctuations in regional climate. Recurrent prairie fires, ignited either by lightning or Indians, tended to retard forest encroachment (Gleason, 1923:84-85), and as described by early historical accounts, prairies and open oak groves were quite extensive within the Darby Plains just prior to European settlement.

Presettlement Time (1750 to 1795)

In February 1751, Christopher Gist in the employ of the Ohio Company traveled through the region and recorded descriptions of the landscape in his journal. Although it is problematical whether he actually passed through the Darby Plains as defined here, he certainly was in the general area (Darlington, 1893:123). His journal provides the first written records of presettlement conditions in this part of Ohio (Darlington, 1893:47):

> All the Way from the Shannoah Town [Portsmouth in Scioto County] to this Place [West Liberty in Logan County] (except the first 20 M[iles or 48 km] which is broken [hilly]) is fine, rich level Land, well timbered with large Walnut, Ash, Sugar Trees, Cherry trees, &c, it is well watered with a great Number of little Streams or Rivulets, and full of beautiful natural

[1] On the basis of pollen data from Silver Lake in Logan County, Ogden (1966) indicated that in central Ohio this period occurred later, about 3,600 to 1,300 years ago. The apparent conflict in dating the Xerothermic Period in Ohio is discussed by Wright (1968), but additional studies are necessary to resolve the discrepancy.

Table 2. Generalized phases of postglacial vegetational history in the uplands of the Darby Plains, Ohio. Based primarily on Sears (1948) with adaptations from Sears and Clisby (1952), Kapp and Gooding (1964), Ogden (1966, 1967), Davis (1967), Wright (1968), Shane (1976), and Kapp (1977).

	Name	Typical Vegetation as Indicated by Pollen Analysis and Extant Vegetation	Climate Characteristics	Approximate Years Before the Present
I	Arctic tundra and park-tundra	Sedges, grasses, bog and open country herbs and shrubs with widely scattered spruce and fir	Cold, arctic and subarctic	16,000-14,000
II	Cold humid conifer	Spruce and fir forests	Cold, moist	14,000-11,000
III	Xerophytic conifer	Pine and scattered pines with some oak, elm, and open country with grasses and sedges	Cool, dry	11,000-10,000
IV	Mesophytic deciduous	Mixed deciduous forests with elm, oak, hickory, walnut, and maple	Warming, moist	10,000-8,000
V	Xerophytic deciduous (the Xerothermic Period)	Extensive prairies with scattered oak and hickory groves and forests	Warming, dry	8,000-4,000
VI	Mesophytic deciduous	Mixed oak and hickory forests and groves interspersed with prairies	Cooling, moist	4,000 to present

> Meadows, covered with wild Rye, blue Grass and Clover, and abounds with Turkeys, Deer, Elks and most Sorts of Game, particularly Buffaloes, thirty or forty of which are frequently seen feeding in one Meadow . . .

Possibly the first published account of prairies on the Darby Plains was presented by Col. James Smith who, in 1755 at the age of 18 had been captured by Indians in Pennsylvania. They carried him to the Ohio country and adopted him into one of their families. Before escaping in 1759, Smith (1799, reprinted 1978:114) recorded the following in his journal: "A considerable way up Ollentangy [Big Darby Creek] on the southwest side thereof, or betwixt it and the Miami, there is a very large prairie, and from this prairie down Ollentangy [Big Darby Creek] to Sciota [Scioto River] is generally first rate land." Smith (1799:107) also reported shooting a buffalo (bison) on a winter hunting trip in the vicinity of the Darby Plains.

The Darby Plains were frequently used for hunting expeditions by Indians. On the south bank of Big Darby Creek, about 3 km (2 miles) above Milford Center, was a favorite Indian camping ground which, after settlement, was known locally as the "Indian Fields" (Durant, 1883:289). Mansfield (1883:263) described a more permanent village:

> The principal haunt of the red men before they were disturbed by the pioneers, was on the banks of Big Darby, just northwest from Plain City. They dwelt here in considerable numbers about the year 1800, in wigwams built of bark and covered with brush. Their chief subsistence was game, although the squaws cultivated small patches of corn.

Under the pressure of more settlers, hunting expeditions eventually ceased, and Indians had been forced from the area by 1820 (Brown, 1883:249-251).

The first white settler in the Darby Plains was Jonathan Alder, for whom the local school district in the Plain City area is currently named. As an eight-year-old boy in Virginia, he had been captured by Indians in 1782, and as with James Smith earlier, he was carried to the Ohio country and adopted into an Indian family. Alder became completely integrated into the Indian (Mingo) way-of-life and learned much about large portions of Ohio. Shortly after the signing of the Treaty of Green Ville in 1795 (which, except for hunting and fishing privileges, required all Indians to move to northern Ohio), Alder married a squaw and built a cabin near the present site of Plain City. He related this event as follows (Davison, 1935:44):

> As soon as that treaty was confirmed and made, I concluded my arrangements with Barshaw and we was finally married according to the Indian custom and we immediately began to prepare and arrange our business to move to Darby as this was the greatest and best hunting ground of the whole Indian territory.

Alder also related an earlier hunting experience in the Darby Plains (Davison, 1935:55):

> I went out one day, that was before peace was made [Treaty of Green Ville, 1795] whilst I was staying on the Darby Plains before there was any whites here, to make a ring fire and capture a few deer that way. The grass was very nice and dry for burning. I went out two or three miles [3.2 or 4.8 km] southwest from Pleasant Valley [Plain City] and commenced my fire. I cut some of the long grass and made a torch and set it afire and then ran with it and I circled round and took in three or four thousand acres [1200 or 1600 ha] and then got inside of my ring and it soon made a fine fire all around and I very soon saw deer running from one side to the other. And in my ring I killed seven deer. When I would kill one, I dragged it into a thicket where there was no grass and scrapped the leaves away so as not to have the hide injured by fire. But at last the fire began to close in onto me and it burned very rapid. I could see no good place of escape. I looked me out a good piece of ground where there was no brush and when the fire began to get pretty warm, I put my powder horn under my arms and fired off my gun then leaped. I had wraped my blanket tight around me—head and face all covered. I could not see a particle; I was perfectly blindfolded. I turned my face in the direction that I wanted to run before I covered it. The fire was then a perfect blaze, ten or fifteen feet [3 or 4 m] high, and I started and ran through it. The main blaze was not more that thirty or forty feet [9 or 12 m] wide, but I ran about two hundred yards [180 m] before I was uncovered. I was out of the main fire, but it was still burning—I had to run farther to get entirely out of the fire on account of my powder horn. My moccasins was entirely ruined and my leggings and blanket was nearly spoiled. I then hunted up the deer and skinned them. Some of them had their hair pretty well singed off, but the hides were not injured—But that was my last ring fire.

Eventually Barshaw returned to her family in the Upper Sandusky reservation, and in 1805 Alder returned to his in Virginia. There he married a Virginian but soon came back with his family to live in the Darby Plains because he was much impressed with the beauty of the region. A cabin that Jonathan Alder built in 1806 still exists. It has been restored by the Madison County Historical Society and relocated on the Plain City-Georgesville Road (Madison County Route 7) about 1 km (0.6 mile) north of the intersection of Interstate 70 on a site adjacent to Foster Chapel Cemetery where he was buried in 1849.

From the Time of Settlement (1795) to the Present

General Accounts

European settlers quickly moved into the area after the Treaty of Greene Ville was signed in 1795. They generally located along the streams where the land was more elevated and drier, and where the best timber grew. Mosquitoes, however, were extremely abundant and as reported by Durant (1883:281): "the fever and ague [malaria] prevailed so generally in the fall seasons as to totally discourage many of the settlers."

The first settlers referred to the wet prairies as "barrens" and considered them entirely unfit for agriculture except for pasture (Brown, 1883:341). Atwater (1827), after considerable study, rejected the term "barrens" for these lushy vegetated landscapes, and Holder (1883:162), in his history of Union Township in Union County, reported:

> . . . the central and southern portion [of Union Township] are a part of the celebrated "Darby Plains," noted for their level surface and deep, rich soil consisting of black vegetable mold. Originally, as the first settlers found these plains, they consisted of prairie and oak openings, the former covered with an exuberance of grass, which in some portions grew to an enormous height; some of the settlers testifying that, as they rode through it on horseback, they could grasp a handful on each side of the horse, and tie them together over the rider's head.

Mansfield (1883:218) stated that the small patches of timber on the plains in Darby Township, Union County, consisted primarily of bur oak and hickory. Bur oak, according to Dobbins (1937:68) was the first tree to become established in the wet prairies, and it commonly occurred as an individual tree or in groves. Mansfield (1883:218) also reported clusters of hazel bushes in addition to thickets of wild plum trees which produced "a lucious variety of fruit." As indicated by John A. Littler (1980, personal communication), a longtime resident, Plumwood in Madison County probably was named for the many wild plum trees which formerly grew in the area.

Gowey (1881:561) described the portion of the Darby Plains in Champaign County:

> In the early history of the country, the southern part [of Rush Township] was covered by a dense growth of prairie grass, interspersed here and there with swamps covered with a profusion of rush . . . in the southern portions is mostly oak with here and there a shellbark hickory.

Dr. Jeremiah Converse, a physician of Plain City and an 1848 graduate of Starling Medical College in Columbus, Ohio, described the prairies of Madison County (Brown, 1883:341-342) in this manner:

> This whole country was a sea of wild grass, and flowering herbs. . . There were many other varieties that grew upon the prairie besides those that were found skirting, and in the oak-openings; such as the daisies, buttercups, wild pink, coxcomb, lilies and many others equally beautiful. It was, indeed, a grand sight to a nature-loving mind, to look over these extensive prairie fields and behold them mantled with so luxuriant a growth of vegetation and decorated so lavishly with an almost endless variety of flowers, variegated with all the colors of the rainbow . . .

Nearly every spring or autumn, prairie fires swept over the Darby Plains. These fires were vividly described by Dr. Converse (Brown, 1883:341):

> It was majestically grand to see these prairies on fire, fifty years ago! The blaze of the burning grass seemed to reach the very clouds; or, when driven by a fierce wind, would leap forty or fifty feet [12 or 15 m] in advance of the base of the fire. Then add to all this a line of the devouring element three miles [4.8 km] in length, mounting upward and leaping madly forward with lapping tongue, as if it were trying to devour the very earth, and you have a faint idea of some of the scenes that were witnessed by the early settlers of this country.

As more settlers moved into the area, they tended to control the wild fires out of fear of burning their crops and buildings. Within a few years, the luxurious growths of grass accumulated and became a "wet thick mass of decay" (Mansfield, 1883:231). During 1822 and 1823, a great epidemic (probably malaria) swept the area and made sad inroads on the human population of the sparsely settled Darby Plains. According to Dr. Converse (Mansfield, 1883:228-231):

> There was scarcely a family but what had its sick or dying . . . All business transactions ceased, gloom brooded over the minds of the people and many a stout heart was made to tremble over the impending doom . . .

There were a few instances where the father was compelled to construct the rude coffin, dig the grave and deposit beneath the clods of the valley the loved form of his child. The territory invaded by this epidemic extended from a short distance east of Big Darby to perhaps the same distance west of Little Darby.

The epidemic was generally believed to have occurred "because of failure to burn out the sedge" (Ohio Historical Records Survey Project, 1941:4) and the resulting decomposition of the vegetable matter. Another deadly disease in the area was milk sickness. It developed when cattle ate white snakeroot *(Eupatorium rugosum)* and people subsequently used the milk. Milk sickness was reputed to have been responsible for nearly one-fourth of the deaths of the early settlers in Madison County (Moseley, 1941:7). Increasing agricultural use and drainage of many of the wet prairie sites soon followed and no other outbreaks of either disease developed in the area (Laufersweiler, 1960:47).

The settlers extensively pastured the wet prairies. Efforts to drain them, however, soon began, and as reported by Orton (1878a:426): "As soon as the surface water is withdrawn . . . *Poa pratense,* or Kentucky Bluegrass, comes in to displace the wild grasses that have occupied the ground hitherto, and it comes to stay." The transformation of much of the wet prairie to blue grass pastures was so successful that, by the middle of the nineteenth century, London, Ohio, had become a nationally recognized center for the shorthorn cattle industry (Ohio Historical Records Survey Project, 1941:5).

Further draining the wet fertile soils, however, and planting them to corn and wheat provided for even greater levels of agricultural production (Holder, 1883:162). Orton (1878a:425) accurately observed: "Madison county is found to be one of the finest agricultural districts of the State. There is scarcely [sic] a foot of waste land in it and most of it, if not already highly productive, is easily susceptible of being made so." Private and public enterprise, assisted by drainage laws passed by the Ohio Legislature, accelerated the drainage projects and gradually changed the face of the landscape (Brown, 1883:342).

Katharine D. Sharp of London, Ohio, studied and appreciated the local flora around the turn of the twentieth century. She was the wife of a local physician and expressed her apparent mixed emotions about these changes in the landscape when she wrote (Sharp, 1913:20): "But bogs [wet prairies] are growing fewer yearly in Madison County, owing to the network of tiling in the low fields and meadows. That way lies health and wealth." These prairie lands still rank as the most productive for agriculture in the area (Laufersweiler, 1960:64) and the Darby Plains have some of the best farm lands in the state.

Floristic Accounts

The prairie plants of west-central Ohio, including those of the Darby Plains, were observed, described, collected, and recorded by several Ohio naturalists throughout the nineteenth century. These workers included Caleb Atwater (1818, 1827, 1828), John L. Riddell (1834, 1835, 1836), Johnathan R. Paddock, William Starling Sullivant (1840, 1842), Leo Lesquereux, William Ashbrook Kellerman and William C. Werner (1893), and Katharine D. Sharp (1913).

Possibly the first herbarium specimens of plants from the Darby Plains were those collected by John L. Riddell while he was teaching at the Reformed Medical College in Worthington, Ohio, from 1832 to 1834. Because he sold many of his specimens, much of his herbarium has been destroyed or widely scattered (Stuckey, 1978:273). However, Riddell (1835) identified many Ohio prairie plants in his *Synopsis of the Flora of the Western States* in which he reported ten taxa (as listed below) occurring specifically in prairies on the Darby Plains. In 1836, he added another taxon (indicated by an asterisk) in *A Supplementary Catalogue of Ohio Plants* (Riddell, 1836). Although Riddell's use of the term "Darby Plains" was not geographically precise, and although the modern taxonomic equivalents of some of his taxa are uncertain in the absence of voucher specimens, he provided the basis for the initial scientific listing of prairie species for this area. Riddell's names when different from the species of Fernald (1950) are in parentheses:

Cassia fasciculata (*C. chamaecristata)*	Partridge-pea
Eryngium yuccifolium (E. aqaticum)	Rattlesnake-master
Helianthus laetiflorus var. *rigidus (H. scaberrimus)*	Showy sunflower
Lespedza violacea (L. divergens)	Bush-clover
Populus heterophylla	Swamp cottonwood
Silphium laciniatum	Compass-plant
Silphium laciniatum (S. gumniferum)	Compass-plant
Silphium terebinthinaceum	Prairie dock
Silphium terebinthinaceum (S. pinnatifidum)	Pinnatifid prairie dock
**Stenanthium gramineum (Veratrum angustifolium)*	Featherbells
Vernonia fasciculata var. *corymbosa (V. corymbosa)*	Western ironweed

Of these eleven taxa, the author is aware of extant populations in the Darby Plains of only three: *Cassia fasciculata*, and the typical and pinnatifid forms of *Silphium terebinthinaceum* (Table 4).

Undoubtedly, additional prairie species of the Darby Plains were included in Riddell's *Synopsis,* but their specific distribution is masked by such annotations as "borders of prairies," "grassy prairies," wet prairies," and "Central Ohio." He specifically annotated eight additional species as occurring in the Darby Plains:

Hypericum sp. *(H. densiflorum)*	Indeterminable species
Hypericum sp. *(H. galioides)*	Indeterminable species
Lilium philadelphicum	Wood lily
Lonicera prolifera (L. flava)	Grape honeysuckle
Polygonum hydropiperoides (P. mite)	Mild water-pepper
Quercus stellata (Q. obtusiloba)	Post oak
Ranunculus flabellaris (R. lacustris)	Yellow water crowfoot
Sparganium chlorocarpum (S. angustifolium)	Green-fruited bur-reed

Johnathan R. Paddock was a colleague of Riddell at the Reformed Medical College, and he also assembled a collection of central Ohio plants (Stuckey, 1978:273). In contrast to that of Riddell, Paddock's herbarium remained intact, and in 1919 it was acquired by the Herbarium, University of Illinois, Urbana (Anonymous, 1920), into which it has now been integrated. Specimens of ten species (as listed below) which were collected from the Darby Plains have been recorded from Paddock's herbarium (Stuckey and Roberts, In preparation). One specimen (as indicated by an asterisk) was collected from Big Darby Creek. Species names are from Fernald (1950) with Paddock's names and year of collection, when known, in parentheses:

Baptisia leucantha (B. alba)	White false indigo
**Ceratophyllum demersum (Myriophyllum,* 1833)	Hornwort
Cuscuta gronovii (Cuscuta, 1839)	Gronovius' dodder
Desmodium canadense (Hedysarum canadense, 1833)	Showy tick-trefoil
Demodium cuspidatum (Hedysarum bracteosum, 1833)	Large-bracted tick-trefoil
Gentiana puberula (G. Catesbii, 1837)	Downy gentian
Nuphar advena (N. sagittaefolia, 1839)	Yellow pond lily
Polygala senega (P. senega, 1835)	Seneca snakeroot
Quercus macrocarpa (Q. obtusiloba)	Bur oak
Silene regia (S. regia, 1835)	Royal catchfly

These valuable specimens from Paddock's herbarium probably are the oldest existing specimens from the Darby Plains.

Surprisingly, Riddell and Paddock experienced some confusion with their different uses of the name "*Quercus obtusiloba.*" Riddell's "*Q. obtusioloba*" is definately *Q. stellata* (post oak) as interpreted from his annotations for the species (Riddell, 1835:354). Paddock's "*Q. obtusiloba*" is definately *Q. macrocarpa* (bur oak) as determined from his herbarium specimen (Stuckey and Roberts, In preparation; Almut G. Jones, 1980, personal communication). Both species are still present in the Darby Plains as discussed below.

William S. Sullivant, a son of the founder of Columbus, Ohio, was a successful businessman who became interested in botany (Rodgers, 1940). In his travels in the Darby Plains about 24 km (15 mi) west of Columbus in the late 1830's and early 1840's, Sullivant obtained three very rare taxa that have not been seen there since. Two of these species were named and described as new to science: flat-stemmed spike rush, *Eleocharis compressus,* by Sullivant (1842; Braun, 1967:191); and a sunflower, *Helianthus cinereus* var. *sullivantii* by Torrey and Gray (1843). The latter has been determined to belong to the hybrid, *H.* x *cinereus,* as discussed by Heiser et al. (1966:208). The third is a carrot-like species, *Periderdia americana (Eulophus americanus),* which Sullivant noted on a specimen mount at the Gray Herbarium, Harvard University, as "always in dry meadows ½ to 1 mile [0.8 to 1.6 km] west of Lafayette Madison Co."

Sullivant also collected "Near Columbus, Ohio," the specimen from which the species Sullivant's milkweed *(Asclepias sullivantii)* was named (Gray, 1848:367). "Near Columbus, Ohio," likely could have been in the Darby Plains as Sullivant usually did not record on his specimen labels the actual location where he obtained the specimen (Stuckey, 1974).

Sullivant, Leo Lesquereux, a close botanical associate of Sullivant, and William A. Kellerman, a botanist at The Ohio State University, were poetically entwined with the Darby Plains in a verse written by Katharine D. Sharp (1913:133-134):

Helianthus kellermanii.

When August beams with sultry rays
Along luxuriant country ways,
When verdure droops and brooks are dry,
Rejoicing in the summer sky,
The Helianthus opes her gold,
Her gorgeous beauties all unfold,
And to her lord, the blazing sun,
She lifts her bright eyes, one by one.

On Darby's plains and to the west
The prairie decks her bounteous breast
With many a flower of varied hue;
And here our Sullivant and Lesquereux,
Earliest among the pioneers,
Unchecked by solitude or fears
Of deadly, lurking, savage foe,
Into these wilds devoutly go
And on this wealth of nature pore
With zeal of scientific lore.

Along Scioto's plains, I wist,
Ohio's later botanist
Has crowned his wanderings aestival,
His part in nature's festival
By blending in discovery's thought
His name with Helianthus wrought.

Oft as the boscage wild I scour
I long to hap upon some flower
By page botanical unkenned,
Whereto my name I may append,
As here along the summer lea
I find the *Sullivantii,*
Or that *giganteum's* form obscure
Which *Kellermanii* shall endure.
But, ah! no flower unknown thus far
Has crowned my vision like a star.
Yet happy fate it were for me
To rear some flower of Poësy.

O Muse, to whom the power belongs,
Inspirer of our sylvan songs,
Grant to this verse one touch divine
To link those gracious names with mine!
August 21, 1899.

Limited plant collecting continued in the Ohio prairies west of Columbus in the twentieth century, and the resulting herbarium records added to the expanding information base regarding the distribution of Ohio flora as reported primarily by Schaffner (1932) and Braun (1961, 1967). Sears (1926) using the annotations of Riddell (1835), as referred to above, developed reconstructed species lists for treeless areas throughout Ohio. Other species lists have been published for Ohio prairie plants including those collected from, but not necessarily limited to the wet prairies of west-central Ohio: Dobbins (1937:124-127), Jones (1944), Gordon (1969:58-59), and Troutman (Cusick and Troutman, 1978:49-55). A fragmentary species list of the flora of the Madison County area was presented by Sharp (1913:33-35). Among rare and endangered wetland species, Stuckey and Roberts (1977) recorded five species for Madison County: lake cress, *Armoracia aquatica;* lesser prickly sedge, *Carex sterilis;* flat-stemmed spike rush, *Eleocharis compressus;* inland rush, *Juncus interior;* and marsh arrow-grass, *Triglochin palustre*. A complete checklist of plant species collected from the Darby Plains is not available, but a list of vascular plant species with Ohio prairie affinities as suggested by Troutman (Cusick and Troutman, 1978:52-55) having extant populations within the Darby Plains is presented in Table 4.

Floristic and ecological research on the prairies of west-central Ohio, and indeed on the original vegetation of the entire state, developed in the 1920's with the appearance of papers by Sears (1925, 1926) and the initiation of the Ohio Vegetation Survey under the direction of Edgar N. Transeau, the Department of Botany, The Ohio State University (Gordon, 1969:2-5, 1981; Stuckey, 1981). Transeau had been studying (Transeau, 1981) and mapping original prairies in the area for some time while preparing the map of the Prairie Peninsula in his classic paper (Transeau, 1935), but the most detailed mapping of original prairies in the Darby Plains and adjacent areas was done by one of his students, Raymond A. Dobbins.

Dobbins mapped the primary vegetational types on a block of twenty 15′ United States Geological Survey topographic maps of west-central Ohio. These vegetational maps were never published as such, but they formed the basis for the several vegetational maps in his dissertation (Dobbins, 1937). Of special interest to this paper is his prairie map (p. 113 and 114) which has provided the information from which the original prairies of the Darby Plains have been mapped in Fig. 1. Gordon (1966) also relied heavily upon Dobbins' data for the west-central portion of his map of the natural vegetation of Ohio. Dobbins used various sources of information, including original land surveys, local histories, soils data, extensive field surveys, and word-of-mouth records from elderly residents who were well acquainted with the area. These original topographic maps of Dobbins are currently preserved in the archives of the Ohio Biological Survey.

By the mid-1930's, Dobbins (1937:117) reported that prairie remnants which contained characteristic plants were scarce and fragmentary. Although he did not identify specific sites, Dobbins indicated that some of the best prairie remnants in his study area were in the Darby Plains in southern Union County and northern Madison County near Plain City and in north-central Madison County near Plumwood.

Thomas (1932) reported the presence of prairie vegetation along roadsides west of West Jefferson. He also mapped prairie remnants stretching for miles along roads in Madison County where not a single prairie plant exists today (Thomas, 1980).

EXISTING PRAIRIE REMNANTS

Sites Previously Known to the Scientific Community

The scientific community in Ohio, for the past several decades, has been aware of only two prairie remnants in the Darby Plains. One is in a metropolitan park and the other is a pioneer cemetery (Thomas, 1963).

Battelle-Darby Creek Metropolitan Park Bluff Prairie

This 1.6 ha (4 acre) dry prairie occupies a narrow strip on the east bank of Big Darby Creek between the stream and hilltop in Battelle-Darby Creek Metropolitan Park about 1 km (0.6 mile) northeast of Georgesville in western Franklin County (Cusick and Troutman, 1978:20; Stahl, 1978; see my Table 3, Fig. 1). Big Darby Creek continually erodes the base of this hill of glacial till which causes the hillside to be heavily eroded. The well-drained soils at this site have been mapped as eroded Hennepin and Miamian loams on 25 to 50 percent slopes (McLoda et al. 1980:photomap 49). The area was purchased for a park on 5 October 1962 by the Columbus and Franklin County Metropolitan Park District.

The prairie vegetation occurs in scattered small clumps on the heavily eroded bluff. Although grasses are well represented, the diversity of forbs provide "the spectacular aspect of this small prairie" (Stahl, 1978). A total of 50 species of prairie plants has been recognized of which five are known from no other station within the Darby Plains (Table 4): ground nut *(Apios americana)*, Canadian milkvetch *(Astragalus canadensis)*, purple-headed sneezeweed

Table 3. Known sites of significant prairie remnants in the Darby Plains in west-central Ohio. Numbers identify sites in Figure 1 and Table 4. All sites except 1 and 2 were discovered from 1976-1981 in coopreation with the Prairie Survey Project of the Ohio Biological Survey.

		County-Township	Location	Ohio Prairie Plant Taxa Recorded**	Remarks	References
1.	Battelle-Darby Creek Metropolitan Park Bluff Prairie	Franklin-Pleasant	1 km NE of Georgesville on E bank of Big Darby Creek in park.	50	Dry prairie on heavily eroded bluffs. Good display of forbs including purple coneflower, wild bergamot, and blazing star.	Cusick & Troutman, 1978:20; Stahl, 1978; see this paper
1a.	Prairie Reconstruction	Franklin-Pleasant	Off road W of Georgesville-Plain City Rd (Co 281), 1 km NW of Georgesville.	—	Reconstructed prairie, started in 1975 using local and non-local ecotypes. Park property.	None
1b.	Prairie Reconstruction	Franklin-Pleasant	0.5 km S of Georgesville, E of Georgesville-Wrightsville Rd (Co 139).	—	Reconstructed prairie, started 1980 by Jack H. McDowell, using only local ecotypes. Park property.	McCutcheon, 1980
2.	Bigelow Cemetery State Nature Preserve	Madison-Pike	On Rosedale (Weaver) Rd (Co 25 in Madison County & Co 56 in Union County) 0.4 km S of jct with Ohio Rt 161, 2.3 km W of jct Ohio Rt 161 & Ohio Rt 38 at Chuckery.	29	Formerly known as Chuckery or Boerger Cemetery. Graves date to 1814. Good forbs including purple coneflower, royal catchfly, stiff goldenrod, and whorled rosinweed.	Cusick & Troutman, 1978:30; Carr, 1981; King, 1981; Overton, 1981; see this paper
3.	Bradley Cemetery	Madison-Monroe	2 km SE of Plumwood, 0.8 km W of Lafayette-Plain City Rd (Co 5).	9	Well-drained site with purple coneflower, butter-fly-weed, and flowering spurge. Surrounded by private property.	Cusick & Troutman, 1978:30
4.	Dayton Power & Light Co. Right-of-way at Van Ness Road	Champaign-Goshen	Along Van Ness Rd (Twp 243) 1 km E of jct Ohio Rt 4.	6	Disturbed right-of-way, a continuation of the one at Milford Center Prairie, which see. Private property.	Cusick & Troutman, 1978:13
5.	Debolt Road Roadside	Madison-Darby & Union-Darby	Along Debolt Rd (Twp 129 in Madison County & Twp 54 in Union County) just S of jct Ohio Rt 161.	6	Big bluestem sod.	Cusick & Troutman, 1978:42
6.	Garrette Site	Madison-Jefferson	0.8 km NE of West Jefferson on either side of railroad on E bank of Little Darby Creek.	17	Abundant butterfly-weed, short green milkweed, and partridge pea. Discovered by Jack H. McDowell. Private property.	None
7.	Georgesville Railroad Site	Franklin-Pleasant	1.5 km W of Georgesville along railroad either side of intersection with Alkire Rd (Co 11).	20	About 0.4 km of railroad right-of-way mostly W of intersection with Alkire Rd. Discovered by Jack H. McDowell.	None

Table 3. (cont.) Known sites of significant prairie remnants in the Darby Plains in west-central Ohio. Numbers identify sites in Figure 1 and Table 4. All sites except 1 and 2 were discovered from 1976-1981 in cooperation with the Prairie Survey Project of the Ohio Biological Survey.

		County-Township	Location	Ohio Prairie Plant Taxa Recorded**	Remarks	References
8.	Graessle Road Bluff Site	Franklin-Pleasant	2.0 km W of Darbydale on E side of Graessle Rd (Twp 285) and unnamed stream, 0.2 km S of Ohio Rt 665.	27	Habitat and species similar to Battelle-Darby Creek Metropolitan Park Bluff Prairie. Abundant New Jersey tea and stiff gentian. Discovered by Jack H. McDowell. On Big Darby Wildlife Area managed by Ohio Division of Wildlife.	None
9.	Lilly Chapel Site	Madison-Fairfield	3.5 km W of Lilly Chapel & 0.5 km S of Lilly Chapel-Georgesville Rd (Co 102).	3	Sullivant's milkweed is common. Owners claim land was never plowed, but used as hog pasture. Private property.	Cusick & Troutman, 1978:30
10.	Martin Cemetery	Champaign-Rush	120 m N of jct Lincoln Rd (Twp 209) & Martin Rd (Twp 210), 1.8 km N of Woodstock.	1	Unmowed cemetery. Vigorous population of royal catch-fly. Surrounded by private property.	King, 1981
11.	McMahill Road Roadside	Champaign-Rush	Along Twp 206 immediately S of jct U.S. Rt 36.	1	Big bluestem sod.	Cusick & Troutman, 1978:12
12.	Milford Center Prairie	Union-Union	3 km SW of Milford Center on Dayton Power & Light Co. Right-of-way primarily between Connor Rd (Co 81) & Ohio Rt 4.	57	Largest assemblage of prairie plants located thus far in Darby Plains. See description in this paper. Private property.	Cusick & Troutman, 1978:42; see this paper
13.	Ohio Rt 38 Roadside	Madison-Deer Creek	Along Ohio Rt 38 for 3 km immediately S of jct Ohio Rt 29.	5	Intermittant stands of prairie grasses.	None
14.	Phellis Cemetery	Madison-Pike	0.6 km E of Rosedale (Weaver) Rd (Co 25) on N side of Barron Creek, 1.7 km NE of Rosedale.	1	Sullivant's milkweed has survived pasturing. Surrounded by private property.	Cusick & Troutman, 1978:31
15.	Pinnatifid Prairie Dock Site	Madison-Jefferson	On NE-facing slope 0.2 km SW of U.S. Rt 42 bridge at Little Darby Creek.	4	An exceptional stand of a pinnatifid-leafed form of prairie dock. Plowed in 1981. Private property.	Fisher, 1966; Cusick & Troutman, 1978:31; see this paper
16.	Railroad Right-of-way Between Plain City and Unionville Center	Union-Darby	Along railroad tracks between Co 57 & Co 55.	12	A highly disturbed area with typical and pinnatifid-leafed forms of prairie dock. Railroad property.	Cusick & Troutman, 1978:43
17.	Railroad Right-of-way Between West Jefferson and London Including Plymell Cemetery	Madison-Jefferson, Deer Creek, & Union	Along railroad tracks for about 12.5 km between West Jefferson and London.	45	A highly disturbed area with intermittent, but sizeable populations of prairie plants. Discovered by Jack H. McDowell. Railroad property.	See this paper

Table 3. (cont.) Known sites of significant prairie remnants in the Darby Plains in west-central Ohio. Numbers identify sites in Figure 1 and Table 4. All sites except 1 and 2 were discovered from 1976-1981 in cooperation with the Prairie Survey Project of the Ohio Biological Survey.

		County-Township	Location	Ohio Prairie Plant Taxa Recorded**	Remarks	References
18.	Scheiderer Road at Railroad	Union-Darby	Along railroad at intersection with Co 44, 2 km W of Unionville Center.	15	Tall coreopsis, prairie dock and Sullivant's milkweed. Railroad property.	Cusick & Troutman, 1978:43
19.	Silver-Forrest Site	Madison-Jefferson	1.5 km N of jct US Rt 40 and Ohio Rt 29.	34	Scattered openings and edges on upland S of Little Darby Creek. Arrow-leaved violet, round-headed bush clover, pinnatifid prairie dock, and prairie dropseed. Discovered by Jack H. McDowell. Private property.	See this paper
20.	Smith Cemetery	Madison-Darby	N of Boyd Rd (Co 42), 0.8 km W of jct with Converse Chapel Rd (Co 41), 5 km W of Plain City.	30	Occasionally mowed but not manicured. Purple coneflower, stiff goldenrod, white wild indigo, big bluestem, little bluestem, purple milkweed, gray willow. Private property.	See this paper
21.	Township Road 403	Champaign-Rush	Between U.S. Rt 36 & McMahill Rd (Twp 206) at Union-Champaign County Line.	2	Abandoned roadway with big bluestem, cord grass, and 13-lined ground squirrels.	Cusick & Troutman 1978:12
22.	W. Pearl King Prairie Grove	Madison-Monroe	West side of jct Mechanicsburg-Sanford Rd (Co 27) and David Brown Rd (Co 119).	18	Excellent prairie grasses including rare prairie dropseed in mixed oak grove. Private property.	Thomas, 1980, 19 Oct; see this paper
23.	Wilson Road at Railroad	Madison-Fairfield	Along railroad tracks at intersection with Wilson Rd (Co 103)	18	Disturbed area along abandoned railroad. Discovered by Jack H. McDowell.	None

**As suggested by Troutman (Cusick and Troutman, 1978:49-55).

Table 4. Alphabetical list of 96 vascular plant taxa with Ohio prairie affinities (as suggested by Troutman in Cusick and Troutman, 1978:52-55) which have extant populations (or recent records as indicated) at sites of significant prairie remnants in the Darby Plains of west-central Ohio. Sites are described briefly in Table 3 and located in Figure 1. Scientific names are primarily from Fernald (1950).

		Battelle-Darby Creek Metropolitan Park Bluff Prairie[2,7]	Bigelow Cemetery State Nature Preserve[3]	Bradley Cemetery	Dayton Power & Light Co. Right-of-way at Van Ness Road	Debolt Road Roadside	Garrette Site[7]	Georgesville Railroad Site[7]	Graessie Road Bluff Site[7]	Lilly Chapel Site	Martin Cemetery	McMahill Road Roadside	Milford Center Prairie	Ohio Rt. 38 Roadside	Phellis Cemetery	Pinnatifid Prairie Dock Site	Railroad Right-of-way Between Plain City and Unionville Center	Railroad Right-of-way Between West Jefferson and London Including Plymell Cemetery[7]	Scheiderer Road at Railroad	Silver-Forrest Site	Smith Cemetery	Township Road 403	W. Pearl King Prairie Grove	Wilson Road at Railroad[7]
Identifying number on Table 3 and Fig. 1		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Total taxa with prairie affinities		**50**	**29**	**9**	**6**	**6**	**17**	**20**	**27**	**3**	**1**	**1**	**57**	**5**	**1**	**4**	**12**	**45**	**15**	**34**	**30**	**2**	**18**	**18**
Allium canadense	Wild garlic	x							x									x			x			
A. cernuum	Nodding onion	x					x		x				x					x						
Andropogon gerardii	Big bluestem	x	x	x	x	x		x	x	x		x	x	x			x	x	x	x	x	x	x	x
A. scoparius	Little bluestem	x			x			x	x								x	x		x	x		x	x
Anemone canadensis	Canadian anemone	x	x	x			x	x	x				x					x		x	x			x
Antennaria plantaginifolia	Plaintain-leaved everlasting	x							x											x				
Apios americana	Ground nut	x																						
Asclepias purpurascens	Purple milkweed																				x			
A. sullivantii	Sullivant's milkweed	x[6]				x	x			x					x			x	x	x				x
A. tuberosa	Butterfly-weed	x		x			x	x	x				x					x		x				x
A. verticillata	Whorled Milkweed	x[6]																						
A. viridiflora	Short green milkweed	x					x													x				
Aster laevis	Smooth aster																				x			
A. novae-angliae	New England aster	x				x							x			x	x	x					x	
Astragalus canadensis	Canadian milkvetch	x																						
Baptisia leucantha	White wild indigo																	x			x			
Blephilia ciliata	Downy wood mint	x																			x			
Cacalia tuberosa	Tuberous Indian-plantain	x							x															
Camassia scilloides	Wild hyacinth	x											x											
Cassia fasciculata	Partridge-pea	x					x																	
C. marilandica	Wild senna												x											
Castilleja coccinea	Indian paintbrush	x							x															
Ceanothus americanus	New Jersey tea	x							x									x			x			
Cicuta maculata	Spotted water-hemlock												x											
Cirsium discolor	Oldfield thistle							x					x					x		x	x		x	x
Comandra umbellata	Bastard toadflax	x	x						x				x											
Coreopsis tripteris	Tall coreopsis		x[4]															x	x					
Cornus racemosa	Gray dogwood	x	x			x		x					x				x	x	x		x			x
Corylus americana	Hazelnut	x	x	x				x					x				x	x						
Desmodium canadense	Showy tick-trefoil	x	x					x					x					x	x	x			x	
[1]*D. canescens*	Hoary tick-trefoil												x								x			
Echinacea purpurea	Purple coneflower	x	x	x														x		x	x			
Elymus canadensis	Canada wild rye	x						x										x						
Equisetum laevigatum	Smooth scouring-rush	x											x											
Eupatorium altissimum	Tall boneset						x	x	x				x				x	x						x

Table 4. (cont.) Alphabetical list of 96 vascular plant taxa with Ohio prairie affinities (as suggested by Troutman in Cusick and Troutman, 1978:52-55) which have extant populations (or recent records as indicated) at sites of significant prairie remnants in the Darby Plains of west-central Ohio. Sites are described briefly in Table 3 and located in Figure 1. Scientific names are primarily from Fernald (1950).

		Battelle-Darby Creek Metropolitan Park Bluff Prairie[2,7]	Bigelow Cemetery State Nature Preserve[3]	Bradley Cemetery	Dayton Power & Light Co. Right-of-way at Van Ness Road	Debolt Road Roadside	Garrette Site[7]	Georgesville Railroad Site[7]	Graessle Road Bluff Site[7]	Lilly Chapel Site	Martin Cemetery	McMahill Road Roadside	Milford Center Prairie	Ohio Rt. 38 Roadside	Phellis Cemetery	Pinnatifid Prairie Dock Site	Railroad Right-of-way Between Plain City and Unionville Center	Railroad Right-of-way Between West Jefferson and London Including Plymell Cemetery[7]	Scheiderer Road at Railroad	Silver-Forrest Site	Smith Cemetery	Township Road 403	W. Pearl King Prairie Grove	Wilson Road at Railroad[7]
Identifying number on Table 3 and Fig. 1		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Total taxa with prairie affinities		**50**	**29**	**9**	**6**	**6**	**17**	**20**	**27**	**3**	**1**	**1**	**57**	**5**	**1**	**4**	**12**	**45**	**15**	**34**	**30**	**2**	**18**	**18**
Euphorbia corollata	Flowering spurge	x	x	x	x		x	x	x				x				x	x	x	x	x			
Gaura biennis	Biennial gaura	x[6]		x	x								x					x			x		x	
Gentiana quinquefolia	Stiff gentian	x							x															
Gerardia tenuifolia	Slender foxglove	x					x																	
Helenium autumnale	Sneezeweed	x											x											
[1]*H. nudiflorum*	Purple-headed sneezeweed	x																						
Helianthus grosseserratus	Saw-toothed sunflower	x[6]	x[4]		x								x				x	x	x				x	x
H. laetiflorus	Showy sunflower												x											
H. strumosus	Pale-leaved wood sunflower	x	x					x					x					x		x				x
Heliopsis helianthoides	Ox-eye	x		x				x					x					x		x	x			x
Hypoxis hirsuta	Yellow stargrass	x							x											x				
Ipomoea pandurata	Wild potato-vine	x[6]		x			x	x					x					x						x
Krigia biflora	False dandelion	x																						
Lactuca canadensis	Tall wild lettuce	x	x															x						
Lathyrus venosus	Veiny pea												x											
Lespedeza capitata	Round-headed bush-clover																			x				
Liatris aspera	Rough blazing-star								x															
L. scariosa	Blazing-star												x											
L. squarrosa	Scaly blazing-star	x							x											x				
Lilium michiganense	Michigan lily												x											
Lithospermum canescens	Hoary puccoon	x							x															
Lobelia spicata	Pale-spike lobelia	x							x											x	x		x	
Lycopus americanus	Water-horehound	x											x										x	
Lysimachia lanceolata	Lance-leaved loosestrife		x										x								x		x	
Lythrum alatum	Winged loosestrife												x							x				
Melica nitens	Tall melic grass												x											
Mirabilis nyctaginea	Wild four-o'clock												x						x					
Monarda fistulosa	Wild bergamot	x	x				x						x					x		x	x			
Panicum virgatum	Switchgrass	x[6]					x							x				x					x	x
Penstemon digitalis	Foxglove beardtongue	x[6]																		x				
Physostegia virginiana	Obedient plant		x[5]																					
Polygala senega	Seneca snakeroot	x	x[4]						x				x											
P. verticillata	Whorled milkwort																						x	
Polygonatum commutatum	Giant solomon's-seal	x	x						x				x					x						
[1]*Prunus americana*	Wild plum	x[6]	x					x					x					x						
Psoralea onobrychis	Sainfoin		x					x					x					x					x	

Table 4. (cont.) Alphabetical list of 96 vascular plant taxa with Ohio prairie affinities (as suggested by Troutman in Cusick and Troutman, 1978:52-55) which have extant populations (or recent records as indicated) at sites of significant prairie remnants in the Darby Plains of west-central Ohio. Sites are described briefly in Table 3 and located in Figure 1. Scientific names are primarily from Fernald (1950).

		Battelle-Darby Creek Metropolitan Park Bluff Prairie[2,7]	Bigelow Cemetery State Nature Preserve[3]	Bradley Cemetery	Dayton Power & Light Co. Right-of-way at Van Ness Road	Debolt Road Roadside	Garrette Site[7]	Georgesville Railroad Site[7]	Graessie Road Bluff Site[7]	Lilly Chapel Site	Martin Cemetery	McMahill Road Roadside	Milford Center Prairie	Ohio Rt. 38 Roadside	Phellis Cemetery	Pinnatifid Prairie Dock Site	Railroad Right-of-way Between Plain City and Unionville Center	Railroad Right-of-way Between West Jefferson and London Including Plymell Cemetery[7]	Scheiderer Road at Railroad	Silver-Forrest Site	Smith Cemetery	Township Road 403	W. Pearl King Prairie Grove	Wilson Road at Railroad[7]
Identifying number on Table 3 and Fig. 1		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Total taxa with prairie affinities		50	29	9	6	6	17	20	27	3	1	1	57	5	1	4	12	45	15	34	30	2	18	18
Pycnanthemum virginianum	Virginia mountain-mint	x					x						x					x		x	x		x	
Quercus macrocarpa	Bur oak	x	x										x					x		x	x		x	
Ratibida pinnata	Gray-headed coneflower	x	x		x		x	x	x	x			x					x	x	x	x			x
Rosa blanda	Smooth rose												x											
R. carolina	Pasture rose	x	x										x						x					
Rudbeckia hirta	Black-eyed susan	x	x			x			x				x			x		x	x	x	x			
Ruellia humilis	Wild petunia	x[6]	x				x		x				x							x			x	
Salix humilis	Gray willow																				x			
Silene regia	Royal catchfly		x								x		x					x						
Silphium terebinthinaceum	Prairie dock		x[4]										x			x	x	x	x	x				
S.t. (pinnatifid hybrid)	Pinnatifid prairie dock												x			x	x	x		x				
S. trifoliatum	Whorled rosinweed	x	x				x	x	x				x					x		x	x			
Sisyrinchium albidum	White blue-eyed grass												x							x				
Solidago rigida	Stiff goldenrod		x				x	x					x					x			x			x
Sorghastrum nutans	Indian grass	x	x						x				x	x			x	x	x	x	x		x	
Spartina pectinata	Prairie cord grass					x							x	x			x	x	x		x	x	x	x
Spiranthes gracilis	Slender ladies tresses	x																						
Sporobolus asper	Rough dropseed												x	x						x				
S. heterolepis	Prairie dropseed																			x			x	
Teucrium canadense	Germander												x					x						
Thalictrum revolutum	Skunk meadow-rue		x										x					x			x			
Tradescantia ohiensis	Ohio spiderwort												x					x						x
Veronicastrum virginicum	Culver's-root							x					x					x	x					
Viola sagittata	Arrow-leaved violet																			x				
Zizia aurea	Golden alexanders	x							x				x							x	x			

[1] Not included on Troutman's list in Cusick and Troutman (1978:52-55) but added with his approval.
[2] James E. Stahl, 1980, personal communication; and Richard E. Moseley, Jr. 1980, personal communication.
[3] Carr, 1981.
[4] Species previously reported but absent in 1978.
[5] Observed August 1976 about 200 m (600 feet) south of cemetery along roadside by Charles C. King. Not included in total species for the cemetery.
[6] Not on prairie but on adjacent park property. Not included in total species for the bluff prairie.
[7] Jack H. McDowell, 1981, personal communication.

(Helenium nudiflorum), false dandelion *(Krigia biflora)* and slender ladies tresses *(Spiranthes gracilis)*. The site is managed by the Park District to protect and enhance the prairie species. Nine additional species are also present on nearby park land (Table 4).

A small prairie reconstruction using local and non-local propagule sources was initiated on park land in 1974 (Fig. 1 see 1a) with the assistance of Gary Moore, Chris Toops, and Jack McDowell, all park employees. Also, at a site on recently purchased park land just south of Georgesville (Fig. 1 see 1b), Jack McDowell initiated in October 1980 a sizeable reconstruction project using only local ecotypes (McCutcheon, 1980).

Bigelow Cemetery State Nature Preserve

This 0.2 ha (0.5 acre) pioneer cemetery is in Pike Township in northern Madison County along Rosedale (Weaver Road) about 2.5 km (1.6 miles) west of Chuckery (Thomas, 1963, 1975; Cusick and Troutman, 1978:30; see my Fig. 1). For many years, ecology classes from The Ohio State University visited this site and referred to it as "Chuckery Cemetery." It is designated as "Boerger Cem" on the Plumwood, Ohio, 1961, United States Geological Survey 7½' topographic map. Graves date from 1814 to 1892 (Overton, 1981), and most of the cemetery occurs on Crosby-Lewisburg silt loams with Kokomo (Brookston) silty clay loam on the northern margin (Gerken and Scherzinger, 1979, 1981:photomap 2).

The cemetery combines a valuable assemblage of native wet prairie plants (Carr, 1981; see my Table 4) with the fascinating history of the first settlers from New England and Pennsylvania who struggled for survival in the prairies and oak groves of the Chuckery area (Overton, 1981). Upon the recommendation of the Prairie Survey Project of the Ohio Biological Survey (King, 1978), the Pike Township Trustees transferred administration of this cemetery to the Division of Natural Areas and Preserves, Ohio Department of Natural Resources (Thomas, 1979). On 3 October 1978, this valuable remnant of the human and natural history of the area officially became the Bigelow Cemetery State Nature Preserve commemorating the name of the family of settlers who early owned the tract and many of whom are buried there (Ohio Division of Natural Areas and Preserves, 1979:6).

Chuckery as a settlement is gone from the intersection of Ohio Routes 161 and 38 on the east bank of Little Darby Creek. Agricultural fields now replace the very sites of former buildings. As indicated by Maude Ellen King Burns (1978, personal communication), a lifelong resident of the area, the name "Chuckery" was assigned to the small settlement by Henry King, an early resident, because of the numerous "chuckholes" in the Old Post Road (now Ohio Route 161) and the other roads in the immediate area. The chuckholes undoubtedly resulted when roads were built across the poorly drained Kokomo silty clay loam and Crosby silt loam so widespread in the area.

Sites Discovered by the Prairie Survey Project

During August 1976 in cooperation with the Prairie Survey Project of the Ohio Biological Survey, the author initiated a continuing search for other sites possessing significant prairie communities or populations in the Darby Plains. Species indicative of such communities as suggested by the Prairie Survey Project (Cusick and Troutman, 1978:1-3) include the following:

Andropogon scoparius	Little bluestem
A. gerardii	Big bluestem
Echinacea purpurea	Purple coneflower
Helianthus grosseserratus	Saw-toothed sunflower
Liatris spp.	Blazing-stars
Ratibida pinnata	Gray-headed coneflower
Silphium terebinthinaceum	Prairie dock
Sorghastrum nutans	Indian grass

Additionally, I have included Sullivant's milkweed *(Asclepias sullivantii)* in this list.

This search is primarily being accomplished by scanning the landscape for indicator species from public roads and those private roads associated with railroads. For those railroads which do not have adjacent passable roads, I am conducting the survey by walking the tracks. Thus far, many public roads have been surveyed on numerous occasions, and all public roads and most private roads and railroads have been checked at least once. All of the cemeteries in the Darby Plains indicated on the United States Geological Survey 7½' series topographic maps and several additional cemeteries have been examined at least once. Upon observation of an indicator species, an intensive investigation of the general area is made to ascertain and record the presence of any additional Ohio prairie species as suggested by Troutman (Cusick and Troutman, 1978:49-55). When merited, voucher specimens are collected for deposit in the Herbarium, The Ohio State University.

I have observed specimens of a few indicator species, especially big bluestem, Sullivant's milkweed, gray-headed coneflower, and saw-toothed sunflower, at numerous roadside locations. However, only 23 additional sites have been found which possess either significant assemblages or populations of prairie species (Table 3, Fig. 1). Although most of these remnants are small and have only a few prairie species, five sites as described below are very noteworthy, namely: Milford Center Prairie, Railroad Right-of-way between West Jefferson and London including Plymell Cemetery, Silver-Forrest Site, Smith Cemetery, and W. Pearl King Prairie Grove.

Numerous old-age bur oaks and fewer post oaks *(Quercus stellata)*, common prairie associates, still survive in the Darby Plains, some from presettlement times. I have made no attempt to record their specific locations, but they generally occur in oak groves (virtually all of which are subjected to continual grazing), in yards around homesteads, and in fields where they stand out as isolated, rounded sentinels. Unfortunately, their numbers are constantly decreasing, and there is very little regeneration of these species on this intensively managed landscape. Each year, lightning, wind, and chainsaws deliver sudden destruction to a few more of these venerable links to the prairies of past centuries on the Darby Plains.

Milford Center Prairie

Milford Center Prairie is located about 3 km (2 miles) southwest of Milford Center in Union Township, Union County, It occupies about 2 km (1.3 miles) of a former railroad right-of-way which is now used for an electric power line by the Dayton Power and Light Company, Dayton, Ohio 45401. The right-of-way is about 0.3 km (0.2 mile) west of and parallel to Ohio Route 4, and prairie plants occur from about 1 km (0.6 mile) northeast to about 1 km (0.6 mile) southwest of Connor Road (Union County No. 81). As described by Thomas (1977), the best exposure of prairie plants occurs southwest of Connor Road and Treacle Creek.

The charter for the original railroad was granted 21 March 1850. This railroad, which was the first one constructed in Union County, was completed from Springfield to Delaware, Ohio, in the spring of 1854, and had its first train run on 29 March 1854 (Durant, 1883:417). Ownership changed several times and at one time it was known as the Delaware Branch of the Cleveland, Cincinnati, Chicago, and St. Louis Railway Company from whence was derived its commonly known nickname of "the Big Four." On 24 October 1962, The Dayton Power and Light Company officially purchased the right-of-way, and upon constructing a power line, has been managing it as a power line right-of-way to the present. (Harper, 1980; Ullmer, 1980).

The right-of-way demonstrates considerable evidence of past uses and disturbances. Coal ashes, old charred and weathered ties, and other fill materials are abundant. Some common Eurasian species have invaded the area, but the right-of-way continues to provide a refugium for at least 57 prairie taxa virtually all of which have been eliminated from the fertile adjacent agricultural lands, and 12 of which are known from no other station within the Darby Plains (Table 4). Annually, during July, August, and September, portions of the right-of-way are reminiscent of the "almost endless variety of flowers, variegated with all the colors of the rainbow" as described above by Dr. Jeremiah Converse for the original prairies in the Darby Plains. Original prairie occurred at this site as indicated by Dobbins (1937; see my Fig. 1). This presence of prairie is corroborated by the extensive occurrence of the prairie soil, Kokomo (Brookston) silty clay loam, directly on portions of the right-of-way and in adjacent fields as mapped by Waters, et al. (1975:photomaps 42, 47). Other soils on the right-of-way include Montgomery silty clay loam in the low area just south of Treacle Creek, and Crosby and Celina silt loams on the gently sloping areas. The former presence of the railroad obviously presents the possibility that some of the existing prairie species and/or populations may have gained access to the site via railroad transportation. However, in view of the historic and soil records, the extant prairie plants here, most probably, represent progeny of original Darby Plains prairie plants.

Populations of at least six noteworthy species are present. Three which have been designated as endangered species in Ohio are royal catchfly *(Silene regia)*, tall melic grass *(Melica nitens)*, and vetchling or veiny pea *(Lathyrus venosus)*; one which is designated as threatened is smooth rose *(Rosa blanda)*; and two which are potentially threatened are stiff goldenrod *(Solidago rigida)* and wild petunia *(Ruellia humilus)* (Ohio Division of Natural Areas and Preserves, 1980; Cooperrider, ed., In press).

Royal catchfly, with its spectacular scarlet blossoms in July and August, is known currently from only five other locations in Ohio (King, 1981). This population with approximately 800 flowering stems is the largest in the state, and possesses more flowering stems than the four other stations combined. Tall melic grass, recorded from only three other Ohio counties (Braun, 1967:91), has a small but vigorous population here. Vetchling or veiny pea is a rare legume which blooms in May and June. Troutman (Cusick and Troutman, 1978:53) suggested that the species was known in Ohio only from herbarium records and that it was probably extirpated from the state. Allison W. Cusick (1980, personal communication) confirmed that the small Milford Center Prairie population is the only one known currently in Ohio. Smooth rose, recorded from eight other counties in Ohio (Braun, 1961:214), is well established here; stiff goldenrod is very abundant; and wild petunia is common.

Another significant, but small, population is that of blazingstar *(Liatris scariosa)* which blooms in late August and September. This population is possibly a hybrid between *L. scariosa* and *L. scabra* (Barbara Schall, 1979, personal communication).

Milford Center Prairie has the highest prairie species diversity of any prairie remnant identified thus far in the Darby Plains. Curiously, four generally occurring species have not been observed: little bluestem, Indian grass, Sullivant's milkweed, and purple coneflower. Nevertheless, the entire assemblage of prairie species is a very valuable resource, especially as a seed and propagule source for prairie restoration projects within the Darby Plains.

Harry Reed, now deceased, tilled the fields adjacent to Milford Center Prairie for many years. During a conversation in 1977, this 95-year-old, retired farmer told me that he had watched many Big Four trains go by his farm. Occasionally, sparks from a passing train would set fire to the right-of-way and adjacent fields. He said that dry summers with nearly ripe grain in the fields were especially nervous times for himself and his neighbors. He was not familiar with prairie plants and was quite surprised when I informed him that much of his farm had once been prairie. He was well aware that there was prairie in Illinois. His grandmother had died there after having become lost in the tall grass one stormy night and contracting pneumonia. At the time, her husband was a soldier in the Civil War. Mr. Reed's father became a virtual orphan and eventually returned to central Ohio. How ironical that Harry Reed lived most of his life on this farm so close to some of the prairie species which in Illinois, had played such a significant role in the scenario that resulted in his living in the Darby Plains.

Silver-Forrest Site

The Silver-Forrest Site was discovered by Jack H. McDowell. It is a privately owned area with numerous bushy openings and edges associated with the woods on the south side of Little Darby Creek about 3.0 km northwest of the junction of U.S. Route 40 and Ohio Route 142 in West Jefferson. Soils are silt loams of the Lewisburg-Celina, Crosby-Lewisburg, and Miamian series (Gerkin and Sherzinger, 1981:photomaps 20, 21).

The site, for which 34 prairie plant species have been recorded (Table 4), is noteworthy because it contains the only known populations in the Darby Plains of round-headed bush-clover *(Lespedeza capitata)* and arrow-leaved violet *(Viola sagittata)* in addition to small but vigorous populations of prairie dropseed *(Sporobolus hetreolepis)*, short green milkweed *(Asclepias viridiflora)*, scaly blazing star *(Liatris squarrosa)*, and pinnatifid prairie dock. Some of the populations of prairie species appear to be decreasing because of encroaching trees and shrubs.

Railroad Right-of-Way Between West Jefferson and London Including Plymell Cemetery

This right-of-way and cemetery have been investigated for the presence of prairie plants by Jack H. McDowell. The right-of-way exhibits typical disturbances commonly associated with railroads; but it also possesses good to excellent populations of numerous prairie species growing intermittently along 12.5 km of tracks between West Jefferson and London. Plymell Cemetery, a 0.2 ha (0.5 acre) site is contiguous to the railroad right-of-way on the south side, 0.5 km east of the intersection of the railroad and Glade Run Road (Co. Rt. 70). Most of the soils on the right-of-way are Kokomo silty clay loam, Crosby-Lewisburg silt loam, Lewisburg-Celina silt loam, and Crosby silt loam; there are smaller areas of Eldean silt loam, Sloan silty clay loam, Wea silt loam, and Westland silty clay loam (Gerken and Scherzinger, 1981:photomaps 24, 24, 26, 29).

A total of 45 prairie plant species has been recorded thus far for the right-of-way (Table 4). It possesses substantial populations of big bluestem, little bluestem, switch grass *(Panicum virgatum)*, prairie cord grass *(Spartina pectinata)*, Ohio spiderwort *(Tradescantia ohiensis)*, sainfoin *(Psoralea onobrychis)*, Sullivant's milkweed, purple coneflower, gray-headed coneflower, whorled rosinweed *(Silphium trifoliatum)*, and prairie dock. A small population of eight flowering stems of royal catchfly is located in the right-of-way in the Deer Creek flood plain, and New Jersey tea (*Ceanothus americanus*) occurs in Plymell Cemetery.

A sizeable population of prairie dock with pinnatifid (deeply lobed) leaves occurs here. Basal leaves of many plants in this population are deeply lobed and very similar to those of compass-plant *(Silphium laciniatum)*. The upper stems, however, are typical of prairie dock *(S. terebinthinaceum)*: branched, leafless, and glabrous. Riddell (1834:502) referred to this taxon on the Darby Plains as *Silphium pinnatifidum*. Schaffner (1932:196) listed it as *S. terebinthinaceum pinnatifidum* and recorded Ohio populations from Madison County and Clark County. Fisher (1966) working with a Marion County, Ohio, population indicated that the taxon was a hybrid between *S. terebinthinaceum* and *S. laciniatum* with backcrossing and hybrid segregation in the direction of *S. terebinthinaceum*. Populations of typical prairie dock are known from several sites in the Darby Plains (Cusick and Troutman 1978:42-43; see my Table 4), but neither extant populations nor herbarium records of compass-plant are known for the Darby Plains. Riddell (1834:502), however, as indicated above, recorded the presence of compass-plant in the Darby Plains in the 1830's. Presumably the hybridizing occurred many years ago. The primary value of this site is that it preserves a sizeable genetic reservoir of this and other uncommon prairie taxa.

Smith Cemetery

Smith Cemetery is a privately owned cemetery with a unique assemblage of prairie species for the Darby Plains. It is about 0.2 ha (0.5 acre) in size and is located about 5 km (3 miles) west of Plain City in Darby Township, Madison County, just north of Boyd Road (Madison County Road 42). Graves date from 1816 to 1884 (Mrs. Edgar Yerian, 1980, personal communication).

The cemetery is located on Crosby-Lewisburg silt loams (Gerken and Scherzinger, 1979, 1981:photomap 3) and is flanked on the north and east by five old-aged bur oaks. Although subjected to frequent mowing, the cemetery appears to have been spared treatment with herbicides since it possesses abundant and vigorous populations of forbs. Purple coneflower and stiff goldenrod are especially numerous (Thomas, 1980, 14 Sep.). Big bluestem is very abundant, and little bluestem, Indian grass, and prairie cord grass are also present in lesser amounts. Smith Cemetery possesses the only known population in the Darby Plains of purple milkweed (*Asclepias purpurascens*), smooth aster (*Aster laevis*), and gray willow (*Salix humilis*).

Thus far 30 native prairie plant species have been recorded from Smith Cemetery (Table 4) in addition to several Eurasian species. With appropriate management the Eurasian invaders could be minimized or eliminated, and the prairie elements could be enhanced. Smith Cemetery offers great potential for an exceptional nature preserve complementing Bigelow Cemetery State Nature Preserve, 8 km (5 miles) to the west.

W. Pearl King Prairie Grove

W. Pearl King Prairie Grove is a privately owned, mixed oak grove interlaced with exceptional stands of native prairie grasses. It is about 5.6 ha (14 acres) in size and is located about 7 km (4.5 miles) southeast of Mechanicsburg in the northwestern corner of Monroe Township, Madison County, immediately west of the intersection of David Brown Road (Madison County Road 119) and Mechanicsburg-Sanford Road (Madison County Road 27). The site has about equal areas of Kokomo (Brookston) silty clay loam and Crosby-Lewisburg silt loams (Gerken and Scherzinger, 1981:photomaps 6, 10).

Prairie dropseed *(Sporobolus heterolepis)* grows here vigorously and abundantly (Thomas, 1980, 19 Oct.). It has been designated as an endangered species in Ohio (Ohio Division of National Areas and Preserves, 1980; Cooperrider, ed., In press), and this is the largest known extant population of the species in the state. In addition to Madison County, the species has been recorded in Ohio from only two adjacent counties, Franklin and Champaign. A Franklin County record was obtained within the Darby Plains at Georgesville in 1892 by William G. Werner (Herbarium, The Ohio State University). The Champaign County records are from two localities west of the Darby Plains, Cedar Bog (Frederick, 1974:19) and Blue Clay Railroad Cut (Cusick and Troutman, 1978:10-11). The previous Madison County record came from a specimen collected 80 years ago by Katherine D. Sharp in 1900 and deposited in the Herbarium, The Ohio State University. She cited London as the collection locality which suggests that W. Pearl King Prairie Grove was not the source of her specimen. In October 1980, Jack H. McDowell also discovered a small population at the Silver-Forrest site as described above.

Other prairie grasses are also well represented here. Little bluestem and Indian grass are very abundant while big bluestem, prairie cord grass, and switch grass are present in lesser amounts. Forbs, however, are not abundant and are limited to only a few species (Table 4), the most abundant of which is Virginia mountain-mint *(Pycnanthemum virginianum)* and pale-spike lobelia *(Lobelia spicata)*. The dominant trees include young to old-aged specimens of bur oak, white oak *(Quercus alba)*, shingle oak *(Quercus imbricaria)*, and post oak. Also present are shagbark hickory *(Carya ovata)*, slippery elm *(Ulmus rubra)*, and honeylocust *(Gleditsia triacanthos)*.

According to Chester A. Clime (1980, personal communication), manager of the farm of which the grove is a part, the site has long been used as a pasture but apparently has never been plowed. A natural water course crossing the area, however, has been channelized to increase drainage of adjacent fields. Recent annual burnings by Mr. Clime in an effort to eliminate multiflora rose *(Rose multiflora)* and brambles *(Rubus* spp.) have undoubtedly enhanced the expression of the prairie grasses.

W. Pearl King Prairie Grove is one of the most significant prairie groves in Ohio. The presence of prairie dropseed and the other prairie grasses in combination with mixed-aged oaks provides not only an exceptional genetic reservoir but also an irreplaceable remnant of the presettlement landscape in the Darby Plains. The site offers exceptional features for a unique nature preserve not only for the Darby Plains but also for the eastern portion of the Prairie Peninsula.

CONCLUSIONS

The pristine prairies of the Darby Plains were sizeable, complex, and intricate ecosystems that survived on the Ohio landscape for thousands of years. In some ways they were very durable and rugged, whereas in other ways they were very fragile. These prairies required thousands of years to develop. Yet, in less than 200 years, they have been almost totally obliterated. Only a few depaupered remnants still survive. But these remnants assume major significance by providing the only available genetic reservoirs of a once-abundant resource. While this resource still exists, one or several tracts of prairie soil of ample size should be restored to the crowning glory of prairie to ensure perpetuation of an unique gene pool and to afford modern society the privilege of experiencing, in at least a small measure, the natural heritage that was the prairie on the Darby Plains.

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HISTORY OF BIGELOW (CHUCKERY) CEMETERY STATE NATURE PRESERVE, A PIONEER PRAIRIE CEMETERY IN NORTHERN MADISON COUNTY, OHIO

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Bigelow Cemetery, formerly known as Chuckery, Boerger/Burgher, or King Cemetery, is an approximately 0.2 ha (0.5 acre) plot in Pike Township on the west side of Rosedale Road (County Route 25), just south of the border between Union and Madison Counties, Ohio. The history of this cemetery is important because of its early human history as well as being a preserved prairie remnant in west-central Ohio. This cemetery has been used extensively as a field trip site for the plant ecology courses of The Ohio State University which were taught by Edgar N. Transeau, Robert B. Gordon, John N. Wolfe, and Gareth E. Gilbert. The vascular plants of this site are listed in Carr (1981), and King (1981) has discussed the flora, geology, and history of the area surrounding Bigelow Cemetery, the Darby Plains. On 3 October 1978, the cemetery was officially dedicated as Bigelow Cemetery State Nature Preserve, commemorating the name of members of this family buried there. The preserve is a public nature sanctuary classified as "interpretative" in the state nature preserve system.

EARLY HISTORY

Soon after the Revolutionary War, Canada encouraged settlers to locate within its boundaries by offering cheap sections of land. Many New Englanders, especially those from the mountainous areas of Vermont and western Connecticut, moved their families and worldly possessions to an area then called Canada East. However, the War of 1812 between Great Britain and the United States generated deep patriotic unrest among many of the new settlers. Once they realized they were on "the wrong side of the fence," they packed up their belongings and "took up their line of march for the far West." Perhaps attracted by New England friends and relatives who had already settled at Worthington, Ohio, a small group of about eight families came to Franklin County where they spent the winter.

When the spring of 1813 arrived, the leaders of this small group looked for suitable lands on which to make their new homes. They were not as fortunate as those New Englanders who had received free lands in the Refugee tract east of Columbus because of personal losses incurred during the Revolutionary War. The group located in what is now southern Union County, Ohio, because they did not want to be too far removed from the Worthington and Refugee tract residents. The lands they chose were in what was then considered a barren waste, the prairies. These "wastes," however, had the distinct advantage of being priced at about one-half the cost of more desirable forested acreage. By the time winter arrived, the families had built cabins and were ready to welcome the next group of settlers who were following their path. This area became known as the "Green Settlement" on what was later named the Post Road.

One of the first group's leaders was Nehemiah Sabin whose son later recalled:

> Most of the families composing the Green Settlement were very large, many of them numbering from ten to twelve souls. By this it can be seen that we were not destitute of material to receive the benefits of free schools, which were soon put into operation, my father being the first teacher. But sickness soon made its appearance among us to an alarming extent, in a short time decimating the inhabitants by death (*History of Union County, Ohio,* 1883:172).

EARLY CEMETERY BURIALS

Indeed, John Sabin's observation was correct: in 1814 his brother, Hiram, died of milk sickness and his father, Nehemiah Sabin, died at the age of forty-four. Nehemiah's tombstone documents the first known burial in Bigelow Cemetery. His death was followed within five days by that of Elizabeth McCloud. She was a daughter of Charles McCloud, an early settler from Vermont, who located in the McCloud Settlement, Darby Township, Union County.

The land chosen for the cemetery was apparently unoccupied and unsurveyed. It was part of the Virginia Military District. In July 1815 Benjamin Hough, a Virginian from Ross County, Ohio, had the area surrounding and including the cemetery surveyed. The boundaries of this area were established according to the following directions: "beginning at three bur oaks, two of them from one root, the survey line went to three bur oaks from one root, to two bur oaks and a hickory . . . to a stake in the prairie, thence to another stake in the prairie, and thence to the beginning." Three months after it was officially marked off, Benjamin Hough received this land for his past military services. Thirteen months later in November of 1816, he sold the acreage for $344 to Russell Bigelow. After burying one son, three daughters, and two grandchildren there, Russell Bigelow and his wife, Lucy, sold the cemetery in 1822 to Uriah Wood who died two years later.

Henry King and his family moved into Madison County in 1818. Originally from Schuylkill County, Pennsylvania, they first settled in Ross County, Ohio, about 1811 or 1812. The Kings had six children who grew to adulthood and married into the New England families who have previously settled along the Post Road in Union County. The first burial of a member of the King family in Bigelow Cemetery was in 1844. The cemetery was used primarily by the original New Englanders and their descendants. Other area residents who migrated from New York, New Jersey, Delaware, Pennsylvania, Virginia, Kentucky, and Ireland were also interred there. Three veterans of the War of 1812 are listed in the *Cemetery Location* book as having been buried in this cemetery: John Harrington, Nathaniel Newman, and Robert Russel. The last known burial occurred in January 1892, when Miranda Kent, born Miranda Harrington in 1807 at East Montpelier, Vermont, was inhumed.

METHODS OF STUDYING CEMETERY HISTORIES

The headstones are the most important source of data, relating names and dates. If the inscriptions are easy to read, simply copy them in an orderly manner making sure to include all the information provided. To facilitate reading badly eroded or soiled stones, a researcher will need these supplies: paper, lots of pencils, white chalk, a rag or two, a small scrub brush, and some aluminum foil. First try using a stick of chalk by rubbing the length of the chalk across the surface of the stone, making sure not to color the depressions of the engraving. Excess chalk dust may be removed by gently swatting the stone with a rag. Another approach is to cover the hard to read inscription with aluminum foil and depressing it into the letters and numerals of the writing. A small scrub brush can be used to remove obscuring lichens or dirt. Care must always be taken not to damage or deface the stone in any manner and to leave it in a decent state of appearance. Once all of the information has been transcribed, type it as soon as possible.

The history of the cemetery's ownership can be ascertained with land records. However, when difficulties arise, other county court records may be helpful including civil and criminal court proceedings, and probate court information. Location histories are another information source. Many county histories have been reprinted and frequently these editions contain a recently compiled index. Cemeteries are often discussed in township history sections.

Federal census records, especially for 1850 and later, are helpful in establishing the birth state of persons not listed as well as their relationships. Indices to these census records are often available. If your area has not been indexed, go through the township of interest page by page including surrounding townships, if necessary, to obtain a good sampling of the people interred in the cemetery. Using all of these sources of information, you should be able to develop a cemetery's history which will be both interesting and accurate.

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VASCULAR PLANTS OF BIGELOW (CHUCKERY) CEMETERY STATE NATURE PRESERVE IN NORTHERN MADISON COUNTY, OHIO

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Bigelow Cemetery has long attracted botanists and students from The Ohio State University, as well as other interested individuals, to its striking assemblage of now uncommon species of prairie plants. King (1981a) has discussed the flora, geology, and history of the area surrounding Bigelow Cemetery, the Darby Plains, and he (1981b) has also investigated the distribution of royal catchfly which occurs in Bigelow Cemetery. As a cemetery dating back to the nineteenth century (Overton, 1981), it has escaped the plowing and grazing that have eliminated much of the native flora from the surrounding farmlands. Although "weedy" nonindigenous species occupy portions that are periodically mowed by township caretakers, patches of prairie species surround tombstones and line fencerows out of a mower's reach.

In anticipation of the acquisition and dedication of Bigelow Cemetery as a state nature preserve, a flora and vegetation map of the site was compiled to serve as an available reference for any future management study. The following checklist of vascular plants was prepared from collections made during this 1978 study as well as from earlier herbarium records. Incorporated were species from a previous list developed by Edgar N. Transeau, John N. Wolfe, and Gareth E. Gilbert of the Department of Botany, The Ohio State University. Species not native to Ohio are indicated by an asterisk (*) on the checklist. Species previously reported from the site, but absent in 1978, are indicated by two asterisks (**). Species native to Ohio, but not native to the cemetery are appropriately noted in the list. Nomenclature is according to Weishaupt (1971).

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GYMNOSPERMAE

Pinus nigra Arnold
**P. sylvestris* L.
Thuja occidentalis L. (not native to the cemetery)

ANGIOSPERMAE

MONOCOTYLEDONAE

GRAMINEAE

Agrostis alba L.
Andropogon gerardii Vitman
**Bromus inermis* Leyss.
**B. tectorum* L.
**Dactylis glomerata* L.
**Elymus* sp.
**Festuca elatior* L.
**Lolium multiflorum* Lam.
Muhlenbergia schreberi Gmel.
**Phleum pratense* L.
**Poa pratensis* L.
**Setaria glauca* (L.) Beauv.
**S. viridis* (L.) Beauv.
Sorghastrum nutans (L.) Nash
Triodia flava (L.) Smyth

CYPERACEAE

Carex davisii Schwein. & Torr.
C. sparganioides Muhl.
Carex sp.

LILIACEAE
Polygonatum canaliculatum (Muhl.) Pursh
Smilacina racemosa (L.) Desf.
Smilax herbacea L.
**Yucca* sp.
DIOSCOREACEAE
Dioscorea villosa L.

DICOTYLEDONEAE

CORYLACEAE
Corylus americana Walt.
FAGACEAE
Quercus imbricaria Michx.
Q. macrocarpa Michx.
ULMACEAE
Celtis occidentalis L.
MORACEAE
**Morus alba* L.
SANTALACEAE
***Comandra umbellata* (L.) Nutt.
POLYGONACEAE
Polygonum cristatum Engelm. & Gray
P. pensylvanicum L.
**Rumex crispus* L.
CHENOPODIACEAE
Atriplex patula L. var. *patula*
Chenopodium album L.
C. standleyanum Aellen
AMARANTHACEAE
**Amaranthus hybridus* L.
PHYTOLACCACEAE
Phytolacca americana L.
PORTULACACEAE
Claytonia virginica L.
CARYOPHYLLACEAE
Silene regia Sims
RANUNCULACEAE
Anemone canadensis L.
Anemonella thalictroides (L.) Spach
Delphinium tricorne Michx.
Thalictrum revolutum DC.
CRUCIFERAE
**Brassica nigra* (L.) Koch
Cardamine douglassii Britt.
ROSACEAE
Fragaria vesca L.
Geum canadense Jacq.
Prunus sp.
Rosa carolina L.
R. setigera Michx.
Rubus sp.
LEGUMINOSAE
Desmodium canadense (L.) DC.
D. paniculatum (L.) DC.
Gleditsia triacanthos L.
**Medicago lupulina* L.
**M. sativa* L.
Psoralea onobrychis Nutt.
**Trifolium pratense* L.
OXALIDACEAE
Oxalis europaea Jord.
GERANIACEAE
Geranium maculatum L.
POLYGALACEAE
***Polygala senega* L.
EUPHORBIACEAE
Euphorbia corollata L.
ANACARDIACEAE
Rhus radicans L.
CELASTRACEAE
Celastrus scandens L.
VITACEAE
Parthenocissus quinquefolia (L.) Planch.
Vitis sp.
VIOLACEAE
Viola palmata L.
V. sororia Willd.
UMBELLIFERAE
**Daucus carota* L.
CORNACEAE
Cornus racemosa Lam.
PRIMULACEAE
Lysimachia lanceolata Walt.
APOCYNACEAE
Apocynum cannabinum L.
ASCLEPIADACEAE
Asclepias syriaca L.
CONVOLVULACEAE
Convolvulus sepium L.
LABIATAE
**Lamium purpureum* L.
Monarda fistulosa L.
**Nepeta cataria* L.
SOLANACEAE
Physalis longifolia Nutt.
SCROPHULARIACEAE
**Verbascum thapsus* L.
ACANTHACEAE
Ruellia humilis Nutt.
PLANTAGINACEAE
**Plantago lanceolata* L.
RUBIACEAE
Galium aparine L.
G. triflorum Michx.
CAPRIFOLIACEAE
Sambucus canadensis L.
COMPOSITAE
**Achillea millefolium* L.
Ambrosia artemisiifolia L.
A. trifida L.
**Arctium lappa* L.
Aster pilosus Willd.
A. sagittifolius Wedemeyer var. *drummondii* (Lindl.) Shinners
A. simplex Willd.
**Cirsium arvense* (L.) Scop.
***Coreopsis tripteris* L.
Echinacea purpurea (L.) Moench
***Helianthus grosseserratus* Martens
H. strumosus L.
Lactuca canadensis L.
Ratibida pinnata (Vent.) Barnh.
Rudbeckia hirta L.
***Silphium terebinthinaceum* Jacq.
S. trifoliatum L.
Solidago rigida L.
**Taraxacum officinale* Weber
**Tragopogon pratensis* L.

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Prairie Slough in Madison County, Ohio

A prairie "slough" with *Spartina michauxiana* (= *S. pectinata*) and *Ascelepias incarnata* bordered by willows. (Undated photograph by Robert B. Gordon. Original in the possession of R. L. Stuckey.)

DISTRIBUTION OF ROYAL CATCHFLY (*SILENE REGIA*) WITH SPECIAL REFERENCE TO OHIO POPULATIONS

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Royal catchfly (*Silene regia* Sims) is a strikingly distinctive, scarlet-crimson flowering, Nearctic member of the pink family (Caryophyllaceae). This species was discovered by Thomas Nuttall who later offered the opinion in his classic, *The Genera of North American Plants and a Catalogue of the Species to the Year 1817*, that it is "one of the most splendid species in existence" (Nuttall, 1818:288).

Fernald (1950:634) presented the following description:

> Perennial; *stems erect*, 0.7-1.5 *m. high, closely pulverulent-pubescent, with* 15-30 *pairs of* lance-ovate *round-based* puberulent *firm sessile leaves;* panicle elongate, ellipsoid, leafy-bracted, the branches and pedicels strongly ascending; *calyx* 2-2.5 *cm. long*, cylindrical, becoming fusiform in fruit, glandular-pilose; *petals with scarlet subentire limb* 1.5-2 *cm. long*. – Dry woods, barrens and prairies, Ga. to Okla., n. to O., Ind., s. Ill. and Mo. June-Aug.

Hitchcock and Maguire (1947:53) and Gleason (1952:142) indicated the habitat to be prairie and open woodland over a range similar to that described by Fernald. Dobbins (1937:124) and Troutman (Cusick and Troutman 1978:49, 55) included the species in their lists of Ohio prairie plants.

Although morphologically and ecologically distinct, royal catchfly has close genetic affinities with two other species: (1) the more common fire pink (*Silene virginica* L.) which occurs in rich or open woodlands, thickets, and on rocky slopes; and (2) the infrequent round-leafed catchfly (*Silene rotundifolia* Nutt.), which is limited to limestone and sandstone ledges and cliff crevices (Hitchcock and Maguire, 1947:4, 52-54; Heaslip, 1951:68-69). All three species are self-fertile and tetraploid with an n-chromosome number of 24 (Heaslip, 1951:65, 69). According to Heaslip (1951:64, 70), these three species are cross-fertile in all combinations as determined from vegetatively vigorous, but sterile, hybrids from cross-pollinations produced in the laboratory. Although the ranges of the three species overlap, populations of each are ecologically isolated because of their varying habitats. This isolation and the sterility of the hybrids prevent these populations from becoming one species (Heaslip, 1951:69).

ORIGINAL DESCRIPTION

Silene regia was described as a species new to science by John Sims (1815), an English medical doctor, fellow of the Linnean Society of London, and editor of *Curtis's Botanical Magazine*. Included in his description in *Curtis's Botanical Magazine* is a beautiful color plate of the flowering portion of the plant.

Nuttall had previously collected seeds of royal catchfly sometime between September 1810 and March 1811 from plants he found "growing spontaneously in great abundance in the environs of St. Louis, on the Missis[s]ippi" (Sims, 1815). At the time, however, Nuttall was engaged in a collecting expedition supported by Professor Benjamin S. Barton of the University of Pennsylvania and the Philadelphia Linnaean Society. Nuttall was under contract prohibiting him from publishing any of his findings (Pennell, 1936:45-49). As discussed by Graustein (1967:40, 83), these restrictions, apparently, did not prohibit Nuttall from providing seeds and live plants to certain seedpersons and horticulturists. In any case, Alymer B. Lambert, a botanist, horticulturist, and vice-president of the Linnean Society of London, received some seeds and planted them in his garden at Boyton, Willshire, England (Sims, 1815).

Sims (1815), who was not subjected to the publishing restrictions that inhibited Nuttall, wrote the scientific description of the species based upon "dried specimens in Mr. Lambert's herbarium." In this description, Sims fully acknowledged Nuttall as the original discoverer of the species.

Presumably, the type specimen remained deposited in the Lambert Herbarium (Hitchcock and Maguire, 1947:53). The Lambert Herbarium, however, was dismembered at a sale in 1842 (Graustein, 1967:364) and the fate of the type specimen is unknown. Edward Tuckerman, a botanist from Boston, Massachusetts, purchased half of the American portion of the Herbarium and in 1856, donated these specimens to the Academy of Natural Sciences in Philadelphia (Graustein, 1967:364-365). Apparently, the *Silene regia* type specimen was not included as it is not at the Academy (Stuckey, 1977, personal communication). Another noteworthy specimen, however, is at the Academy. It was collected by Nuttall on his 1816 trip through the Ohio valley and bears the label, "Ohio and Kentucky." Although this specimen cannot be considered to be a type (Stuckey, 1966:193), it is very likely the oldest specimen of *Silene regia* in existence.

SYNONYMS

Sims (1815) suggested that his *Silene regia* may perhaps be the variety found by Michaux in the Illinois country, and simultaneously with his original description of the species, Sims created a synonym "*Silene virginica*, var. *illinoensis*," using Michaux (1803:272) as an authority. Michaux, however, had only listed "in regione Illinoensi" as habitat for *Silene virginica*. Since the morphologically distinct *S. virginica* does occur in Illinois (Mohlenbrock and Ladd, 1978), Sims' postulation was very likely erroneous, and his suggestion of a variety *illinoensis* only initiated confusion where there was none. K.A. Otth (1824:382) in de Candolle's *Prodromus* acknowledged this synonym.

A second synonym, *Muscipula regia* Bannisterii, listed by Sims (1815) in the same publication, was also based on ill-conceived rationale. Sims postulated that his *Silene regia* "possibly . . . may have been the same that Bannister sent a design of to the Bishop of London." Sims continued, "whether it be or not, his [Bannister's] name of *regia* cannot be badly applied to the most splendid plant of the genus." Apparently, Sims adopted the specific epithet "*regia*" for his newly described species from this name of Bannister. Although Sims' using of *regia* was quite appropriate because of the royal characteristics of this plant, his listing of *Muscipula regia* as a synonym based on such scanty evidence was not appropriate.

Rafinesque (1840:18-19) described *Silene scabra* Raf. "from the barrens of West Kentucky." As indicated by Fernald (1944), this species "is very definitely *Silene regia* Sims," and as frequently has been the case with many of Rafinesque's taxa, *Silene scabra* has been relegated to synonomy.

In 1893, Kellerman and Werner (1895:178) prepared a manuscript "Catalogue of Ohio Plants" in which they used the name "*Silene illinoensis* (Michaux)" and indicated that *Silene regia* was a synonym. Printing of the "Catalogue" was completed shortly thereafter, but binding into a finished volume was delayed until 1895. During this delay, Kellerman inserted four pages (80a-d) of changes "to make the Nomenclature correspond to that officially adopted by the American Botanists and published in the 'List of Pteridophyta and Spermatophyta of Northeastern North America.' " One of these changes (p. 80c) returned the name *Silene regia* and deleted the name "*Silene illinoensis* (Michaux)." The volume was finally bound and made available in 1895. Therefore, even though "*Silene illinoensis* (Michaux)" appears in the "Catalogue" (p. 178), this name was not actually published since it was corrected and eliminated within the same volume (p. 80c). A casual reading of the volume, however, will not detect this correction, and "*Silene illinoensis* (Michaux)" has been offered as a legitimate synonym for *Silene regia* in some publications, for example, Hitchcock and Maguire (1947:53). Jones and Fuller (1955:202) appropriately indicate that "*Silene illinoensis*

(Michaux) is a "nomen illeget."

As indicated by Hitchcock and Maguire (1947:2), Rohling in 1812 separated *Melandryum (Melandrium* of some authors) from *Silene*. Rohrbach (1868) and Williams (1896), both European authorities on *Silene*, recognized this segregate and as a result, the names *Melandrium reginum* A.C.H. Braun and *Melandrium illinoense* Rohrbach became established in the European literature as replacements for *Silene regia*. American authorities of *Silene*, however, have not accepted a distinct genus *Melandrium* as appropriate for North American plants. The rationale for this decision is presented by Hitchcock and Maguire (1947:2-5) and Heaslip (1951:62-64, 69). Since *Melandrium* is not a recognized name for North American species, *M. reginum* and *M. illinoense* have been relegated to synonomy. Early references and synonomy were summarized by Watson (1878:109).

Several common names for *Silene regia* appear in the literature. Sims (1815) in his original description used the name "Splendid Catch-fly," but this name rarely appears thereafter. Nuttall (1818:288) used "Catch-Fly" and "Wild-Pink" collectively for the genus *Silene*, but he did not present a common name for *Silene regia*. Torrey (1824) also referred to *Silene* as "Catch-fly," but *Silene regia* was not included in his publication. Torrey and Gray (1838-1840:193) did include *Silene regia* in their *Flora of North America*, but they gave no common name. John L. Riddell (1835:365) in his *Synopsis of the Flora of the Western States*, possibly was the first to use the name "Royal catch-fly" in a floristic publication. Sullivant (1840) used it as did Gray (1848:59) in his *A Manual of the Botany of the Northern United States*. "Royal catchfly" has been used predominately for the species by authors of floras and floristic studies since. Britton and Brown (1913, 2:65) used it but also added "Wild Pink" as a second common name. Gleason (1952, 2:142) and Gleason and Cronquist (1963:299) deleted the name "royal catchfly" and refer to *Silene regia* only as "Wild Pink" in spite of their use of "Wild Pink" for other species of *Silene*.

DISTRIBUTIONAL STUDIES

I was introduced to royal catchfly on 19 June 1976 by Dr. Edward S. Thomas, Curator of Natural History, Emeritus, The Ohio Historical Society, while he was conducting a field trip to Chuckery Cemetery (now Bigelow Cemetery State Nature Preserve), a pioneer cemetery in northern Madison County, Ohio (Carr, 1981; King, 1981; Overton, 1981). Although not yet in flower, the plants (about 30) were, nevertheless, quite distinctive. Thomas said that this population had been known to botanists at The Ohio State University for almost half a century, and that he knew of no other extant populations in the state (Thomas, 1963, 1975). I observed these plants blooming on several subsequent visits during July and August 1976 (Figs. 1, 2).

On 22-24 August 1976, while attending the Fifth Midwest Prairie Conference in Ames, Iowa, I inquired of several colleagues concerning the distribution and status of royal catchfly in their areas. Most of these individuals were not familiar with the species, and little information was obtained. Shortly thereafter, I initiated a study to determine the distribution of *Silene regia*, especially in Ohio, but also more generally throughout its range. I sought information from herbarium records, the literature, field reconnaissance in Ohio, and personal communications.

HERBARIUM RECORDS

Although *Silene regia* is a morphologically distinct species, rarely it may be confused with *Silene virginica* even by experienced curators.

Figure 1. Royal catchfly *(Silene regia)* in full flower, Bigelow Cemetery State Nature Preserve, Madison County, Ohio. (Photograph by Richard E. Moseley, Jr.)

Figure 2. Royal catchfly *(Silene regia)* in Bigelow Cemetery State Nature Preserve, Madison County, Ohio. (Photograph by Richard E. Moseley, Jr.)

Accepting this small degree of potential error, I sent letters to curators of 112 selected herbaria east of the Rocky Mountains and 2 in England requesting collection data from their holdings of *Silene regia*. Curators from 59 herbaria reported having specimens (Table 1), and curators from 39 herbaria reported having no specimens. The other 16 curators, primarily of small herbaria, did not reply.

I verified the accuracy of the species determinations of all specimens reported for Ohio from Ohio herbaria prior to recording the data. I accepted as valid almost all the species determinations and records as reported from other herbaria. For several records which suggested questionable identifications and/or range extensions, I requested those specimens to be sent to me for verification; and a few of those specimens, indeed, had been misidentified. Before returning them, I annotated all specimens sent to me at my request. To provide opportunity for future researchers to make specific determinations, the locations of all specimens of *Silene regia* reported to me in this study are identified as indicated.

State and county-of-record were determined, when possible, from credible information supplied from each herbarium and listed by county in Table 2. When determination of county-of-record was not possible, but state-of record was, the herbarium was cited under "County not specified" for the appropriate state. Counties-of-record as determined from herbarium records were also included in the distributional map presented in Figure 3.

Problematic Records

Ten herbarium records as listed below were determined to be problematic and are not included in Table 2 or Figure 3 unless specified:

1. An undated specimen at NY was reported to have been collected by Dr. Holmes, Montreal, Canada. This specimen probably is the source of the account published by Torrey and Gary (1838-1840:193) about which they justifiably questioned its credibility as a record of the species being indigenous to Quebec. No other Canadian records have been detected in the current study, and the addition of Quebec to the range of *Silene regia* based on this questionable record is not warranted.
2. A specimen at US is mistakenly labeled "Miami County, Alabama" since there is no Miami County in Alabama. The collector is indicated as "J. Ridell" in 1839. Possibly, the collector was John L. Riddell and the collection locality was Miami County, Ohio; but such conclusions are only conjecture.
3. A specimen at MO from the Bernhardi Herbarium was collected in 1854, but the notation indicating the collection locality is unintelligible (Croat, 1980, personal communication).
4. A specimen at MSC collected by C. F. Wheeler, 29 July 1896, from the Botanical Gardens of Michigan Agricultural College (Michigan State University) at East Lansing, Michigan, obviously does not constitute a valid record of the species being indigenous to Michigan. Voss (1976, personal communication) reported that he was not aware of any published reports of the species in Michigan.
5. An undated specimen at PH was reported to have been collected in Iowa by C.W. Williamson. No other Iowa records have been located in this study and the addition of Iowa to the range of *Silene regia* based on this fragmentary record is not warranted.

Table 1. List of 59 herbaria containing specimens of royal catchfly *(Silene regia)* as located in this study and arranged alphabetically by standard abbreviation as presented by Holmgren and Keuken (1974).

APCR	Arkansas Polytechnic College, Russellville, Ark. 72801
AUA	Auburn University, Auburn, Ala. 36830
BGSU	Bowling Green State University, Bowling Green, Ohio 43403
BKL	Brooklyn Botanic Garden, Brooklyn, N.Y. 11225
BM	British Museum (Natural History) London, Engl. SW7 5BD
BUT	Butler University, Indianapolis, Indiana 46208.
CINC	University of Cincinnati, Cincinnati, Ohio 45221
CM	Carnegie Museum, Pittsburgh, Pa. 15213
CU	Cornell University, Ithaca, N.Y. 14850
DMNH	The Dayton Museum of Natural History, Dayton, Ohio 45414
DUKE	Duke University, Durham, N.C. 27706
F	Field Museum of Natural History, Chicago, Ill. 60605
FSU	The Florida State University, Tallahassee, Fla. 32306
GA	The University of Georgia, Athens, Ga. 30602
GEO	Emory University, Atlanta, Ga. 30322
GH	Harvard University, Cambridge, Mass. 02138
	Hendrix College, Conway, Ark. 72032
ILL	University of Illinois at Urbana-Champaign, Urbana, Ill. 61801
ILLS	Illinois Natural History Survey, Urbana, Ill. 61801
IND	Indiana University, Bloomington, Indiana 47401
ISC	Iowa State University, Ames, Iowa 50010
ISM	Illinois State Museum, Springfield, Ill. 62706
JHWU	Wittenberg University, Springfield, Ohio 45501
K	Royal Botanic Gardens, Kew, Richmond, Surrey, Engl.
KANU	The University of Kansas, Lawrence, Kansas 66044
KE	Kent State University, Kent, Ohio 44242
MICH	The University of Michigan, Ann Arbor, Mich. 48109
MIN	University of Minnesota, St. Paul, Minn. 55108
MISS	The University of Mississippi, University, Miss. 38677
MO	Missouri Botanical Garden, St. Louis, Mo. 63166
MOR	Morton Arboretum, Lisle, Ill. 60532
MSC	Michigan State University, East Lansing, Mich. 48824
MU	Miami University, Oxford, Ohio 45056
MUS	Muskingum College, New Concord, Ohio 43762
NCU	University of North Carolina, Chapel Hill, N.C. 27514
ND, NDG	University of Notre Dame, Notre Dame, Indiana 46556
NO	Tulane Univeristy, New Orleans, La. 70118
NY	The New York Botanical Garden, Bronx, N.Y. 10458
OKLA	Oklahoma State University, Stillwater, Okla. 74074
OS	The Ohio State University, Columbus, Ohio 43210
OWU	Ohio Wesleyan University, Delaware, Ohio 43015
PAC	The Pennsylvania State University, University Park, Pa. 16802
PENN	University of Pennsylvania (housed at The Academy of Natural Sciences) Philadelphia, Pa. 19103
PH	The Academy of Natural Sciences, Philadelphia, Pa. 19103
PUR	Purdue University, West Lafayette, Indiana 47907
SDU	The University of South Dakota, Vermillion, S.D. 57069
SIU	Southern Illinois University at Carbondale, Carbondale, Ill. 62901
SMS	Southwest Missouri State University, Springfield, Mo. 65802
SMU	Southern Methodist University, Dallas, Tex. 75222
SOTO	The School of the Ozarks, Point Lookout, Mo. 65726
TENN	The University of Tennessee, Knoxville, Tenn. 37961
UARK	University of Arkansas, Fayetteville, Ark. 72701
UMKC	University of Missouri-Kansas City, Kansas City, Mo. 64110
UMO	University of Missouri-Columbia, Columbia, Mo. 65201
	Urbana College, Urbana, Ohio 43078
US	National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560
VDB	Vanderbilt University, Nashville, Tenn. 37235
VPI	Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061
WAB	Wabash College, Crawfordsville, Indiana 47933
WIS	University of Wisconsin—Madison, Wis. 53706

Table 2. Distribution of royal catchfly *(Silene regia)* by states and counties as determined from credible herbarium and published records, and personal communications. Herbaria are abbreviated as indicated in Table 1.

Alabama	
County not specified	BM; GH; Chapman, 1860:51, 1883:51; Britton and Brown, 1897:10; Mohr, 1901:94; Britton, 1907:390; Britton and Brown, 1913:65; Hitchcock and Maguire, 1947:53; Gleason 1952:142; Gleason and Cronquist, 1963:299.
Bibb	US; Mohr, 1901:497.
Butler	Mohr, 1901:497.
Dallas	GH.
Montgomery	US; Kral, 1980, personal communication.
Wilcox	Mohr, 1901:497.
Arkansas	
Benton	APCR; F; GH; ISC; MICH; MO; NCU; NY; OKLA; SDU; SMU; UARK; US; WIS; Tucker, 1974:50; Smith, 1978:44.
Boone	Hendrix College; Smith 1978:44.
Hot Spring	FSU; GA; GH; NCU; NO; SMU; Smith, 1978:44.
Newton	UARK; Tucker, 1974:50; Smith, 1978:44.
Sharp	UARK; Tucker, 1974:50; Smith, 1978:44.
Washington	APCR; SMU; UARK; WIS; Tucker, 1974:40; Smith, 1978:44.
Florida	
Jackson	ISC; MIN. (Specimens from both herbaria verified by Charles C. King, 1980).
Georgia	MO; Small, 1903:427; Small, 1933:507; Hitchcock and Maguire, 1947:53; Fernald, 1950:634; Gleason, 1952:142; Gleason and Cronquist, 1963:299.
Floyd	AUA; MO; US.
Polk	MO.
Randolph	CU; GEO.
Illinois	
County not specified	GH; K; US; Gray, 1857:89, 1867:89; Hitchcock and Maguire, 1947:53; Fernald, 1950:634; Jones, 1963:85; Steyermark, 1963:660.
Clark	ILLS; Mohlenbrock and Ladd, 1978.
Cook	Mohlenbrock and Ladd, 1978; Swink and Wilhelm, 1979:706.
Lawrence	ILL; ILLS; ISM; ND AND NDG; Jones and Fuller, 1955:202; Mohlenbrock and Ladd, 1978.
Madison	GH; MIN.
St. Clair	GH; ILLS; Jones and Fuller, 1955:202; Mohlenbrock and Ladd, 1978.
Wabash	ILL; Jones and Fuller, 1955:202; Mohlenbrock and Ladd, 1978.
White	Mohlenbrock and Ladd, 1978.
Will	F; WIS; Mohlenbrock and Ladd, 1978; Swink and Wilhelm, 1979:706.
Winnebago	Mohlenbrock and Ladd, 1978.
Indiana	
County not specified	ILL; K; Fernald, 1950:634.
Delaware	BUT; IND; NY.
Floyd	PH.
Hamilton	Deam, 1940:448.
Harrison	Deam, 1940:448.
Knox	IND; Deam, 1940:448.
LaPorte	MOR; Kurz, 1979, personal communication.
Parke	IND; Deam, 1940:448.
Tippecanoe	DUKE; IND; OWU; PH; PUR; Deam, 1940:448.
Vermillion	BUT; GH; IND; MICH; ND and NDG: NY; OKLA; SMU; VPI; Deam, 1940:448.
Vigo	IND; MICH; PH; US; WAB; Deam, 1940:448.
Wayne	Deam, 1940:448.
Kansas	
County not specified	McGregor et al., 1976:19.
Cherokee	KANU; Barkley, 1968:144; McGregor and Barkley, 1977:560; McGregor, 1977:6.
Kentucky	
County not specified	K; NY; PH; Riddell, 1834:365; Torrey and Gray, 1838-1840:193; Rafinesque, 1840:18-19; Gray, 1858:56, 1859:56; McFarland, 1942:89; Fernald, 1944; Hitchcock and Maguire, 1947:53.
Christian	PH.
Edmonson	ILL.
Hardin	Medley, 1980, personal communication.
Hart	GH; US; Braun, 1943:55.
Warren	MO.
Missouri	
County not specified	BKL; BM; F; GH; K; NY; US; Sims, 1815; Nuttall, 1818;288; Tracy, 1886:15; Gray, 1887:76, 1889:84; Britton and Brown, 1897:10; Small, 1903:427; Britton, 1907:390; Robinson and Fernald, 1908:386; Britton and Brown, 1913:65; Small, 1933:507; Hitchcock and Maguire, 1947:53; Fernald, 1950:634; Gleason, 1952:142; Gleason and Cronquist, 1963:299.
Barry	GH; MIN; NY; PENN; US; Steyermark, 1963:660-661.
Camden	FSU; UMKC; VDB; Henderson, 1980:35.
Carter	Steyermark, 1963:660-661.
Cedar	GA: MISS; Steyermark, 1963:660-661.
Christian	ISC; PH; Steyermark, 1963:660-661.
Cole	Steyermark, 1963:660-661.
Crawford	MIN; Steyermark, 1963:660-661.
Dade	OS; UMKC; UMO; VDB; Steyermark, 1963:660-661.
Dallas	FSU; UMKC; VDB; Henderson, 1980:35.
Dent	MO; Steyermark, 1963:660-661.
Douglas	F; Steyermark, 1963:660-661.
Franklin	Steyermark, 1963:660-661.
Greene	GH; MIN; MO; SIU; SMS; US; Bush, 1931:490; Steyermark, 1963:660-661.
Howell	MO; Steyermark, 1963:660-661.
Iron	MO.
Jasper	CM; CU; F; GH; ILL; K; MIN; MSC; NY; SMU; UMO; US; Steyermark, 1963: 660-661; McGregor and Barkley, 1977:560.
Jefferson	MIN; MO; Steyermark, 1963:660-661.
Laclede	F; Steyermark, 1963:660-661.
Lawrence	SIU; UMO; Steyermark, 1963:660-661.
Madison	MO.
Maries	Steyermark, 1963:660-661.
McDonald	MIN; MO; NY; Steyermark, 1963:660-661.

Table 2. (cont.). Distribution of royal catchfly *(Silene regia)* by states and counties as determined from credible herbarium and published records, and personal communications. Herbaria are abbreviated as indicated in Table 1.

Miller	MO; UMO; US; Steyermark, 1963:660-661.
Moniteau	UMO.
Newton	UMO.
Oregon	Steyermark, 1963:660-661.
Ozark	F; MO; SOTO; Steyermark, 1963:660-661.
Perry	UMO.
Phelps	F; MIN; SIU; UMO; Steyermark, 1963:660-661.
Polk	SMS; UMO; Steyermark, 1963:660-661.
Pulaski	MO; UMO; Steyermark, 1963:660-661.
Reynolds	MIN.
St. Louis	BKL; F; ISC; K; MICH: MIN; MSC; MUS; NY; PH; US; Steyermark, 1963:660-661.
Shannon	F; GH; ILL; K; MIN; MO; ND and NDG; SMS; SMU; UMO; US; Steyermark, 1963:660-661.
Stone	F; SOTO; Steyermark, 1963:660-661.
Taney	F; SOTO; Steyermark, 1963:660-661.
Texas	MO; UMO; Steyermark, 1963:660-661.
Washington	MO; Beck, 1826:182; Steyermark, 1963:660-661.
Webster	CM; F; ISC; MIN; MO; NY; OS; TENN; WIS; Steyermark, 1963:660-661.
Wright	F; MO; Steyermark, 1963:660-661.
Ohio	
County not specified	BGSU; NY; PH; Urbana College; Nuttall, 1818:288; Riddell, 1835:365; Torrey and Gray, 1838-1840:193; Sullivant, 1840:15; Gray, 1848:59, 1857:89, 1858:56, 1859:56; Newberry, 1860:13; Gray, 1867:89, 1868:66; Beardslee, 1874:2; Gray, 1887:76; Britton and Brown, 1897:10; Kellerman, 1899:22; Small, 1903:427; Britton, 1907:390; Robinson and Fernald, 1908:386; Britton and Brown, 1913:65; Schaffner, 1928:273; Small, 1933:507; Dobbins, 1937:127; Deam, 1940:448; Hitchcock and Maguire, 1947:53; Fernald, 1950:634; Gleason, 1952:142; Gleason and Cronquist, 1963:299; Stuckey, 1966:189, 193; Weishaupt, 1960:114, 1968:101, 1971:101; Ohio Division Natural Areas and Preserves, 1980:11.
Champaign	MICH; KE; OS; Jones, 1943a:104, 1943b:189; King, 1981.
Clark	BM; GH; JHWU; OS; Kellerman and Werner, 1895:178; Williams, 1913:183; Schaffner, 1914:179, 1932:147; Jones, 1943a:104; Jaworski, 1979, personal communication; Ramey, 1981, personal communication; Mahony, 1981, personal communication.
Fairfield	Bigelow, 1841.
Franklin	Riddell, 1834:120; Sullivant, 1840:15; Selby and Craig, 1890:10; Kellerman and Werner, 1895:178.
Hamilton	Clark, 1852; Bodley, 1865:10; Beardslee, 1874:2; Kellerman and Werner, 1895:178.
Madison	OS; KE; Kellerman and Werner, 1895:178; Williams, 1913:183; Schaffner, 1914:179, 1932:147; Jones, 1943a:104; Thomas, 1963, 1975, 1979; Cusick and Troutman, 1978:30; Carr, 1981; McDowell, 1981, personal communication; King, 1981.
Marion	OS; DeSelm, 1978, personal communication.
Montgomery	CINC; DMNH; PH; WIS; Schaffner, 1931:303, 1932:147.
Union	KE; MU; OS; Thomas, 1977; Cusick and Troutman, 1978:42; King, 1981.
Oklahoma	
County not specified	Small, 1903:427; Jeffs and Little, 1930:61; Small, 1933:507; Fernald, 1950:634; Steyermark, 1963:660.
Adair	OKLA; Waterfall, 1969:97.
Delaware	OKLA; Waterfall, 1969:97.
Tennessee	
County not specified	PH; Britton, 1907:390; Britton and Brown, 1913:65; Hitchcock and Maguire, 1947:53.
Knox	CINC; GH; MIN; NCU; NY; OS; Gattinger, 1901:76.
Marion	FSU; MISS.

6. Another undated specimen at PH was collected by Rev. Lewis David von Schwienitz, a Moravian clergyman and botanist, either in 1823 or 1831 as determined by Stuckey (1977, personal communication). The herbarium sheet bears the name "Muskingum" which probably refers to the Moravian Church lands at Gnadenhutten, Tuscarawas County, Ohio (Stuckey, 1979:50). However, intrepretation of Schweinitz's cryptic notes is very difficult (Stuckey, 1979:14), and the translation of "Muskingum" into a valid locality record for Tuscarawas County is probably not appropriate (Stuckey, 1980, personal communication). I have chosen to cite this record in Table 2 under "Ohio, County not specified."
7. Another undated specimen at PH bears only the information "Columbus, Ohio." Rather than representing the collection locality, this notation could be the address of the collector (Stuckey, 1976, personal communication). I have cited this fragmentary record in Table 2 under "Ohio, County not specified."
8. A specimen in the herbarium of Urbana College, Urbana, Ohio, was collected by Milo G. Williams, a botanist and also a former president of the school (Stuckey, 1966:7). A brief notation on the herbarium sheet records only "Fields and fences. 25 August. 2-3 ft." Schaffner (1931:303, 1932:147) ascribed the locality of this specimen to Montgomery County, Ohio, although such information is not directly evident from the herbarium sheet. Two other specimens collected by Milo G. Williams, one housed at CINC and the other at WIS, do list Dayton, Ohio, Montgomery County) as the collection locality. I have chosen to cite this record in Table 2 under "Ohio, County not specified," although I cite Schaffner's published references to in under "Montgomery County."
9. A specimen in full bloom at BSGU (No. 438) bears a label from the herbarium of Sandusky High School with the following information: "Name, *Silene regia* Sims; Locality, Lakeville, Ohio; Date, May 15, 1897; Collector Leslie D. Stair?" The label was handwritten by Edwin L. Moseley, former curator of both herbaria (Easterly, 1977, personal communication). Leslie D. Stair was a reputable collector of northeastern Ohio plants, and he deposited numerous specimens (none of *Silene regia*) with the Herbarium at The Ohio State University (Kellerman, 1899:4, 1900:4-5; Kellerman and Tyler, 1902:4). However, the "question-mark" after Stair's name indicates Moseley was not

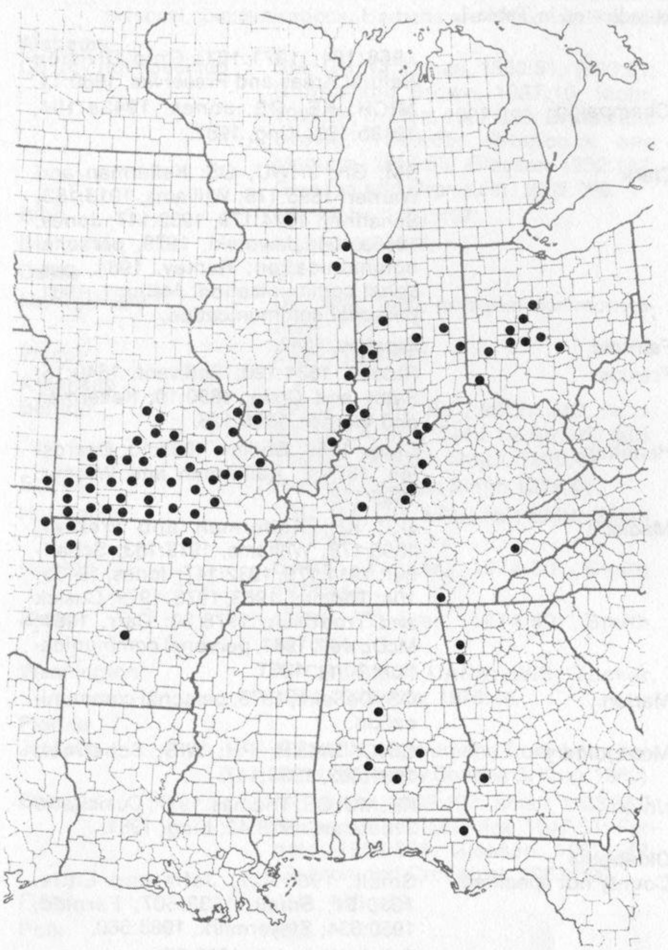

Figure 3. Distribution of royal catchfly *(Silene regia)* by county as determined from credible herbarium and published records, and personal communications as recorded in Table 2.

completely certain of the source of the specimen. Also, the collection date of 15 May precedes the normal flowering date of *Silene regia* in Ohio by about six weeks. "Lakeville" might refer to Lakeville in Holmes County or to the southeastern portion of Conneaut in Ashtabula County which formerly was known as Lakeville. The uncertainties associated with the collector and the date of collection tend to cloud the credibility of other data on the label. I do not consider the specimen to be a valid record for either Holmes or Ashtabula County. However, I do consider it to be an Ohio record and have cited it in Table 2 under "Ohio, County not specified."

10. A specimen at NY which was received from BM bears no data except the designation of "Ohio" and an uninterpretable figure (Maguire, 1976, personal communication). I have cited it in Table 2 under "Ohio, County not specified."

THE LITERATURE

Most of the distributional data provided by the literature were extracted from regional and state manuals and floras for areas in the United States east of the Rocky Mountains. Some additional data were supplied by a variety of other publications. I made an intensive literature search for Ohio records, but I investigated only the major works for most of the other states. When possible, state and county-of-record were determined and listed with the appropriate reference in Table 2. When determination of county-of-record was not possible, but state of record was, the reference was cited under "County not specified" for the appropriate state. Counties-of-record as determined from the literature were also included in the distributional map presented in Figure 3.

Problematic Records

Five published records as listed below were determined to be problematic and are not included in Table 2 or Figure 3 unless specified:

1. Nuttall (1818:288) described the range of *Silene regia* as "Throughout the western states sparingly from Ohio to Lower Louisiana." In 1818 "the western states" were those states west of the Appalachian Mountains and "Lower Louisiana" was that portion of the Louisiana Territory south of the Missouri River. As indicated by Ewan (1971:xxvii), Nuttall's St. Louis, Louisiana is now St. Louis, Missouri. In Table 2, I have cited Nuttall (1818:288) under "Missouri, County not specified." Nuttall's "Lower Louisiana" has been inaccurately interpreted to infer the state of Louisana by some authors when describing the range of *Silene regia* (Torrey and Gray, 1838-1840:193; Steyermark, 1963:660; Tucker, 1974:50). No valid records for Louisiana were detected in this study, and *Silene regia* is unknown for the state of Louisiana (Ewan, 1976, personal communication; Rhodes, 1976, personal communication). Moreover, no valid records are known for Mississippi (Watson, 1976, personal communication).
2. Torrey and Gray (1838-1840:193) published a questionable record of Dr. Holmes of Quebec, Canada, based on a problematic herbarium specimen as described above.
3. In an obscure publication, Mansfield (1903:85) listed "*Silene regia* — Royal Campion" as a member of the flora of Beaver County, Pennsylvania. The species has neither been reported in major works for Pennsylvania (Porter, 1903; Wherry, Fogg, and Wahl, 1979), nor by curators associated with three major herbaria in the state (Fogarasi, The Academy of Natural Sciences, 1980, personal communication; Ward and Buker, Carnegie Museum of Natural History, 1980, personal communication; and Keener, The Pennsylvania State University, 1980, personal communication). Mansfield had many interests including a greenhouse and collecting plants from the area (Fatula, 1980, personal communication). He may have misidentified *Silene virginica* which he did not list in his flora but which does occur in Beaver County (Wherry, Fogg, and Wahl, 1979:155). Unfortunately, the current location of the Mansfield herbarium, which Mansfield (1903:5-6) developed from 1865 to 1903, is unknown. In the absence of a voucher specimen, inclusion of Beaver County, Pennsylvania, within the range of *Silene regia* based solely on Mansfield's publication, is not warranted.
4. Sharp (1913:132) when listing some of the wild flowers which grew in Madison County, Ohio, included "silene." She had collected *Silene regia* from the area in 1892 as recorded in the Herbarium of The Ohio State University (OS 17561), and probably the "silene" in her book, was, in fact, royal catchfly.
5. As recorded by Brown (1883:342), Dr. Jeremiah Converse of Plain City, Ohio, while describing some of the original prairie flowers in Madison County, listed among others, "wild pink." Although the name "wild pink" is ambiguous, it is one of the common names of *Silene regia* (Gleason, 1952, 2:142; Gleason and Cronquist, 1963:299). Conceivably, Converse was including royal catchfly in his list.

FIELD RECONNAISSANCE IN OHIO

In conjunction with the Prairie Survey Project of the Ohio Biological Survey (Cusick and Troutman, 1978:1-3), I initiated in September 1976 a continuing field reconnaissance effort to locate extant populations of *Silene regia* in Ohio. I examined herbarium records and relevant references in the literature in an attempt to locate possible sites of recorded populations. These sites are listed in Table 3. Unfortunately, except for records of the known populations at Bigelow Cemetery State Nature Preserve in Madison County, all but one of the sources provided only generalized information regarding former collection localities. The single exception was a 1952 Marion County record provided by H.R. DeSelm from a railroad prairie remnant in

Table 3. Possible collection localities of *Silene regia* in Ohio as indicated by herbarium records from specimens collected prior to September 1976 and by relevant references in the literature. Herbaria are abbreviated as indicated in Table 1, and collectors and dates of collection are indicated when known. All the herbarium records detected in this study for Ohio prior to 1976 are included except the Nuttall specimen at PH as discussed under "Original Description" and a problematic record at NY as discussed under "Herbarium Records—Problematic Records No. 9."

Champaign County	Jones, 1943a:104.
Salem Township	MICH, *John Samples 575*, 11 Aug 1838; OS 17565, *Jane Roller*, 13 July 1941; Jones, 1943b:189.
Clark County	Williams, 1913:183; Schaffner, 1914: 179, 1932:147; Jones 1943a:104.
Clifton area	JHWU, *Harvey Martin*, 26 July 1888.
Pleasant Township	OS 17562, *Clyde H. Jones*, 1 Sept. 1938.
Springfield area	BM, *E. Doubleday from J.G. Lea*, 24 July; GH, *Milo G. Williams*, undated; OS 17563, *E. Jane Spence*, 15 Aug 1883; OS 17564, *E. Jane Spence*, July 1884; Kellerman and Werner, 1895:178.
Fairfield County	Bigelow, 1841.
Franklin County	Riddell, 1834:120; Sullivant, 1840:15; Kellerman and Werner, 1895:178.
Columbus area	PH, undated (A questionable record as discussed under "Herbarium Records, Problematic Records No. 7," which see).
Hamilton County	
Cincinnati area	Clark, 1852; Bodley, 1865:10; Beardslee, 1874:19; Kellerman and Werner, 1895:178.
Holmes County	
Lakeville area	BGSU 438, Leslie D. Stair? 15 May 1897. (A questionable record as discussed under "Herbarium Records, Problematic Records No. 9," which see).
Madison County	Kellerman and Werner, 1895:178; Williams, 1913:183; Schaffner, 1914:179, 1932:147; Jones, 1943a:104.
Bigelow Cemetery State Nature Preserve	KE 37815, *Allison W. Cusick*, 2 Aug 1976; OS 17558, *Robert B. Gordon*, Summer 1932; OS 17559, *Robert B. Gordon*, 9 Aug 1931; OS 17560, *Lawrence E. Hicks*, 23 July 1932; OS 84314, *Lawrence E. Hicks*, 23 July 1932; Thomas, 1963, 1975.
Darby Plains	ILL, *Johnathan R. Paddock*, 1835.
London area	OS 17561, *Katherine D. Sharp*, July 1892; Kellerman and Werner, 1895:178.
Marion County	
Marion Township, Section 20	OS 49323, *H.R. DeSelm*, 5 Aug 1952 (on a railroad prairie remnant).
Montgomery County	Schaffner, 1931:303, 1932:147.
Dayton area	CINC, *Milo G. Williams*, undated; DMNH B741, *Julia M. Deuel*, undated; DMNH B742, *Julia M. Deuel*, undated; DMNH B743, *Julia M. Deuel*, undated; DMNH, *John W. Van Cleve*, July (Collected between 1830 and 1850 as determined by Coovert, 1976, personal communication.); PH, *John W. Van Cleve*, undated (Collected in the 1830's as determined by Stuckey, 1977, personal communication.); Urbana College, *Milo G. Williams*, 25 Aug (A questionable record as discussed under "Herbarium Records, Problematic Records No. 8, which see"; WIS, *Milo G. Williams*, undated.
Tuscarawas County	
Gnadenhutten area	PH, *Lewis David von Schweinitz*, undated. (Collected either in 1823 or 1831 as determined by Stuckey, 1977, personal communication; a questionable record as discussed under "Herbarium Records, Problematic Records No. 6," which see).

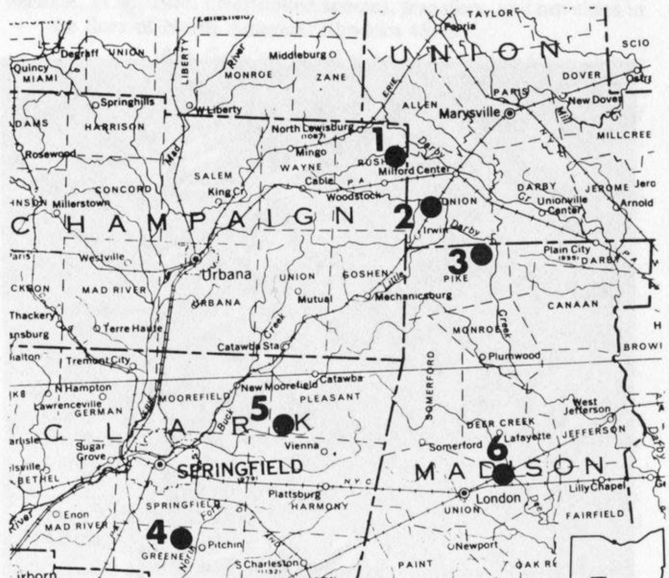

Figure 4. Locations of the known extant populations of royal catchfly (*Silene regia*) in Ohio: (1) Martin Cemetery, (2) Milford Center Prairie, (3) Bigelow Cemetery State Nature Preserve, (4) Mills Road Roadside, (5) Clark Lake Wildlife Area, and (6) Conrail Right-of-way.

Marion Township. The Holmes County and Tuscarawas County localities as listed are especially problematic as previously discussed.

I have surveyed very intensively two of the localities: (1) the Darby Plains in Madison, Franklin, Union, and Champaign Counties (King, 1981), and (2) the Marion County railroad prairie remnant in Marion Township. I have surveyed less intensively all the other possible collection localities as listed in Table 3, in addition to many other areas throughout the state. Also, I have requested other contributors to the Prairie Survey Project to report any occurrence of *Silene regia* which they may have located by their survey activities.

I could not locate, with repeated visits during 1977-1980, the Marion County population as recorded by DeSelm in 1952. Cusick (1980, personal communication), Troutman (1980, personal communication) and Yoder (1980, personal communication) also intensively surveyed this site and found no trace of royal catchfly. Up to 57 species of Ohio prairie plants persist at this disturbed site (Cusick and Troutman, 1978:33), but *Silene regia* apparently does not. It may have been eliminated by the disturbances associated with the recurring railroad maintenance activities in the area. The most recent disturbance occurred in 1976 (Cusick and Troutman, 1978:33).

In addition to the previously known population at Bigelow Cemetery State Nature Preserve, where on 2 August 1981 I counted 227 flowering stems, only five additional extant populations of *Silene regia*, as indicated in Figure 4, have been found in Ohio: Martin Cemetery, Milford Center Prairie (Fig. 5), Mills Road roadside, Clark Lake Wildlife Area, and Conrail right-of-way near London. All five populations were previously unknown to the scientific community.

Martin Cemetery is located about 1.6 km (1 mile) north of Woodstock in Rush Township, Champaign County, 0.15 km (0.1 mile) north of the junction of Ohio Route 559 and Martin Road(Champaign County Road T-210). While conducting a survey of prairie plants in the cemeteries of the Darby Plains, I investigated this small, unmowed cemetery on 31 May 1980 and observed many vigorous stems of *Silene regia* not yet in bloom. This population is the most densely concentrated in Ohio, and when I revisited the site on 11 July 1980, the royal catchfly was in full bloom and presented a striking display. On 2 August 1981, I counted 508 flowering stems here. Surprisingly, no other Ohio prairie species have been observed at Martin Cemetery.

Figure 5. *Silene regia* cyme with seed-bearing capsules collected at Milford Center Prairie, Union County, Ohio. (Photograph by Charles C. King, 1977-78.)

Milford Center Prairie is located about 3 km (2 miles) southwest of Milford Center in Union Township, Union County. It occupies about 2 km (1.3 miles) of a former railroad right-of-way with most of the prairie species occurring between Connor Road (Union County Road 81) on the north and U.S. Route 36 on the south (Thomas, 1977; King 1981:122). The right-of-way is now used for an electric power line by the Dayton Power and Light Company, Dayton, Ohio 45401. I found several royal catchfly plants in seed at this site on 24 October 1976, and on August 1981, I counted 810 flowering stems here. This vigorous population is the largest known in Ohio and possesses more flowering stems than the other five sites combined. A small extension of this population, with about four flowering stems, occurs on the north side of Connor Road 0.5 km (0.3 mile) west of the power line right-of-way, Frequently these plants are mowed during routine roadside maintenance activities.

Mills Road roadside possesses a small population of royal catchfly. The site is located near the north bend of Mills Road (Clark County Road Twp 71) virtually in the center of Section 24, Green Township, Clark County, about 1.9 km (1.2 miles) northwest of Pitchin. This population was brought to the attention of Terry Jaworski (1979, personal communication) by a participant on a field trip which Jaworski was conducting to Bigelow Cemetery State Nature Preserve. Upon seeing royal catchfly in bloom in the cemetery, the participant informed Jaworski of this Clark County population. On 3 August 1981, Ralph Ramey (1981, personal communication) counted 62 flowering stems here.

A small population of royal catchfly occurs in the Clark Lake Wildlife Area in Section 19, Pleasant Township, Clark County. This station near the east side of Clark Lake was discovered by Vince Mahony (1981, personal communication), and on 26 July 1981 he counted 11 flowering stems. On the Conrail right-of-way in Deer Creek Township, Madison County, Jack H. McDowell (1981, personal communication) discovered another small population. This station is located in a fence row on the north side of the railroad about 0.1 km west of Deer Creek. On 29 July 1981, Jack McDowell counted eight flowering stems here. The right-of-way is described briefly by King (1981:123).

The population and habitat at Bigelow Cemetery State Nature Preserve is protected by the Division of Natural Areas and Preserves, Ohio Department of Natural Resources, and the population of royal catchfly at this site has increased substantially since 1978 when management of the area was assumed by the Division. Also, the population and habitat at Milford Center Prairie is protected by the Dayton Power and Light Company since the area is managed in such a manner to protect the extant prairie species (Harper, 1980). The Clark Lake Wildlife Area is managed and protected by the Division of Wildlife, Ohio Department of Natural Resources.

In contrast, Martin Cemetery, the Mills Road roadside, and the Conrail right-of-way have no protective management plans for royal catchfly, and the habitats and populations there could be eliminated if subjected to inappropriate management procedures. *Silene regia* has been designated as an endangered species in Ohio (Ohio Division of Natural Areas and Preserves, 1980:11) and thereby is afforded a measure of legal protection from commercial exploitation and over collecting, but destruction of habitat is still the primary threat to survival of the species.

With the possible exception of the population recorded for Hamilton County, all the documented populations of *Silene regia* in Ohio are from areas of Wisconsinan glaciation. This situation indicates post-glacial migration into Ohio. As suggested by the distributional data presented in Figure 3, post-Wisconsinan migration into Ohio might have originated from pre-Wisconsinan populations along the lower Wabash River in Indiana and Illinois and proceeded eastward into Ohio via the Wabash River corridor. Once established in west-central Ohio, royal catchfly might have migrated to Hamilton County via the Great Miami River or the Little Miami River corridors. In the absence of records from northern Kentucky, a northeastern migration route from the unglaciated barrens of western Kentucky appears to be less likely.

CONCLUSIONS

Nuttall's (1818:288) description of the distribution of *Silene regia* as "sparingly from Ohio to Lower Louisiana [the Louisiana Territory south of the Missouri River]" is basically accurate. Documentation by herbarium specimens (Table 2) identifies portions of twelve states as constituting the range of the species: Alabama, Arkansas, Florida, Georgia, Illinois, Indiana, Kansas, Kentucky, Missouri, Ohio, Oklahoma, and Tennessee. Previous to this study, Florida was not recognized as being within the range limits.

Deam's (1940:488) description of royal catchfly in Indiana as "A very local plant" also applies, with the possible exception of Missouri, to all the other states within its range. In Missouri, royal catchfly is recorded for nearly every county in the Ozark region south of the Missouri River (Fig. 3). James M. Sullivan in a letter to Alice A. Nightingale (1976, personal communication) indicates that *Silene regia* in the Ozark region occurs "infrequently but consistently." Elsewhere, the species is rare and widely dispersed, if not extirpated: Alabama (Thomas, 1976, personal communication; Kral, 1980, personal communication); Arkansas (Tucker, 1974:50, 1976, personal communication; Smith, 1976, personal communication); Florida (Ward, 1977, personal communication); Georgia (Faircloth, 1976, personal communication; Drapalik, 1980, personal communication); Illinois (Mohlenbrock, 1976, personal communication; Kurz, 1978, personal communication); Indiana (Pelton, 1980, personal communication); Kansas (McGregor, 1976, personal communication; 1977:6); Kentucky (Medley, 1980, personal communication); Ohio (see "Field Reconnaissance in Ohio" above); Oklahoma, (Taylor, 1976, personal communication; Tyrl, 1976, personal communication); and Tennessee (DeSelm, 1978, personal communication; Kral, 1980, personal communication).

Special protective procedures are probably necessary to insure the survival of this "splendid species" in states other than Missouri, and possibly even there.

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At the Stillwater Prairie Preserve

Clara G. Weishaupt (right) and Scott L. Huston on the bank of the Stillwater River, Miami County, Ohio. (Photograph by Charles C. King, 1981.)

PRAIRIE REMNANTS ALONG THE STILLWATER RIVER IN MIAMI COUNTY, OHIO

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Whether described as noncontiguous outliers of Transeau's great triangle or botanical archipelagos amidst beech—maple and oak—hickory associations, the Stillwater Prairies are unique prairie remnants. These small "islands" of prairie communities are prime examples of sites that may not have exceeded 12-16 ha (30-40 acres) in historic time. These prairies were frequently referred to as "nice bottome," "thin broken land," "broken bushy land," and "wet bushy prairie" in survey notes recorded by Colonel Ludlow (1801). The frequency of such observations in his notes suggests that at postsettlement time, open prairie lands occurred with regularity throughout the northern reaches of the river. Until recently, however, local people had nearly forgotten that these prairies were part of the native landscape.

The Stillwater River, located in west-central Ohio (Fig. 1), traverses the counties of Darke, Miami, and Montgomery along its approximately 80 km (50 miles) course and terminates at the Great Miami River in Dayton. Passing through Wisconsinan glacial till plains, slightly less than half of its course is in a east-southeast direction until reaching a point just north of Covington where, owing to previous glacial blockage, the river abruptly shifts to the south traversing a deeply cut valley of preglacial times. Included in the state's scenic rivers system, the Stillwater River remains one of Ohio's least disturbed streams, supporting excellent populations of great blue heron and outstanding smallmouth bass fisheries.

This paper discusses three prairie sites which occur along a 5.6 km (3.5 miles) section of the Stillwater River (Fig. 2). It highlights the Stillwater Prairie Preserve, an area administered by the Miami County Park District. The discussion is based on preliminary investigations.

DESCRIPTIONS OF THE PRAIRIES

Site 1, Hoary Puccoon Prairie

Location. NE¼ of the NW¼ of Section 11, Newberry Township.

Size. Approximately 0.08 ha (0.20 acres).

Exposure. The Hoary Puccoon Prairie occupies the extreme edge of a southwest-facing 15-18 m (50-60 ft) bluff, at a point where the river splits into two distinctive channels during high water. The land immediately above the bluffs to the north has virtually no relief.

Soils. The soil is Miamian-Hennepin silt loam of the type located on slopes of 25-50 percent incline along rivers and their tributaries. These soils were formed from medium-textured calcareous glacial till and have a well-drained shallow to medium root zone. Surface runoff is rapid, and the hazard of erosion and slumping is very severe (Lehman and Bottrell, 1978).

Vegetation. With the exception of several large *Juniperus virginiana*, this site is dominated by *Andropogon scoparius* on the drier upper reaches, with *A. gerardii* interspersed more frequently downhill toward the wetter portions of the slope. Forbs and woody prairie species, such as *Ceanothus americana, Asclepias tuberosa, Spiranthes cernua, Cassia fasciculata,* and *Ratibida pinnata,* make up approximately 50 percent of the remaining vegetation. The population of *Lithospermum canescens* has spread over the slumping and eroding slope, and has increased in abundance over the past three years. Its spreading possibly will continue southerly to other known sites along the river where presently it does not occur. At the base of the slope, several specimens of *Silphium terebinthinaceum* occur near the river's edge. Vegetation surrounding the prairie includes wooded ravines and a field of primarily *Bromus inermis* to the north.

Discussion. While the present owner has been quite appreciative and protective of the plants at the Hoary Puccoon Prairie, the future of the site is in question. The xeric nature of the upper flat and southwest-facing slope, apparently prohibits invasion of woody plants; however, the undercutting of this small area by the slumping slopes might destroy this delicately balanced hillside prairie. Natural migration of the prairie into the *Bromus inermis* field to the north appears improbable. Virtually no invasion by prairie species has occurred to the stand of *B. inermis* that was established 15-20 years ago. Destructive management of the *B. inermis* cover would, of course, allow movement of prairie species into that area. Prairie dominants and selected associated species in Hoary Puccoon Prairie are listed in Table 1.

Site 2, Pentz Prairie

Location. NW¼ of the SE¼ of Section 11, Newberry Township.

Size. Approximately 0.1 ha (0.25 acre).

Exposure. The Pentz Prairie is composed of two parts: the first facing directly west, approximately 7.5 m (25 ft) above the river, and the second, separated from the former by invading woody species, more to the southwest and only 3-4.5 m (10-15 ft) above the river.

Soils. The soil is Eldean loam, a soil generally present on slopes of 2-6 percent incline along river courses and their tributaries. It is formed on high stream terraces, kames, or eskers (Lehrman and Bottrell, 1978). This site, underlaid with sand and gravel, is moderately eroded, tends to be droughty during summer months, and becomes warmer earlier than surrounding areas. Wet years, however, produce high water tables in adjacent poorly drained soils which "seep" at their interface with the prairie (Fig. 3).

Vegetation. The soil pattern present at the Pentz Prairie has resulted in vegetation quite unlike that at the Hoary Puccoon Prairie and Stillwater Prairie Preserve, as evidenced by the presence of numerous hydrophytic species such as *Carex* spp., *Juncus* spp., *Impatiens*

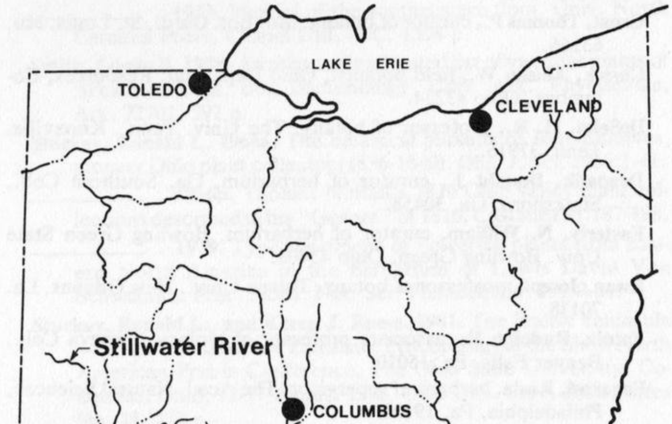

Figure 1. Location of the Stillwater River in Ohio.

biflora, Asclepias incarata, and *Thalictrum polygamum.* These species are interspersed throughout with typical prairie species such as *Allium cernuum, Andropogon scoparius. A. gerardii, Monarda fistulosa,* and *Ratibida pinnata.* In addition, woody species such as *Ulmus americana* and *Fraxinus americana,* usually not exceeding 20 cm (8 inches) in diameter, occupy approximately 15-20 percent of the vegetation.

Discussion. The mixture of hydrophytic and prairie species at the Pentz Prairie is believed to result from a long-term fluctuation of available soil moisture within and surrounding the prairie site. During long droughty periods the source of water from well-drained upland soils may have ceased to flow over the exposed xeric site and prairie species were established. Periodically during wetter periods, the soil became recharged and hydrophytic species became established and interspersed with the previously established prairie species. The wetter periods probably never prevailed long enough to create true forest conditions, which would have eliminated the prairie element, and during ensuing dry periods the prairie once again flourished. These reoccurring cycles, if patterned appropriately, would have adversely affected forest succession much more than prairie continuance because of the greater tolerance of prairie plants to the wide range of fluctuating soil moisture conditions.

Prairie dominants and selected associates. The present owner has ceased to allow study of the Pentz Prairie; hence, no updating of this list has been made since 1976. Prairie dominants and selected associated species in Pentz Prairie are given in Table 1.

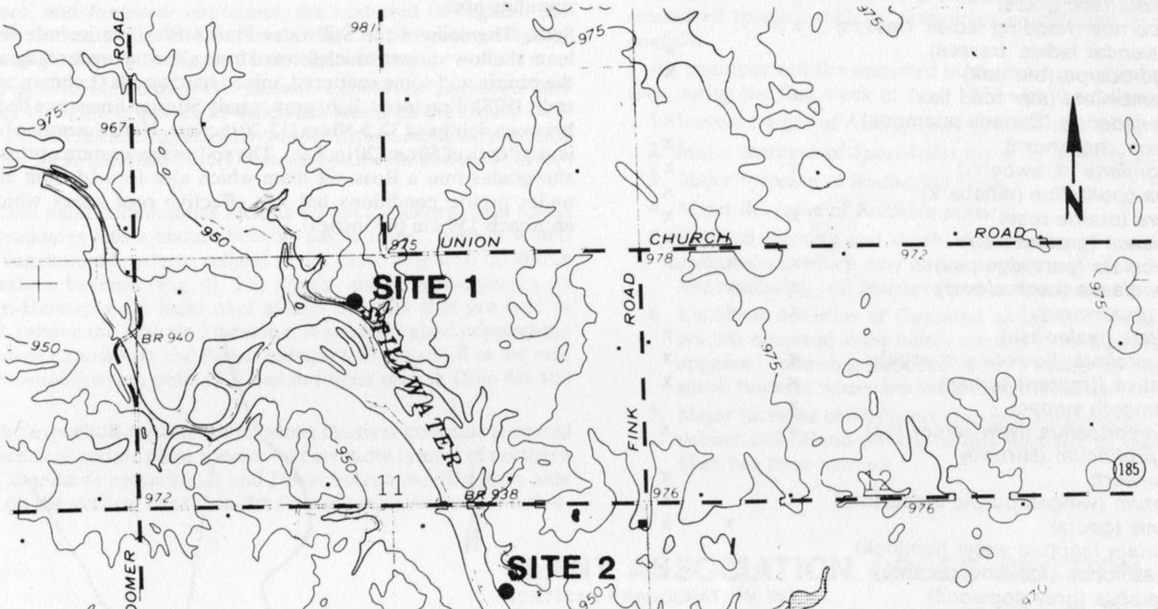

Figure 2. Location of the three Stillwater River prairie sites in Newberry Township, Miami County, Ohio: Hoary Puccoon Prairie (1), Pentz Prairie (2), and Stillwater Prairie Reserve (3).

Table 1. Prairie dominants and selected associated species in three prairie remnant sites along the Stillwater River: Hoary Puccoon Prairie (1), Pentz Prairie (2), and Stillwater Prairie Reserve (3).

	Sites 1	2	3
Andropogon gerardii (big bluestem)	x	x	x
A. scoparius (little bluestem)	x	x	x
Sorghastrum nutans (Indian grass)			x
Sporobolus asper (dropseed)			x
Allium cernuum (nodding onion)	x	x	x
Camassia scilloides (wild hyacinth)			x
Lilium michiganense (Michigan lily)			x
Hypoxis hirsuta (star grass)	x		
Spiranthes cernua (nodding ladies' tresses)	x		
S. gracilis (slender ladies' tresses)			x
Quercus macrocarpa (bur oak)			x
Comandra umbellata (star toad flax)	x		
Anemone canadensis (Canada anemone)			x
Crataegus spp. (hawthorn)			x
Fragaria virginiana (strawberry)	x		x
Physocarpus opulifolius (ninebark)			x
Rosa setigera (prairie rose)	x		x
Apios americana (ground nut)			x
Cassia fasciculata (partridge pea)	x	x	x
Lespedeza violacea (bush clover)	x	x	
L. virginica (bush clover)	x		
Ptelea trifoliata (wafer-ash)	x		
Euphorbia corollata (flowering spurge)	x		x
Rhus aromatica (fragrant sumac)	x		x
R. glabra (smooth sumac)	x		
Ceanothus americanus (New Jersey tea)	x		x
Hypericum prolificum (shrubby St. John's-wort)			x
Lythrum alatum (winged purple loosestrife)			x
Gaura biennis (gaura)		x	x
Cicuta maculata (spotted water hemlock)			x
Thaspium barbinode (meadow parsnip)			x
Cornus racemosa (gray dogwood)	x		
C. amomum (silky dogwood)			x
Dodecatheon meadia (shooting star)			x
Lysimachia quadriflora (prairie loosestrife)		x	x
Gentiana andrewsii (bottle gentian)		x	x
G. quinquefolia (stiff gentian)			x
Asclepias tuberosa (butterfly weed)	x		x
A. verticillata (whorled milkweed)			x
Ipomoea pandurata (wild potato-vine)	x		x
Lithospermum canescens (hoary puccoon)	x		x
Monarda fistulosa (wild bergamot)	x	x	x
Physostegia virginiana (obedient plant)			x
Pycnanthemum virginianum (Virginia mountain-mint)	x	x	x
Scutellaria parvula (smaller skullcap)			x
Gerardia tenuifolia (slender gerardia)			x
Penstemon digitalis (foxglove penstemon)	x	x	x
Ruellia humilis (hairy ruellia)			x
Aster ericoides (heath aster)			x
A. laevis (smooth aster)	x		
A. novae-angliae (New England aster)			x
Echinacea purpurea (purple coneflower)			x
Eupatorium altissimum (tall boneset)			x
Helenium autumnale (sneezeweed)			x
Helianthus grosseserratus (saw-toothed sunflower)			x
H. hirsutus (sunflower)	x		
Ratibida pinnata (prairie coneflower)	x	x	x
Rudbeckia hirta (black-eyed susan)		x	x
R. triloba (thin-leaved coneflower)	x		x
Silphium terebinthinaceum (prairie-dock)	x		x
S. trifoliatum (whorled rosinweed)			x

Site 3, Stillwater Prairie Preserve

Location. SE¼ of the SW¼ of Section 12, Newberry Township.

Size. Approximately 2 ha (5 acres).

Exposure. The Stillwater Prairie Preserve occurs on both sides of the Stillwater River in a generally east-west direction and has full westerly exposure on the eastern portion which rises approximately 3 m (10 ft) above the water's edge. The western portion does not possess sufficient relief to manifest an extreme topographic exposure; however, it occurs in a bowl-like depression having winter temperatures considerably lower than the surrounding area. Summer westerly winds are virtually nonexistant on the Stillwater Prairie Preserve due to a large block of forest immediately to the west, resulting in higher daytime summer and autumn temperatures there than in the surrounding area.

Soils. The soils of the Stillwater Prairie Preserve include Ross silt loam shallow variant which formed from alluvium under tallgrasses of the prairie and some scattered, mixed hardwoods (Lehman and Bottrell, 1978). Fractured, light gray, sandy Silurian limestone bedrock is between depths of 32.5-50 cm (13-20 inches). Hard limestone bedrock is at a depth of 50 cm (20 inches). The soil on the western portion of the site grades into a Ross silt loam which also formed from alluvium under prairie conditions but has effective root zones which may approach 150 cm (60 inches).

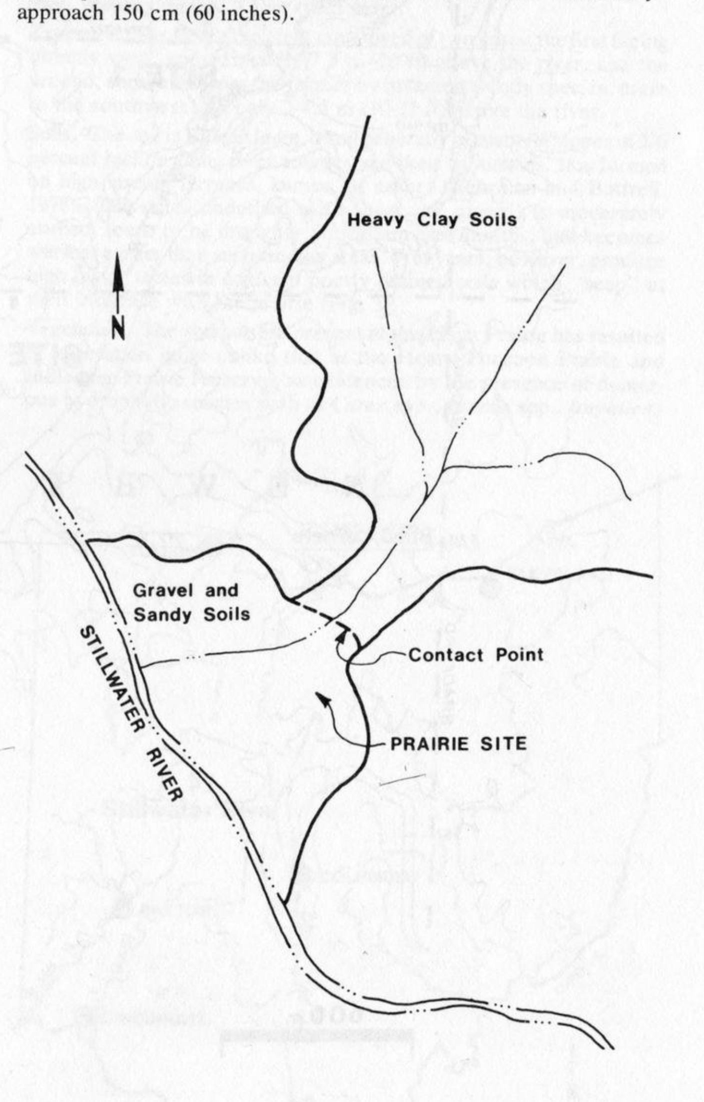

Figure 3. Soils of the Pentz Prairie (2) in Miami County, Ohio.

Vegetation. A screen of bottomland forest lies between the river and the Stillwater Prairie Preserve. Beyond these trees lies a mosaic of grasses, forbs, trees, vines, and shrubs which hardly resemble a western prairie. Depth of glacial till ranging from 15 to 150 cm (6 to 60 inches) above limestone bedrock directly influences the composition of plant community zones within the prairie itself (Fig. 4). These communities can be described as follows:

1. *Andropogon gerardii* and forbs.
2. *Andropogon scoparius* and forbs.
3. *Andropogon gerardii, A. scoparius, Sorghastrum nutans, Sporobolus asper,* and forbs.
4. Shrubland prairie.

Shrub thickets of *Physocarpus opulifolius* and *Rhus aromatica,* and individual trees, such as, *Juglans nigra, Fraxinus pennsylvanica* var. *lanceolata,* and *Juniperus virginiana*, are scattered throughout the grassland communities listed above in areas possessing slightly deeper soil pockets with higher percentages of clay.

Good prairie indicator forbs include *Echinacea purpurea* and *Asclepias verticillata* neither of which are found on the Hoary Puccoon or Pentz Prairies. *Silphium terebinthinacium, Ratibida pinnata, Pycnantheum virginianum,* and *Dodecatheon media* add to the diversity.

Adjacent plant communities include an oak—hickory—ash forest which graduates into a mature beech—maple forest, both of which exhibit vegetational patterns related to the depth of glacial till above the limestone bedrock (Fig. 4). The beech—maple forest occurs on Miamian-Hennepin silt loam over glacial deposits that are 6-15 m (20-50 ft.) above the Silurian limestone. It supports good populations of *Hydrastis canadensis* and *Panax quinquefolium* as well as the rare *Veratum woodii* which until 1977 had not been seen in Ohio for 100 years.

Nearby exposed limestone banks along the river continue to reveal the presence of certain plant species that are more typical of northern areas. *Campanula rotundifolia* and *Dodecatheon meadia* grow side by side on the vertical banks amidst *Prunus virginiana* and *Amelanchier spicata*. *Aralia racemosa* has been recently located 4.8 km (3 miles) from this site on Greenville Creek, a tributary of the Stillwater River which also supports many aspects of relict prairie.

Discussion. The Stillwater Prairie Preserve was purchased in 1977 by the Miami County Park District as part of what is now a 217-acre reserve. It enjoys perpetual protection and will receive the finest management available to increase its quality and expand its limits.

Although the tract was included as a part of a larger property north of the river since the time of the original land grant in 1812, access for farming purposes was difficult because of high spring flood water; as a result, no major exploitation of the prairie has occurred. A few minor efforts at plowing were attempted in the past and some historical evidence exists that a small melon patch was established on the deeper soils sometime in the 1930's. It is believed that no plowing has occurred in the nucleus of the site because of the presence of easily eradicated species, such as, *Spiranthes gracilis* and *Gentiana quinquefolia*.

An unauthorized fire occurred in the xeric grassland zones of the area during the first week of June 1977 with the following results:

1. Increase vigor of *Andropogon gerardii* and *A. scoparius*.
2. Major increase of *Sporobolus asper* in quantity and vigor.
3. Major increase of *Rudbeckia hirta*.
4. Major decrease of *Ratibida pinnata*.
5. Physical burning and death of a species of moss, *Thuidium delicatulum,* which may have an important effect in stabilizing and regulating soil moisture and temperature.
6. Excellent densities of *Gentiana quinquefolia* and *Spiranthes gracilis* occurred in the mossy areas in 1976; however, no plants appeared following the burn in 1977 except in areas near the shrub thickets where burnable materials were less dense.
7. Major increase of *Melilotus alba* in a burned area with slightly deeper soil. Hand pulling of this undesirable and aggressive alien has been started.

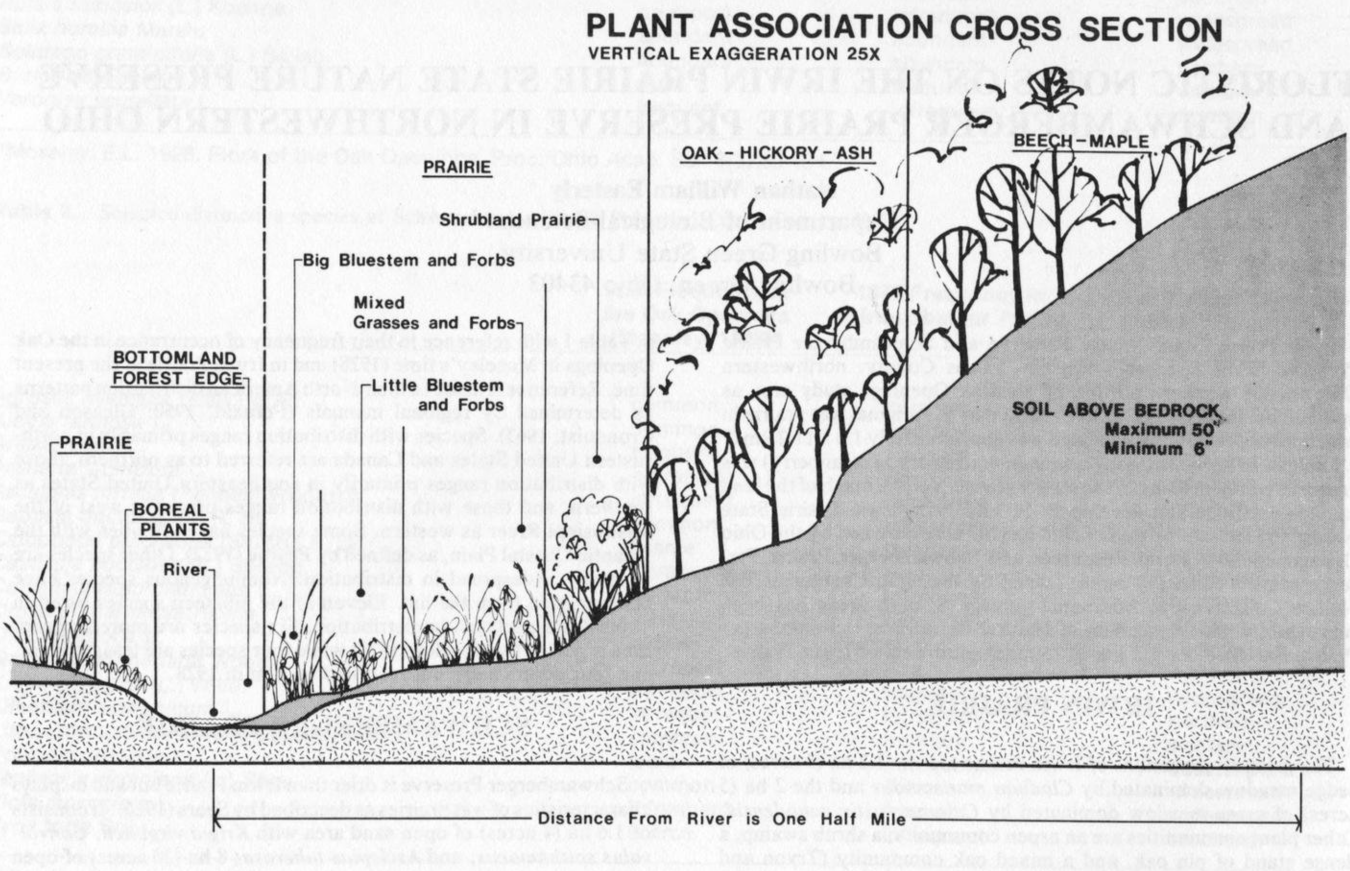

Figure 4. Plant communities and their relationships to depth of limestone bedrock at the Stillwater Prairie Preserve in Miami County, Ohio.

8. Prior to the burn, only three blooming stations of *Echinacea purpurea* were noticed. In 1978 at least 50 stations were observed.

While woody plants are selectively controlled on portions of the site with deeper soils, complete elimination will not be attempted as it is believed that these woody associates are a natural component of this prairie site. Widely scattered trees on the site rarely exceed 25.4 cm (10 inches) dbh, and these exhibit clear signs of decline and lack of vigor. Increment borings of trees averaging 15 cm (6 inches) dbh indicate an age range of 30-50 years. Therefore, woody plant succession is not considered a major threat to the prairie.

In less than three years, indelible foot paths were being established with only four to five individuals visiting the site three or four times a year. To control this damage, a 50 cm (20 inch) wide, white oak planked boardwalk was constructed through and around the site in 1978. Boards 5 x 15 cm (2 x 6 inches) and 2.4-3.6 m (3-12 ft.) long were spiked to 15 x 15 cm (6 x 6 inches) treated pine headers to form the walk that passes by main features of the site.

It is anticipated that the existing 2 ha (5 acres) tract will ultimately be expanded to its estimated postsettlement size of 6-8 ha (15-20 acres) by allowing prairie species to migrate into newly acquired Park District lands and by upgrading, through woody plant control, marginal prairie communities occurring on adjacent sites.

Prairie dominants and selected associates. Species in Stillwater Prairie Preserve are listed in Table 1.

CONCLUSION

The foregoing discussion has shown that prairie and forest plant species coexist as a result of slight differences in site characteristics. The species soils, for example, of the Hoary Puccoon Prairie, are the same as those of the beech—maple community 1.6 km (1 mile) downstream, except that the former is on a southwest-facing slope and the latter on a north-facing slope. An excellent way to illustrate this intermingling of plant communities is to describe a short, transect (Fig. 4) through the Stillwater Prairie Preserve covering a distance of approximately 0.8 km (0.5 mile). Starting in the prairie east of the river, *Allium cernuum* and *Andropogon scoparius* grow on thin soil that barely covers the bedrock. Nearby, on exposed limestone, *Lysimachia quadrifolia* and *Campanula rotundifolia* live only centimeters apart in small depressed pockets of soil. Across the river on an elevated sandy bar next to a tree-lined bank, *Trillium nivale* and *Jeffersonia diphylla* bloom in spring a mere 6 m (20 ft) from the late summer *Silphium terebinthinaceum* and *Monarda fistulosa*. *Sorghastrum nutans* mingles with *Ptelea trifoliata*; on higher ground *Quercus alba* and *Sassafras albidum* is found in association with *Carya cordiformis*. Proceeding still upward, *Fagus americana* stands over the prairie below and equally shares with *Andropogon gerardii* the grandeur of antiquity.

ACKNOWLEDGEMENTS

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FLORISTIC NOTES ON THE IRWIN PRAIRIE STATE NATURE PRESERVE AND SCHWAMBERGER PRAIRIE PRESERVE IN NORTHWESTERN OHIO

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Irwin Prairie State Nature Preserve and Schwamberger Prairie Preserve lie in Spencer Township, Lucas County, northwestern Ohio, in the northern portion of the Oak Openings study area as outlined by Moseley (1928). He stated that the original wet prairie in which these preserves are located was approximately 1.6 x 11.2 km (7 x 1 miles). In former times, *Vaccinium macrocarpon* (cranberry) was grown as a crop in many of the wetter places. Today, much of the land has been drained and developed. In July 1978, Irwin Prairie State Nature Preserve consisted of 58.8 ha (147 acres) owned by the Ohio Department of Natural Resources and Schwamberger Prairie Preserve totaled 12 ha (30 acres) owned by the Ohio Chapter of The Nature Conservancy. Additional acreage at both areas has been surveyed by the Department of Natural Resources. Schwamberger Prairie Preserve lies 1.2 km (0.75 mile) southwest of Irwin Prairie.

IRWIN PRAIRIE

The primary attractions of Irwin Prairie are the 1.2 ha (3 acres) of sedge meadow dominated by *Cladium mariscoides* and the 2 ha (5 acres) of grass meadow dominated by *Calamagrostis canadensis*. Other plant communities are an aspen community, a shrub swamp, a dense stand of pin oak, and a mixed oak community (Tryon and Easterly, 1975). Selected distinctive species at Irwin Prairie are listed in Table 1 with reference to their frequency of occurrence in the Oak Openings in Moseley's time (1928) and in Irwin Prairie at the present time. Reference is made to their North American distribution patterns as determined by regional manuals (Fernald, 1950; Gleason and Cronquist, 1963). Species with distribution ranges primarily in northeastern United States and Canada are referred to as northern, those with distribution ranges primarily in southeastern United States as southern, and those with distribution ranges primarily west of the Mississippi River as western. Some species have affinities with the Atlantic Coastal Plain, as defined by Peattie (1922). Other species are generally widespread in distribution. Nonindigenous species have been omitted from the list. Eleven of the nineteen species listed in Table 1 are northern in distribution. Six species are more frequent than reported by Moseley (1928) while four species are less frequent, and four others were not recorded by him in 1928.

SCHWAMBERGER PRAIRIE

Schwamberger Preserve is drier than Irwin Prairie but still displays characteristics of wet prairies as described by Sears (1926). It consists of 1.6 ha (4 acres) of open sand area with *Krigia virginica*, *Convolvulus spithamaeus*, and *Asclepias tuberosa*; 8 ha (20 acres) of open wet area with *Aletris farinosa*, *Hypericum spathulatum*, *Agrostis* *hyemalis*, and *Asclepias hirtella*; and 2.4 ha (6 acres) of aspen (*Populus tremuloides*) thickets at the margins of the open areas. Additional hectares under consideration by the Ohio Department of Natural Resources consists of a small pond with *Drosera intermedia*, *Calopogon pulchellus*, and *Xyris torta* along its margin; an open sand area with *Tephrosia virginiana*, *Baptisia tinctoria*, *Lithospermum canescens*, *Lupinus perennis*, and *Gerardia skinneriana*; 8-12 ha (20-30 acres) of aspen thickets; and several naturally-occurring open areas within the thickets. *Angelica venenosa*, *Vaccinium angustifolium*, *Drosera rotundifolia*, *Castilleja coccinea*, and *Pogonia ophioglossoides* grow in these openings. Selected distinctive species of Schwamberger Prairie are listed in Table 2 along with frequency and distribution notations. Eight of the twenty species listed in Table 2 are widespread in distribution while six species are northern. Changes in frequency of occurrence show five species that are less frequent than reported by Moseley (1928) while four species are more frequent.

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Table 1. Selected distinctive species at Irwin Prairie State Nature Preserve, Lucas County, Ohio.

	1928 Frequency in the Oak Openings (Moseley,1928)[1]	1978 Frequency in Irwin Prairie	North American Distribution
Bidens coronata (L.) Britt.	local	frequent	northern
Calamagrostis canadensis (Michx.) Nutt.	frequent	common	northern
Cladium mariscoides (Muhl.) Torr.	rare	local	coastal plain
Cypripedium calceolus L.	rare	scarce	widespread
Gentiana crinita Froel.	local	rare	northern
Hierochloe odorata (L.) Beauv.	no report	rare	northern
Iris versicolor L.	common	frequent	northern
I. virginica L.	common	common	northern
Liatris spicata (L.) Willd.	frequent	frequent	widespread
Oenothera perennis L.	no report	frequent	northern
Pedicularis lanceolata Michx.	frequent	infrequent	northern
Penstemon digitalis Nutt.	no report	frequent	widespread
Polygonum amphibium L.	frequent	frequent	northern
Proserpinaca palustris L.	frequent	abundant	southern
Rotala ramosior (L.) Koehne	no report	infrequent	widespread
Salix humilis Marsh.	abundant	abundant	widespread
Solidago graminifolia (L.) Salisb.	abundant	abundant	northern
S. riddellii Frank	rare	frequent	western
Veronica scutellata L.	frequent	infrequent	northern

[1]Moseley, E.L. 1928. Flora of the Oak Openings. Proc. Ohio Acad. Sci. 8(3):80-134.

Table 2. Selected distinctive species at Schwamberger Prairie Preserve, Lucas County, Ohio.

	1928 Frequency in the Oak Openings (Moseley, 1928)[1]	1978 Frequency in Schwamberger Prairie	North American Distribution
Agrostis hyemalis (Walt.) BSP.	common	common	coastal plain
Aletris farinosa L.	common	frequent	widespread
Arabis lyrata L.	frequent	frequent	northern
Arenaria lateriflora L.	no report	rare	northern
Asclepias hirtella (Pennell) Woodson	infrequent	infrequent	western
Baptisia tinctoria (L.) R. Br.	common	common	southern
Calopogon pulchellus (Salisb.) R. Br.	scarce	frequent	widespread
Castilleja coccinea (L.) Spreng.	infrequent	rare	widespread
Convolvulus spithamaeus L.	no report	infrequent	northern
Drosera intermedia Hayne	local	rare	northern
D. rotundifolia L.	scarce	rare	widespread
Gerardia skinneriana Wood	no report	rare	northern
Krigia virginica (L.) Willd.	no report	frequent	widespread
Lilium philadelphicum L.	infrequent	infrequent	northern
Lithospermum canescens (Michx.) Lehm.	common	frequent	western
Polygala cruciata L.	local	infrequent	coastal plain
Tephrosia virginiana (L.) Pers.	common	common	widespread
Viola lanceolata L.	infrequent	frequent	widespread
Xyris torta Sm.	scarce	infrequent	southern

[1]Moseley, E.L. 1928. Flora of the Oak Openings. Proc. Ohio Acad. Sci. 8(3):80-134.

FLORA OF DAYTON PRAIRIE, A REMNANT OF TERRE COUPEE PRAIRIE, IN MICHIGAN

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Terre Coupee Prairie, Portage Prairie, and Rolling Prairie were among the finest and largest prairies of northern Indiana, in LaPorte and St. Joseph Counties, and in Berrien County, Michigan. They contained 6000-8000 ha (15,000-20,000 acres). The Terre Coupee Prairie extended northward into Michigan, just south of the present town of Dayton (Fig. 1).

HISTORY OF TERRE COUPEE PRAIRIE

Prairies were important in the early history of the area (Chapman, 1880). The Indians, seeking out the easiest route of travel, established The Great Sauk Trail across these prairies (Hinsdale, 1931). In Michigan, the Trail followed a line of prairies, passing through Beardley, White Pigeon, Baldwin, Sturgis, Bronson, Coldwater, and Allen Prairies (Butler, 1947). When a Chicago to Detroit Road was surveyed, it was laid along the Sauk Trail. The Michigan Road, a common early route of travel in Indiana, extended north from Indianapolis to South Bend and then continued westward to Lake Michigan at Michigan City, crossing Portage, Terre Coupee, and Rolling Prairies. These prairies were favorite camping grounds for several tribes of Indians.

The prairies were among the first lands selected for homes by incoming settlers. The first settler on Terre Coupee Prairie was Charles Vail in 1830. Terre Coupee village, founded on The Sauk Trail in 1837 on the prairie, was a thriving trading post and stage coach stop, whose name was later changed to Hamilton. In Michigan, fur trader Joseph Bertrand in 1806 established a trading post on St. Joseph River at the site of Bertrand, "Parc-aux-vaches" (Burgh, 1939). Squire Isaac Thompson settled at Niles in 1823 and in 1828 Rev. Isaac McCoy established the Cary Mission at this locality (Coolidge, 1906).

At the present site of Dayton, Benjamin Redding built a log cabin and sawmill on the creek in 1831. When the Michigan Central Railroad was completed, this stop was known as Terre Coupee, but later the name was changed to Dayton as several families, who settled here, came from Dayton, Ohio. A road extending southwesterly from Buchanan towards Dayton retains the name Terre Coupee.

DAYTON PRAIRIE

Because of the rich prairie soil Terre Coupee Prairie, like many of its kind, was plowed early for agriculture. Today the prairie consists of large, rich farms. However, a small sector known as the Dayton Prairie, located along the northeastern edge of the farmlands, still retains some prairie plants. This area extends along both the north and south sides of Curran Road (Section 16 in Bertrand Township) where two branches of McCoy Creek cross the road. The tract is much lower and wetter than most of Terre Coupee Prairie which probably explains why it has escaped cultivation.

FLORISTIC COMPOSITION OF DAYTON PRAIRIE

Several visits were made to the Dayton Prairie at different seasons during 1974 to 1977 to obtain data on the flora. A list of the plants in the tract is in Table 1. This prairie, containing 176 species, compares favorably with other prairies of southern Michigan (Thompson, 1968, 1975) and is classed as a wet prairie.

Although only slight changes in elevation occur throughout the area, the composition of local plant communities show distinct differences in character and exhibit considerable variation. The species

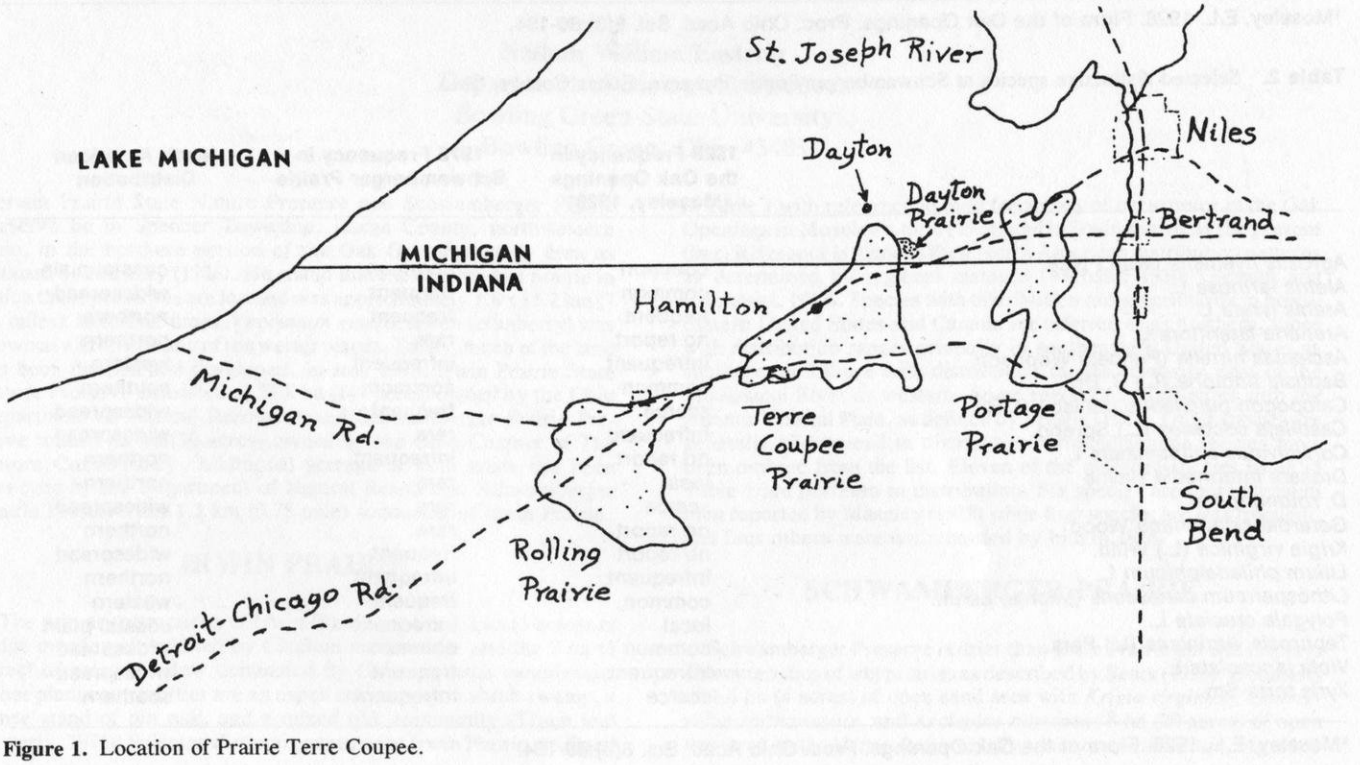

Figure 1. Location of Prairie Terre Coupee.

Table 1. Floristic composition of Dayton Prairie. Nomenclature follows Gleason (1952)[1].

Composites
Achillea millefolium
Aster laevis
A. lateriflorus
A. lucidulus
A. novae-angliae
A. pilosus
A. praealtus
A. puniceus
A. umbellatus
Bidens cernua
B. coronata
Chrysanthemum leucanthemum
Cirsium arvense
C. muticum
Coreopsis tripteris
Erigeron philadelphicus
E. strigosus
Eupatorium maculatum
E. perfoliatum
Helianthus giganteus
H. grosseserratus
H. laetiflorus
Hieracium aurantiacum
Lactuca canadensis
Rudbeckia hirta
Senecio pauperculus
Silphium integrifolium
S. terebinthinaceum
Solidago altissima
S. canadensis
S. gigantea
S. graminifolia
S. juncea
S. nemoralis
S. ohioensis
S. patula
S. riddellii
S. rugosa
S. uliginosa
Sonchus uliginosus
Tragopogon pratensis
Vernonia missurica

Figworts
Chelone glabra
Pedicularis lanceolata
Penstemon digitalis
Veronicastrum virginicum

Sedges, Grasses
Scirpus americanus
S. atrovirens
S. cyperinus
S. validus
Agrostis stolonifera
Andropogon gerardii
Bromus ciliatus
B. inermis
Calamagrostis canadensis
Dactylis glomerata
Elymus canadensis
Hierochloe odorata
Leersia oryzoides
Muhlenbergia sp.
Phleum pratense
Phragmites communis
Poa compressa
Sorghastrum nutans
Spartina pectinata

Roses
Agrimonia gryposepala
Fragaria virginiana
Geum canadense
Potentilla canadensis
P. recta
Rosa blanda
R. palustris
Rubus allegheniensis
R. occidentalis
Spiraea alba

Legumes
Amphicarpa bracteata
Apios americana
Desmodium canadense
Lathyrus palustris
Lespedeza capitata
Melilotus alba
M. officinalis
Trifolium hybridum
T. pratense
Vicia villosa

Violets
Viola cucullata
V. papilionacea
V. septentrionalis

Crowfoots
Anemone canadensis
A. virginiana
Caltha palustris
Clematis virginiana
Ranunculus abortivus
R. septentrionalis
Thalictrum dasycarpum

Umbels
Angelica atropurpurea
Cicuta maculata
Daucus carota
Heracleum lanatum
Oxypolis rigidior
Zizia aurea

Mints
Lycopus americanus
Mentha arvensis
Monarda fistulosa
Prunella vulgaris
Pycnanthemum virginianum
Scutellaria galericulata

Lilies
Allium cernuum
Asparagus officinalis
Lilium michiganense
Smilacina stellata

Milkweeds
Asclepias incarnata
A. syriaca
Apocynum cannabinum
A. sibiricum

Shrubs
Salix bebbiana
S. candida
S. discolor
S. glaucophylloides
Betula pumila
Corylus americana
Rhus radicans
R. vernix
Ceanothus ovatus
Vitis riparia
Cornus purpusi
C. racemosa
C. stolonifera
Sambucus canadensis
Viburnum lentago

Other Species
Equisetum arvense
E. laevigatum
Onoclea sensibilis
Osmunda regalis
Thelypteris palustris
Typha angustifolia
T. latifolia
Tradescantia ohiensis
Hypoxis hirsuta
Iris virginica
Sisyrinchium albidum
Cypripedium candidum
Urtica dioica
Rumex obtusifolius
Polygonum pensylvanicum
Dianthus armeria
Barbarea vulgaris
Cardamine bulbosa
Lepidium campestre
Rorippa islandica
Parnassia glauca
Saxifraga pensylvanica
Oxalis europaea
Geranium maculatum
Impatiens biflora
Hypericum majus
H. perforatum
Epilobium angustifolium
Oenothera biennis
Dodecatheon meadia
Lysimachia terrestris
Steironema quadriflorum
Gentiana andrewsii
G. procera
Convolvulus sepium
Phlox maculata
Polemonium reptans
Verbena hastata
Physalis heterophylla
Solanum dulcamara
Galium asprellum
G. boreale
Valeriana ciliata
Campanula aparinoides
Lobelia kalmii
L. siphilitica

[1]Gleason, H. A. 1952. The new Britton and Brown illustrated flora of the northeastern United States and adjacent Canada. 3 vols. N.Y. Bot. Gard., N.Y., N.Y.

which occur frequently are *Solidago ohioensis*, *S. gigantea*, *Aster lucidulus*, *Coreopsis triptera*, *Silphium integrifolium*, *Angelica atropurpurea*, *Zizia aurea*, *Pycnanthemum virginianum*, *Steironema quadriflorum*, *Polemonium reptans*, *Valeriana ciliata*, and *Thelypteris palustris*. Several species are on the Michigan list of rare and endangered species (Wagner et al., 1977). These species are shooting star (*Dodecatheon meadia*), sweet william phlox (*Phlox maculata*), white ladyslipper (*Cypripedium candidum*), Jacob's ladder (*Polemonium reptans*), valerian (*Valeriana ciliata*), and rosinweed (*Silphium integrifolium*). Listed in decreasing order the major groups are composites, grasses and sedges, roses and legumes, crowforts and umbels, and mints with 42, 19, 10, 7, and 6 species, respectively.

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SAVING MICHIGAN'S RAILROAD STRIP PRAIRIES

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A management agreement with AMTRAK has safeguarded Michigan's railroad strip prairies. Some of southwestern Michigan's last prairie remnants lie along the AMTRAK route between Lawton, Michigan, and the Michigan-Indiana border. In November 1977, AMTRAK began bulldozing from fence to fence along the entire length of the railroad right-of-way as part of a program to upgrade the Michigan line. AMTRAK officials were receptive to the idea of preserving prairie relicts if they contained uncommon species and arrangements could be made to maintain them properly. Six representative prairie strips were identified with the help of the District Engineer for AMTRAK. It was agreed that these would be excluded from immediate clearing provided encroaching brush was removed from the parcels. A management agreement appeared to be the best vehicle to provide for continued maintenance of the prairie strips. The Nature Conservancy negotiated the management agreement with AMTRAK. Four miles (6.4 km) of prairie ecosystem, containing 15 species on the list of endangered, threatened, and rare plants of Michigan (Wagner, et al., 1977) have been preserved through this arrangement.

THE RAILROAD

Michigan Central Railroad constructed the line from Kalamazoo to Niles in the autumn of 1848 and completed the section from Niles to New Buffalo in the spring of 1849. The route was built in part through existing prairies. The original right-of-way was 30.3 m (100 ft) wide and provided a refuge for prairie species. In some places the sod remained unbroken, virgin prairie. Disturbed areas were quickly reseeded from surrounding prairie not yet cultivated. The railroad right-of-way was burned regularly until 1950 preserving an ideal habitat for prairie species.

In April 1976, AMTRAK acquired the line for passenger service. Projected improvements including bulldozing, brush removal, and use of herbicides threatened prairie remnants along the tracks. Since some of southwestern Michigan's last prairie relicts were located along these railroad strips, it seemed desirable to preserve those which contained uncommon plants. In August 1977, negotiations were begun to prevent obliteration of these prairies in Michigan.

Little precedent has been established for negotiating with a railroad to set aside parcels for plant conservation. The problem was first presented to Ben Stark, the AMTRAK District Engineer. He indicated that AMTRAK might be willing to cooperate in such a project if these areas were unique and if permanent arrangements could be made for maintenance according to government specifications.

The area between New Buffalo and Kalamazoo was surveyed jointly with railroad representatives to determine where the major prairie relicts were located, how they could be protected, and how they were to be maintained. Six areas were selected for preservation in August 1977. Through an informal agreement these parcels were not to be bulldozed, and, in return, the encroaching brush was to be removed. A lease agreement between AMTRAK and a conservation agency appeared to be the best vehicle to provide for continued maintenance.

During 1978, protection of selected sites began. Signs were installed to prevent future bulldozing and brush was cut from the preserved areas. With cooperation from AMTRAK and the Department of Natural Resources, two strip prairies were burned in the spring of 1978. Negotiations with The Nature Conservancy as a private agency to lease and manage these strip prairies are underway.

DESCRIPTION OF PRAIRIE REMNANTS

The railroad prairie remnants consist of six individual parcels totaling about four miles (6.4 km) between the Michigan-Indiana boundary and Lawton, Michigan. These tracts represent some of the last prairie relicts in Michigan. Dry, mesic, and wet prairie sites along the tracks contain many of the endangered and threatened prairie species on the state list.

Grand Beach Tract in Berrien County is in New Buffalo Township, T8S, R21W, Section 17, Section 18, SE¼, and Section 19, NE¼, on

[1] Current address: The Nature Conservancy, 328 E. Hennepin Ave., Minneapolis, Minnesota 44514.

the north side of the tracks between mile post 220 and 222. It is flat sand prairie bordered by oak and pine forest. The soil is well-drained humic, composed of Oakville, Pipestone, and Bridgman Series. Most of the area is covered with little bluestem *(Andropogon scoparius)*, with a few scattered stands of Indian grass *(Sorghastrum nutans)*. Among the characteristic dry prairie species are bush clover *(Lespedeza capitata)*, puccoon *(Lithospermum croceum)*, starved panic grass *(Panicum depauperatum)*, and butterfly weed *(Asclepias tuberosa)*. Meadow beauty *(Rhexia virginica)*, listed as rare on Michigan's endangered species list, is also present.

Schwark Road prairie is in Berrien County, in Three Oaks Township, on the four corners of the intersection of Schwark Road with the railroad. It is in T8S, R20W, Section 3 and Section 4, SE¼, from mile post 212.6 to 212.9, on both sides of the tracks. Soils at Schwark Road are part of the Pewamo Series with mollic in the A horizon and heavy clay loam in the B horizon. This mesic prairie has scattered stands of big bluestem *(Andropogon gerardii)*, wild lupine *(Lupinus perennis)*, and mountain mint *(Pycnanthemum virginianum)*. Of special interest is compass plant *(Silphium laciniatum)* which is listed as threatened and occurs in only a few places in Michigan.

Bakertown Fen in Berrien County, Buchanan Township, T7S, R18W, Section 34, SE¼, is located on both sides of the tracks from mile post 119.5 to 200. The fen and wet prairie soils are Houghton Muck with a pH of 7.2. This fen encompasses both wet and mesic prairies. The area has white lady's-slipper *(Cypripedium candidum)*, spotted phlox *(Phlox maculata)*, Jacob's ladder *(Polemonium reptans)*, Sullivant's coneflower *(Rudbeckia sullivantii)*, and rosinweed *(Silphium integrifolium)* which are all on the Michigan list of threatened plants. Valerian *(Valeriana ciliata)*, which is listed as rare, is also present.

The prairie at Thompson Road in Cass County, Pokagon and Howard Townships, T6S, R16W, Section 32, SE¼, andT7S, R18W, Section 5, NE¼, is on the north side of the tracks between mile post 186.5 and 186.7, where the road and the railroad are parallel. The soil consists of Thetford and Brady Series, probably formed under grass vegetation. Thompson Road is the best mesic prairie site in Cass County. Typical prairie species are prairie coreopsis *(Coreopsis palmata)*, rosinweed *(Silphium integrifolium)*, rattlesnake master *(Eryngium yuccifolium)*, and bird foot violet *(Viola pedatifida)*; all of which are threatened.

Klumbis Road Prairie in Cass County, Pokagon Township, T6S, R16W, Section 22, SW¼, lies on the south side of the tracks between mile post 183.8 and 184, where the road and the railroad are parallel. Klumbis Road soils are Morocco and Spinks Series developing towards prairie soil types. Klumbis Road is a mesic prairie, but it tends to have species requiring sandy soil. Prairie coreopsis (*Coreopsis palmata*) and rosinweed (*Silphium integrifolium*), which are listed as threatened, and columbo (*Swertia caroliniensis*), which is listed as rare, are abundant on the site.

Lawton is in VanBuren County, T35, R13W, Section 22, SW¼, from mile post 158.9 to 159.5. It is mesic prairie with large stands of big bluestem *(Andropogon gerardii)* and with the following threatened species: white wild indigo *(Baptisia leucantha)*, rattlesnake master *(Eryngium yuccifolium)*, and dropseed *(Sporobolus heterolepis)*.

Because these areas constitute some of the last prairie remnants in Michigan and contain 15 species on the Michigan list of endangered, threatened, and rare species (Wagner, et al., 1977), their preservation is warranted. Through the negotiations between AMTRAK and The Nature Conservancy, these railroad prairies in Michigan have been preserved.

ACKNOWLEDGEMENTS

The author thanks the management and staff of AMTRAK for support and assistance with this project. Ben Stark, district engineer, was particularly helpful in facilitating arrangements with AMTRAK and assisted with surveying in August 1977. The regional engineer, Ken Kulck, aided in the designation of the areas to be preserved.

In addition, Stan Beikmann, director of Fernwood, Inc., 1720 Range Line Road, Niles, Michigan, 49120, and his staff provided the labor force for cutting brush and burning the railroad right-of-way in the spring of 1978.

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A SURVEY OF PRAIRIE PRESERVATION AND RECONSTRUCTION IN MICHIGAN

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Progress has been made in the preservation of native grassland communities in Michigan since the survey of preserved remnants by Thompson (1972). Currently preserved native grassland sites and prairie reconstructions in Michigan are listed here with a brief description of each. Additional native grasslands in the state are recommended for preservation on further study and are also described. The survey covers preserved sites belonging to federal, state, local, and private agencies, in addition to prairie reconstructions and sites which have no protection but which should be evaluated.

Information is presented in the following manner: name of site; ownership (owner); location (site); type of community and dominant species (type); species listed which are noted as endangered, unusual for the area, or of assistance in categorizing the community (other); management and nature of preservation (management); literature pertaining to the area (cite); names and addresses of persons to whom inquiries may be directed (inquire).

PRESERVED SITES

Federal

Newaygo Dry Prairies

Owner. U.S. Forest Service.
Site. Newaygo County, Brooks Township, Section 35, NE ¼, 32 ha (80 acres). (Part of larger grassland area; see Newaygo Plant Preserve and Newaygo Dry Prairies in "Unprotected Sites.")
Type. Dry Prairie; *Carex pensylvanica*.
Other. *Stipa spartea, Opuntia humifusa, Koeleria cristata, Liatris cylindracea, Campanula rotundifolia, Aureolaria pedicularia*, and *A. flava*.

Management. Limited, experimental burning in quadrats. Accidental fire in fall 1975. Dedicated by Forest Service on recommendation of Michigan Natural Areas Council (MNAC).
Cite. Hauser (1953). *MNAC Site and Reconnaisance Reports.*
Inquire. Dr. Ronald Kapp, Provost, Alma College, Alma, Michigan 48801; Pat Allen, 529 Greenwood SE, Grand Rapids, Michigan 49506.

State

Allegan Oak Plains

Owner. Michigan Department of Natural Resources (MDNR), Allegan State Game Area.
Site. Allegan County, Manlius Township, Section 35, NE ¼, 48.8 ha (122 acres). (Part of larger grassland area; see Allegan State Game Area in "Unprotected Sites.")
Type. Oak Barren; *Quercus velutina, Andropogon scoparius, Carex pensylvanica,* and *Koeleria cristata.*
Other. *Viola pedata, Senecio plattensis, Lupinus perennis, Lithospermum croceum, Liatris cylindracea,* and *Swertia caroliniensis.*
Management. Burned in spring 1978. Wildlife Management Plan designated site as prairie management area.
Cite. Schaddelee (1975). *MNAC Site and Reconnaisance Reports.*
Inquire. Lee Schaddelee, 272 Clardelle, Benton Harbor, Michigan 49022; Allegan State Game Area, Allegan, Michigan 49010.

Algonac State Park Prairies

Owner. MDNR
Site. St. Clair County, Clay and Cottreville Townships, ca 14 ha (35 acres) in four tracts. (Part of larger grassland area; see Algonac State Park Prairies in "Unprotected Sites.")
Type. Wet Prairie (three tracts); Compositae, *Pycnathemum* spp. Wet Sand Prairie: *Andropogon scoparius.*
Other. *Asclepias sullivantii, A. purpurascens, Calopogon pulchellus, Spiranthes cernua,* and *Liatris spicata.* Wet Sand; *Aletris farinosa, Baptisia tinctoria,* and *Polygala sanguinea.*
Management. Periodic mowing of two wet tracts. Dedicated as Managed Tract on recommendation of MNAC.
Cite. Thompson (1972, 1975). *MNAC Site and Reconnaisance Reports.*
Inquire. Paul Thompson, 17503 Kirkshire Rd., Birmingham, Michigan 48009; Harold Buchenmeyer, Mgr., Algonac State Park, Algonac, Michigan 48001.

Bowerman Prairie

Owner. MDNR, Barry State Game Area.
Site. Barry County; Yankee Springs Township; Section 10, SE ¼; Section 15, NE ¼; 18 ha (45 acres.)
Type. Wet to Mesic Prairie and Sand Barren.
Other. Dry; *Asclepias viridiflora, Stipa spartea,* and *Viola pedata.* Wet; *Aletris farinosa,* and *Gentiana crinita.*
Management. Informal preservation. Status unclear.
Cite. *MNAC Site and Reconnaisance Reports.*
Inquire. S. Ouwinga, TNC, 531 N. Clippert, Lansing, Michigan 48912.

Minong Prairie

Owner. MDNR, Petersburg State Game Area.
Site. Monroe County, Summerfield Township, Section 16, SE ¼, ca 4 ha (10 acres). (Part of larger grassland area located within Petersburg State Game Area.)
Type. Wet Sand Prairie; *Andropogon scoparius* and *A. gerardii.*
Other. *Aletris farinosa, Polygala sanguinea, Liatris spicata, L. novae-angliae, Heuchera richardsonii, Asclepias hirtella,* and *Vaccinium angustifolium.*
Management. Informal preservation by verbal agreement.
Inquire. M. Cooley, MDNR, Stephens T. Mason Bldg., Lansing, Michigan 48908.

Local

Ann Arbor Wet Prairie

Owner. City of Ann Arbor, Parks and Recreation Department.
Site. Washtenaw County, S bank of Huron River, E of Geddes Bridge, 2 ha (5 acres).
Type. Wet Prairie and Mesic Railroad Strip Prairie.
Other. *Lilium philadelphicum* and *Silphium terebinthinaceum.*
Management. Dedicated as Managed Tract on recommendation of MNAC. Recent road construction disturbed part of this site.
Cite. Thompson (1968, 1972, 1975).
Inquire. Paul Thompson, 17503 Kirkshire, Birmingham, Michigan 48009.

Bakertown Fen

Owner. City of Buchanan.
Site. Berrien County, Buchanan Township, Section 34, SE ¼, 2.8 ha (7 acres).
Type. Fen and Wet Prairie.
Other. *Cypripedium candidum, Phlox maculata, Polemonium reptans, Rudbeckia speciosa* and *Dodecatheon meadia.*
Management. Brush clearing and burning planned for fall 1978. Dedicated as Managed Tract on recommendation of MNAC.
Cite. Kohring, In preparation.
Inquire. TNC, 531 N. Clippert, Lansing, Michigan 48912.

Decatur School Pines

Owner. Decatur Board of Education.
Site. Van Buren County, Decatur Township, Section 16, S ½, 0.2 ha (0.5 acres.)
Type. Sand Barren; *Andropogon scoparius.*
Other. *Viola pedata, Liatris aspera, L. cylindracea, Lithospermum croceum,* and *Polygala polygama.*
Management. Informal agreement to hold undisturbed.
Inquire. Mr. Frank Popp,% Decatur High School, Decatur, Michigan 49045.

Helmer Brook Fen

Owner. City of Battle Creek, pending sale to Michigan Nature Association (MNA).
Site. Calhoun County, T1S, R8W, Section 33, SE ¼, ca 12 ha (30 acres) of various prairie communities, 4 ha (10 acres) pending sale to MNA.
Type. Fen with adjacent Mesic Prairie.
Other. *Silphium terebinthinaceum, Phlox pilosa, Lithospermum canescens, Heuchera richardsonii, Oenothera pilosella, Solidago ohioensis, Gentiana crinita, Cypripedium calceolus, C. pubescens, Potentilla fruticosa,* and *Filipendula rubra.*
Management. Informal preservation pending sale.
Inquire. Bertha Daubendiek, 7981 Beard Rd., Avoca, Michigan 48006.

Middlebelt Prairie

Owner. Huron-Clinton Metropolitan Authority.
Site. Wayne County, Huron Township, N bank of Huron Slough, S of Huron River Rd., 0.4 km (0.25 mile) W of Middlebelt Rd., ca 8 ha (20 acres).
Type. Open oak forest; *Quercus velutina* and *Q. rubra.* Adjacent old field with prairie species.
Other. *Andropogon gerardii, Aster ericoides, Aureolaria flava, Heliopsis helianthoides, Heuchera richardsonii,* and *Hepatica americana.*
Management. Periodic mowing and brush removal. Dedicated as Managed Tract on recommendation of MNAC.
Cite. Thompson (1972). *MNAC Site and Reconnaisance Reports.*
Inquire. Bob Wittersheim, Oakwoods Metropark, P.O. Box 332, Flat Rock, Michigan 48134.

Private

AMTRAK Railroad Strip Prairies

Owner. AMTRAK, leased to The Nature Conservancy (TNC).
Site. Six separate sites on Michigan Central line between Kalamazoo and Michigan City, totaling ca 6.4 km (4 miles) of rights-of-way.
Type. Broad spectrum of prairie communities.
Other. *Silphium laciniatum, S. integrifolium, Coreopsis palmata, Dodecatheon meadia, Eryngium yuccifolium, Viola pedatifida, V. palmata, Swertia caroliniensis,* and *Gentiana flavida.*
Management. Two sites burned in spring 1978. Brush removal.
Cite. Kohring (1981), Scharrer (1971).
Inquire. TNC, 531 N. Clippert, Lansing, Michigan 48912.

Goodison Prairies

Owner. Private owners subject to Scenic Easement held by Oakland Township. A portion has been voluntarily placed under a local Open Space Easement under the Michigan Farmland and Open Space Protection Act.
Site. Oakland County, Oakland Township, Section 33, NE 1/4, ca 0.4 ha (1 acre).
Type. Degraded with Dry and Mesic Prairie species.
Management. None.
Inquire. Alice Tomboulian, 798 W. Gunn Rd., Rochester, Michigan 48063.

Karl Chen Memorial Prairie

Owner. MNA.
Site. St. Joseph County, Mottville Township, Section 21, NE 1/4, 12 ha (30 acres). Prairie is small portion of entire property.
Type. Oak woods; *Quercus velutina, Q. borealis,* and *Sassafras albidum* with prairie species in groundstory.
Other. *Baptisia leucantha, Amorpha canescens, Heuchera richardsonii, Phlox pilosa, Swertia caroliniensis,* and *Helianthus divaricatus.*
Management. Occasional brush removal. Preserved through purchase by MNA.
Inquire. B. Daubendiek, 7981 Beard Rd., Avoca, Michigan 48006.

Lefglen

Owner. MNA.
Site. Jackson County, Grass Lake Township, Section 18, NW¼. Open area 4-8 ha (10-20 acres). Prairie community ca 0.4 ha (1 acre).
Type. Aggregation of Dry Prairie species in old-field setting.
Other. *Solidago nemoralis, Lespedeza capitata, Asclepias verticillata, Ceanothus americanus,* and *Verbena stricta.*
Management. MNA policy.
Inquire. B. Daubendiek, 7981 Beard Rd., Avoca, Michigan 48006.

Newaygo Plant Preserve

Owner. MNA.
Site. Newaygo County, Brooks Township, Section 2, SW¼; Section 11, W½ and NW¼; 44 ha (110 acres). (Part of larger grassland area; see Newaygo Dry Prairies in "Preserved Sites" and "Unprotected Sites.")
Type. Dry Prairie; *Carex pensylvanica.*
Other. *Geum triflorum, Viola pedata, Stipa spartea, Bouteloua curtipendula, Opuntia humifusa, Aster sericeus,* and *A. ptarmicoides.*
Management. MNA policy.
Inquire. B. Daubendiek, 7981 Beard Rd., Avoca, Michigan 48006.

Rattlesnake Master Plant Preserve

Owner. MNA.
Site. St. Joseph County, Park Township, Section 15, NW ¼, 1.2 ha (3 acres). Part of a larger, contiguous grassland area of which 10.8 ha (27 acres) are unprotected and privately owned.
Type. Disturbed Wet Sand Prairie; *Andropogon scoparius, Carex bicknellii,* and *Juncus greenii.*
Other. *Baptisia leucantha, Eryngium yuccifolium, Polygala sanguinea,* and *Spiranthes cernua.*
Management. MNA policy.
Inquire. B. Daubendiek, 7981 Beard Rd., Avoca, Michigan 48006.

Sauk Trail Plant Preserve ("The Sturgis Triangle")

Owner. MNA.
Site. Triangle formed by U.S. Rt. 12, Shimmel Rd. and Conrail Railroad in Section 6, Sturgis Township, St. Joseph County. Some maps are in error and show site 3.2 km (2 miles) east. Four-tenths ha (0.24 acre) with an equal adjacent area unprotected railroad right-of-way prairie.
Type. Dry Mesic Prairie with border elements; *Andropogon gerardii.*
Other. *Coreopsis palmata, Amorpha canescens, Claytonia virginica, Lupinus perennis, Ranunculus fascicularis, Solidago rigida,* and *Quercus prinoides.*
Management. MNA policy.
Inquire. Robert Pleznac, Kalamazoo Nature Center, 7000 N. Westnedge, Kalamazoo, Michigan 49007.

Woodruff Creek Plant Preserve

Owner. Private owner.
Site. Livingston County, near Brighton, 0.2 ha (0.5 acre).
Type. Fen and Wet Prairie with small adjacent dry area.
Other. *Silphium terebinthinaceum, Hierochloe odorata, Potentilla fruticosa, Drosera rotundifolia, Liatris cylindracea, Viola pedata,* and *Heuchera richardsonii.*
Management. Informal preservation by owner pending possible transfer to MNA.
Inquire. B. Daubendiek, 7981 Beard Rd., Avoca, Michigan 48006.

RECONSTRUCTIONS

Local

Earl's Prairie, Seven Ponds Nature Center

Owner. Michigan Audubon Society.
Site. Lapeer County, Dryden Township, Section 8, 4 ha (10 acres). More people visit this area, the largest reconstruction in the state, than visit all other Michigan prairie reconstructions combined. Surrounding a pond is a relatively "weed-free" Wet-Mesic Prairie of ca 0.4 ha (1 acre). The balance of the reconstruction has significant prairie grass cover and showy, late-season forbs, but large alien elements exist. Among the most prominent prairie species are *Ratibida pinnata, Silphium terebinthinaceum,* and *S. laciniatum.*
Inquire. Dan Farmer, Dir. Seven Ponds Nature Center, Crawford Rd., Dryden, Michigan 42428.

University of Michigan Botanical Gardens Prairie

Owner. University of Michigan.
Site. Mathei Botanical Gardens, Dixboro Rd., N of Geddes Rd., Ann Arbor, ca 0.8 ha (2 acres). This prairie reconstruction was begun by Bland (1970). Three and two-tenths ha (8 acres) were planned but not completed. The project has established several communities. One nearly "weed-free" area presents a dry aspect, with *Stipa spartea* dominating a community of such forbs as *Lespedeza capitata, Potentilla arguta,* and *Echinacea pallida.* Portions will require management to control "weeds."
Inquire. Patricia Pachuta, c/o Univ. Michigan Botanical Gardens, 1800 Dixboro Rd., Ann Arbor, Michigan 48109.

Chippewa Nature Center Prairie

Owner. Chippewa Nature Center, Inc.
Site. 400 Badour Rd., 4 km (2.5 miles) W of Midland, S of Chippewa

Rd. This project began in 1978 and may qualify as a "restoration" with its goal to enrich a degraded native grassland community. The remnant has been invaded by pines, oaks, and various "weeds." *Andropogon scoparius* dominates a community of dry species, but wetter species suggest a Wet Sand Prairie. *Gentiana crinita, Veronicastrum virginicum, Polygala sanguinea, Physostegia virginiana,* and *Sisyrinchium albidum* occur here.
Inquire. Mark Thogerson, Chippewa Nature Center, Rt. 9, Midland, Michigan 48640.

Whitehouse Nature Center Prairie

Owner. Albion College.
Site. Nature Center lies E of athletic complex on campus of college, 1.2 ha (3 acres). Broadcast planting from 1973 to 1976 yielded a significant aggregation of prairie plants including large number of *Eryngium yuccifolium* and *Liatris spicata* on a clay-loam site. Management includes annual spring burning.
Inquire. Will Redding, Whitehouse Nature Center, Albion College, Albion, Michigan 48224.

Kalamazoo Nature Center Prairie

Owner. Kalamazoo Nature Center.
Site. 7000 N. Westnedge, 11.2 km (7 miles) N of Kalamazoo, 0.4 (1 acre). Over 100 forb species established here in a grassland community with few "weeds." Overplanting of tallgrasses, especially *Panicum virgatum,* is a threat to the success of newer plantings. Legumes are abundant, especially *Amorpha canescens, Baptisia leucantha,* and *Petalostemum purpureum.*
Inquire. Monica Evans, Kalamazoo Nature Center, 7000 N. Westnedge, Kalamazoo, Michigan 49007.

Fernwood Prairie Project

Owner. Fernwood, Inc..
Site. Four and eight-tenths km (3 miles) N of Buchanan on Range Line Rd., E Bank St., Joseph River, ca 0.8 ha (2 acres). Over 130 prairie species grow on a mesic site notable for a spring display of such forbs as *Phlox pilosa, Senecio plattensis,* and *Heuchera richardsonii.* Invasion by *Setaria virdis* and other "weedy" species of grasses has been a problem in the newer planting, but a policy of handweeding and burning should control "weeds."
Inquire. Dan Nepstad, 1720 Range Line Rd., Niles, Michigan 49120.

UNPROTECTED SITES

Recommended for Preservation

Cemeteries

Barry. Adjacent to Bowerman Prairie (See "Preserved Sites" above.), Barry County. Dry Prairie.

Railroad Rights-of-Way

Bertrand. Penn Central Line, Section 11, 14, Bertrand Township E, Berrien County (Thompson, 1975).

West Fruit Belt Line. N of 64th Ave., Section 19, Paw Paw Township, Van Buren County. Mesic to Dry. *Eryngium yuccifolium, Lilium philadelphicum,* and *Baptisia leucantha.*

East Fruit Belt Line. Section 4, 7, 8, Texas Township, Kalamazoo County.

Fairfax. Conrail line. Section 18, 19, Colon Township, St. Joseph County (Thompson, 1975).

Parma. Parma and Concord Township, Jackson County. Mesic to wet. *Lilium philadelphicum, Silphium terebinthinaceum, Cypripedium candidum, and Baptisia leucantha.*

Jackson Prairie. Between Penn Central line and Park St., SW of city of Jackson (Thompson, 1975).

Otter Creek. Penn Central line between Lasalle Station and Cousino Station, Lasalle Township, Monroe County (Thompson, 1975).

State

Allegan State Game Area. Allegan County. Large areas S and E of managed site. (See Allegan Oak Plains in "Preserved Sites.")

Algonac State Park Prairies. St. Clair County. More Wet Sand Prairies in open areas along W park entrance road off of Marsh Rd. (See Algonac State Park Prairies in "Preserved Sites.")

Gourdneck State Game Area. Kalamazoo County, Section 19, Portage Township, Fen and Wet Prairie, W of Hampton Lake. Under study by Ken Sytsma, Dept. Biology, Western Michigan Univ., Kalamazoo, Mich.

Federal

Newaygo Dry Prairies. Newaygo County. Three Dry Prairie sites of ca 176 ha (440 acres) in parts of Section 1,2,11,12,25,26,35,36, Brooks Township;Section 2,3,4,9,10,11,13, Croton Township; Section 35, Everett Township *(MNAC Reconnaisance Reports).* This far northern outlier of the Prairie Peninsula holds the largest concentration of prairie in the state and, compared to Dry Prairies in other parts of the state, exhibits greater affinities to sites of western states. (See Newaygo Dry Prairies and Newaygo Plant Preserve in "Preserved Sites.")

Private

Bakertown Fen. Bertrand Township, W Berrien County. S and W of the Bakertown Fen discussed in "Preserved Sites."

Dayton Prairie. Bertrand Township W, Section 16, Berrien County. Wet Prairie of ca 168 ha (420 acres) (Thompson, 1981). The Nature Conservancy is reviewing the area and may receive a gift of land in it.

Concord Fen. Section 9, NW ¼, Pulaski Township, Jackson County. Fen of ca 16 ha (40 acres). *Castilleja coccinea, Cypripedium candidum, Liatris spicata, Gentiana crinita,* and *Solidago ohioensis.*

Indian Bowl. Berrien Township, Berrien County. Parts of Section 8, 17, 18, hold ca 80 ha (200 acres) of Fen, Wet Prairie, and Forest having over 300 species (Medley, 1970). Kamer Fund monies have been denied for state purchase of Indian Bowl for the second year in a row.

Recommended for Further Study

Cemeteries

German Settler Cemetery. Wayne County, NW of 194 and Telegraph Rd. and S of Van Born Rd.

Sumnerville. Cass County, E of Village on Pokagon Highway. A remnant of Pokagon Prairie.

Hillside Cemetery. Washtenaw County, City of Ypsilanti.

Railroad Rights-of-Way

Air Line Railroad. Cassopolis to Corey, Cass County.

Moshierville Station Area. Hillsdale County.

Cavanaugh Road and Snow Prairie Road. Branch County.

State

Bald Mountain State Recreation Area. Oakland County.

Island Lake State Recreation Area. Livingston County.

Fort Custer State Recreation Area. Kalamazoo County *(MNAC Site and Reconnaisance Reports).*

Livermore Creek Area. Jackson-Lakeland Linear Park, Livingston County.

Fish Point State Game Area and Fen Habitat near Saginaw Bay. Bay and Tuscola Counties (Davis, 1898).

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COMPARISONS BETWEEN A PRAIRIE GROVE IN ILLINOIS AND SOUTHWESTERN MICHIGAN

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Before settlement of the Midwest, travelers reported crossing forested land until they reached large open prairie lands in Ohio, Indiana, Illinois, and Michigan (Hanes, 1944). Isolated on Michigan's largest prairie was a 300 acre (120 ha) mixed hardwood forest which came to be known as the Big Island. Most of the former acreage is now occupied by the village of Schoolcraft, 15 miles (24 km) south of Kalamazoo, Michigan. A similarly isolated forest in Gillet County, Elkhart, Illinois, called Gillet Hill, was settled by one family and has remained rather undisturbed since.

The Island appears to be more closely related to Gillet Hill prairie grove of central Illinois rather than the surrounding beech—maple forests of Michigan. A systematic comparison of the Island and Gillet Hill supports this contention. More tree species are shared in common between the Island and Gillet Hill than between the Island and typical beech—maple forests surrounding the Island. Forty-two percent of the major tree species in the Island grove occur in the surrounding beech—maple forests of southern Michigan; whereas, sixty-two percent of the major tree species at Gillet Hill occur in the Island suggesting a greater presence of a southwesterly forest element in Michigan. Tree species in both prairie groves are hackberry, basswood, blue ash, paw paw, sugar maple, and, notably, black maple which replaces sugar maple in western associations (Aikman and Smelser, 1938). In addition, the lack of beech trees in the Island is noted with amazement in historical records, since beech could be found surrounding the prairie closer than two miles (3.2 ha) away. Some indication that prairie lands have a filtering affect on beech seed dispersion has been discussed from a broader geographical viewpoint (Benninghoff, 1963). Thus, migration of beech to isolated groves locally may even be interrupted. The herbaceous vegetation is typically mesic in both locations. The presence of the white trout lily, *Erythronium albidum,* while not at Gillet Hill, has a distribution similar to the prairies of the central and midwestern states. The Island is the only location in Kalamazoo County and southwestern Michigan for this perennial.

The prairies that occurred in the Prairie Peninsula were rather well established ecotypes, the result of weather, soil, climatic, and topographic effects. Isolated prairie groves were scarce yet well defined, forming unique habitats. Research in the past century by Cottam (1949) and Woodward (1925) paid passing attention to the significance of isolated prairie groves. However, historical work (Gleason, 1909) and more recent work (Fleckenstein and Pippen, 1977) have treated this topic in more depth. The occurrence of the Big Island grove in Michigan may serve well in defining the Prairie Peninsula and will probably strengthen its phytogeographic significance.

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A PLANT SURVEY OF THE GENSBURG-MARKHAM PRAIRIE, COOK COUNTY, ILLINOIS

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Sampson (1921) estimated that about 2024 ha (5,000 acres) of virgin prairie were left on the lake plain of glacial Lake Chicago. While the criteria used to determine this area is unknown, certainly in the past 58 years much of this prairie has been destroyed. The rapid growth of the Chicago metropolitan area has destroyed portions of prairie that had managed to survive the early settlers (Betz and Cole, 1969; Kummer, 1942).

Some ecological investigations have been conducted on prairies in the Chicago area, notably those by Vestal (1914), Paintain (1929), and Betz and Cole (1969). These studies dealt with black soil prairies on moraines adjacent to the lake plain. Sherff (1913) examined the Skokie marshes north of Chicago and Gates (1914) reported on the sand prairie on Lake Michigan at the Illinois-Wisconsin line. This study was done as thesis research at Northeastern Illinois University (Hanson, 1975).

The Gensburg-Markham Prairie is located in Markham, Illinois, mainly in the N½ of the SW¼ of Section 13, Township 36, Range 13 east of the third principal meridian in Illinois. The preserved prairie covers about 38.8 ha (95 acres) and is located on the lake plain of glacial Lake Chicago. Several more acres of high quality prairie are adjacent to the current boundaries but not yet preserved. The southwest half of the prairie is elevated and is located on a sandy, near shore deposit from the Calumet stage of Lake Chicago. The northeast half is lower and is underlain by the clayey glacial lake bottom.

HISTORY

The prairie site passed into private ownership from the federal government in 1854. It is believed that until the mid-1920's the main agricultural use of this area was grazing or mowing for hay once or twice per year. Present plant composition of the prairie suggests that this use was not severe enough to extirpate species that decrease with this kind of use.

Some evidence exists that attempts at cultivating the area were probably made on two different occasions at the western, mesic end of the prairie. The other attempt was made at the northeastern corner of the prairie; the date is unknown, but aerial photographs indicate it occurred many years before 1939. Aerial photographs taken in the spring after the prairie had been burned show parallel, linear, shallow depressions that appear to be dead furrows, a trough at the edge of a field from which soil is plowed out, but where none is plowed in. About 1920 a tenant living on the property tried to develop a truck garden of about 3.2 ha (8 acres) at the extreme western edge. The sandy soil proved to be unsuitable for crops and the attempt was abandoned. The tenant soon left the property and it has not been occupied since. Another effort of an unknown date preceded the one just described. Prairie vegetation has reoccupied these areas so effectively that nonindigenous species make up an insignificant portion of the total cover in this area.

In the mid-1920's this property was purchased by a housing developer who subdivided the land into about 440 individual lots and sold them. The 1929 Depression effectively prevented any further development of the land including installation of utilities. The prairie remained in this condition until the land was preserved in the early 1970's by Northeastern Illinois University and The Nature Conservancy.

METHODS

Ten quadrats, each 10 m x 10 m, were established. The quadrats were placed so as to represent all of the different soil types and the three different physiographic conditions present: mesic, low, and transitional (Mapes, 1973; Persinger, 1972). Paths, roads, and "weedy" boundaries were avoided. Most of the quadrats were studied once a week from early May to mid-September in 1973 and 1975. For each quadrat the presence of individual species was noted and the period over which they bloomed was recorded. Quadrats 1, 2, 4, 5, and 6 located on 49 Watseka loamy fine sand were on elevated sandy beach deposits and were classified as mesic prairie. Quadrats 7, 8, and 10 situated on 664 Rensselaer loam were in a low, wet prairie. Quadrat 9 placed on 740 Darroch loam was classified as mesic, but was underlain by sandy clay. Quadrat 3 has both 49 Watseka and 664 Rensselaer soils and is on a transitional slope between mesic and low. The distribution of quadrats and locations of soil types and physiographic areas is in Figure 1. Nomenclature is according to Fernald (1950).

RESULTS

One hundred plant species were encountered in the ten quadrats during the study. As of January 1978, 219 naturally occurring prairie species have been identified (Betz et al., 1978) on the prairie as a whole. Sixteen species that occurred in more than half of the quadrats in the mesic prairie are listed in Table 1 and fifteen species known to occur in more than half of the quadrats in the low prairie are recorded in Table 2. The transitional nature of quadrat 3 is reflected by the fact that the most abundant species of the mesic and low prairie were located here. Half of this quadrat was dominated by *Spartina pectinata, Carex stricta,* and *Solidago gymnospermoides;* the higher half was dominated by *Andropogon gerardii* and *Sorghastrum nutans*.

DISCUSSION

In the mesic section of this prairie all plants on the above list were not evenly distributed. The following species were only in quadrats 4, 5, or 6: *Amorpha canescens, Gaylussacia baccata, Gentiana saponaria, G. puberula, Liatris aspera, Parthenium integrifolium, Pedicularis canadensis, Polygala sanguinea, Koeleria cristata, Helianthemum canadense, Eryngium yuccifolium, Solidago juncea,* and *Viola pedata. Baptisia leucophaea* was also abundant in all of these quadrats and a few plants of this species were also seen in quadrat 7.

Quadrats 4, 5, and 6 were located on the same soil types as quadrats 1 and 2. The difference seemed to be whether the soil had been plowed or not. Quadrat 2 was located in areas that appeared to have been plowed no later than the 1920's. Quadrat 1 was in an area that showed

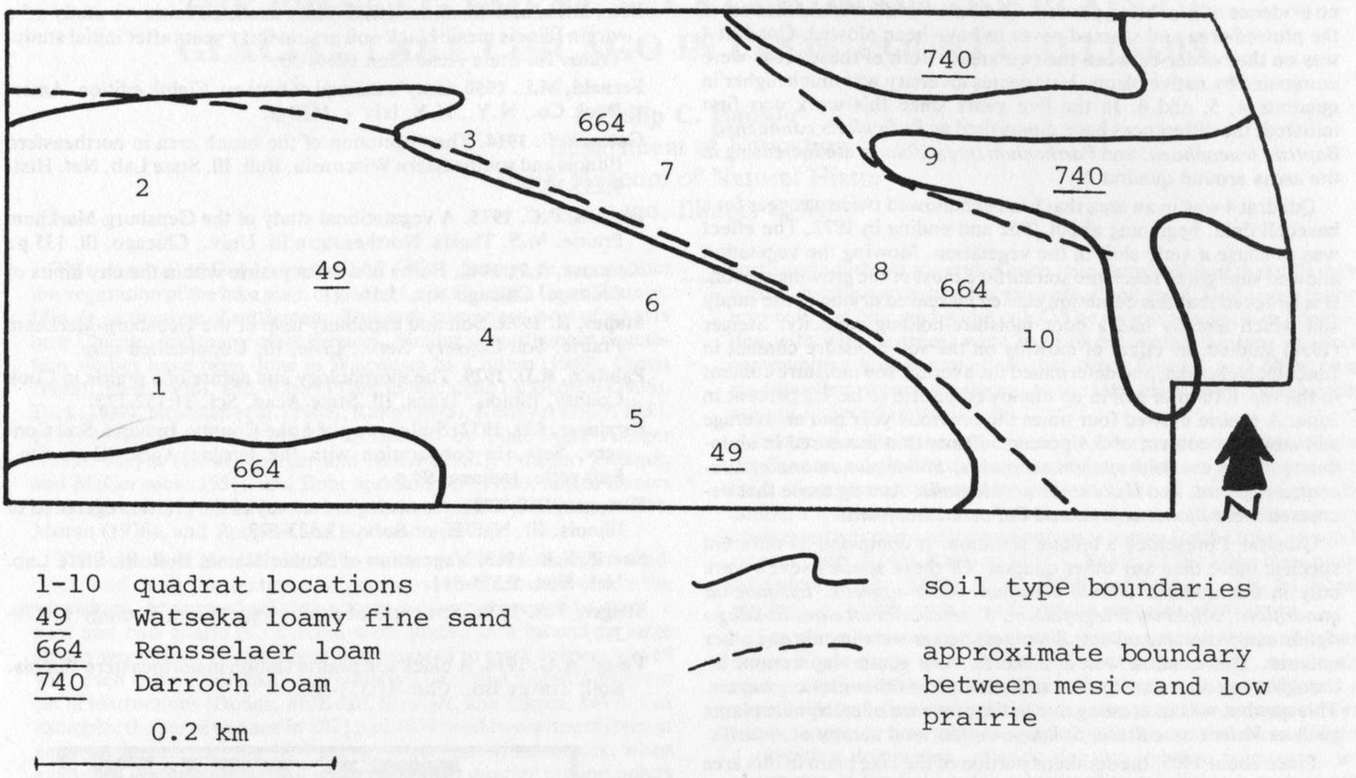

Figure 1. Location of quadrats, soil types, and physiographic boundaries.

Table 1. Plants occurring in half or more than half of the quadrats in mesic prairie.

	Occurrence in Mesic Quadrats (%)	Occurrence in All Quadrats (%)
Andropogon gerardii	67	60
A. scoparius	50	40
Aster dumosus	67	60
Baptisia leucophaea	50	40
Euphorbia corollata	50	40
Gentiana saponaria	50	30
Houstonia caerulea	50	30
Hypoxis hirsuta	50	40
Liatris aspera	50	30
L. spicata	83	70
Parthenium integrifolium	50	30
Pedicularis canadensis	50	30
Phlox glaberrima	67	60
Solidago gymnospermoides	83	70
S. nemoralis	67	40
Sorghastrum nutans	67	50

Table 2. Plants occurring in more than half of the quadrats in the low prairie.

	Occurrence in Low Quadrats (%)	Occurrence in All Quadrats (%)
Aster dumosus	67	60
Aster novae-angliae	100	50
Carex stricta	100	40
Carex sp.	100	50
Fragaria virginiana	100	50
Iris virginica v. *shrevei*	100	50
Juncus canadensis	100	40
Lythrum alatum	67	20
Oenothera pilosella	67	40
Phlox glaberrima	100	60
Potentilla simplex	100	60
Rubus flagellaris	67	40
Rudbeckia hirta	67	30
Solidago gymnospermoides	100	70
Spartina pectinata	100	60

no evidence of ever being plowed. Quadrats 5 and 6 were to the east of the plowed area and seemed never to have been plowed. Quadrat 4 was on the border between the two areas. Both of these areas were dominated by native plants, but species diversity was much higher in quadrats 4, 5, and 6. In the five years since this work was first initiated, the differences have diminished as *Pedicularis canadensis, Baptisia leucophaea,* and *Parthenium integrifolium* are increasing in the areas around quadrat 2.

Quadrat 4 was in an area that has been mowed twice per year for a baseball field, beginning about 1962 and ending in 1972. The effect was to cause a xeric shift in the vegetation. Mowing the vegetation allowed sunlight to reach the soil surface most of the growing season. It is believed that this condition caused increased drying of the sandy soil which already had a poor moisture-holding capacity. Steiger (1930) studied the effect of mowing on the soil moisture content in Lincoln, Nebraska, and determined the average soil moisture content in the top 1.16 m of soil in an unmowed prairie to be 7.2 percent in June. A prairie mowed four times the previous year had an average soil moisture content of 5.4 percent. Plants that increased in abundance here were *Andropogon scoparius, Solidago nemoralis, Lespediza capitata,* and *Helianthus occidentalis*. Among those that decreased were *Liatris aspera* and *Baptisia leucophea*.

Quadrat 1 presented a unique situation. It contained 34 different species, more than any other quadrat. Of these species seven were only in this quadrat: *Allium cernuum, Aster azureus, Lysimachia quadriflora, Silphium integrifolium, S. terebinthinaceum, Solidago rigida,* and *Valeriana ciliata*. Six other species were in only one other quadrat. This quadrat was in a moist, very gentle depression, although it was underlain by the same sand as the other mesic quadrats. This quadrat was interesting due to the presence of calciphilic plants such as *Valeriana cilitata, Solidago rigida,* and nearby *S. riddelli*.

Since about 1905, the southern portion of the lake plain in this area has become better drained. The creation of drainage districts has allowed a system of drainage ditches to be installed. Mosquito Abatement Districts have also ditched areas and drained wetlands. In 1834 the Government Land Office Survey showed this end of the prairie to be a wet prairie with a marsh just to the east. The lower portion of this prairie has probably been affected by the lowering of the water table. Since this area had not been studied before drainage in adjacent areas began it is not possible to measure any change that may have occurred. Drainage of the prairie itself is slow. In some portions several centimeters of water are retained until mid-June. Nearby drainage ditches gradually fill up with debris, thereby decreasing their efficiency.

CONCLUSIONS

1. About 25-35 percent of the prairie was plowed no later than the 1920's.
2. This small area has recovered very well from plowing. *Andropogon gerardii, Sorghastrum nutans,* and *Panicum virgatum* clearly dominate the area while *Liatris spicata* is one of the most common forbs. Some forbs have taken much longer to become established in the plowed area. *Baptisia leucophaea, Pedicularis canadensis,* and *Parthenium integrifolium* are much more common in areas that show no signs of disturbance.
3. The lower portion of the prairie has been affected mostly by the lowering of the water table. It is thought that species diversity is probably less affected by this phenomenon than the relative dominance and relative density of each species.

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Original Prairie and Forest Area in Illinois
(After Brendel and Barrows)

Map of Original Prairie and Forest in Illinois

Map of original prairie and forest in Illinois, after Frederick K. Brendel and H. H. Barrows. (Reprinted from H. C. Sampson, 1921. An ecological survey of the prairie vegetation of Illinois. Bull. Ill. State Lab. Nat. Hist. Surv. 13:519-577 + pl. 48-77, map on p. 526.)

THE PRESETTLEMENT VEGETATION OF THE PLAIN OF GLACIAL LAKE CHICAGO IN COOK COUNTY, ILLINOIS

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This paper uses Government Land Office surveys to reconstruct the vegetation of the lake plain of glacial Lake Chicago, Cook County, Illinois, at the time of settlement. This area comprises most of what is now Chicago and many of its suburbs. Similar presettlement vegetation studies have been done in Wisconsin by Cottam (1949), Curtis (1959), Tans (1976), and Ward (1956); in Michigan by Bourdo (1956), Dick (1937), Huschen et al. (1966), Kapp (1978), Kenoyer (1929, 1933, 1939, 1942), and Meyer (1950); in Indiana by Finley and Potzger (1952), Meyer (1950), Potzger and Keller (1952), Potzger, Potzger, and McCormick (1954), and Rohr and Potzger (1950); and in Illinois by Anderson (1970), Anderson and Anderson (1975), Kilburn (1959), Moran (1978), and Rodgers and Anderson (1979).

The purpose of the early surveys was to establish township boundaries, and mark the section and quarter-section corners within the townships. At corners where no trees were near enough to mark, a post and two quarts of charcoal were placed in a mound or large stones were used. The numbers of trees used to mark corners varied with each survey because each surveyor operated under a different set of instructions (Dodds, McKean, Stewart, and Tigges, 1943). For example, the surveys done in 1821 and 1834 used two witness trees at each section corner; the 1839 survey used four witness trees, when available, at these points. All surveys marked quarter section points with two trees.

DESCRIPTION OF THE LAKE PLAIN OF LAKE CHICAGO

Lake Chicago was formed after the Wisconsinan glacier retreated from the Chicago area about 14,000 years ago. The Tinley and Valparaiso Moraine Systems, parallel to but 19.3 or 20.9 km (12 or 13 miles) west of the present shoreline, dammed up the meltwater from the retreating glacier. The impounded water level was 18.2 m higher than the present level of Lake Michigan and is known as the Glenwood Stage of glacial Lake Chicago. This glacial lake approached the present level of Lake Michigan in two steps, the first being 12.1 m above present level (Calumet Stage), and the second 6 m above present level (Toleston Stage). When the level fell to 182-176 m, its present height above sea level, the lake plain was covered by glacial lakes known as Lakes Algonquin, Nipissing, and Algoma.

The bottom of glacial Lake Chicagö, is a flat surface that is approximately 72 km long and 24 km wide. The area was flattened by the action of waves in the glacial lake and is underlain by glacial till with thin deposits of silt, clay, and sand locally present (Willman, 1971). The plain is almost entirely uneroded by modern streams and because of the very shallow slope, runoff of water is very slow.

At each of the stages of Lake Chicago, near shore features such as beaches and spits that are predominantly medium-grained sand, were created by wave action. When the plain became completely exposed, these features appeared as low, long sandy ridges usually not more than 3 m high. Well-sorted sand and gravel occur in the north end of the Des Plaines River valley and in parts of the glacial sluiceway that drained the lake plain to the southwest. These beach ridges and sand spits have been mapped by Alden (1902), Bretz (1939), and Willman (1971).

METHODS

Microfilm copies of the original surveyors' field notes (Clark, 1834; Morrison, 1840; Walls, 1821) were examined at Northeastern Illinois University. The diameter, corner to tree distance, and species of all trees mentioned in their notes were recorded. The location and bearing of various plant communities the surveyors encountered were noted, such as 35 links from corner, enter timber, leave marsh, bears north and south. At the end of each mile, summaries of that mile were written by the surveyors, for example, "soil good, land level, timber burr oak, red oak, and white oak." The mile summaries, in conjunction with witness trees, were used to determine the type of forest communities that prevailed at that time. Forests and other communities that occurred adjacent to the lake plain on morainal slopes are not included in this study.

Information from the survey records were used to calculate relative dominance, relative frequency, and relative density of the species of trees. Importance values were computed for all species of trees by adding these three values. The forest structure for two areas was contrasted by comparing the importance values for the trees on sandy ridges (T36N, R14E, R15E and T37N, R14E, R15E) to the trees on the lake plain proper (T40N, R12E, R13E and T41N, R 12E, R13E; see my Fig. 1), which were usually on the east side of rivers.

The plat maps of the original surveys were copied and used as base maps. These maps show the location of forest, prairie, marsh, and open water, but they do not differentiate between types of forest or prairie..Information in the field notes and the mile summaries were used to separate prairie from wet prairie in the construction of Figure 1. Relative dominance, relative density, relative frequency, and comments in the field notes were used to subdivide forest into the forest types depicted in Figure 1.

To determine the forest density, the distance of each tree from a corner post was used to calculate the number of trees/ha, using the point-quarter method (Cottam and Curtis, 1956). By using the number of trees/ha, it was possible to differentiate between savanna and forest. Curtis (1959) defined savanna as at least 0.5 trees/ha, but not more than 50 percent canopy cover which would correspond to 46.9 trees/ha (Anderson, 1975). Anderson (1975) also differentiated between open forest and closed forest, open forest having between 46.9 and 98.8 trees/ha. In this study, locations where trees averaged between 93 m (or 0.5 trees/ha) and 9.6 m (or 46.9 trees/ha) from the corner were considered to be savanna. Where distances averaged shorter than 9.6 m, the location was simply designated as forest with no distinction being made between open and closed forest.

The determination of the extent of prairie, wet prairie, and marsh was made exclusively from field notes. The location of these communities was marked on the base map when mentioned by the surveyor. Nowhere in the field notes did the surveyors refer to specific plants from any of these communities. Moran (1978) reported that surveyors in Lake County mentioned redroot (*Ceanothus americanus*), rosin (*Silphium* sp.), and indigo (*Baptisia* sp.), all prairie plants, but none were mentioned in our area of study which is located just south of Lake County.

The area in the center of Figure 1, between the two Indian Boundary Lines, was surveyed in 1821. The surveyors (Walls, 1821) recorded 221 trees as "W. oak" and 137 trees as "B. oak." The "W. oak" was interpreted as white oak, *Quercus alba,* but it is not certain whether "B. oak" meant burr oak, black oak, or both. In all of the townships surveyed, no oak trees were designated as black or burr. This surveyor was operating under instructions issued in 1815 by E. Tiffin, Surveyor General of the United States (reproduced in Dodds et al., 1943), where the abbreviation "B. oak" is used as an example of proper recording techniques. In calculating importance values for the entire plain, those trees designated "W. oak" were added to those designated white oak. Since it is not possible to decipher further "B. oak," these trees were presented under that name.

The section south of the southern Indiana Boundary Line was surveyed in 1834 where the most common tree reported was "yellow oak" which was noted as occurring almost exclusively on the sandy ridges that are common in this area (Clark, 1834). By inspection of remnant sandy ridges in this area, it was determined that yellow oak

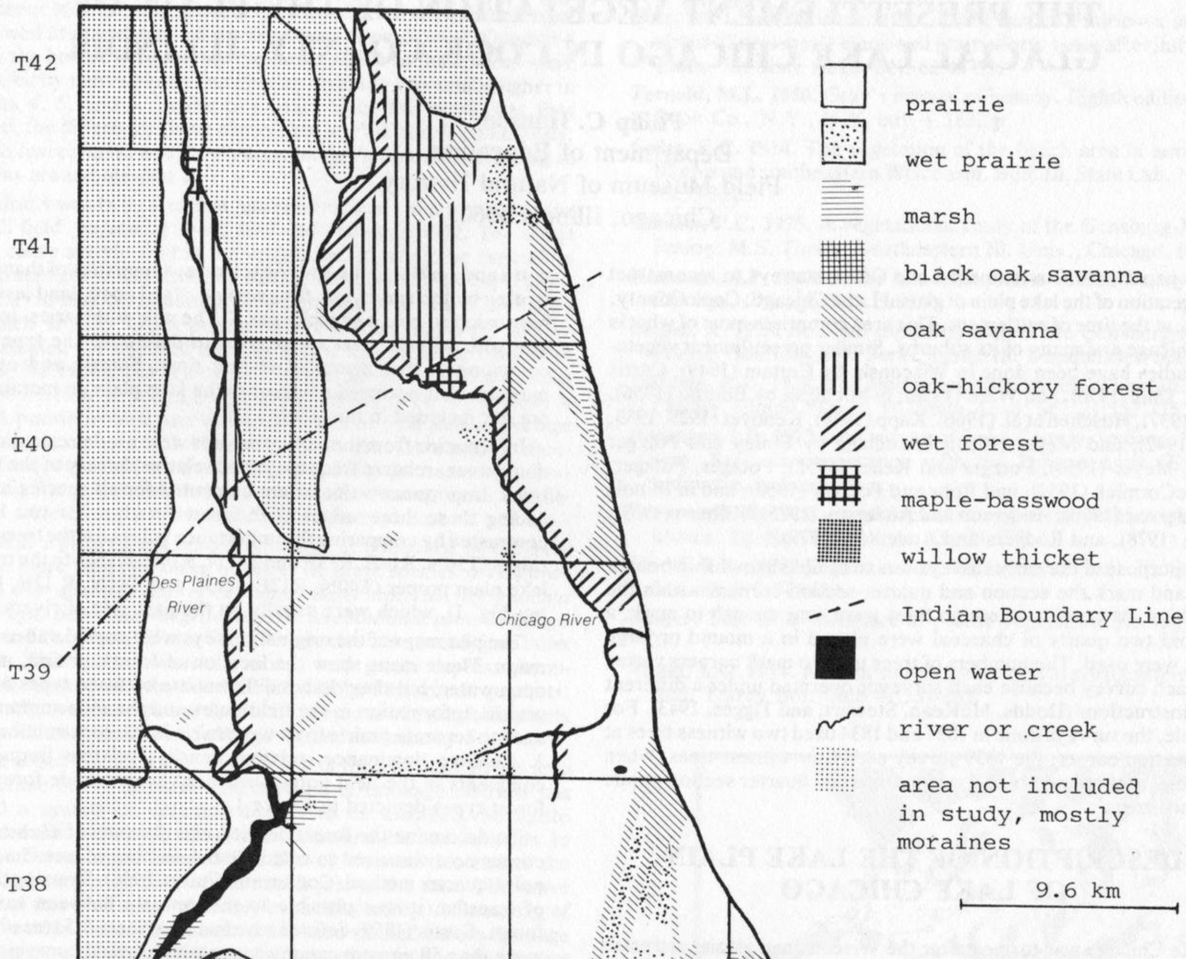

Figure 1. Presettlement vegetation of the lake plain of glacial Lake Chicago.

was black oak, *Quercus velutina*. Little (1953) listed yellow oak as a common name for *Q. muehlenbergii*, *Q. stellata v. mississipiensis*, and *Q. velutina*. *Quercus stellata* is not in Cook County (Swink, 1974) and *Q. muehlenbergii* is in more calcareous situations.

RESULTS AND DISCUSSION

Nine plant communities were distinguished: prairie, wet prairie, marsh, black oak savanna and oak savanna, oak—hickory forest, wet forest, sugar maple—basswood, willow thicket, and Lake Michigan beach. Prairie accounted for more than half of the total area, while black oak savanna was a forest type restricted mainly to the sandy beaches and spits deposited on the lake plain at the various levels of Lake Chicago. This community was almost the only forest type in the southern end of the lake plain known as the Calumet area. In the four townships comprising this area where most of the sandy ridges occur (T36N, R14E, R15E and T37N, R14E, R15E), the average tree to corner distance was 16.7 m which corresponds to an average density of 15.6 trees/ha.

Oak—hickory forests occurred mainly east of the Des Plaines River and the North Branch of the Chicago River. A similar forest occurrence was noted along the Des Plaines River in Lake County, Illinois, by Moran (1978). In the four townships sampled as representing forests on the silt and clay deposited on the bottom of the lake plain (T40N, R12E, R13E and T41N, R12E, R13E), the average post to tree distance was 8.4 m which corresponds to about 62.2 trees/ha.

The importance values for most species in these two samples are compared in Table 1, so that a comparison can be made between trees growing on predominantly sandy beach ridges in the southern portion of the plain with the trees growing on the silt and clay of the glacial lake bottom at the north end of the plain. Twenty-four species of trees were used as witness trees and the size-class distribution of these trees is in Table 2. Importance values for all trees encountered in the entire study area are given in Table 3.

When Figure 1 is superimposed on a map of the surficial geology of the lake plain, the strips of oak savanna on the section of the lake plain south of the mouth of the Chicago River nearly coincide with sandy

Table 1. Comparison of relative frequency, relative dominance, relative density, and importance values for tree species occurring in four townships (T36N, R14E, R15E and T37N, R14E, R15E) where trees occur predominantly on sand or gravel ridges (R) and four townships (T40N, R12E, R13E and T41N, R12E, R13E) where trees occur on silt and clay deposited on the plain of glacial Lake Chicago (P).

	Relative Frequency (%)		Relative Dominance (%)		Relative Dominance (%)		Importance Values	
	R	P	R	P	R	P	R	P
Bur oak	22.8	20.7	28.0	25.0	21.7	23.4	72.5	69.1
White oak	17.7	17.5	10.9	21.7	15.9	20.6	44.5	59.8
Red oak	4.7	7.4	5.6	16.9	4.1	10.9	14.4	35.2
Hickory	2.7	11.7	2.4	5.7	2.9	10.3	8.0	27.7
Elm	3.6	9.0	2.6	8.0	2.9	8.4	9.1	25.4
Ash	8.3	11.7	7.4	5.2	7.3	7.6	23.0	24.5
Black oak	28.5	5.3	35.1	4.7	33.4	3.5	97.0	13.5
Basswood	1.6	4.8	1.1	2.6	1.3	4.0	4.0	11.4
Silver maple		4.3		3.2		2.7		10.2
Aspen	1.0	2.1	0.5	2.9	0.6	2.7	2.1	7.7
Sugar maple		1.0		0.6		1.1		2.7
Walnut		1.0		0.3		0.3		1.6
Cottonwood		0.5		0.5		0.5		1.5

Table 2. Diameter class distribution of tree species encountered in all townships of the entire lake plain of glacial Lake Chicago in Cook County, Illinois. All measurements are in centimeters.

	0-10	11-15	16-20	21-25	26-30	31-35	36-41	42-46	47-51	52-56	57-61	62-66	67-71	72-76	77-81	82-86	87-91	92-96	97-101	>101	Totals
White oak		1	1	15	25	48	27	15	34	16	6	22	1		2			2	1	3	219
Bur oak		4	13	11	55	64	72	14	47	23	4	27	1		8			4		11	358
"B. oak"	1	6	4	21	23	23	24	4	11	7		6	1		2					2	135
Black oak				7	14	17	23	30	24	3	6	3	3	4						1	135
Ash		1		12	20	25	1	7	6	3		4	1							1	81
Red oak			1	2	6	17	13	2	19	2	4	9					1				76
Hickory	1	1	2	10	16	26	3	6	4	1										1	71
Elm		3	4	4	16	6	4	6	1	5		2	1		1					3	56
Basswood			1	1	6	10	2	1	1	1										1	24
Aspen			2	1	2	10	3		1	1		1			1						22
Willow	2	2	6	7	1		1														19
Cottonwood		1	2	3	3	2		1	1			1								3	17
Silver maple						4	4	1	6						1						16
Pine			2		2															1	5
Sugar maple					1	3															4
Black walnut			1		3																4
Birch					1			1													2
"Pin oak"				2																	2
Swamp white oak				1											1						2
Cedar					1																1
Cherry				1																	1
Hackberry								1													1
Ironwood				1																	1
"Thorn"				1																	1
Totals	4	19	39	100	195	255	177	89	155	62	20	75	8	4	16	0	1	6	1	27	1253

Table 3. Relative frequency, relative density, relative dominance, and importance values for tree species occurring in all townships on the lake plain of glacial Lake Chicago in Cook County, Illinois.

	Relative Frequency (%)	Relative Density (%)	Relative Dominance (%)	Importance Value
White oak	28.0	29.1	27.4	84.5
Bur oak	17.8	17.2	22.6	57.6
Black oak	9.9	10.5	12.7	33.1
"B. oak"	10.6	10.6	8.2	29.4
Red oak	5.2	5.9	9.4	20.5
Ash	6.9	6.4	5.0	18.3
Hickory	5.8	5.6	3.7	15.1
Elm	4.7	4.6	3.8	13.1
Aspen	2.2	1.7	1.6	5.5
Basswood	2.1	1.9	1.4	5.4
Cottonwood	1.2	1.5	1.4	4.1
Silver maple	1.2	1.2	1.3	3.7
Willow	1.5	1.4	0.4	3.3
Walnut	0.5	0.3	1.2	2.0
Birch	0.3	0.1	0.9	1.3
Pine	0.5	0.5	0.1	1.1
Sugar maple	0.3	0.3	0.2	0.8

beach ridges and spits. In the western portion of the plain are apparent extensions of oak savanna pointing northeast as well as other scattered groups; these areas are actually beach ridges and the groves are intermittent wooded areas along those ridges. The nine plant communities are described below.

Prairie

Although the most common community in presettlement times, occupying about 60 percent of the area, the prairie is also the community with the least descriptive survey field notes and plats. Many mile field-note summaries simply state "prairie rich level," or, less descriptive, "land similar to last mile" (Walls, 1821). Occasionally the notes mentioned "sandy soil." Once, in a prairie along the path of the Lake Chicago outlet to the southwest the phrase "stony prairie" was recorded. This prairie may have been a boulder field similar to those described by Bretz (1939). This community is assumed to include dry prairie which is usually dominated by little bluestem (*Andropogon scoparius*) and mesic prairie which is dominated by big bluestem (*A. gerardii*), Indian grass (*Sorghastrum nutans*), and panic grass (*Panicum virgatum*).

Wet Prairie

Again, no plant species are mentioned as being characteristic of this community. However, the surveyors clearly demonstrated an intuitive feeling for this community. Since their criteria for designating wet prairie are not explained, the definition must be inferred. In all cases where wet prairie is indicated in Figure 1, the area was described as such in the notes. Entries often read, "leave dry prairie, enter wet prairie" or "leave wet prairie enter marsh" (Clark, 1834; Morrison, 1840; Walls, 1821). These entries indicate that they had some criteria for separating these three communities. Possibly what they referred to as "wet prairie" would be classified today as sedge meadow or fen depending on soil and groundwater conditions. These communities are often very wet, but visually quite distinct from cattail and rush marshes. The areas where the wet prairies were located in the Chicago area have been so drastically disturbed by construction and changes in surface water springs and seeps that these communities may never be fully defined.

Marsh

As before, no plant species are recorded for the marshes. Little doubt, however, exists that the locations of marshes described in the surveys are accurate. One surveyor defined what he meant by "marsh" at the beginning of each of his books, "a low wet piece of land, utterly destitute of timber and generally covered with a growth of strong, coarse grass" (Morrison, 1840). This information is a useful and practical working definition, and appears to be the only instance where a surveyor presented a definition. On 22 May 1834 one surveyor gave a qualitative description of the marshes in the Calumet region: "Land all marsh, grass is so high that it is impossible for me to see my flag more than 3.00 chains when the flag is elevated 14 feet [4.2 m] above ground" (Clark, 1834).

A description appearing in Brown (1884:184) of the Kankakee marshes in northwestern Indiana, probably very similar to the marsh described above, gave an indication of the species encountered. "The balance of these wetlands running west to the state line, is open marsh, covered with a luxuriant growth of wild grasses, wild rice, and flags [*Typha* sp.?]."

The surveyor (Clark, 1834) was careful about recording the depth of water in these marshes. Water depths ranged from 0.1 to 1.06 m with most depths between 0.3 and 0.9 m. The deepest water encountered was east of Lake Calumet where most depths were over 0.6 m.

Black Oak Savanna and Oak Savanna

This community is almost entirely on the sandy beaches and ridges that cross the lake plain. Black oak and burr oak were the dominant species of trees; they accounted for more than 50 percent of trees in a sample. These trees predominated because of their ability to resist fire. Clark (1834) also noted that common understory plants were oak, hazel, and occasionally wortleberry (*Vaccinium* sp.). The surveyor's use of "B. oak" in the area between the two Indian Boundary Lines, makes it impossible to determine the burr oak to black oak ratio. The composition of these ridges was probably similar to the beach ridges south of the lower boundary line (Cowles, 1901). However, on Figure 1, these ridges are designated as "Oak Savanna."

Curtis (1959) stated that in the sand plains of central Wisconsin the oak savanna was dominated by Hill's oak (*Quercus ellipsoidalis*) with black oak (*Q. velutina*) also occurring. At the time of this survey, Hill's oak had not been defined as a separate species (Hill, 1899); consequently, the abundance of this species at the time of settlement is unknown. From observations of present remnants, it seems that black oak was the dominant tree. A few remnants of this community are in Calumet City, Illinois, at the Sand Ridge Nature Preserve where sandy ridges with black oak and dry prairie understory are separated by long, narrow marsh areas.

Oak—Hickory Forest

This type of forest was most extensively developed in the northern half of the lake plain, mainly to the east of the Des Plaines and Chicago Rivers. The main difference between this community and the black oak savanna was that black oak is relatively unimportant in these oak—hickory forests. Burr oak, white oak, red oak, hickory, elm, and ash represented more than 80 percent of the importance values in the oak—hickory forest. Surveyor's notes sometimes mentioned an undergrowth of vines and briars in these areas. One can only guess what plants, vines and briars actually were. In the black oak savanna, black oak, burr oak, white oak, and red oak comprised approximately the same percentage (Table 1).

In much of this forest type east of the Chicago River, the surveyor's summaries read, "level and wet" (Morrison, 1840). It is possible that swamp white oak was present here but not distinguished by the surveyor. When forests occurred adjacent to but west of the river, this area was open oak savanna. Trees mentioned west of the Chicago River in R41N, R13E are burr oak and black oak. Summaries of miles through these areas referred to "Scattering timber" (Morrison, 1840). Since these areas are small little quantitative data is available to describe them accurately.

Wet Forest

This type of forest is encountered along rivers and their floodplains, where there was periodic flooding or flooded backwaters. Silver maple, elm, basswood, and ash were the most frequently mentioned trees. The relative densities of basswood, ash, elm, silver maple, and burr oak accounted for almost 70 percent of the trees with the remaining 30 percent shared by 11 other species. This community is quite common along the north branch of the Chicago River. The riparian forest along the Calumet River and its main tributary Thorn Creek was more complex. In most places the surveyor (Clark, 1834) mentioned that the timber adjacent to the river and creek on the uplands was "very scattering," "thinly timbered," or "very poor and scrubby." Most of the trees mentioned were black oak and burr oak with an understory of oak. In a few sheltered places more mesic oak—hickory forests developed. Occasionally along the flood plain white ash, elm, or swamp white oak were noted. Many times these trees were used as witness trees to mark the places where section lines intersected the Calumet River and Thorn Creek. Also at several places along these watercourses the surveyors noted that the flood-plains, or bottoms as they were called, were "destitute" of timber. In the southeast corner of T36N, R14E an area of oak—hickory forest existed as indicated in Figure 1. Within this area was an unusual swamp flatwoods dominated by pin oak and black tupelo. The area is too small to be shown on Figure 1.

Sugar Maple—Basswood

The survey field notes give slight indication of the presence of this community. Two locations for sugar maple, one on the Des Plaines River and the other on the Chicago River, were noted for the area. In the surveyor's notes, silver maple was referred to as maple while sugar maple is called sugar tree.

Willow Swamp

This vegetational type was a very small community and was only mentioned at the south end of the plain in the Calumet marsh. The surveyor referred to it as "willow thicket" (Clark, 1834). It is difficult to know which willow or willows comprised this community.

Lake Michigan Beach

By examining the bearing trees used to locate the Lake Michigan beach, some insight can be gained about the trees that prevailed. The beach was composed entirely of sand with low dunes extending a short distance back from the beach. Forty-eight individual trees were used as bearing trees on Lake Michigan: black oak, 29 percent; white oak, 23 percent; cottonwood, 19 percent; pine, 10 percent; and aspen, 8 percent. Other trees recorded were cedar, red oak, burr oak, and willow. The vegetation was probably similar to that currently along the Lake Michigan Beach at Waukegan in the Illinois Beach State Park. Here, black oak savanna was on low sand dunes extending back from the beach. Pratt (1935:13) described the area north and south of the Chicago River as follows:

> . . . there were along where Michigan Avenue now is walled with palatial mansions innumerable sand hills rising to a considerable height, overrun by the wild juniper loaded with its fragrant berries at the feet of which stretched away to the southeast the soft smooth beach of firm glistening sand . . . along the beach north of the river where also the drifting sand has been piled by the shifting winds into a thousand hills stretching farther back from the waters than on the south, but here the juniper bush was replaced by a stunted growth of scraggy pines often hilled up by the drifting sand . . . Further back was a broad ramble among stately oaks sparsely scattered over the even plain among which a horseman could be seen at a great distance, and if one sought a deeper solitude it might be found still further west in the densely tangled mass of bushes among which one could not see a deer at a distance of twenty feet [6m].

CONCLUSIONS

1. The lake plain of glacial Lake Chicago consists of about 3370 ha. According to Government Land Office Survey field notes, about 60 percent of the miles walked were considered dry or mesic prairie; 30 percent, tree covered, either forest or savanna; 6 percent, wet prairie; and 4 percent, marsh.
2. Tree cover occurred mostly under two conditions. First, trees were usually on sandy and gravelly beach ridges or spits on the lake plain. These areas were dry and were dominated by black oak, burr oak, and white oak. Most of these locations had corner to tree distances greater than 9.6 m and were considered savanna. Secondly, forests developed on the east side of the Chicago and Des Plaines Rivers where they were sheltered from prairie fires blown by westerly winds. Surveyors' notes indicated the most common trees here were burr oak, white oak, hickory, ash, and elm. While investigating the lake plain forests in Evanston, Waterman (1920) mentioned that swamp white oak was very common in these forests. The surveyors, however, did not list swamp white oak for this area. At corners where bearing trees were used, 62 percent were classified as savanna, and 38 percent as forest.
3. Because the criteria used by the surveyors to separate prairie from wet prairie and wet prairie from marsh were not clearly defined, the boundaries for these areas are approximations. As a result of the mild slope of the lake plain and the lack of a developed drainage pattern, moderate rains could have flooded large areas. So, if the presence or absence of water was used as a criterion to separate these communities, the proportion of prairie, wet prairie, and marsh could have varied considerably with the amount of rain or the season of the year.

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PRAIRIE FENS IN NORTHEASTERN ILLINOIS: FLORISTIC COMPOSITION AND DISTURBANCE

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Prairie fens, as delimited in this study, are areas of firm sapric peat soils constantly saturated with cold, calcareous, artesian groundwater, and supporting a distinctive calciphilous herbaceous flora. Prairie fens are usually dominated by typical prairie grasses and/or sedges and contain a large prairie element in their flora. The term "prairie fen" is used here in a strict sense to distinguish fens within the Prairie Peninsula from a variety of wetland communities that are also termed "fens." Prairie fens, hereafter shortened to "fens," were probably once a common floristic community in northeastern Illinois during presettlement times, because the topography and hydrologic conditions favoring them occur frequently. In this paper, the flora of 12 fens in northeastern Illinois is analyzed. No previous work has been done on Illinois fens.

METHODS

Data were collected by the Illinois Natural Areas Inventory personnel during the months of July and August, 1976 and 1977, and from the author's studies during 1978. At each site the species were listed and the natural boundaries of the plant communities were mapped on aerial photographic overlays. Frequency values of the species in each fen were determined by recording species presence in a series of circular 0.25 m^2 plots randomly placed along an arbitrary transect through the undisturbed portions of the fen. The sampling results and locations for individual sites are obtainable from the Natural Areas Section, Illinois Department of Conservation, 605 State Office Building, Springfield, Illinois 62706. Nomenclature throughout this paper follows Mohlenbrock (1975).

Presence among the ten prairie grass dominated fens was calculated as the number of stands a species occurred in divided by the total number of stands, and expressed as a percentage. Frequency presence indices (FPI) were calculated as the percentage multiplied by the mean percentage frequency. This index has a maximum value of 10,000 where a species occurs in all stands with a sampling frequency of 100 percent and a minimum value approaching zero for rare plants (Curtis, 1959).

The prevalent species (Curtis, 1959) were determined by arranging the species in decreasing order according to their FPI, and listing the top group of species equal in number to the average species density among the ten stands included in the calculation. The index of homogeneity (Curtis, 1959) was calculated as the ratio of the sum of the percentage presence of the prevalent species to the total sum of the percentage presence of all species, and expressed as a percentage.

MINFO (acronym for "minimal information") was the computer program used for the cluster analysis shown in Fig. 2 (Goldstein and Grigal, 1972). MINFO clusters on a mutual information theory measure by linking pairs or groups with minimum increase in mutual information.

Dominance-diversity structure was analyzed by plotting relative frequency on the ordinate against species sequence from most to least important on the abscissa. Such curves are useful in comparing structural differences among communities or sample sets. To quantify these relationships, diversity indices including species richness, S; the number of species in the set; the Shannon index, H', which is a dual concept diversity or heterogeneity index (Peet, 1974); and J' which is an equitability index (Pielou, 1966) were calculated. H' is an information theory measure and is given by Shannon and Weaver (1949), as:

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

where S is the number of species and p_i is the decimal fraction of the Importance Value which in this case is relative frequency. J' is a measure of the dominance-diversity curve evenness (Peet, 1974) and is calculated by:

$$J' = H' / \ln S$$

where H'is the value calculated above and S is the number of species. As the measure of importance becomes more evenly distributed among the species, J' approaches 1.

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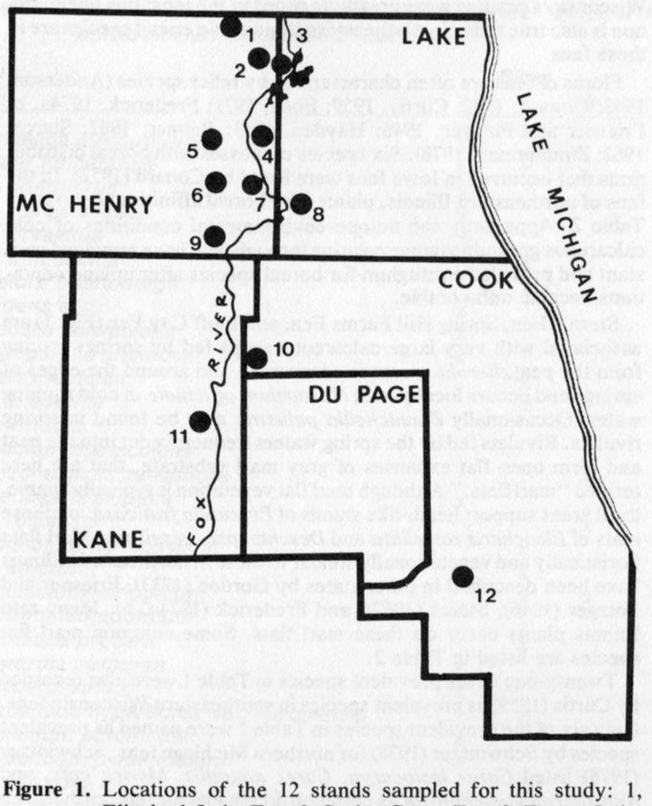

Figure 1. Locations of the 12 stands sampled for this study: 1, Elizabeth Lake Fen; 2, Spring Grove Fen; 3, Turner Lake Fen; 4, Kettle Moraine Nature Preserve Fen; 5, Stern's Fen; 6, Boone Creek Fen; 7, Bate's Fen; 8, Tower Lake Fen; 9, Spring Hill Farms Fen; 10, Bluff City Fen; 11, Ferson's Creek Fen; and 12, Palos Fen. Counties are named on the map.

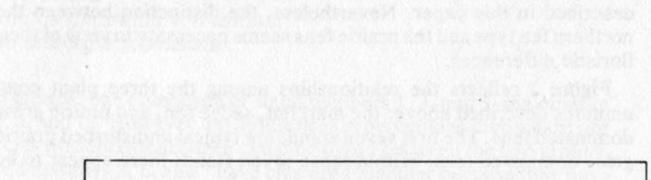

Figure 2. Dendrogram relationships among the 12 stands studied in northeastern Illinois. Stand numbers correspond to those given in Fig. 1.

PHYSICAL CHARACTERISTICS

All study sites, except the Palos Fen, are located in the Fox River valley within Cook, Kane, Lake, and McHenry Counties, Illinois (Fig. 1). The Palos Fen is on the southeastern slope of a morainal deposit in Cook County overlooking the flat lake plain formed by Glacial Lake Chicago. The Fox River valley fens are located in morainal upland depressions, and around the sides and in the bottoms of postglacial lake beds and potholes.

All the fens studied have a constant supply of artesian groundwater available throughout the year, as evidenced by the occurrence of springs, rivulets, marl flats, and saturated peat. Three fens studied are in close proximity to gravelly morainal ridges. Presumably these gravel ridges have a very high hydraulic conductivity, providing the fens with the constant flow of groundwater necessary for peat formation. Dolomite and limestone cobbles in these ridges are probably an important source of calcium and magnesium carbonates in the groundwater. Geological studies of other fens would probably reveal association with lenses of porous materials having high hydraulic conductivities. Richard (1974) found that the source springs of a fen in Ohio appears to be supplied through a gravel-filled tributary of the ancient Teays River. Friesner and Potzger (1946) made a detailed geological study of Cabin Creek Raised Fen in Indiana and also found this fen to be associated with porous lenses of sand and gravel. Van Der Valk (1975), in his diagrammed cross-section of a fen in Iowa, illustrated the typical hydrologic conditions characteristic of prairie fens, i.e., a water discharge "window" of porous material confined by water impervious clays and resultant fen peat formation above the water discharge surface. Because the fen community depends upon a specific set of hydrologic conditions for their existance, further hydrologic and geologic studies will be important to preservation of fens as natural ecosystems.

In five fens studied the peat is topographically higher and presumably thicker than the surrounding area, resulting in a raised appearance. The raised fens appeared to be 1-2 m above the general level of the associated wetlands. This raised peat condition has been noted in other states, with raised elevations ranging 3-6 m (Anderson, 1943; Friesner and Potzger, 1946; Gordon, 1933; Van Der Valk, 1975, 1976). At a fen in Indiana, Lindsey et al. (1969) noted that the peat appeared to be physically raised by the hydrostatic pressure of upwelling groundwater. At Silver Lake Fen in Iowa, Anderson (1943) reported that "Limy concretions have been formed around the roots of plants, building up mounds of loosely consolidated lime and peat to a height of 20 feet [6 m] above the level of Silver Lake." Apparently peat accumulates to higher elevations without oxidation because of the constant supply of groundwater being forced up through the peat.

The soil in all fens studied is well-decomposed sapric peat with pH values of 6.9-8.2. Presumably, this peat develops because of greater activity and diversity of decomposing organisms in environments with pH values of 6-8 (Boelter and Verry, 1977). Sapric peat soils contribute to the higher water tables in fens because of their low hydraulic conductivities.

A common feature of springs and marl flats is the formation of tufa, precipitated aggregates of calcium and magnesium carbonates. Pieces of tufa, 3-10 cm in size, are common at Spring Hill Farms and Stern's Fen in McHenry County. At Bluff City Fen in Cook County tufa forms conical mounds as high as 12 cm upon the peat. Apparently the groundwater in the peat is under enough pressure to force its way up through small channels in the tufa, trickle down the sides and evaporate, leaving precipitated calcium and magnesium carbonates in the form of a conical mound.

FLORISTIC COMPOSITION

Ten fens are dominated by characteristic Illinois prairie grasses. Large clumps of *Andropogon gerardii* and *Schizachyrium scoparium* dominate these stands. *Muhlenbergia glomerata* has a high FPI (Table 1), but it should not be considered a dominant because its few and slender culms are not densely caespitose like the bluestems. Fens studied both in Ohio (Frederick, 1974a, b; Gordon, 1933) and in Indiana (Friesner and Potzger, 1946; Starcs, 1962) were also dominated by these same prairie grass species. *Sporobolus heterolepis* does not become dominant in these fens which seems unusual since it commonly occurs in calcareous prairies.

The most abundant sedge in the Illinois fens is *Carex sterilis* which usually occurs as scattered culms and rarely forms caespitose clumps. Ferson's Creek Fen in Kane County (Fig. 1) is dominated by *Carex stricta* and has a different floristic composition than the prairie grass dominated fens (Figs. 2, 3). This particular site is unique among the areas studied because it is located at the base of a morainal bluff in the floodplain adjacent to the Fox River. Apparently *C. stricta* is better adapted to the Fox River's fluctuating waters and is therefore dominant instead of the prairie grasses.

These fens are unique in contrast to communities of similar physiognomy. They support several characteristic species such as *Cirsium muticum, Lobelia kalmii, Parnassia glauca,* and *Solidago ohioensis*. Many typical plants of mesic and wet-mesic prairies, and marshes occur in the fens, but with a much greater abundance than they do in these other habitats (Table 1). Accordingly, fens have a high homogeneity index (Curtis, 1959) of 68.2 percent. Species represented in the sampling data, except those given in Table 1, are listed in Table 2.

Absent from fens are many typical northeastern Illinois prairie plants including *Amorpha canescens, Baptisia leucantha, B. leucophea, Coreopsis palmata, Eryngium yuccifolium, Lithospermum canescens, Parthenium integrifolium, Petalostemum purpureum, P. candidum, Ratibida pinnata,* and *Silphium laciniatum*. Curtis (1959) pointed out that legumes which were prominent in

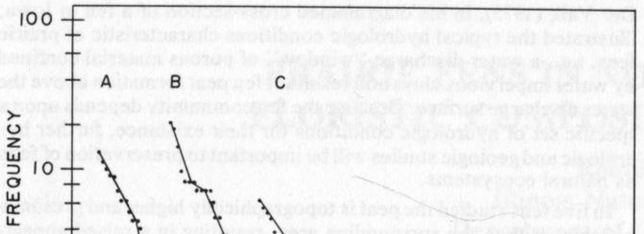

Figure 3. Dominance-diversity curves and diversity indices for (A) marl flat, (B) *Carex stricta* dominated fen, (C) prairie grass dominated fens.

Wisconsin's prairies were greatly reduced in the fens; this phenomenon is also true today in northeastern Illinois. No ericad species are in these fens.

Floras of fens are often characterized by relict species (Anderson, 1943; Conard, 1952; Curtis, 1959; Foos, 1971; Frederick, 1974a, b; Friesner and Potzger, 1946; Hayden, 1943; Reimer, 1962; Starcs, 1962; Zimmerman, 1978). Six species of mosses with boreal distributions that occurred in Iowa fens were listed by Conard (1952). In the fens of northeastern Illinois, plants with boreal affinities are given in Table 2. Apparently the unique environmental conditions of cold calcareous groundwater percolating through peat have remained constant and provided a refugium for boreal species after upland conditions became unfavorable.

Stern's Fen, Spring Hill Farms Fen, and Bluff City Fen (Fig. 1) are associated with very large calcareous seeps fed by springs issuing from the peat. *Berula erecta* is common in and around the edges of springs and occurs locally with *Nasturtium officinale* in cold running water. Occasionally *Zannichellia palustris* may be found in spring rivulets. Rivulets fed by the spring waters frequently cut into the peat and form open flat expanses of gray marl substrate, that are here termed "marl flats." Although marl flat vegetation is typically sparse, local areas support heath-like stands of *Potentilla fruticosa,* or dense mats of *Eleocharis rostellata* and *Deschampsia cespitosa*. Marl flats floristically and vegetationally similar to these in northeastern Illinois have been described in other states by Gordon (1933), Friesner and Potzger (1946), Starcs (1962), and Frederick (1974a, b). Many rare Illinois plants occur on these marl flats. Some common marl flat species are listed in Table 2.

Twenty-one of the prevalent species in Table 1 were also recorded by Curtis (1959) as prevalent species in southeastern Wisconsin fens. Only six of the prevalent species in Table 1 were named as prevalent species by Schwintzer (1978) for northern Michigan fens. Schwintzer (1978) listed *Carex lasiocarpa, Carex aquatilis, Myrica gale,* and *Andromeda glaucophylla* as common dominants for this northern fen type. She also included several Ericaceae as prevalent species, in contrast to the prairie fens studied here in which no Ericaceae occurred. Sedge-dominated floating alkaline peat mats similar to those described by Schwintzer (1978) occur in a few rare instances in northeastern Illinois around the margins of glacial pothole lakes. Here they are usually associated with the typical prairie fen community described in this paper. Nevertheless, the distinction between the northern fen type and the prairie fens seems necessary in view of their floristic differences.

Figure 2 reflects the relationships among the three plant communities described above: the marl flat, sedge fen, and prairie grass dominated fens. The first seven stands are typical undisturbed prairie grass dominated fens. Within these seven stands there appear to be

Table 1. Prevalent vascular plants in the prairie fens of northeastern Illinois in order of decreasing frequency-presence index (FPI). Atypical stands numbers 10 and 11, the marl flat and sedge dominated fen, were not used in calculating FPI values.

	FPI		FPI
Carex sterilis	7100	*Carex haydenii*	1425
Solidago ohioensis	6100	*Solidago gigantea*	1320
Andropogon gerardii	5900	*Lycopus americanus*	1260
Muhlenbergia glomerata	5400	*Thalictrum dasycarpum*	1080
Viola cucullata	3645	*Aster junciformis*	1050
Pycnanthemum virginianum	3555	*Senecio pauperculus*	990
Rudbeckia hirta	3550	*Solidago uliginosa*	950
Lysimachia quadriflora	3450	*Calamagrostis canadensis*	880
Schizachyrium scoparium	3080	*Sorghastrum nutans*	875
Solidago riddellii	3060	*Carex buxbaumii*	840
Lycopus virginicus	2840	*Gentiana procera*	780
Aster puniceus	2565	*Carex stricta*	660
Oxypolis rigidior	2070	*Lythrum alatum*	650
Valeriana ciliata	2065	*Lobelia kalmii*	550
Liatris spicata	1850	*Solidago graminifolia*	525
Cirsium muticum	1665	*Calystegia sepium*	525
Galium boreale	1560	*Eupatorium maculatum*	525
Parnassia glauca	1435	*Potentilla fruticosa*	400

Table 2. Vascular plants of Illinois prairie fens which are (1) typical of mesic and wet-mesic prairies, and marshes; (2) relict species with boreal affinities; and (3) common to marl flats.

	Sites 1	2	3
Angelica atropurpurea	x		
Aster junciformis	x	x	
A. lateriflorus	x		
A. novae-angliae	x		
A. praealtus	x		
A. umbellatus		x	
Betula x sandbergii		x	
Bidens spp.	x		
Cacalia suaveolens	x		
Campanula uliginosa	x		
Carex leptalea		x	
C. trisperma		x	
C. viridula			x
Cladium mariscoides			x
Deschampsia caespitosa			x
Eleocharis elliptica	x		
E. rostellata			x
Epilobium leptophyllum		x	
E. strictum		x	
Equisetum variegatum		x	x
Galium labradoricum		x	
Gentiana procera		x	
Gerardia purpurea	x		
Glyceria striata	x		
Habenaria hyperborea var. *huronensis*		x	
Helenium autumnale	x		
Hypericum pyramidatum	x		
Iris shrevei	x		
Juncus brachycephalus		x	x
J. nodosus	x		x
Lathyrus palustris	x		
Liparis loeselii	x		
Lobelia kalmii		x	x
Lysimachia quadriflora			x
L. thyrsiflora	x		
Mimulus glabratus v. *fremontii*			x
Muhlenbergia glomerata		x	
M. mexicana	x		
Panicum lanuginosum	x		
Parnassia glauca		x	x
Pedicularis lanceolata	x		
Phlox glaberrima	x		
Rhamnus alnifolia		x	
Rhynchospora alba		x	
R. capillacea		x	x
Salix discolor	x		
Sarracenia purpurea	x		
Scirpus americanus	x		
S. cespitosus		x	x
S. validus		x	x
Scleria verticillata			x
Scutellaria epilobiifolia	x		
Selaginella apoda	x		
Senecio aureus	x		x
Silphium terebinthinaceum			x
Smilacina stellata	x		
Solidago canadensis	x		
S. gymnospermoides	x		
S. ohioensis			x
S. patula	x		
S. uliginosa		x	x
Spiranthes cernua	x		
Sporobolus heterolepis	x		
Stachys palustris	x		
Thelypteris palustris	x		
Tofieldia glutinosa		x	x
Triadenum fraseri	x		
Triglochin maritima		x	x
T. palustris		x	x
Typha latifolia	x		
Utricularia cornuta		x	x
U. intermedia			x
Valeriana uliginosa		x	

two groups: one composed of stand numbers 1, 3, and 9; the other of 4, 5, 8, and 12. However, no differences in percentage dissimilarity or species presence or absence could be found between the two groups. Stand numbers 2, 6, and 7 have clustered together because they have a mutual history of minor disturbance that has changed the frequencies of certain species. The two remaining stands, 10 and 11, join the prairie grass dominated fens at a high mutual information level. Stands 10 and 11 are atypical from the previous ones in that 10 is a marl flat and 11 is the *Carex stricta* dominated fen. Although stands 10 and 11 have almost no species in common, they join at a low mutual information level. This discrepancy is probably due to the large number of double zero matches in the data set making the two stands appear more similar than they actually are. Ordination with reciprocal averaging (Hill, 1973), using percentage dissimilarity as the community coefficient, supports the above interpretation of Fig. 2.

Dominance-diversity curves and their associated indices (Fig. 3) reflect changes in structure among the three different community types. The *Carex stricta* dominated fen (C) shows a relatively steep line curve characteristic of species poor, strongly dominated plant communities. The prairie fens (B) are characterized by the sigmoid curve characteristic of species rich equitable plant communities. The greater species richness, S, in the prairie fens is due to ten stands being used to construct the curve. Among the prairie fens the average number of species per stand is 38. The marl flat (A) exhibits low diversity, but a high J' value. This large J' value is a result of over half the species having high relative frequencies and consequently a more equitable distribution.

DISTURBANCE

Grazing, ditching, and lack of fire are the major disturbances in these fens. These disturbances result in an increase of such herbaceous species as *Aster puniceus, Calystegia sepium, Carex sterilis, Eupatorium maculatum, Helianthus grosseserratus, Panicum flexile, Solanum dulcamara,* and *Solidago gigantea.* Woody species typically increased with disturbance, including *Betula pumila, Cornus racemosa, C. stolonifera, Crataegus* spp., *Ulmus rubra, Populus tremuloides, Rhamnus cathartica, R. frangula, Salix bebbiana, S. discolor,* and *Viburnum lentago. Aster puniceus* and *Solidago gigantea* are especially frequent in grazed areas because locally reduced competition enabled these two aggressive natives to form large colonies. Grazing also produces grass hummocks that are difficult to traverse. In the absence of fire, Starcs (1962) observed *Carpinus caroliniana, Rhus vernix,* and *Salix* spp. invading open areas of Cabin Creek Raised Fen in Indiana. A drainage ditch through Cabin Creek Raised Fen may also have fostered shrub invasion as well as lack of fire. In Dane County, Wisconsin, Bedford et al. (1974) found that shrubs characteristically increased in many different peat wetland communities particularly after the water table had been artifically lowered. The fens appear to be particularly susceptible to this kind of disturbance because of their dependence on a specific set of hydrological conditions.

Evidence of recent fires, consisting of charred fence posts and burned stems of shrubs, was seen at five fens. The Spring Hill Farms Fen (Fig. 1) had been purposely burned for several years through 1978 by nearby subdivision maintenance men who desired to suppress "weeds" in an old field adjacent to the subdivision's sewage treatment plant. The burned portions of this fen exhibited the richest and most diverse flora of the fens studied; additionally, the abundance of species flowering in the burned areas was far greater than in the unburned area. Many plants which are rare in Illinois thrive in the burned portions of Spring Hill Farms Fen including *Pogonia ophioglossoides, Habenaria hyperborea* var. *huronensis, Scirpus ces-*

pitosus var. *callosus*, and the only known Illinois population of *Valeriana uliginosa*.

Presettlement vegetational patterns (Gleason, 1913; Hanson, 1981; Kilburn, 1959; Moran, 1978) and early accounts of Indians burning prairies in the area (Benton, 1957; Halsey, 1912) suggest that fires were common. Because dominant fen grasses were contiguous with prairie grasses on the uplands, it seems reasonable to assume that in presettlement times these fens burned as did the surrounding prairies and savannas.

Reports of fire in fens from other states have been sparse. Starcs (1962) reported that the trees and shrubs invading Cabin Creek Raised Fen in Indiana were formerly repressed by annual burns. Curtis (1959:363) believed that "the natural agent maintaining the fens was fire, which could burn the mulch and top growth of the community with little danger to the peat beneath because of the steady water supply."

The DuPage County Forest Preserve District has developed a fire management plan for their fens. This fire management plan has retarded woody plant invasion and increased the abundance and vigor of native fen species.

The necessity of a fire management plan at Ferson's Creek Fen (Fig. 1) has been discussed by Wilhelm (1978:35), who wrote, "The fen portions are in imminent danger of being overrun by shrubs. There are insular domes of shrub invasion throughout the area, and each is increasing in size annually—at the expense of the fen species. Each year in which fire is withheld brings Ferson's Creek Fen, and the species which enrich it, closer to oblivion." If indeed fire was present in these fens during presettlement times, then a fire management program is essential if the fens are to be managed as natural ecosystems.

SUMMARY

The flora of 12 prairie fens in the Fox River valley of northeastern Illinois is described. Ten fens were dominated by such characteristic Illinois prairie grasses as *Andropogon gerardii, Schizachyrium scoparium*, and *Sorghastrum nutans*. One fen located in the floodplain adjacent to the Fox River was dominated by *Carex stricta*. The remaining stand was a marl flat dominated by such calciphilic species as *Deschampsia caespitosa, Eleocharis rostellata, Potentilla fruticosa*, and *Rhynchospora capillacea*. Fens differ floristically from communities of similar physiognomy because they support numerous calciphilic prairie and marsh plants, along with boreal relict species. These characteristic plants, and the fen peat soils, depend upon a constant supply of cold, calcareous, artesian groundwater. The fens studied are fire-adapted communities that burned in presettlement times.

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CLASSIFICATION OF PRAIRIE COMMUNITIES IN ILLINOIS

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The natural community classification system developed by the Illinois Natural Areas Inventory uses the approach described in the *Natural Divisions of Illinois* (Schwegman et al., 1973). This system recognizes 34 regions of the state on the basis of topography, glacial history, bedrock, soil, and distribution of native plants and animals. The Natural Areas Inventory subdivides these natural regions with nine community classes: prairie, savanna, forest, wetland, lake and pond, stream, cave, cultural, and primary successional communities. The classification system has been detailed by White and Madany (1978).

A natural community is a group of organisms that are interrelated with each other and their environment. Although a natural community might be defined at any scale, it was used as the smallest unit of land that could be mapped on 1:7,920 scale aerial photographs. The communities are classified by considering many natural features and choosing the dominant features to identify, name, and describe them. Important characteristics for identifying natural communities include physiognomy, soil moisture, substrate, soil reaction, species composition, vegetation structure, and topographic position.

Each Natural Division and Section (Schwegman et al., 1973) has its own distinct set of natural communities, and the name of the Natural Division and Section is part of the natural community name. For example, a loess hill prairie of the Northern Section of the Ozark Division is a community distinct from a loess hill prairie of the Glaciated Section of the Middle Mississippi Border Division.

Although vegetation is frequently used to identify, name, and describe natural communities, in this classification system, plant communities are not synonymous with natural communities. A plant community is a feature of a natural community. A plant community name is based on vegetation, and a natural community is based on all of the natural features, including vegetation. More than one plant community may exist in a natural community. Plant community names are variable and descriptive, but natural community names are part of a standard classification. For example, the loess hill prairie natural community may have the following plant communities: *Andropogon scoparius–Bouteloua curtipendula, Sorghastrum nutans–Andropogon scoparius,* and *Andropogon scoparius*.

SOIL MOISTURE CLASSES

Many closely related natural communities are separated on the basis of soil moisture. The following seven soil moisture classes are adopted with changes from the soil-drainage classes in the United States Department of Agriculture's *Soil Survey Manual* (Soil Survey Staff, 1953). The classes are based on runoff, permeability, and internal drainage characteristics. No prairie communities are on xeric or hydric soils.

Xeric

Excessively drained. Water is removed from the soil very rapidly, because sloping bedrock or gravel is at or near the surface. A soil profile is poorly developed or absent.

Dry

Somewhat excessively drained. Water is removed from the soil rapidly. Many of these soils have little horizon differentiation. Prairie soils usually have no mottling; relatively thin A horizons; and brownish, yellowish, grayish, or reddish thin B horizons.

Dry-mesic

Well-drained. Water is removed from the soil readily but not rapidly. Well-drained soils are commonly intermediate in texture. Prairie soils have thick, dark A horizons; reddish, brownish, or yellowish B horizons; and C horizons that may or may not be mottled.

Mesic

Moderately well-drained. Water is removed from the soil somewhat slowly because of a slowly permeable layer within or immediately beneath the solum, a relatively high water table, additions of water through seepage, or a combination of these conditions. Prairie soils have thick, dark A horizons, and yellowish or grayish faintly mottled B horizons.

Wet-mesic

Imperfectly or somewhat poorly drained. Water is removed from the soil slowly enough to keep it wet for significant periods due to a slowly permeable layer within the profile, a high water table, additions through seepage, or a combination of these conditions. Prairie soils have thick, dark A horizons, and have faint evidence of gleying immediately beneath the A horizon.

Wet

Poorly drained. Water is removed so slowly that the soil remains wet for a large part of the time due to flooding, a high water table, a slowly permeable layer within the profile, seepage, or some combination of these conditions. Prairie soils commonly have slightly thickened, dark surface layers.

Hydric

Very poorly drained. Water is removed from the soil so slowly that the water table remains at or above the surface the greater part of the time. Nonforested soils commonly have gleying, and mucky or peaty surfaces.

DESCRIPTIONS OF PRAIRIE COMMUNITIES

The prairie community class includes communities dominated by grasses on mineral soil. Low shrubs may dominate locally; and trees may be present, but less than ten percent of the area has a tree canopy. The prairie communities are described below, and they are grouped into six subclasses. Dominant plants are listed, and other species are named if they are characteristic of a community. Because the descriptions of soil moisture and vegetation usually define the communities well, animals are listed only when naming the species gives a clearer picture of the community.

Prairie Subclass

This subclass is termed simply prairie, with no modifier, because it includes the typical "black-soil" prairies. Soils are deep and fine-textured, usually silt loam or clay loam derived from loess or glacial till, although the prairies may occur on alluvium.

Dry Prairie

This community occupies steep, exposed slopes and it is relatively rare because the hilly topography necessary for its existence is usually forested. Grasses are shorter than 1 m.

Dominant plant species. *Andropogon scoparius, Bouteloua curtipendula,* and *Stipa spartea.*

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Dry-mesic Prairie

Grass height in dry-mesic prairie approaches that of mesic prairie and species diversity is greater than in dry prairie.

Dominant plant species. *Andropogon scoparius, Sorghastrum nutans,* and *Stipa spartea.*

Characteristic plant species. *Amorpha canescens, Echinacea pallida, Liatris aspera,* and *Potentilla arguta.*

Mesic Prairie

Favorable moisture conditions allow the greatest plant species diversity, and maximum grass and forb height. The grass layer may be only 1 m tall if *Sporobolus heterolepis* dominates, but it is sometimes 2 m.

Dominant plant species. *Andropogon gerardii, Sorghastrum nutans,* and *Sporobolus heterolepis.*

Characteristic plant species. *Baptisia leucophaea, Dodecatheon meadia, Eryngium yuccifolium, Liatris pycnostachya, Lithospermum canescens, Petalostemum candidum, Phlox pilosa, Silphium laciniatum,* and *S. terebinthinaceum.*

Characteristic animal species. Prairie garter snake or eastern plains garter snake, prairie kingsnake, dickcissel, grasshopper sparrow, prairie vole, and short-tailed shrew.

Wet-mesic Prairie

Surface water is present after heavy rains, and the water table is near the surface. Grass composition is a mixture of mesic prairie and wet prairie species.

Dominant plant species. *Andropogon gerardii, Calamagrostis canadensis, Panicum virgatum, Sorghastrum nutans,* and *Spartina pectinata.*

Characteristic plant species. *Lysimachia quadriflora, Phlox glaberrima, Senecio pauperculus, Veronicastrum virginicum,* and *Zizia aurea.*

Characteristic animal species. Eastern massasauga and bobolink.

Wet Prairie

Surface water is present during the winter and spring, and the soil is nearly always saturated. Plant species diversity is lower than in other prairie communities.

Dominant plant species. *Calamagrostis canadensis, Carex* spp., and *Spartina pectinata.*

Characteristic plant species. *Cacalia tuberosa, Eupatorium perfoliatum, Iris virginica* var. *shrevei, Lythrum alatum,* and *Sium suave.*

Sand Prairie Subclass

Sand, loamy sand, and sandy loam can support sand prairie, but prairies on sandy loam are considered sand prairies only if they are acid enough to have characteristic plants.

Dry Sand Prairie

The soil lacks a dark A horizon and grass is less than 1 m tall. Dry sand prairie occurs on the crests of sand dunes.

Dominant plant species. *Andropogon scoparius, Calamovilfa longifolia, Koeleria cristata,* and *Stipa spartea.*

Characteristic plant species. *Arenaria stricta, Artemisia caudata, Callirhoe triangulata, Monarda punctata,* and *Opuntia compressa.*

Dry-mesic Sand Prairie

Unlike the preceding community, a dark A horizon is present in dry-mesic sand prairie. The average height of grass and the plant species diversity approach that of mesic sand prairie.

Dominant plant species. *Andropogon scoparius, Sorghastrum nutans,* and *Stipa spartea.*

Characteristic plant species. *Aster linariifolius, Liatris aspera, Solidago speciosa,* and *Viola pedata.*

Characteristic animal species. Western hognosed snake, bullsnake, lark sparrow, savannah sparrow, vesper sparrow, and plains pocket gopher.

Mesic Sand Prairie

This community has a deep A horizon in acid sand. Mosses and low shrubs are common, but the shrubs are not dominant.

Dominant plant species. *Andropogon gerardii, A. scoparius,* and *Sorghastrum nutans.*

Characteristic plant species. *Aletris farinosa, Aronia melanocarpa. A. prunifolia, Aster umbellatus, Calopogon tuberosus, Helianthus mollis, Parthenium integrifolium, Rubus hispidus, Scleria triglomerata,* and *Vaccinium angustifolium.* Common mesic prairie forbs such as *Echinacea pallida, Ratibida pinnata,* and *Silphium laciniatum* are rare or absent.

Wet-mesic Sand Prairie

Surface water is present in this community for short periods and a deep, acid, dark A horizon is present.

Dominant plant species. *Andropogon gerardii, Calamagrostis canadensis, Carex* spp., *Sorghastrum nutans,* and *Spartina pectinata.*

Characteristic plant species. *Osmunda cinnamomea, O. regalis, Pycnanthemum virginianum, Rhexia virginica, Viola lanceolata,* and *Xyris torta.*

Wet Sand Prairie

Surface water is present in this community for as much as one-third of the year. Wet sand prairie is floristically very similar to wet prairie.

Dominant plant species. *Calamagrostis canadensis, Carex* spp., *Spartina pectinata,* and *Thelypteris palustris.*

Gravel Prairie Subclass

This subclass includes prairies on gravel or very gravelly soil. The soils are usually calcareous.

Dry Gravel Prairie

These prairies are on steep gravel slopes, and the grasses average less than 1 m in height.

Dominant plant species. *Andropogon scoparius* and *Bouteloua curtipendula.*

Characteristic plant species. *Anemone patens, Arenaria stricta, Asclepias lanuginosa, Linum sulcatum, Lithospermum incisum, Ranunculus rhomboideus,* and *Wulfenia bullii.*

Dry-mesic Gravel Prairie

This community occurs on lower slopes, and the grass is intermediate in height between dry gravel prairie and mesic gravel prairie.

Dominant plant species. *Andropogon scoparius, Sorghastrum nutans, Sporobolus heterolepis,* and *Stipa spartea.*

Characteristic plant species. *Aster ptarmicoides, Psoralea tenuiflora,* and *Scutellaria parvula.*

Mesic Gravel Prairie

Soil moisture is relatively high because of the low topographic position. The height of the grass and diversity of plant species approach that of mesic prairie.

Dominant plant species. *Andropogon gerardii, Sorghastrum nutans,* and *Sporobolus heterolepis.*

Characteristic plant species. *Satureja arkansana* and *Valeriana ciliata.*

Dolomite Prairie Subclass

Dolomite is less than 0.5 m below the surface. Certain common prairie plants are absent because of the shallow soils and high pH.

Dry Dolomite Prairie

The soil is extremely shallow to negligible in this community and patches of dolomite pavement are common. The grass is shorter than 1 m.

Dominant plant species. *Andropogon scoparius* and *Bouteloua curtipendula.*

Characteristic plant species. *Blephilia ciliata, Kuhnia eupatorioides, Muhlenbergia cuspidata,* and *Penstemon hirsutus.*

Dry-mesic Dolomite Prairie

The soil is slightly deeper over bedrock and the topographic position is lower than in dry dolomite prairie. Also, grass height is taller and species diversity is greater.

Dominant plant species. *Andropogon scoparius, Sorghastrum nutans,* and *Stipa spartea.*

Mesic Dolomite Prairie

The soil depth is 15 cm or more over dolomite. As bedrock depth decreases, the natural community intergrades with mesic prairie, but deeply rooted forbs, such as *Baptisia leucantha, B. leucophaea, Silphium laciniatum,* and *S. terebinthinaceum,* are usually absent from mesic dolomite prairie.

Dominant plant species. *Andropogon gerardii, Sorghastrum nutans,* and *Sporobolus heterolepis.*

Characteristic plant species. *Galium boreale* and *Petalostemum foliosum.*

Wet-mesic Dolomite Prairie

The soil depth to bedrock averages 0.3 m. Water is at the surface for short periods throughout the year.

Dominant plant species. *Andropogon scoparius, Calamagrostis canadensis, Carex* spp., *Deschampsia cespitosa, Sorghastrum nutans,* and *Spartina pectinata.*

Characteristic plant species. *Gentiana procera, Solidago ohioensis,* and *S. riddellii.*

Wet Dolomite Prairie

The soil is usually quite shallow over bedrock and is frequently saturated, or surface water is present. This community is very rare even in extensive dolomite areas because depressions usually have deep enough soil to support a sedge meadow at this moisture level.

Dominant plant species. *Carex lanuginosa, Deschampsia cespitosa,* and *Spartina pectinata.*

Characteristic plant species. *Cacalia tuberosa.*

Hill Prairie Subclass

A hill prairie is a prairie opening on a forested slope, caused by a combination of factors that result in droughty, well-drained or somewhat excessively drained soil. Hill prairies typically occur on steep, exposed, south- to west-facing bluffs. The kind of substrate often contributes to the existence of hill prairies, and periodic fires have maintained many hill prairies. Because the soil moisture class is limited to dry or dry-mesic in hill prairies, the moisture class is not part of the natural community name. Instead, the substrate is the modifier.

Loess Hill Prairie

This community is developed on deep loess on the bluffs of major rivers. They are the largest hill prairies in Illinois, sometimes larger than 1 ha.

Dominant plant species. *Andropogon scoparius, Bouteloua curtipendula,* and *Sorghastrum nutans.*

Characteristic plant species. *Asclepias viridiflora, Kuhnia eupatorioides, Linum sulcatum, Lithospermum incisum, Penstemon pallidus, Psoralea tenuiflora, Sisyrinchium campestre,* and *Spiranthes magnicamporum.*

Characteristic animal species. Six-lined racerunner.

Glacial Drift Hill Prairie

These hill prairies occur on eroded glacial drift, especially where a river valley cuts through an end moraine and there are many deep, steep-sided tributary ravines.

Dominant plant species. *Andropogon scoparius, Bouteloua curtipendula,* and *Sorghastrum nutans.*

Gravel Hill Prairie

This community is similar to dry gravel prairie or dry-mesic gravel prairie, but the hill prairies occur as openings in a forest rather than as part of a continuous prairie.

Dominant plant species. *Andropogon scoparius* and *Bouteloua curtipendula.*

Characteristic plant species. *Helianthemum canadense* and *Geum triflorum.*

Sand Hill Prairie

These prairies are developed mostly on sand dunes atop river bluffs.

Dominant plant species. *Andropogon scoparius, Bouteloua hirsuta, B. curtipendula,* and *Koeleria cristata.*

Characteristic plant species. *Chenopodium leptophyllum, Lechea villosa, Monarda punctata, Plantago purshii, Selaginella rupestris,* and *Tephrosia virginiana.*

Shrub Prairie Subclass

This community subclass is dominated by shrubs and grasses. Only one natural community, on mesic to wet-mesic, sandy soil, is recognized. Another kind of shrub prairie, consisting of hazel and plum thickets, existed on fine-textured soils in presettlement times, but no natural remnants are known.

Shrub Prairie

The community is dominated by a wide variety of shrubs and grasses, and there is a nearly continuous groundlayer of mosses. Shrub prairie intergrades with mesic sand prairie and wet-mesic sand prairie.

Dominant plant species. *Andropogon gerardii, A. scoparius, Gaylussacia baccata, Polytrichum commune, Rubus hispidus, R. setosus, Sorghastrum nutans, Spiraea tomentosa* var. *rosea,* and *Vaccinium angustifolium.*

Characteristic plant species. *Aronia melanocarpa, A. prunifolia, Habenaria flava, Sphagnum* spp., *Viola lanceolata,* and *V. primulifolia.*

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A SURVEY OF ILLINOIS PRAIRIES

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The Illinois Natural Areas Inventory was a three-year project completed in 1978 to find, describe, and evaluate natural areas for the Illinois Department of Conservation. The inventory identified habitats with endangered and threatened species, relict associations, outstanding geologic areas, existing nature preserves, and high quality natural communities of all types. This discussion is limited to high quality, relatively undisturbed prairies. The survey's methods and results have been detailed by White (1978).

METHODS

The staff included seven to nine permanent employees and as many as ten summer assistants. Survey methods included compiling information from individuals and agencies, reviewing literature, examining maps and aerial photographs, surveying from an airplane, and studying sites in the field. As many as 90 points of information were collected for the significant sites, and a computer-based information system was developed for the data.

Two factors were emphasized and given equal weight: ensuring that areas were not overlooked and investigating the significant sites. In addition to surveying 3,923 cemeteries for prairie and savanna remnants, approximately 5,300 other areas were surveyed as possible natural areas; about one-third of these were potential prairies. A first step in the inventory was the compilation of available information, which accounted for about 690 potential natural areas including non-prairie sites; 62 percent of these were later rejected. The main source of information was the examination of maps and aerial photographs, which assured systematic and complete coverage of the state and produced 73 percent of the potentially significant sites. One in fifteen of the sites selected from maps and photographs ultimately qualified as a natural area. The next step was an aerial survey during which sites selected from the previous stages were examined and new areas, particularly railroad prairies and hill prairies, were found. About 47 percent of the potentially undisturbed sites were disqualified during the aerial survey, and to attempt the inventory without the use of airplanes would have cost seven to ten times as much time and money. Less than 0.4 percent of the natural areas were located by ground surveys unsupported by previous investigations.

Both compiling available information and conducting new surveys are necessary for an adequate level of confidence and completeness. A review of literature revealed 1,413 references to the biology and ecology of specific natural areas, of which 93 publications referred to a total of 38 prairies, all of which are well known and 17 of which are already preserved. Information from publications is not always completely suitable for incorporation into an inventory because evaluation criteria differ or the publication is out-of-date. The classic study by Evers (1955) listed 61 hill prairies and limestone glades in Illinois, but only 16 of these sites met the Natural Areas Inventory's criteria as natural areas and the project found 102 more areas with natural hill prairies and limestone glades.

If the inventory had relied on available information and had not conducted original surveys with maps, aerial photos, and field visits, then 15 percent of the significant prairies could have been identified with certainty and 59 percent would have been overlooked. Inadequate information requiring field investigations to substantiate would have been available for the remaining 26 percent of the prairies. Systematic searches and on-site inspections remove doubt about the total number and relative value of natural areas.

RESULTS

A total of 253 areas of high quality, relatively undisturbed prairie were identified. The prairies total 952 ha (2,352 acres), of which 343 ha (847 acres) are undisturbed or nearly undisturbed and 609 ha (1505 acres) are somewhat disturbed but not heavily degraded. The prairie natural areas include 259 ha (641 acres) of typical black-soil prairie on fine-textured soil, 452 ha (1,116 acres) of sand prairie, 50 ha (123 acres) of gravel and dolomite prairies, 167 ha (412 acres) of hill prairie, and 24 ha (60 acres) of shrub prairie. The most extensive high quality remnants are dry sand prairie (168 ha, 415 acres) and loess hill prairie (151 ha, 372 acres), and the smallest natural remnants are dry prairie (0.6 ha, 1.4 acres) and sand hill prairie (0.9 ha, 2.1 acres).

An estimated 118 ha of natural prairie remains for every 1,000,000 ha of prairie in presettlement Illinois, but this ratio is exaggerated because many prairie remnants are small hill prairies that were not even included in estimates of the original extent of prairie. About 39 ha of typical black-soil prairie survives for each 1,000,000 ha that once occurred in Illinois.

The natural prairie remnants occur in 63 of the 102 counties, but they are concentrated along the Illinois and Mississippi Rivers and in northeastern Illinois. Fifty-nine percent of the prairies are on land that is too wet, steep, dry, rocky, gravelly, sandy, or shallow to cultivate; fifty-eight percent of these are hill prairies. Because these soil characteristics usually occur along forested valleys, prairie has been seven times as likely to survive in counties that once were over 75 percent forest than in counties that originally were over 90 percent prairie.

Forty-three percent of the prairies have survived primarily as accidents of land use patterns; seventy-three percent of these are along railroads and in cemeteries. Others are odd tracts of unused land such as part of an army arsenal and an airport. Fifteen prairies in the Chicago area are undeveloped tracts held by speculators or consist of subdivision lots sold in the 1920's but never developed due to the economic depression of the 1930's. Because of these undeveloped tracts and the presence of nature preserves and sandy soil, three adjoining counties in the Chicago region have 54 percent of the natural prairie in the state.

Ten prairies owe their existence primarily to deliberate protection. Five were acquired by a conservation or preservation organization, and five prairies totaling 13 ha (32.3 acres) were preserved by private individuals and families.

Seventy percent of the prairies are in private ownership and are not protected. Twenty-two percent are wholly or partly in public ownership, and about twenty-five percent of these are formally protected. Twelve percent of all prairies are formally protected, compared with fifteen percent for all types of communities combined. However, a relatively high percentage of the total land area with natural prairie is preserved because many of the unpreserved remnants are small: 32 percent of the prairie acreage is preserved, compared with 23 percent for savannas, forests, wetlands, lakes, ponds, and glades.

Threats of destruction or disturbance were identified for 66 percent of the prairies. Private lands are twice as likely to be threatened as public areas. The most common threats are maintenance of road and railroad rights-of-way, mowing and burials in cemeteries, cultivation, grazing, construction of buildings, and unnatural invasion by woody plants. Many instances of destruction of prairies occurred during the inventory project and some prairies have been destroyed so recently that they have been included in this report's summaries as though they still exist.

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AN INVENTORY OF RAILROAD PRAIRIES IN ILLINOIS

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Railroad rights-of-way are among the few remaining sites in Illinois where high quality prairie remnants still occur. Many of the railroads were built across the prairie before it was disturbed by farming or grazing. Although most of the rights-of-way were severely disturbed during construction, a few scattered remnants were left undisturbed. Occasional fires set for maintenance purposes or set by accident helped these prairie remnants to remain in a natural state. Today, the remaining high quality railroad prairies are continually being lost due to alternative maintenance procedures such as grading and spraying with herbicides.

The Illinois Natural Areas Inventory conducted a complete survey of railroad rights-of-way during 1975 and 1976 to locate the remaining high quality prairie remnants.

PROCEDURES

Preparation for the Field Survey

About 17,600 km (11,000 miles) of railroad track are in Illinois, excluding the major urban areas (White, 1974a). About 11,400 km (7,000 miles) of track were determined to have potential for prairie remnants. This determination was made by studying the *Presettlement Vegetation Atlas of Illinois* (White, 1974b) which showed the location of forests, prairies, and wetlands in Illinois at the time of the original U.S. Public Land Survey. The railroads that followed forested floodplains or crossed wooded hills were eliminated from further consideration. Railroads built after 1900 were also eliminated unless they crossed sandy or wet land because the land was cultivated prior to construction. Aerial photographs proved useful in eliminating railroads with very narrow rights-of-way.

Aerial Survey

Railroads with potential for prairie vegetation were surveyed from the air. The aerial survey was conducted in the fall, when the prairie grasses are brightly colored and easily recognized from the air. The colorful native grasses were distinguishable from nonindigenous grasses and weedy vegetation. The aerial survey was conducted in a Cessna 172 aircraft (single engine, four-seat plane with high wings) flown at relatively slow speeds of 112-192 kmph (70-120 mph) at an altitude of 150 m (500 ft) above ground. Potential prairies were marked on county highway maps. Observations as to type, size, location, access, and disturbance were recorded on a tape recorder. After some experience in the air and on the ground, high quality prairie remnants were easily identifiable. A total of 667 potential prairies were selected for further study.

Initial Ground Survey

The potential prairies identified by the aerial survey were visited during the fall and early winter to select high quality prairies for further study during the growing season. The prairies were evaluated by determining natural quality based on degree of disturbance. Most railroad rights-of-way had severe disturbance to the soil, such as ditching and grading, which resulted in alteration of original drainage patterns. Many of the wider rights-of-way were cultivated. Past disturbances were detected and evaluated by looking for unnatural surface contours, studying the soil profile, and examining the composition of the vegetation.

Proficiency at appraising the natural quality of prairie vegetation increased with experience. Features that were noted when evaluating species composition include the following: (1) the presence of characteristic prairie species, (2) the presence of conservative prairie plants that cannot tolerate disturbance or have narrow ecological tolerances, (3) the presence and abundance of species that increase with disturbance, and (4) the diversity, as indicated by the number of species, of prairie species.

Clumping of individual species, as well as the abundance of nonprairie species, were also considered in evaluating natural quality. Generally, high quality prairies had the following characteristics: (1) a presence of characteristic and conservative species; (2) a scattered distribution of grasses and forbs; (3) a high diversity of prairie species; (4) a lack of weedy, woody, and exotic species; and (5) a relatively undisturbed soil profile.

As the prairie sites were appraised, they were graded for natural quality. The prairies with basically no sign of past disturbance, Grade A, or only slight disturbance, Grade B, were selected for further study. Minimum acreage followed by the survey was 0.1 ha (0.25 acres) for Grade A prairies and 0.4 ha (1 acre) for Grade B prairies. Preliminary species lists, sketch maps, and data forms were completed for 104 areas, totaling 76.4 ha (191 acres).

Final Field Survey

The final evaluation of the sites selected during the initial ground survey took place during the following growing season. The type of natural communities present and their natural quality were mapped for each site. The types of prairie natural communities present were determined by soil texture, soil moisture class (wet, wet-mesic, mesic, dry-mesic, dry), and vegetation. Species lists and site maps were compiled, and the dominant plants in each natural community were noted. Each site was sampled for species frequency using 0.25-m^2 circular plots at random points along a transect through each natural community. A total of 1,245 plots were sampled in the 62 prairie natural communities identified. These prairie natural areas totaled 49.12 ha (123.8 acres) and ranged in size from 0.088 ha (0.22 acres) to 5 ha (12.5 acres).

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CLASSIFICATION OF PRAIRIE NATURAL COMMUNITIES

The classification of significant railroad prairie remnants was developed from field observations, the classification system of the Illinois Natural Areas Inventory (White and Madany, 1981), and analysis of the sampling data. The prairie types (loam, sand, and gravel) were based on general soil texture determined in the field. Prairie types were divided into prairie natural communities based on soil moisture, dominant grasses, and characteristic plants. This procedure is similar to the classification by Curtis (1959). Plant communities were named based on the dominant grasses as determined by sampling data and field observations.

RESULTS AND DISCUSSION

Three prairie types were located during the survey: loam, sand, and gravel prairies. High quality railroad prairies were located in seven of fourteen of Illinois' Natural Divisions and in thirteen of the thirty-four Sections (Schwegmen et al., 1973; see our Fig. 1). Forty-three high quality examples of wet-mesic, mesic, dry-mesic, and dry loam prairies were located. The only wet loam prairies located were too disturbed to be included in the survey. The classification, area, Natural Division/Section, dominant grasses, and the sampling data for the loam prairies are shown in Table 1.

Eighteen high quality examples of wet-mesic, dry-mesic, and dry sand prairie were located. Only one high quality gravel prairie was located during the survey (a dry gravel prairie). The classification, area, Natural Division/Section, dominant grasses, and the sampling data for the sand and gravel prairies are in Table 2.

The most widely distributed prairie natural community was the mesic loam prairie, which was in seven different Sections of Illinois' Natural Divisions. The dry-mesic loam prairie was the most common prairie natural community located during the survey (21 sites) and it also registered the highest total acreage (14.44 ha, 36.1 acres). The rarest prairie natural communities were the dry loam and the dry gravel prairies. Based on the number of species per sampling plot, mesic loam, dry-mesic loam, mesic sand, and dry gravel prairies were the most diverse prairie natural communities sampled with seven species per plot.

The frequency of the major prairie grasses in relation to the moisture gradient is in Table 3. The data indicate that for sand prairies and loam prairies *Andropogon scoparius* and *Stipa spartea* are most frequent on dry and dry-mesic soils, and both species decrease in frequency on more mesic and wet soils. In contrast, *Calamagrostis canadensis, Panicum virgatum,* and *Spartina pectinata* increase in frequency from mesic to wet conditions. Although *Andropogon gerardii* was more frequent in mesic prairies than *Sorghastrum nutans,* both species declined in frequency at the extreme ends of the moisture gradient. In loam prairies, *Sporobolus heterolepis* decreased in frequency as site conditions changed from dry to wet. However, in sand prairie *Sporobolus heterolepis* reached its highest frequency in mesic site conditions. *Spartina pectinata* was the most frequent grass species in wet-mesic prairies.

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Table 1. Classification of Illinois loam railroad prairies, number located by area, Natural Division/Section[1], dominant species of grasses[2], and sampling data. Dominant grasses in association are separated by a hyphen. Numbers in parentheses indicate the number of this type of plant community identified, if greater than one.

	Number Located	Total Area	Natural Division/Section	Dominant Species of Grasses	Species/Plot (0.25 m²)	Number of Plots
Wet-mesic loam prairie	5	7.9	2a	Sp-Ag	6	90
			4a	Sp		
			4b	Sp-Ag-Cc		
			7a	Sn-Sp-Ag		
			9a	Sp-Ag		
Mesic-loam prairie	16	28.7	2a	Ag-Sp-Sn	7	320
			3a	Ag;Ag-Sn-Sh;Sh		
			3d	Sn-Sh		
			4a	Pv-Ag;Sp-Sn-Ag; Sh-Ec;Sh-Sn;Sh		
			4e	Sh-As-Ag-Sn		
			7a	Ag-As;As-Sn;Ag		
			9a	Ag-Sn(2)		
Dry-mesic loam prairie	21	36.1	3a	As-Ag;Sh-Ag; Sh-As	7	400
			3c	Ss-Ag		
			4a	As-Ag(2);Sh-Ag(S);Sh(3); Ss-Sh;Sh-As(2); Ag-Ss		
Dry loam	1	0.4	4a	As-Sh-Ss	6	20

[1]Natural Division/Section: Schwegman, J. E., G. B. Fell, M. Hutchison, G. Paulson, W. M. Shepherd, and J. White. 1973. Comprehensive plan for the Illinois Natural Preserves System, Part 2—the natural division of Illinois. Ill. Nat. Preserves Comm., Rockford, Ill. 32 p. + map.

[2]Dominant grasses include *Stipa spartea* (Ss), *Andropogon scoparius* (As), *Sorghastrum nutans* (Sn), *Andropogon gerardii* (Ag), *Sporobolus heterolepis* (Sh), *Panicum virgatum* (Pv), *Spartina pectinata* (Sp), *Calamagrostis canadensis* (Cc), and Elymus canadensis (Ec).

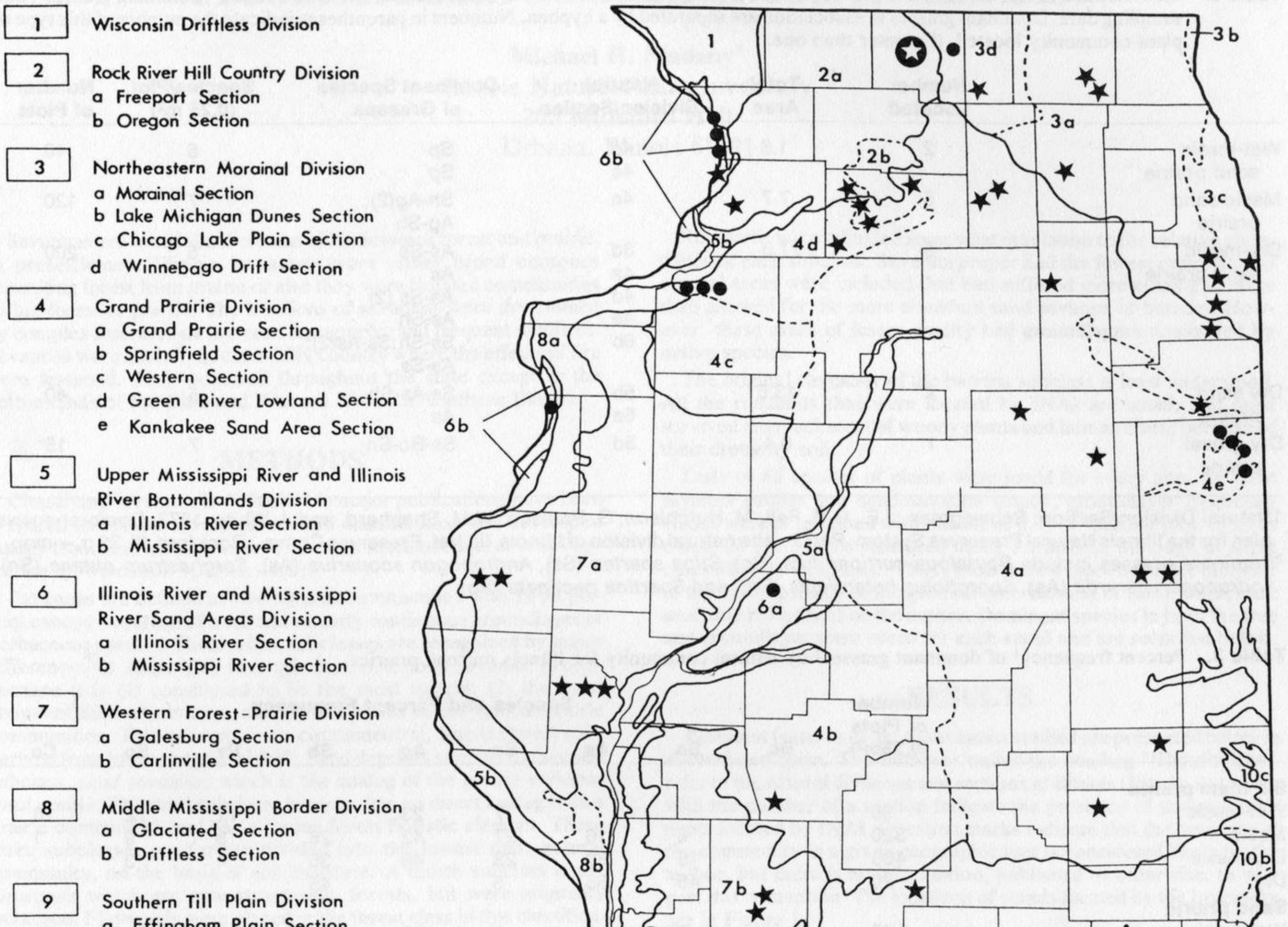

Figure 1. Distribution of high quality railroad prairies surveyed by the Illinois Natural Areas Inventory. (Base map of the Natural Divisions of Illinois is after Schwegman et al., 1973.)

Table 2. Classification of Illinois sand and gravel railroad prairies, number located by area, Natural Division/Section[1], dominant grasses[2], and sampling data. Dominant grasses in association are separated by a hyphen. Numbers in parentheses indicate the number of this type of plant community located, if greater than one.

	Number Located	Total Area	Natural Division/Section	Dominant Species of Grasses	Species/Plot (0.25 m²)	Number of Plots
Wet-mesic sand prairie	2	1.6	4d 4e	Sp Sp	6	40
Mesic sand prairie	5	7.7	4e	Sh-Ag(2); Ag-Sh	7	120
Dry-mesic sand prairie	9	27.5	3d 4a 4d 4e 6b	As-Ss As As-Ss (2) As-Sh Ss-Sh;Ss-As(2); As-Ss	5	200
Dry sand prairie	2	13.5	5b 6a	Ss-As-Sh As	5	40
Dry gravel prairie	1	0.4	3d	Ss-Bc-Sn	7	15

1Natural Division/Section: Schwegman, J.E., G.B. Fell, M. Hutchison, G. Paulson, W.M. Shepherd, and J. White. 1973. Comprehensive plan for the Illinois Natural Preserves System, Part 2—the natural division of Illinois. Ill. Nat. Preserves Comm., Rockford, Ill. 32 p. + map.
2Dominant grasses include *Bouteloua curtipendula* (Bc), *Stipa spartea* (Ss), *Andropogon scoparius* (As), *Sorghastrum nutans* (Sn), *Andropogon gerardii* (Ag), *Sporobolus heterolepis* (Sh), and *Spartina pectinata* (Sp).

Table 3. Percent frequency[1] of dominant grasses[2] by natural community for Illinois railroad prairies.

	Number of Plots (0.25m²)	Species and Percent Frequency								
		Bc	Ss	As	Sn	Ag	Sh	Pv	Sp	Cc
Silt loam prairie										
Wet-mesic	90				17	23		12	72	10
Mesic	320		6	16	27	42	26	8	9	1
Dry-mesic	400		18	30	23	46	35	4	3	
Dry	20		45	55	5		45			
Sand prairie										
Wet-mesic	40		7	5	2	25	12	5	60	12
Mesic	120		4	17	20	33	42	9	3	2
Dry-mesic	200		50	60	16	7	9			
Dry	40		35	70	5	5	12			
Gravel prairie										
Dry	15	30	45	20	25		25			

1Percent frequency is equal to the total number of plots the species occurs in divided by the total number of plots, multiplied by 100.
2The dominant grasses include *Bouteloua curtipendula* (Bc), *Stipa spartea* (Ss), *Andropogon scoparius* (As), *Sorghastrum nutans* (Sn), *Andropogon gerardii* (Ag), *Sporobolus heterolepis* (Sh), *Panicum virgatum* (Pv), *Spartina pectinata* (Sp), and *Calamagrostis canadensis* (Cc).

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A FLORISTIC SURVEY OF SAVANNAS IN ILLINOIS

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Savannas are transitional communities between forest and prairie. In presettlement Illinois, savannas were either broad ecotones separating forest from prairie or else they were isolated communities within forest or prairie. The locations of savannas were determined by complex interactions between topography and frequent wildfires. Savannas were most frequent in hilly country where the effects of fire were lessened. They occurred throughout the state except in the bottomlands of the Ohio and Wabash Rivers in southern Illinois.

METHODS

Classifying savannas is difficult. No major publications have been prepared on Illinois savannas; so, this classification was developed mainly from field observations. The major literature source was *Vegetation of Wisconsin* (Curtis, 1959).

Savannas are defined as two-layered communities with 10-80 percent canopy coverage of trees and a nearly continuous groundlayer of herbaceous species. Three major subclasses are recognized by major differences in soils. The first subclass is termed *savanna proper* because it is (1) considered to be the most typical, (2) the most abundant kind of savanna, and (3) analogous to the typical prairie communities. This savanna is on circumneutral, fine-textured soils derived from loess and glacial drift. Sand deposits support the second subclass, *sand savanna,* which is the analog of the prairie subclass *sand prairie*. The third subclass, *barrens*, has no direct analog with a prairie community, and has a strong forest floristic element. These three subclasses are further divided into the lowest unit, natural community, on the basis of soil moisture. A fourth subclass is the *flatwoods* which are now structurally forests, but were originally savannas. Flatwoods were placed in the forest class in this classification scheme. They are briefly mentioned in this paper because of their close affinity to savannas.

Because of their strong similarity with prairies, the methods used by the Illinois Natural Areas Inventory (INAI) to locate savannas were similar to those used to locate prairies. Savanna proper was the subclass with the fewest number of remnants; the highest-quality stands were discovered during an inventory of cemetery prairies. Sand savannas constituted the overwhelming percentage of existing savannas in terms of acreage and number of stands. They were located by examining maps and aerial photos, and selecting uncultivated, nonforested areas on sand. These sites were surveyed from an airplane in the autumn when most native prairie grasses are brightly colored. However, the assessment of quality was hampered because the groundlayers of some sand savannas are dominated by native cool-season graminoids which are not as brightly-colored. Furthermore, the main effect of past cattle grazing disturbance in sand savannas is to lower forb diversity, a feature not apparent until checked on the ground. Barrens were located by close aerial examination of areas with the proper topographic conditions. They are on steep slopes and narrow ridges in the well-dissected hilly portions of the state.

Natural quality assessment closely followed that developed for prairies. Total diversity of native species, presence of conservative (grazing-sensitive or nonaggressive) species, and the degree of encroachment by woody plants in the groundlayer were the major factors that each fieldworker considered. Periodic fires are essential for savanna maintenance and exceptionally severe ones occasionally removed the above-ground portion of the tree layer (Curtis, 1959). Thus, the fact that a stand may have been logged in the past did not have much effect on the final evaluation. This impact would have simulated a natural disturbance to a certain extent.

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Standards were adjusted somewhat in relation to the relative abundance of each subclass. Savanna proper had the fewest remnants, so several areas were included that had suffered more grazing damage than allowed for the more abundant sand savanna or barrens. However, these areas of lesser quality had groundlayers dominated by native species.

The original character of the barrens subclass is least understood. All the remnants that were located by INAI are small, and most survived encroachment of woody plants and human abuse because of their droughty soil.

Lists of all species of plants were made for every area. In most savanna proper and sand savanna stands, groundlayer frequency values were determined with the use of 0.25 m^2 circular plot. In most cases, 20 plots were measured along a transect, although in some cases 30 plots were used. Thirty plots gave a more accurate measure of the heterogeneity of the groundlayer. Results of these studies are available from INAI or the author. Dominant species in both the tree and groundlayer were noted for each stand and are recorded below.

RESULTS

Pertinent features of the 48 savannas studied are presented below in abbreviated form. The numbers under the heading "Distribution" refer to the natural divisions and sections of Illinois (Fig. 1). Asterisks with the number of a section indicate the presence of savanna remnants located by INAI. Question marks indicate that the presence of the community in a given geographic unit is considered likely by the author, but there is no information, published or otherwise, to support this contention. The locations of stands located by the Inventory are in Figure 1.

To determine the prevalent species for each savanna subclass it was necessary to combine data for a given community from stands throughout the state (Table 1). Prevalent species were selected according to the method of Curtis (1959). Species were arranged in order of decreasing presence; the number of prevalent species then selected for each community corresponds to the average number of species per stand for that community. In order to recognize important regional trends, the presence of certain species (both prevalent and less common ones) is noted under the heading "Localized Species."

CLASSIFICATION OF SAVANNAS

Savanna Proper

Dry-Mesic Savanna

Topography and Soils. Rolling hills; often associated with terminal moraines. Soils well-drained, fine-textured, and developed from deep loess or glacial till.

Distribution. 1, 2a, 2b, 3a, 3b, 3c*, 3d, 4a*, 4b, 4c*, 4d?, 7a, 7b*, 8a, 8b, 9a*, 9b.

Dominants. *Quercus alba, Q. macrocarpa* (north of 9a), *Q. marilandica* and *Q. stellata* (both mainly in 9a and 9b), *Q. velutina, Andropogon scoparius, Sorghastrum nutans, Stipa spartea*.

Localized Species. 2a, 2b, 3a, 3b, 3c, 3d: *Allium cernuum, Lathyrus venosus;* 4a (probably also in 4b, 7a, 7b, 8a, 8b): *Psoralea onobrychis, Sisyrinchium campestre;* 9a: *Helianthus mollis, Hieracium longipilum, Houstonia nigricans, Lechea villosa, Liatris ligulistylis, Sabatia angularis*.

Geographic Range. Southern and western Minnesota, Iowa, Missouri, southern Wisconsin (Bray, 1956, 1958, 1960; Cottam, 1949; Curtis, 1959; Muir, 1965; Stout, 1944; Tans, 1976), central and northern Illinois, southern Michigan, northwestern Indiana, central Ohio (Gordon, 1969).

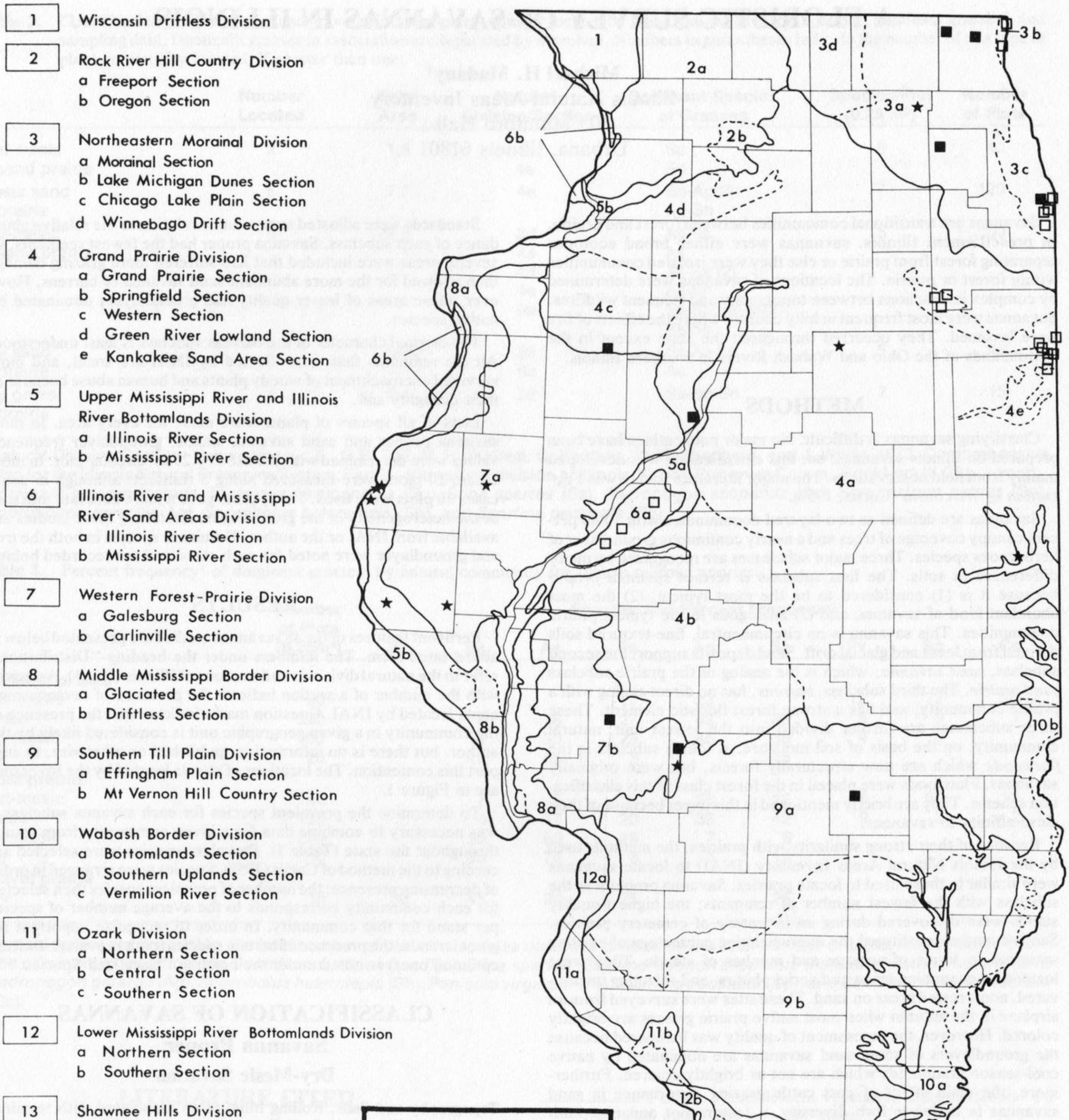

Figure 1. Location of savannas investigated in this paper. (Map of the Natural Divisions of Illinois from Schwegman et al., 1973)

Table 1. Prevalent species of plants in savannas in Illinois. Species in column I are from savannas proper; in II A, dry savannas; in IIB, dry-mesic sand savannas; in III, barrens. Because of the small number of stands, the lists of prevalent species from dry-mesic and mesic savannas have been combined in I; similarly, the lists of dry and dry-mesic barrens have been merged in III. No prevalent species are listed for flatwoods due to lack of information.

	I	IIA	IIB	III
Achillea millefolium	x		x	
Ambrosia artemisiifolia			x	
Amelanchier arborea				x
Amorpha canescens	x	x	x	x
Andropogon gerardii	x		x	x
A. scoparius	x	x	x	x
Antennaria neglecta			x	
A. plantaginifolia	x	x	x	x
Artemisia caudata			x	
Asclepias amplexicaulis		x	x	
A. tuberosa	x	x	x	
A. verticillata	x	x	x	x
Aster azureus	x	x	x	
A. ericoides			x	
A. linariifolius			x	
A. pilosus	x			
Baptisia leucantha	x		x	x
B. leucophaea		x	x	
Calamovilfa longifolia		x		
Carex spp.	x			
Carex spp. (probably *pensylvanica* and/or *artitecta)*				x
C. pensylvanica		x	x	
Carya ovata	x			x
C. tomentosa				x
Cassia fasciculata		x	x	x
Ceanothus americanus	x		x	x
Chenopodium leptophyllum		x		
Comandra richardsiana	x		x	x
Commelina erecta		x		
Coreopsis palmata		x	x	x
C. tripteris	x		x	
Corylus americana			x	
Cunila origanoides				x
Danthonia spicata				x
Desmodium canadense	x			
Elymus canadensis	x			x
Erigeron strigosus				x
Eupatorium altissimum	x			
Euphorbia corollata	x	x	x	x
Fragaria virginiana	x			
Gaylussacia baccata			x	
Gerardia pedicularia		x	x	x
G. grandiflora				x
Helianthemum canadense		x		
Helianthemum spp. *(bicknellii* and *canadense)*			x	
Helianthus divaricatus		x	x	x
H. grosseserratus	x			
H. mollis	x			
H. occidentalis		x	x	
Heuchera richardsonii	x			
Juniperus virginiana				x
Koeleria cristata		x	x	
Krigia biflora			x	
Lactuca canadensis	x			
Lechea spp. (including *minor)*			x	
Lechea spp. (including *intermedia, tenuifolia,* and *villosa)*				x
Lespedeza capitata	x	x	x	x
L. virginica				x
Leucobryum glaucum				x
Liatris aspera	x	x	x	x
Lithospermum canescens	x			
L. croceum		x	x	x
Lupinus perennis			x	
Melilotus alba	x			
Monarda fistulosa	x			
M. punctata		x		
Morus rubra	x			
Oenothera rhombipetala		x		
Opuntia compressa		x		
Ostrya virginiana				x
Panicum spp.			x	
P. virgatum	x	x	x	
Parthenium integrifolium			x	x
Penstemon pallidus				x
Petalostemum candidum				x
P. purpureum	x			
Phlox bifida		x	x	
Physalis virginiana		x		
Poa pratensis			x	
Polygonatum canaliculatum			x	
Potentilla simplex	x		x	x
Prenanthes aspera	x			
Prunus serotina	x	x	x	
Pteridium aquilinum			x	
Pycnanthemum flexuosum	x			
Quercus alba			x	x
Q. imbricaria				x
Q. macrocarpa	x			
Q. marilandica				x
Q. stellata				x
Q. velutina	x	x	x	x
Ratibida pinnata	x			
Rhus aromatica				x
R. copallina			x	
R. glabra	x		x	
Rosa carolina	x	x	x	x
Rubus allegheniensis	x			
Rudbeckia hirta	x	x	x	
Ruellia humilis				x
Rumex acetosella			x	
Salix humilis	x		x	
Sassafras albidum			x	x
Silphium integrifolium	x			
S. terebinthinaceum	x			
Sisyrinchium albidum	x			
Smilacina racemosa			x	
S. stellata		x	x	
Solidago altissima	x			
S. gymnospermoides			x	
S. juncea	x			x
S. nemoralis	x	x	x	x
S. rigida	x			
S. speciosa	x		x	
Sorghastrum nutans	x	x	x	x
Spartina pectinata	x			
Stipa spartea		x	x	
Taenidia integerrima				x
Tephrosia virginiana		x	x	x
Tradescantia ohiensis	x	x	x	
Ulmus rubra	x			
Vaccinium angustifolium			x	
Vernonia missurica	x			
Veronicastrum virginicum	x			
Viola pedata		x	x	x
V. sagittata			x	
Vitis riparia	x			
Zizia aurea	x			

Mesic Savanna

Topography and Soils: flat or gentle slopes. Soils moderately well-drained and usually developed from same parent material as dry-mesic savanna, although alluvium or outwash may be important.

Distribution: 1, 2a, 2b?, 3a*, 3b, 3c, 3d, 4a, 4b, 4c, 4d?, 5a?, 5b?, 7a, 7b, 8a, 8b, 9a, 9b, 12a?, 12b?

Dominants. *Quercus alba, Q. macrocarpa, Q. stellata, Andropogon gerardii, A. scoparius, Panicum virgatum, Sorghastrum nutans.*

N.B. Because of the very limited sample size and the disturbed or unusually small nature of mesic savanna remnants, the prevalent species list (Table 1) does not include certain characteristic savanna species. Both field observation and the literature (Bebb, 1860; Curtis, 1959) suggest that the following species were probably more prominent than indicated in Table 1: *Corylus americana, Heliopsis helianthoides, Parthenium integrifolium, Smilax lasioneura, Smilacina stellata.*

Geographic Range. Probably the same as dry-mesic savanna.

Sand Savanna

Dry Sand Savanna

Topography and Soils. Usually on the tops of sand dunes. Soils somewhat excessively drained, acidic, and little development; the A layer usually less than 2 cm.

Distribution. 2b, 3b*, 3c, 3d, 4e*, 4d, 6a*, 6b.

Dominants. *Quercus velutina, Andropogon scoparius, Calamovilfa longifolia* (mainly in 3b and 6a), *Carex pensylvanica, Koeleria cristata, Poa compressa, Stipa spartea.*

Localized Species. 3b, 3d: *Arctostaphylos uva-ursi;* 3b: *Arenaria stricta. Castilleja sessiliflora, Ceanothus ovatus. Juniperus horizontalis. Lithospermum incisum*; 6a: *Bouteloua hirsuta. Carya ovalis, C. tomentosa. C. texana, Quercus marilandica. Rhus aromatica.*

The following widespread dry sand savanna species are absent from certain sections — 3b: *Asclepias amplexicaulis, Cassia fasiculata, Tephrosia virginica, Viola pedata;* 4e: *Coreopsis lanceolata, Liatris cylindracea, Opuntia compressa.*

Geographic Range. Southern Minnesota, southern Wisconsin (Curtis, 1959; Bray, 1956, 1958, 1960; Tans, 1976; Whitford and Whitford, 1971), central and northern Illinois (Gleason, 1910), northwestern Indiana (Cowles, 1901; Olson, 1958), southwestern Michigan, northwestern Ohio (Gordon, 1969).

Dry-mesic Sand Savanna

Topography and Soils. Lower dune slopes, beach ridges, and other glacial lake features. Soils acidic, well-drained, with a larger A layer than in the dry sand savanna.

Distribution. 2b?, 3b*, 3c*, 3d, 4d, 4e*, 6a, 6b.

Dominants. *Quercus velutina, Q. alba* (occasionally codominant, especially in more mesic locations), *Andropogon scoparius, Carex pensylvanica, Sorghastrum nutans, Stipa spartea.*

Localized Species. 3b: *Potentilla arguta, Taenidia integerrima;* 3b and 3c: *Dodecatheon meadii, Heuchera richardsiana, Lithospermum canescens, Maianthemum canadense;* 3c: *Asclepias purpurascens, Calamagrostis inexpansa, Campanula rotundifolia, Castillega coccinea, Luzula multiflora;* 4e: *Commelina erecta, Phlox bifida* (probably in 6a and 6b as well).

The following widespread dry-mesic sand savanna species are absent from these sections: 3b: *Aster linariifolius, Sassafrass albidum;* 6a, 6b: *Gerardia pedicularia.*

Geographic Range. Identical to that of dry sand savanna.

Barrens

Dry Barrens

Topography and Soils. Restricted to areas with thin soil over bedrock (usually sandstone or shale), often on steep slopes. The thin layer of soil is somewhat excessively drained and usually quite acidic.

Distribution. 1, 2a, 2b, 4a, 7a, 7b*, 8a, 8b, 9a, 9b, 11a, 11b, 11c*, 13a*, 13b, 14a.

Dominants. *Quercus marilandica* (except in 1, 2a, 2b, and 4a), *Q. stellata* (except in 1, 2a, 2b, and 4a), *Q. velutina, Andropogon scoparius, Carex* spp. (probably *C. pensylvanica* and *C. artitecta*), *Danthonia spicata, Koeleria cristata.*

Localized Species. 11c, 13a, 13b, 14a: *Agave virginica, Ulmus alata;* 13a, 13b, 14a: *Vaccinum arboreum, Liatris squarrosa, Clitoria mariana, Stylosanthes biflora.*

Geographic Range. Southern Wisconsin?, Iowa?, Illinois (Anderson, 1970), Missouri (Dyksterhuis, 1957; Hus, 1908), Indiana, Ohio (Gordon, 1969), Kentucky, Tennessee, Arkansas.

Dry-mesic Barrens

Topography and Soils. Often ravine crests favored in addition to shallow soil over bedrock. Soils well-drained, acidic, and probably closer to forest than to prairie soils.

Distribution. 1, 2a, 2b, 3a*, 3d, 4a*, 4b, 4c, 7a*, 7b*, 8a*, 8b, 9a, 9b, 10b, 10c*, 11a, 11b, 11c, 13a, 13b, 14a*.

Dominants. *Quercus alba, Q. falcata* (14a), *Q. imbricaria, Q. marilandica* (south of 8a), *Q. stellata* (south of 8a), *Q. velutina, Andropogon scoparius, Danthonia spicata, Sorghastrum nutans.*

Localized species. 3a: *Lechea intermedia*; 14a: *Buchnera americana. Phaseolus polystachios.*

Geographic Range. Southern Wisconsin, Iowa, Illinois (Vestal, 1936), Indiana, southern Michigan?, Missouri, Ohio, Kentucky, Tennessee (DeSelm et al., 1973), Arkansas.

Mesic Barrens

Topography and Soils. Stream valleys in extreme southern Illinois. Soils fine-textured, moderately well-drained, and acidic.

Distribution. 13a?, 13b?, 14a*.

Dominants. Only one remnant of this community was located in Illinois. Oaks are not presently forming a canopy; *Ulmus alata, Betula nigra, Juglans nigra,* and *Platanus occidentalis* present.

N.B. If this disturbed area represents a former savanna, the trees most likely to dominate the canopy are *Quercus alba* and *Q. falcata.* The groundlayer is dominated by *Andropogon gerardii, A. scoparius,* and *Sorghastrum nutans.* As mentioned above, it is not clear whether this community is a true savanna or perhaps a type of prairie.

Geographic range. Southern Illinois (Anderson, 1970; Anderson and Schwegman, 1971), Kentucky?, Tennessee, Missouri?, Arkansas?

Flatwoods

Topography and Soils. Nearly level areas with slowly permeable soils.

Location. 3a, 3c, 4e, 9a, 9b, 13a, 13b, 14b.

Dominants. *Quercus alba, Q. bicolor, Q. ellipsoidalis* (3a only), *Q. marilandica* (except 3a, 3c, 4e), *Q. palustris* (except 3a), *Q. stellata* (except 3a, 3c, 4e), *Andropogon gerardii, A. scoparius, Carex muskingumensis, C. stricta, Cinna arundinacea, Danthonia spicata, Sorghastrum nutans.*

N.B. Although all the examples of flatwoods recognized by INAI were structurally forests, many still retained some savanna floristic elements which are noted here. Originally most of the flatwoods were true savannas. Among the groundlayer species, in addition to the probable dominants listed above, surviving in open areas are *Aster azureus, Baptisia leucantha, Liatris aspera, L. cylindracea, L. pycnostachya, L. spicata, Silphium integrifolium, S. terebinthinaceum,* and *Sporobolus heterolepsis.*

Geographic range. Southern Wisconsin?, Illinois, Indiana, Ohio (Gordon, 1969), Kentucky?, Tennessee?, Iowa?, Missouri? In states east of Illinois, flatwoods were probably true forests with little savanna element.

ACKNOWLEDGEMENTS

Without the individual efforts of the Illinois Natural Areas Inventory field staff, this paper could not have been written. John White, Dr. Roger C. Anderson, Max D. Hutchison, and Keith Wilson provided valuable comments and criticisms. The research upon which this publication is based was performed pursuant to Contract No. 50-75-226 with the Illinois Department of Conservation.

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A VOLUNTEER-SUPPORTED EFFORT TO FIND AND PRESERVE PRAIRIE AND SAVANNA REMNANTS IN ILLINOIS CEMETERIES

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Settlers of the Illinois prairie established cemeteries on land that had never been plowed or intensively grazed. Some of these early cemeteries support native prairie and savanna vegetation in unused or infrequently mowed parts of the cemetery, and a few abandoned cemeteries have reverted to prairie. Other cemeteries have savanna vegetation because they have been mowed or burned often enough to suppress woody invaders, but they have not been so closely manicured that the native grasses and forbs have been killed.

In some counties, the only undisturbed prairie or savanna remnants are in cemeteries. In the Grand Prairie section of Illinois, cemeteries have some of the very few remnants of the black-soil prairie that once covered thousands of square kilometers. The savanna community, once characteristic of Illinois, is also almost completely destroyed. It is as important to preserve cemeteries with these transitional areas between forests and prairies as it is to preserve prairies. Both are valuable natural areas and memorials to the pioneers buried there.

The purpose of the Illinois Natural Areas Inventory's cemetery survey was to inventory cemeteries for prairie and savanna remnants, using volunteers as much as possible. The actual number and relative value of the remnants was determined because all known cemeteries with potential for prairie or savanna were examined. This survey was completed in 1976 as a part of a state-wide inventory of natural areas for the Illinois Department of Conservation.

Articles and abstracts have been written about cemetery prairies in Illinois to stimulate interest in preservation by Betz (1972, 1976), Betz and Lamp (1973), the Illinois Nature Preserves Commission (1977:15), and Keller (1978).

PROCEDURE

Office Preparation

To locate cemeteries we used county highway maps, topographic maps, and information from genealogists. Then the *Presettlement Vegetation Atlas of Illinois* (an unpublished series of maps developed by John White from original Public Land Survey plats) and soil maps were used to decide which cemeteries had potential for prairie or savanna remnants. This atlas was generally more accurate and easier to use than soil maps; however, because savannas were mapped as timber by the original surveyors, soil maps were used to find sandy areas that might still have savanna vegetation. The result was a set of county highway maps with cemeteries color-coded to show whether they were to be field checked.

We tried to reduce the number of cemeteries to be surveyed by learning which ones were established after 1900 when any upland prairie would have been destroyed by farming. The sources explored were old atlases, state agencies, genealogical societies, historical societies, libraries, church organizations, morticians' organizations, and cemetery associations. These approaches were not productive because most cemeteries were established well before 1900 and the sources did not have the exact information we needed.

Pilot Survey

A staff member and a volunteer surveyed 73 cemeteries in four counties to test and develop the survey methods. Suggestions to the volunteers on equipment and procedure were based on their work.

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Volunteer Survey

Persons were asked to commit themselves to survey one or more counties. The basic requirement was that one volunteer per team be able to identify prairie plants. The volunteers were given instructions, forms to complete, and county highway maps marked to show the cemeteries to be checked. The fieldworkers (1) recorded basic information such as the date and name of the investigator; (2) visited each cemetery and assigned it a number on the map and form; (3) noted whether the cemetery was on prairie, forest, or transitional soil; (4) made a list of prairie plants in the cemetery; (5) gave an opinion about whether the cemetery was a nonqualifying area, notable area, marginal area, or natural area; and (6) recorded any other pertinent observations. Expertise, motivation, and ability to follow instructions varied. Much time was necessary to encourage and persuade volunteers to complete the work.

Staff Survey

To help decide which cemeteries should be revisited, a ranking system was applied to the species lists completed by the volunteers. The prairie plants were placed into five groups:

1. "Weedy" native plants, often present in prairies because of disturbance, and common or abundant in nonprairie habitats. Examples: *Aster pilosus, Eupatorium altissimum,* and *Solidago canadensis*.
2. Typical prairie plants that can withstand heavy disturbance or readily invade disturbed sites. Examples: *Andropogon gerardii, Desmodium canadense, Helianthus grosseserratus,* and *Rosa carolina*.
3. Typical prairie plants, often eliminated by heavy disturbance, but not by light to moderate disturbance. Examples: *Echinacea pallida, Helianthus mollis, Silphium integrifolium,* and *Veronicastrum virginicum*.
4. Prairie species similar to Group 3, but less likely to invade disturbed areas. Examples: *Baptisia leucantha, Salix humilis,* and *Silphium laciniatum*.
5. Conservative prairie species, usually indicating lack of disturbance. Examples: *Amorpha canescens, Baptisia leucophaea, Lilium philadelphicum,* and *Petalostemum candidum*.

The cemeteries were scored with a point system according to the number and kinds of species present. Group 1 and 2 plants scored one point. Group 3 plants were three points, and Group 4 and 5 plants received five points. As a general guideline, cemeteries with 40 or more points were rechecked by the staff, but the volunteer's description of the cemetery's potential as a prairie preserve and our confidence in the volunteer's work were also considered.

The staff rechecked 192 of the cemeteries visited by volunteers. Each site was determined to be either (1) a natural area; (2) a notable area with (a) high, (b) medium, or (c) low potential for recovery with management; or (3) a nonqualifying area. A brief form was completed for each cemetery visited, and the natural savanna or prairie remnants were surveyed with the standard forms and procedures of the Natural Areas Inventory (White, 1978).

RESULTS

Survey Expenses

Information was compiled on 3,923 cemeteries including 2,772 cemeteries checked by the volunteers, 216 by the staff alone, and 935 from prior surveys. The cost of the survey per 100 cemeteries was 53 hours of volunteer fieldwork, 13 hours of office preparation and coordination, and 1,430 km (890 miles) of travel. Volunteers drove 40,270 km (25,030 miles) and worked 2,060 hours. The staff drove 16,170 km (10,050 miles) and worked 910 hours. Total effort was 2,970 hours of fieldwork and 56,440 km (35,080 miles) driven. Volunteers were reimbursed for their mileage, meals, and lodging at a cost of $3,972.19. A few volunteers requested no reimbursement. Staff travel expenses were $1,894.06. Total travel expenses for the survey were $5,866.25. For each of the natural areas or high quality notable areas located, $99.42 and 50 hours of fieldwork were spent. No revisiting of the cemeteries would have been necessary if the survey had been completed by the staff, and we cannot compare the efficiency of the staff and volunteers, so we cannot be precise about savings from the help of volunteers.

Areas Identified

Natural Areas

Twenty-four natural areas of Illinois Nature Preserve quality were identified. The natural areas total about 21 ha (51.8 acres) in eight natural communities. About 6 ha (14.8 acres) are Grade A, with essentially undisturbed soil and vegetation; and 10.8 ha (26.6 acres) are Grade B, with slight disturbance. The remainder (4.2 ha, 10.4 acres) is moderately disturbed and is included only because it is within areas of higher quality.

Grade A or B land was found in one dry prairie (0.4 ha, 1 acre), three dry-mesic prairies (1.7 ha, 4.1 acres), 11 mesic prairies (8.9 ha, 22 acres), one dry-mesic sand prairie (0.4 ha, 1 acre), one glacial drift hill prairie (0.4 ha, 1.1 acres), one loess hill prairie (0.4 ha, 0.9 acre), six dry-mesic savannas (3.7 ha. 9.2 acres), and one dry sand savanna (0.8 ha, 2.1 acres). The only dry-mesic savanna natural areas in Illinois are in cemeteries. In seven counties, the only black-soil prairie remnants are in cemeteries.

Notable Areas

One hundred and eleven notable areas of disturbed prairie or savanna, valuable for teaching or research, were identified. Thirty-five of these areas have high potential for recovery to high natural quality, probably with five years or less of management. Although it often is necessary to study the vegetation with several visits throughout the growing season to determine a remnant's potential for recovery, we tentatively classified 33 cemeteries as having medium potential and 43 cemeteries as having low potential for recovery with management. Some mowed cemeteries do not show their true potential for recovery until they have been protected and managed for a few years.

Distribution

The survey identified natural areas in 22 counties. Cemetery natural areas or notable areas are in 55 counties, mostly in the northern half of Illinois.

Endangered Plants

Two of the cemeteries are known to have endangered plants. One has the federally endangered white-fringed orchid (*Habenaria leucophaea*). The prairie dandelion (*Microseris cuspidata*), a species considered endangered in Illinois by the Natural Land Institute's Endangered Species Project, grows in another.

Management

Disturbed prairies and savannas respond well to management to restore the vegetation. Some of the volunteers are protecting and managing areas that they discovered. Fourteen of the areas are receiving some protection and management, and seven formerly degraded remnants probably qualify as natural areas only because they had already been protected or managed. Seventeen of the areas are in an abandoned cemetery or an unused part of a cemetery. Three of the areas are now Illinois Nature Preserves and the Illinois Nature Preserves Commission plans a program to negotiate preservation of the most significant remnants.

Threats

Mowing and burying are the most common threats, and grazing and invasion by woody vegetation are sometimes threats. Although mowing may be destructive, occasional light mowing has protected some savanna cemeteries from encroachment by trees and shrubs in the absence of fire.

Ten of the remnants have no known threat, but eight are likely to be threatened within five years. Four have known, but not immediate, threats and two are threatened with destruction within one year. Only the three nature preserves can be considered permanently protected.

CONCLUSION

The cemetery prairie survey was as thorough and systematic as practical with adequate funding and good help. A complete survey is important because the amount of natural land becomes known, leaving little doubt about the relative quality or rarity of an area. We recommend that persons in other states organize volunteers to conduct systematic surveys of all cemeteries that have potential prairie or savanna remnants.

ACKNOWLEDGEMENTS

Dr. Robert F. Betz has pioneered in locating, preserving, managing, and studying prairie remnants in cemeteries. He inspired and advised us, and contributed his knowledge gained from visiting over 800 cemeteries in northern Illinois. Much knowledge about cemeteries in northwestern Illinois was contributed by G. Tim Keller. Eighty-one persons contributed to the volunteer field survey. The most outstanding volunteer was Dr. Paul Shildneck, who surveyed all or parts of 17 counties. This publication is based on work performed under Contract No. 50-75-226 between the Illinois Department of Conservation and the University of Illinois, in conjunction with the Natural Land Institute.

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FLORA OF LIMESTONE GLADES IN ILLINOIS[1]

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The location and subsequent study of limestone glades in Illinois has received less attention than most other natural communities in the state. Evers (1955) and Ozment (1967) described and provided species lists for five limestone glades in Illinois, three of which occur along the Mississippi River while the other two are in the Shawnee Hills in extreme southeastern Illinois.

One of the tasks of the Illinois Natural Areas Inventory (INAI) was to locate, describe, and evaluate limestone glades in Illinois. The term, limestone glades, describes openings in the forest with limestone bedrock at or near the surface. These glades usually occur on south- to southwest-facing slopes on thin soil, and they are dominated by prairie grasses and forbs (Fig. 1).

METHODS OF STUDY

A total of 32 limestone glades were identified as natural areas; 16 were previously unknown. Twenty-three of the glades are in the counties of Hardin, Johnson, Pope, and Saline in the extreme southeastern part of the state (Fig. 2). The remaining glades are on uplands along major river valleys. Five occur along the Mississippi River valley in the counties of Jersey, Monroe, St. Clair, and Union. The remaining four glades are on the uplands above the Illinois River in Calhoun and Pike Counties.

Sixteen of the glades designated as natural areas were already known. By personally contacting individuals and reviewing the literature, the locations of the glades were obtained along with pertinent information. The remaining 16 areas were located through a stepwise procedure that proved useful. The first step was to examine geological maps to find outcroppings of limestone bedrock and to locate these regions on topographic maps and aerial photographs. Such items as slope, aspect, and canopy cover were identified on the maps and photographs. Some of the limestone glades appeared as white glares on the aerial photographs because of the angle of light reflecting on the exposed limestone bedrock. Studying forest-glade boundaries also provided important clues regarding the origin of an opening. Forest openings with straight edges on one or more sides of its boundaries were indications of fence lines that were probably used to contain cattle in pastured forest clearings at some time.

After locating potential limestone glades on maps, the next step was to fly over the area for a closer and more detailed examination (Fig. 3). The best season for the aerial survey was in late fall to midwinter when the bluestem *(Andropogon scoparius)* and Indian grass *(Sorghastrum nutans)* had turned a rusty gold color. This procedure helped to differentiate these native species from the pale yellow of cool-season grasses. Another clue as to the location of glades was the presence of limestone rocks and exposed ledges at the surface. The bedrock exposures were obvious from the air. In areas where limestone was not observed, later checking on the ground revealed that the openings were old artificial clearings largely dominated by little bluestem and broom sedge *(Andropogon virginicus)* with few forbs. If, after ground checking, the limestone glade was of high natural quality, a final field survey of the area was conducted with detailed mapping, descriptions, and evaluation. Species checklists and sampling data expressed in percent frequency were recorded.

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Figure 1. A limestone glade in Illinois.

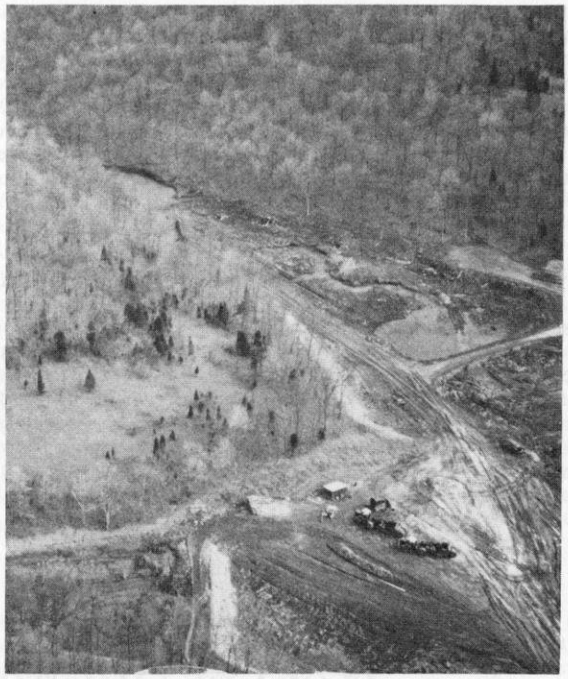

Figure 3. Aerial view of a potential limestone glade.

Figure 2. Distribution of limestone glades in Illinois.

LOCATION OF LIMESTONE GLADES

The glades occur on limestones of the Mississippian System, which is known to be as much as 975 m (3200 ft) thick in southern Illinois. Most of the soils on the uplands, where glades are located, have developed from the deep well-drained Peoria Loess which has a maximum thickness of about 23 m (75 ft), but rarely exceeds 15 m (50 ft) (Willman and Frye, 1970). In the southeastern part of the state the loess forms a thin layer of brownish gray, clayey silt. Particularly, the glades along the major river valleys of the Mississippi and the Illinois Rivers have shallow soils, and where they are in close proximity a loess hill prairie occurs with deep soils. The slope of the glades usually faces south, and it is suggested that the wind-blown silt was not deposited in these areas because of their position. Another suggestion is that the soils eroded over a period of time because of some disturbance leaving little loess covering the bedrock.

All but two of the limestone glades are in unglaciated regions of the state. The aspect varies from south to southwest with the exception of one west-facing glade. The steepness of the slopes commonly ranges from 20 to 30° except for one glade system in Union County that occupies a 40° slope. This glade occurs on resistant cherty limestone and has produced very rugged topography with surface drainage.

The 32 limestone glades vary in size from 0.12 ha (0.3 acres) to 5.6 ha (13.9 acres) with a mean of 1.6 ha (4 acres). Glades in the western part of the state are somewhat larger than those in the southeastern counties with a mean of 1.3 ha (3.2 acres) compared to 0.6 ha (1.5 acres) for the latter. The total acreage for the nine western glades which occur above the river valleys is 31 ha (76 acres) and for the twenty-three glades in the interior southeastern part of the state a total of 21 ha (53 acres).

THE GLADES AS NATURAL AREAS

The glades are designated as natural areas depending upon their natural quality. In determining natural quality of an area, species composition and diversity, and degree of artificial and natural disturbance are important considerations. Only glades with very high or high natural quality are called natural areas. A lower category for natural quality is expressed as medium natural quality which applies to areas that were not usually acceptable as natural areas. They are only considered as a natural area if they are judged to be the best of their type for a particular natural region of the state. No limestone glades inventoried by the INAI were judged to be the best of their type for any particular natural region.

Of the 23 glades in the southeastern part of the state, 85 percent are of very high natural quality, the remaining 15 percent are of high natural quality. On the western side of the state only 27 percent of the glades are of very high natural quality and the remaining 73 percent are of high natural quality. Encroachment of woody plants, a natural disturbance, is the main reason for the lower natural quality rating.

During the inventory two visits were usually made to each glade, once in the spring for a brief check to determine if the glade met the requirements of a natural area, and a second in the summer for a more detailed analysis. During the second visit, each glade was sampled using a 0.25 m^2 circular hoop. Depending upon the size of the glade, 20 to 30 plots were randomly selected along a transect through the area. Species in each plot were noted and their presence expressed in terms of frequency (percent occurrence).

THE FLORA

In 30 of the 32 glades, little bluestem appeared in 80-100 percent of the plots sampled. Of the remaining two glades, one contained a higher frequency of Indian grass while the other glade was dominated by sideoats grama *(Bouteloua curtipendula)*. The glade with the Indian grass had a total frequency of 55 percent in the plots sampled and little bluestem had a frequency of 45 percent. Sideoats grama in the second glade was at 100 percent frequency while little bluestem appeared in 90 percent of the plots. In both cases, the frequency of little bluestem approximated the frequency of the associated species.

Although little blustem was the most dominant plant in most glades, other grasses such as Indian grass, sideoats grama, and dropseed *(Sporobolus asper)* were usually equally abundant. Forbs as a rule were less dominant than the grasses. No consistent species of forbs had the highest frequency of occurrence when the dominant species were summarized for all the glades. Dominant species of forbs occurring in several glades were aster *(Aster oblongifolius)*, pale coneflower *(Echinacea pallida)*, croton *(Croton monanthogynus)*, bluet *(Houstonia nigricans)*, American agave *(Agave virginicus)*, flowering spurge *(Euphorbia corollata)*, false dragonhead *(Physostegia virginiana)*, and false boneset *(Kuhnia eupatorioides)*.

In the 32 limestone glades in Illinois, 260 species have been identified (Table 1). This number is not definitive because the glades were usually visited only twice during the inventory and undoubtedly some species were overlooked. Of the 167 species in the 23 southeastern Illinois glades, 93 species occurred only in these glades and not in the western ones. While in the nine western Illinois glades, a total of 177 species were present with 83 species known only to occur in the western glades. In both glade regions 84 species existed.

Several of the species in the western glades along the river valleys are also in the Ozark region and the Great Plains of the north and west. Among these are Drummond's goldenrod *(Solidago drummondii)*, blue aster *(Aster anomalus)*, cliff onion *(Allium stellatum)*, sideoats grama *(Boutelou curtipendula)*, baby lip fern *(Cheilanthes feei)*, rose verbena *(Verbena canadensis)*, prairie ragwort *(Senecio plattensis)*, dwarf bedstraw *(Galium virgatum)*, slender heliotrope *(Heliotropium tenellum)*, stickleaf *(Mentzelia oligosperma)*, and Missouri coneflower *(Rudbeckia missouriensis)*. The distance between the nearest western Illinois glade and the nearest southeastern Illinois glade is only 48 km (30 miles); yet, the above species are not in any of the southeastern glades. Climatic and edaphic conditions in the western Illinois glades may favor those species that are adapted to more arid regions of the Ozarks and the Great Plains.

In the southeastern Illinois glades are species which have ranges extending into southeastern United States, but they are not in the western Illinois glades. Selected examples are orange coneflower *(Rudbeckia fulgida)*, the climbing milkweed *(Gonolobus obliquus)*, prairie dock *(Silphium terebinthinaceum)*, and white wild indigo *(Baptisia leucantha)*. Here climatic and edaphic conditions may favor plants that require slightly deeper soil, at least on the lower slopes.

ACKNOWLEDGEMENTS

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Table 1. Plant species in 33 Illinois limestone glades: names of species preceded by a plus sign (+) are from western Illinois, those preceded by an asterisk (*) are only from the southeastern part of the state, and those unmarked are from both regions. Nomenclature follows Mohlenbrock (1975)[1].

+*Acalypha rhomboidea*	+*A. stenophylla*	*Camassia scilloides*
+*Acer saccharinum*	**A. tuberosa*	**Campsis radicans*
Agave virginica	*A. verticillata*	**Carex complanata*
**Agrimonia sp.*	*A. viridiflora*	*Carex sp.*
+*Allium canadense*	+*Asplenium platyneuron*	**Carya glabra*
+*A. stellatum*	+*Aster anomalus*	**C. laciniosa*
Ambrosia artemisiifolia	*A. azureus*	**C. ovalis*
+*A. trifida*	+*A. ericoides*	**C. ovata*
Amelanchier arborea	**A. laevis*	*C. texana*
+*Amorpha canescens*	+*A. oblongifolius*	*Cassia fasciculata*
**Ampelopsis cordata*	**A. patens*	*C. marilandica*
**Amsonia tabernaemontana*	+*A. pilosus*	**C. nictitans*
Andropogon gerardii	+*A. sericeus*	*Ceanothus americanus*
A. scoparius	**Aster sp.*	+*Celastrus scandens*
+*Anemone cylindrica*	+*Aureolaria grandiflora*	*Celtis pumila*
**A. virginiana*	**Baptisia leucantha*	*Cercis canadensis*
+*Antennaria plantaginifolia*	**Blephilia hirsuta*	+*Cheilanthes feei*
Apocynum cannabinum	*Bouteloua curtipendula*	**Cirsium discolor*
+*Aquilegia canadensis*	*Bromus commutatus*	**Clitoria mariana*
+*Arabis glabra*	**B. purgans*	**Convolvulus spithamaeus*
+*Asclepias quadrifolia*	**Cacalia tuberosa*	+*Coreopsis lanceolata*

[1]Mohlenbrock, R. H. 1975. Guide to the vascular flora of Illinois. Southern Ill. Univ. Press, Carbondale, Ill. 494 p.

Table 1 (cont.) Plant species in 33 Illinois limestone glades: names of species preceded by a plus sign (+) are from western Illinois, those preceded by an asterisk (*) are only from the southeastern part of the state, and those unmarked are from both regions. Nomenclature follows Mohlenbrock (1975)[1].

Coreopsis palmata
**C. tripteris*
Cornus drummondii
**C. florida*
**C. racemosa*
**Crataegus crus-galli*
**C. engelmannii*
**Crataegus sp.*
**Croton capitatus*
C. monanthogynus
**Crotonopsis elliptica*
+*Cyperus filiculmis*
+*Cystopteris bulbifera*
Danthonia spicata
+*Delphinium carolinianum*
+*Desmanthus illinoensis*
+*Desmodium canadense*
+*D. dillenii*
+*D. sessilifolium*
Desmodium sp.
Diospyros virginiana
**Dodecatheon meadia*
+*Draba reptans*
Echinacea pallida
**E. purpurea*
Elymus canadensis
+*E. hystrix*
**E. virginicus*
+*Eragrostis spectabilis*
+*Erigeron strigosus*
**Eryngium yuccifolium*
Eupatorium altissimum
Euphorbia corollata
**Fragaria virginiana*
Fraxinus americana
+*F. quadrangulata*
**Galactia volubilis*
+*Galium aparine*
+*G. circaezans*
**Gaura biennis*
+*Geranium carolinianum*
**G. maculatum*
+*Gerardia aspera*
+*Gillenia stipulata*
Gleditsia triacanthos
**Gonolobus obliquus*
+*Hedeoma hispida*
Helianthus divaricatus
**H. hirsutus*
**H. microcephalus*
**H. occidentalis*
+*H. rigidus*
+*H. strumosus*
**Heliopsis helianthoides*
+*Heliotropium tenellum*
+*Heuchera richardsonii*
**Houstonia lanceolata*
H. nigricans
Hypericum sphaerocarpum
+*Hystrix patula*
**Ilex decidua*
+*Juglans nigra*
Juniperus virginiana
Koeleria cristata
Kuhnia eupatorioides
+*Lepidium virginicum*

Lespedeza capitata
**L. hirsutus*
L. virginica
**Lespedeza sp.*
+*Liatris aspera*
+*L. cylindracea*
**L. pycnostachya*
**L. scabra*
**L. squarrosa*
+*Linum sulcatum*
Lithospermum canescens
+*L. incisum*
**Lobelia spicata*
Lonicera japonica
**Lysimachia lanceolata*
+*Malus ioensis*
+*Melica nitens*
Melilotus alba
+*Mentzelia oligosperma*
Monarda bradburiana
M. fistulosa
**Morus rubra*
+*Muhlenbergia cuspidata*
**Nothoscordum bivalve*
**Onosmodium hispidissimum*
**Ophioglossum engelmannii*
Opuntia compressa
Ostrya virginiana
+*Oxalis stricta*
+*Oxalis violacea*
+*Panicum boscii*
+*P. scribnerianum*
Panicum sp.
Parthenium integrifolium
**Parthenocissus quinquefolia*
**Passiflora lutea*
Pellaea atropurpurea
Penstemon pallidus
Petalostemum candidum
+*P. purpureum*
Phlox bifida
**P. pilosa*
Physostegia virginiana
**Plantago rugelii*
+*P. virginica*
Poa pratensis
Poinsettia dentata
**Polygala verticillata*
Polytaenia nuttallii
Potentilla recta
**Prunus serotina*
**Psoralea psoralioides*
+*P. tenuiflora*
Ptelea trifoliata
Pycnanthemum flexuosum
+*P. pilosum*
**Quercus alba*
**Q. coccinea*
**Q. imbricaria*
**Q. marilandica*
Q. muhlenbergii
**Q. rubra*
Q. stellata
Q. velutina
Ratibida pinnata
Rhamnus caroliniana

Rhus aromatica
R. copallina
R. glabra
**R. radicans*
Robinia pseudoacacia
Rosa carolina
+*Rubus allegheniensis*
**Rudbeckia fulgida*
**R. hirta*
+*R. missouriensis*
Ruellia humilis
**Rumex crispus*
**Salvia pitcheri*
**Sassafras albidum*
+*Scutellaria lateriflora*
**S. leonardii*
+*S. ovata*
Scutellaria parvula
+*Senecio plattensis*
+*Setaria lutescens*
Silphium integrifolium
**S. terebinthinaceum*
Sisyrinchium albidum
+*S. campestre*
Smilax bona-nox
**Solanum sp.*
Solidago altissima
+*S. drummondii*
S. nemoralis
+*S. radula*
S. rigida
**S. ulmifolia*
Solidago sp.
Sorghastrum nutans
+*Specularia perfoliata*
Sporobolus asper
**S. heterolepis*
**S. vaginiflorus*
**Strophostyles helvola*
**Stylosanthes biflora*
**Swertia caroliniensis*
**Symphoricarpos orbiculatus*
Tephrosia virginiana
+*Tradescantia ohiensis*
**Tragia cordata*
**Tridens flavus*
+*Triosteum perfoliatum*
Ulmus alata
U. rubra
+*Uniola latifolia*
**Vaccinium arboreum*
+*V. vacillans*
+*Valerianella sp.*
+*Verbascum thapsus*
+*Verbena canadensis*
+*V. stricta*
**Verbesina helianthoides*
Vernonia missurica
**Viburnum prunifolium*
V. rufidulum
+*Viola rafinesquii*
**Viola sp.*
**Vitis aestivalis*
**Zizia aptera*
**Z. aurea*

A UNIQUE NATURAL AREA IN DANE COUNTY, WISCONSIN

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The study area of 2.2 ha (5.5 acres) is located in Dane County, Wisconsin (T8N, R12E, Sections 4 and 9). It is part of a 2.8 ha (7 acres) tract of land bordered on the south by railroad tracks and on the remaining sides by the Maunesha River. Almost 70 percent of this site is floodplain with upland, part of a drumlin, forming the remainder. Five soil types are found in the area with silt loams predominating (Glocker and Patzer, 1978).

Ellarson (1949), using original survey records of 1835, mapped the area as an oak opening. From the late 1800's to 1928 this property was used as pasture for a small herd of cows. During this time, the area contained about 25 large trees and no brush (Jerome A. Fullert, personal communication). Spring fires ignited by sparks from the train engines were yearly events which usually burned a sedge meadow; cattle did not graze this sedge meadow as heavily as the remainder of the area. After grazing ceased, fires burned more extensively. Since 1950 when railroads discontinued using coal, spring fires were infrequent. Other changes were the placing of dredgings from the river on its banks in 1915, the digging of a ditch on the east end to aid draining the area south of the railroad tracks, and the modification of a nearby spring. After grazing ceased in 1928, the land was left idle.

METHODS

From August 1975 to August 1978, the area was studied weekly and a list of species was compiled (Table 1). The native species were then determined as to where they were modal (Curtis, 1959:81). Modality is a specialized term to indicate in which community a species achieves its highest presence. This type of anaylsis gives an indication of species diversity and complexity of plant communities.

RESULTS AND DISCUSSION

Judging from the size of the trees, this area was dominated by an oak opening in 1900 which totaled about 1.4 ha. At that time, sedge meadow comprised 0.6 ha and the wooded area was 0.2 ha. The major change in the past 75 years was an increase in brush or shrub carr, mainly trembling aspen (*Populus tremuloides*), smooth sumac (*Rhus glabra*), gray dogwood (*Cornus racemosa*), and willows (*Salix* spp.). This increase was at the expense of the oak opening which decreased by 1.2 ha. This change appears to have taken place primarily in the past 20 years.

As of September 1978, 240 native and 18 alien species in 67 families have been recorded. The Asteraceae is the largest family with 37 native species, followed by Poaceae and Cyperaceae with 19 each. Six families contain more than ten native species. Of the 258 species, 221 are herbaceous plants or vines, 20 shrubs, and 17 trees. In 1975 the major plant communities in the area were mapped. Brush or shrub carr was the dominate cover totaling 1 ha, followed by sedge meadow with 0.5 ha, and upland woods with 0.3 ha. The oak opening totaled 0.2 ha.

Small white lady's slipper (*Cypripedium candidum*), fall coral-root (*Corallorhiza odontorhiza*), and white prairie gentian (*Gentiana alba*) are represented here; these plants are listed as endangered or threatened in Wisconsin (Read, 1976). Small white lady's slipper is also on the United States list as threatened (Ayensu and DeFilipps, 1978). About 60 plants in flower have been found at this site yet this lady's slipper is not present in nearby areas. The fall coral-root is a parasitic orchid flowering in August under trembling aspen and basswood (*Tilia americana*). It is common in a 0.2 ha area where it numbers over 200 plants; this locale is only the second record in Dane County for this species. The white prairie gentian is represented by about 85 flowering plants. A hybrid, *Gentiana* x *pallidocyanea*, between the white prairie gentian and bottle gentian (*Gentiana andrewsii*) is also present. In 1977, 20 individual hybrids were located at the interface between the white prairie gentians and the bottle gentians. This hybrid has only been recorded at three locations in Wisconsin (Pringle, 1964). These rare species are within 20 m of one another, and they illustrate the uniqueness of the area.

In the area 232 native species are listed as modal ones to one plant community in Wisconsin (Curtis, 1959). Out of 34 communities in Wisconsin, at least one modal species is represented for 30 of the communities. Seventeen of these communities contain 20 percent or more of the total modal species for each community (Table 2). In the wet, wet-mesic, mesic, dry-mesic, dry prairie, and oak openings, 58 modal prairie species are known. The wet-mesic prairie species are the most common with 22 modal species (58 percent). Wet prairie with 14 modal species (61 percent) was the second most common prairie community.

Of the wetland communities, the fen has the greatest number of modal species: 21 species (57 percent). The study area has 59 percent of the modal species for the southern sedge meadow but is only represented by ten species.

The southern forest communities are on the drumlin and are well represented with 80 modal species. The greatest number of these are from the southern dry-mesic forest with 32 species followed by the southern dry forest with 16 species. The southern mesic forest is represented by 12 species and the southern wet forest by 11.

A number of prairie species are found within 1,000 m of the area and may have been present formerly. These species are compass plant (*Silphium laciniatum*), lead plant (*Amorpha canescens*), rough blazing-star (*Liatris aspera*), and prairie parsley (*Polytaenia nuttallii*). Prairie parsley, which is endangered in Wisconsin, may have been rare in the area even before grazing began.

SUMMARY

A list of 240 native species is high for an area of this size considering that grazing had once taken place. The species that are present on the area now, were either supressed by grazing or were eliminated from the area and have since reinvaded. These species could have been on the railroad right-of-way or on adjoining land which was not grazed. Selected species that are rare in the study area, but common on the railroad right-of-way, are big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), and prairie willow (*Salix humilis*).

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Table 1. List of species in the study area compiled from August 1975 to August 1978 and a key to the community where each species is modal. The abbreviation following the name of the species indicates the native community where it was located in the study area. The key to these symbols is given below according to Curtis 1959:633[1], except for the asterisk (*) which here indicates that the species is alien.

Emergent aquatic	AQE	Oak openings	OO
Alder thicket	AT	Pine barrens	PB
Lake beach	BEA	Dry prairie	PD
Boreal forest	BF	Dry-mesic prairie	PDM
Bracken-grassland	BG	Mesic prairie	PM
Cedar glade	CG	Wet prairie	PW
Exposed cliff	CLE	Wet-mesic prairie	PWM
Lake dune	DUN	Shrub carr	SC
Fen	FN	Southern dry forest	SD
Northern dry forest	ND	Southern dry-mesic forest	SDM
Northern dry-mesic forest	NDM	Southern mesic forest	SM
Northern mesic forest	NM	Southern sedge meadow	SS
Northern sedge meadow	NS	Southern wet forest	SW
Northern wet forest	NW	Southern wet-mesic forest	SWM
Northern wet-mesic forest	NWM	Not listed by Curtis (1959:633-644)	nl
Oak barrens	OB	Alien species	*

Acer negundo (SW)
A. saccharinum (SW)
Achillea millefolium (PM)
Acorus calamus (SS)
Actaea pachypoda (NM)
A. rubra (BF)
Agrimonia gryposepala (SD)
Agropyron trachycaulum (BG)
* *Agrostis gigantea*
Allium canadense (PWM)
A. tricoccum (SM)
Ambrosia artemisiifolia (PD)*
A. trifida (SW)
Amphicarpa bracteata (SDM)
Andropogon gerardii (PM)
A. scoparius (PD)
Anemone canadensis (SS)
A. quinquefolia (NDM)
A. virginiana (SDM)
Angelica atropurpurea (SS)
Apios americana (SW)
Apocynum androsaemifolium (ND)
A. sibiricum (FN)
Aralia nudicaulis (NDM)
* *Arctium minus*
Arenaria lateriflora (SWM)
Arisaema triphyllum (SDM)
Asclepias incarnata (FN)
A. syriaca (PDM)
* *Asparagus officinalis*
Aster novae-angliae (PWM)
A. puniceus (NS)
A. sagittifolius (SDM)
A. simplex (FN)
Baptisia leucantha (PWM)
Bidens cernua (NS)
B. coronata (FN)
Boehmeria cylindrica (SW)
Bromus ciliatus (AT)
Calamagrostis canadensis (FN)
Caltha palustris (FN)
Campanula aparinoides (FN)
Cardamine bulbosa (SS)
Carex aquatilis (AQE)
C. bebbii (SS)
C. cephalophora (SWM)
C. comosa (NW)
C. convoluta (SM)
C. foenea (nl)
C. granularis (nl)
C. hystericina (BEA)
C. lacustris (NS)
C. lanuginosa (nl)
C. normalis (SW)
C. pensylvanica (SDM)
C. sterilis (nl)
C. stipata (SWM)
C. stricta (SS)
C. trichocarpa (AQE)
C. vulpinoidea (SW)
Carya ovata (OO)
Caulophyllum thalictroides (SM)
Ceanothus americanus (PM)
* *Cerastium vulgatum*
Chelone glabra (AT)
Cicuta bulbifera (NS)
C. maculata (PWM)
Circaea quadrisulcata (SDM)
Cirsium altissimum (SDM)
* *C. arvense*
C. discolor (PM)
C. muticum (PW)
* *C. vulgare*
Comandra richardsiana (OB)
Convolvulus sepium (PM)
Corallorhiza odontorhiza (SDM)
Cornus purpusi (SWM)
C. racemosa (SD)
Corylus americana (SD)
Cryptotaenia canadensis (SDM)
Cuscuta gronovii (SWM)
Cypripedium candidum (FN)
Dentaria laciniata (SM)
Desmodium canadense (PWM)
D. glutinosum (SDM)
Dioscorea villosa (SDM)
Dodecatheon meadia (PWM)
Echinocystis lobata (SWM)
Eleocharis elliptica (nl)
Elymus canadensis (PWM)
E. virginicus (SW)
Equisetum arvense (PW)
Erigeron philadelphicus (SC)
E. pulchellus (SDM)
Erythronium albidum (SM)
Eupatorium maculatum (AT)
E. perfoliatum (FN)
Euphorbia corollata (OB)
Fragaria virginiana (ND)
Fraxinus pennsylvanica (SWM)
Galium boreale (FN)
G. triflorum (BF)
Gentiana andrewsii (PWM)
G. crinita (PWM)
G. alba (PM)
Geranium maculatum (SDM)
Geum aleppicum (AT)
G. canadense (SDM)
* *Glechoma hederacea*
Glyceria grandis (AT)
G. striata (FN)
Habenaria viridis (SM)
Helenium autumnale (PW)
Helianthus grosseserratus (PWM)
H. strumosus (SD)
H. tuberosus (SC)
Heliopsis helianthoides (PM)
Heuchera richardsonii (CG)
Hieracium canadense (BG)
Hierochloe odorata (PW)
Hydrophyllum virginianum (SM)
Hypoxis hirsuta (PW)
Hystris patula (SDM)
Impatiens biflora (NWM)
Iris shrevei (FN)
Juncus dudleyi (FN)
J. nodosus (BEA)
Krigia biflora (PW)
Lactuca biennis (SD)
Lathyrus palustris (SS)
L. venosus (PWM)
Leersia oryzoides (SC)
Lemna minor (AQE)
Liatris pycnostachya (PWM)
Lilium michiganense (PW)
Liparis loeselii (PW)
Lobelia inflata (CLE)
L. siphilitica (FN)
L. spicata (CG)
Lonicera dioica (SD)
* *L. tatarica*
Lycopus americanus (FN)
Lysimachia quadriflora (PB)
L. thyrsiflora (SS)
Maianthemum canadense (BF)
* *Melilotus alba*
* *M. officinalis*
Mimulus ringens (NS)
Monarda fistulosa (CG)
Muhlenbergia racemosa (BG)

[1]Curtis, J. T. 1959. The vegetation of Wisconsin. Univ. Wis. Press, Madison, Wis. 657 p.

Table 1. (cont.) List of species in the study area compiled from August 1975 to August 1978 and a key to the community where each species is modal. The abbreviation following the name of the species indicates the native community where it was located in the study area. The key to these symbols is given below according to Curtis 1959:633[1], except for the asterisk (*) which here indicates that the species is alien.

Emergent aquatic	AQE	Oak openings	OO
Alder thicket	AT	Pine barrens	PB
Lake beach	BEA	Dry prairie	PD
Boreal forest	BF	Dry-mesic prairie	PDM
Bracken-grassland	BG	Mesic prairie	PM
Cedar glade	CG	Wet prairie	PW
Exposed cliff	CLE	Wet-mesic prairie	PWM
Lake dune	DUN	Shrub carr	SC
Fen	FN	Southern dry forest	SD
Northern dry forest	ND	Southern dry-mesic forest	SDM
Northern dry-mesic forest	NDM	Southern mesic forest	SM
Northern mesic forest	NM	Southern sedge meadow	SS
Northern sedge meadow	NS	Southern wet forest	SW
Northern wet forest	NW	Southern wet-mesic forest	SWM
Northern wet-mesic forest	NWM	Not listed by Curtis (1959:633-644)	nl
Oak barrens	OB	Alien species	*

Oenothera biennis (PDM)
Onoclea sensibilis (AT)
Orchis spectabilis (SDM)
Osmorhiza claytoni (SDM)
O. longistylis (SDM)
Oxalis acetosella (NWM)
O. stricta (PDM)
Oxypolis rigidior (PW)
Panicum latifolium (SDM)
P. leibergii (PM)
Parnassia glauca (FN)
Parthenocissus inserta (SD)
* *Pastinaca sativa*
Pedicularis lanceolata (FN)
Phalaris arundinacea (SC)
* *Phleum pratense*
Phlox pilosa (PWM)
Phryma leptostachya (SDM)
Plantago rugelii (PDM)
Poa palustris (NS)
* *P. pratensis*
Podophyllum peltatum (SM)
Polygala senega (FN)
Polygonatum biflorum (OB)
Populus tremuloides (BF)
Potentilla simplex (SD)
Prenanthes alba (SDM)
Prunella vulgaris (BF)
Prunus americana (nl)
P. serotina (SD)
P. virginiana (SD)
Pteridium aquilinum (BG)
Pycnanthemum virginianum (PWM)
Pyrus ioensis (nl)
Quercus alba (SD)
Q. macrocarpa (OO)
Q. rubra (SDM)
Q. velutina (OB)
Ranunculus abortivus (SDM)
R. fascicularis (OO)
R. pensylvanicus (BEA)
R. rhomboideus (CLE)
R. sceleratus (SS)
R. septentrionalis (SWM)
Ratibida pinnata (PWM)
Rhamnus alnifolia (NW)
* *R. cathartica*
Rhus glabra (PDM)
R. radicans (SW)
Ribes americanum (AT)
Rosa palustris (nl)
Rubus allegheniensis (SD)
R. occidentalis (SDM)
R. strigosus (BF)
Rudbeckia hirta (PWM)
R. laciniata (SW)
* *Rumex crispus*
Sagittaria latifolia (AQE)
Salix discolor (SC)
S. humilis (PW)
S. interior (DUN)
S. nigra (SW)
Sambucus canadensis (SD)
Sanguinaria canadensis (SM)
Sanicula gregaria (SDM)
Saxifraga pensylvanica (PW)
Scirpus atrovirens (AT)
Scutellaria galericulata (NS)
* *Setaria viridis*
Silphium integrifolium (PWM)
S. terebinthinaceum (PWM)
Sisyrinchium campestre (PDM)
Smilacina racemosa (SD)
S. stellata (SD)
Smilax herbacea (SD)
S. tamnoides (SDM)
Solanum dulcamara (SWM)
S. nigrum (NWM)
Solidago canadensis (AT)
S. gigantea (PW)
S. nemoralis (PD)
S. riddellii (FN)
S. rigida (PWM)
S. speciosa (PM)
Sorghastrum nutans (PWM)
Sparganium eurycarpum (AQE)
Spartina pectinata (PW)
Spiranthes cernua (FN)
Stachys palustris (SS)
* *Taraxacum officinale*
Thalictrum dasycarpum (FN)
T. dioicum (SDM)
Tilia americana (SM)
Tradescantia ohiensis (CG)
Trillium flexipes (SDM)
Triosteum perfoliatum (SDM)
Typha latifolia (AQE)
Ulmus rubra (SM)
* *Verbascum thapsus*
Verbena hastata (NS)
Veronica catenata (AQE)
Veronicastrum virginicum (PWM)
Viburnum lentago (SDM)
V. rafinesquianum (SDM)
Vicia americana (PWM)
Viola cucullata (SDM)
Vitis riparia (SW)
Zizia aurea (PW)

Table 2. Seventeen of thirty communities in which 20 percent or more of the modal species are known from the study area.

	Number of Modal Species	Percent of Total Modal Species
Oak barrens	4	20
Oak opening	3	38
Dry-mesic prairie	6	23
Mesic prairie	9	23
Wet-mesic prairie	22	58
Wet prairie	14	61
Fen	21	57
Southern sedge meadow	10	59
Northern sedge meadow	8	33
Emergent aquatic	8	24
Shrub carr	5	33
Alder thicket	8	32
Southern dry forest	16	64
Southern dry-mesic forest	32	42
Southern mesic forest	11	26
Southern wet-mesic forest	9	27
Southern wet forest	12	30

THE FINE STRUCTURE OF A PRAIRIE POTHOLE AND POTHOLE BORDER

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Using the techniques of gradient analysis, we undertook an analysis of the distribution of plant species and the resulting community structure along a topographic gradient on Stinson Prairie, a tallgrass prairie remnant in north-central Iowa. The overall results of this analysis, the pattern of dominance and diversity, and some of the edaphic gradients accompanying the vegetation coenocline were reported by Crist and Glenn-Lewin (1978). In testing for the relative continuity of the coenocline, we found that a relatively rapid transition in species composition existed from the mesic upland prairie into the prairie pothole. This transition was illustrated by a plot of the average percentage similarity between each stand and its neighbors (Crist and Glenn-Lewin, 1978, Fig. 1). This study reports the details of species distributions in the prairie pothole and their relationship to water depth.

Descriptions of wetland vegetation in the north-central United States have often referred to the apparent zonation of emergent marsh plants (Millar, 1969; Stewart and Kantrud, 1969, 1972; Brotherson, 1969). Each of these apparent zones is usually dominated by only one emergent species. It is generally agreed that the water regime, both depth and amount of fluctuation, is the most important environmental factor controlling the distribution of wetland species (Walker and Coupland, 1968; Stewart and Kantrud, 1963; Dix and Smeins, 1967; Millar, 1969). Most wetland studies have been done on true marshes; the present report concerns plants in a pothole which regularly is flooded in the spring but becomes dry by summer.

Stinson Prairie is a state-owned 12.5 ha prairie preserve in southern Kossouth County, about 8 km west of Algona, in north-central Iowa. The climate of this area is very continental: 73 cm of precipitation annually, mean January temperature of −8.1°C, mean July temperature of 23.4°C, average of 156 days between killing frosts (Shaw and Waite, 1964). Stinson Prairie is on a recessional moraine of the Des Moines Lobe (Cary Lobe) of the Wisconsinan glaciation. Because of the moraine, several swells, swales, and potholes are on Stinson Prairie, making it an ideal study site for the analysis of the gradient structure of vegetation and environment. More extensive details of the geology, soils, and vegetation of Stinson Prairie are given by Glenn-Lewin (1976), and Crist and Glenn-Lewin (1978).

METHODS

This study was conducted during the growing seasons of 1975 and 1976. Five replicate parallel transects were extended from the center of the pothole out into the mesic upland prairie on the most westerly slope on Stinson Prairie. One meter square quadrats were placed every other meter along the transects (approximately 40 m in total length), and the cover of each species in each quadrat was estimated when the species had achieved full growth for the year. Estimated cover values were relativized. The relative cover values of each species at the same transect position along the five transects were summed, yielding an average relative cover value along a composite-transect.

The elevation at each transect meter along all five transects was surveyed from the pothole center to the edge to an accuracy of less than 1 cm. The maximum height of standing water, its approximate rate of recession, and the time when standing water vanished were also noted. The distribution of pothole species was then plotted against elevation along the transects. Points with the same elevation would be subject to the same duration of flooding, and, therefore, if species are distributed in the pothole according to the water regime, each species should occur at the same elevation along each of the five transects.

RESULTS

A complete list of the plant species in Stinson Prairie is given in Glenn-Lewin (1976). All species falling along the entire upland-pothole coenocline are described by Crist and Glenn-Lewin (1978) and Crist (1978). Nomenclature follows Gleason (1952), except for Cyperaceae (Gilly, 1946) and Gramineae (Pohl, 1966).

The curves of relative cover for each of the pothole and pothole-edge species along the composite transect were generally bell-shaped with one well-defined peak (Fig. 2). Only *Carex lacustris* and *Polygonum coccineum* showed closely similar distributions. Because

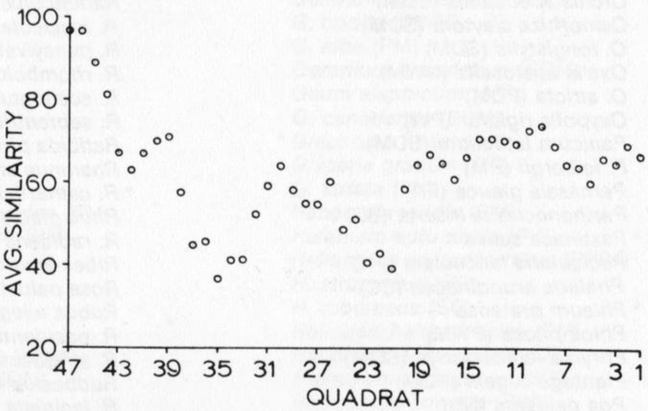

Figure 1. Average percentage similarity of each composite-quadrat to its four nearest neighbors along the Stinson Prairie coenocline. Quadrats 35-47 include the pothole and pothole border. (From Crist and Glenn-Lewin, 1978.)

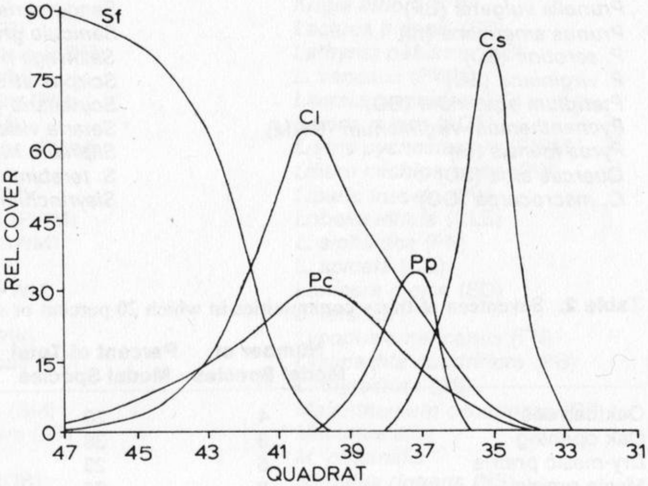

Figure 2. Distributions of the major species in the Stinson Prairie pothole (composite-transect): Cs = *Carex stricta*, Pp = *Poa palustris*, Cl = *Carex lacustris*, Pc = *Polygonum coccineum*, and Sf = *Scirpus fluviatilis*.

of the very low species richness in the pothole, three species per composite quadrat (which is the average of the five transects at each quadrat position), the species in the pothole and the pothole edge showed apparent zonation. Each zone is defined as the position of peak abundance of each species. However, all of the pothole species overlapped broadly in their distributions (Fig. 1). As expected the concentration of dominance, Simpson's Index (Simpson, 1949), was very high for the pothole area, ranging from about 0.35 to almost 0.9.

Transects 1, 2, and 3 had roughly similar elevation profiles, whereas transects 4 and 5 showed somewhat different rates of elevational change (Fig. 2). Because of these differences, linear distributions of the pothole species based upon distance from the pothole center were different along each of the transects. However, when species importance were plotted against elevation rather than distance along the transect, distributions of species along all five transects became nearly congruent. This phenomenon is illustrated for each of the five major pothole species (Figs. 3-7). Each of these species was limited to a rather precise elevational range. This elevational range was narrowest for *Scirpus fluviatilis,* which had a distribution range over about 10 cm of elevation, whereas *Carex lacustris* and *Carex stricta* had elevational ranges of about 30 cm.

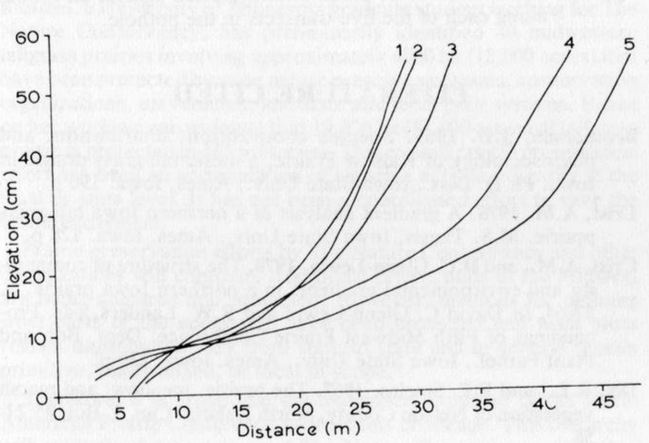

Figure 3. Changes in elevation along the five transects within the Stinson Prairie pothole.

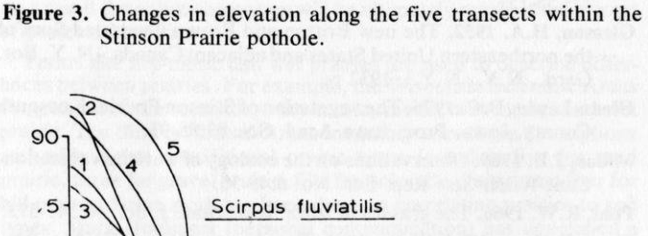

Figure 4. Relative cover of *Scirpus fluviatilis* plotted against elevation along each of the five transects in the pothole.

DISCUSSION

The distribution of individual species in the Stinson Prairie pothole and pothole edge indicated that each species had a unique position along the coenocline. This position for each species appeared to be closely related to elevation along the pothole topographic gradient. The topographic gradient, in turn, was related to water depth and amount of fluctuation in water depth. At the same time that this study was done, soil moisture, water-holding capacity, organic matter, soil texture, and soil pH were also measured along the entire Stinson Prairie coenocline (Crist, 1978). Although all of these edaphic factors changed in the expected gradual manner over the entire upland-pothole topographic gradient, relatively little differentiation of these factors was noted within the pothole: soil moisture was high, water-holding capacity was high, organic matter was high, soil texture was high in silt and clay and low in sand, and pH was 6.5-7 (Crist, 1978). Only the pothole topographic elevation, and therefore the water regimes, varied significantly within the pothole and pothole edge.

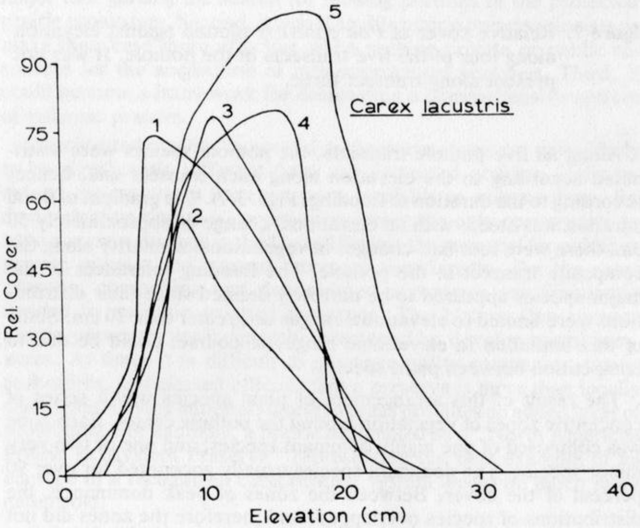

Figure 5. Relative cover of *Carex lacustris* plotted against elevation along each of the five transects in the pothole.

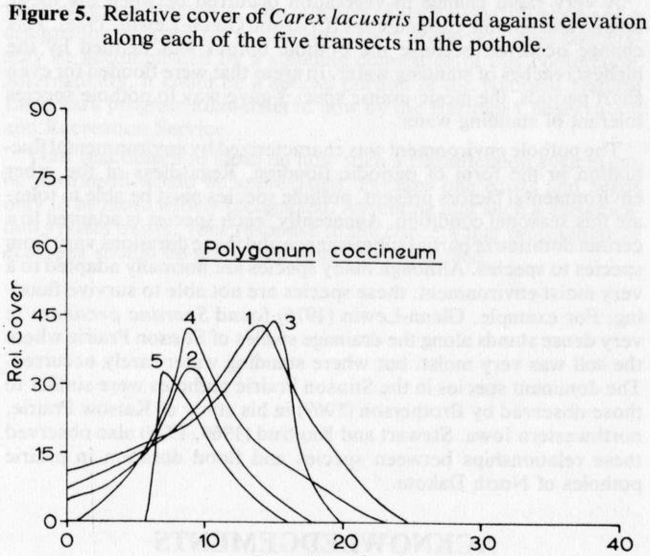

Figure 6. Relative cover of *Polygonum coccineum* plotted against elevation along each of the five transects in the pothole.

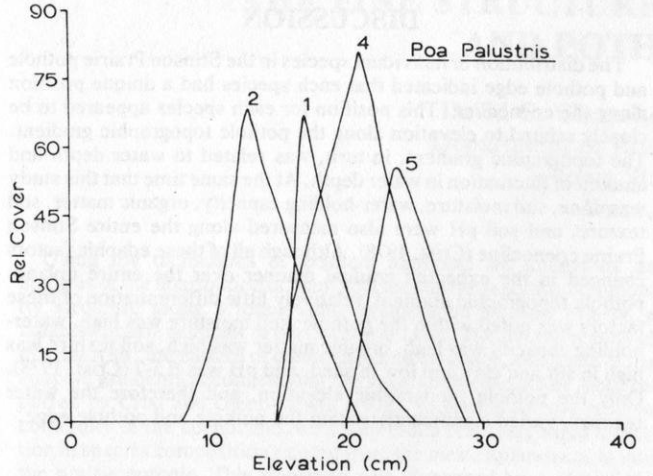

Figure 7. Relative cover of *Poa palustris* plotted against elevation along four of the five transects in the pothole. It was not present along transect three.

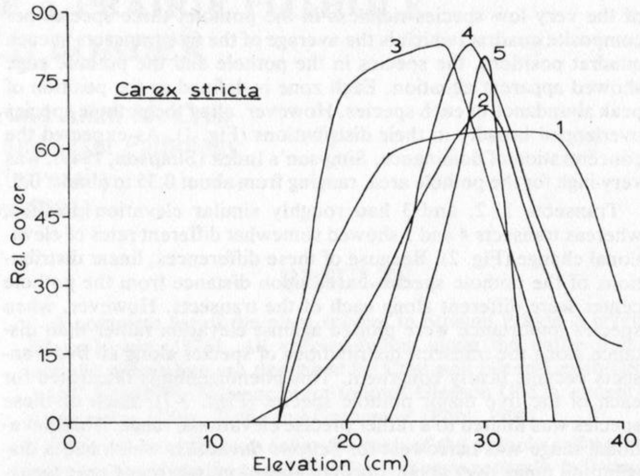

Figure 8. Relative cover of *Carex stricta* plotted against elevation along each of the five transects in the pothole.

Along all five pothole transects, the pothole species were distributed according to the elevation along each transect and, hence, according to the duration of flooding (Figs. 3-7). The gradient of flood duration was steep: with an elevational change of approximately 50 cm, there were four half-changes in vegetational similarity along the composite transect in the pothole. The flooding tolerances of the major species appeared to be narrowly defined since their distributions were limited to elevational ranges no greater than 30 cm. Some of this limitation in elevational range, of course, could be due to competition between plant species.

The result of this arrangement of plant species was a series of concentric zones of vegetation around the pothole center. Each zone was composed of one highly dominant species, and one or two very minor species. The dominant species usually accounted for over 90 percent of the cover. Between the zones of peak dominance, the distributions of species overlapped, and therefore the zones did not have definite boundaries, but rather they rapidly integrated.

A very rapid change in vegetation occurred between the mesic upland and pothole communities (Crist and Glenn-Lewin, 1978). This change occurred because the pothole border was defined by the highest reaches of standing water. In areas that were flooded for even short periods, the mesic-prairie species gave way to pothole species tolerant of standing water.

The pothole environment was characterized by environmental fluctuation in the form of periodic flooding. Regardless of the other environmental factors present, pothole species must be able to tolerate this seasonal condition. Apparently, each species is adapted to a certain duration of partial submergence and these durations vary from species to species. Although many species are normally adapted to a very moist environment, these species are not able to survive flooding. For example, Glenn-Lewin (1976) found *Spartina pectinata* in very dense stands along the drainage swales of Stinson Prairie where the soil was very moist, but where standing water rarely occurred. The dominant species in the Stinson Prairie potholes were similar to those observed by Brotherson (1969) in his study of Kalsow Prairie, northwestern Iowa. Stewart and Kantrud (1969, 1972) also observed these relationships between species and flood duration in prairie potholes of North Dakota.

ACKNOWLEDGEMENTS

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THE NEED FOR AN ECOSYSTEM WIDE TALLGRASS PRAIRIE CLASSIFICATION SYSTEM AS A GUIDE FOR PRAIRIE PRESERVATION

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The tallgrass prairie once covered 96,525,000 km² (250,000,000 mi²) in midwestern United States. Much of this vast ecosystem has been converted to cropland or has been lost to development. The contiguous tallgrass prairie is gone. However, by preserving carefully selected remnants that represent all the aspects of the tallgrass prairie ecosystem most of the organisms that are part of it can be perpetuated.

The Nature Conservancy owns 13,765 ha (34,000 acres) of prairie, primarily tallgrass prairie, in 70 tracts in 11 midwestern states. Thirteen additional prairies containing 405 ha (1,000 acres) have been protected with assistance from The Nature Conservancy. Janet Rimmel, a University of Minnesota graduate student working for The Nature Conservancy, has preliminarily identified 80 midwestern tallgrass prairies involving approximately 4860 ha (12,000 acres) that have been protected by state nature preserve programs, conservation organizations, universities, and state and local park systems. Based on her work we can estimate that 19,030 ha (47,000 acres) of tallgrass prairie is protected in 163 preserves. This overall prairie preservation effort has been an accumulation of separate actions primarily at the local or state level. It has not been a coordinated effort to save the entire ecosystem.

Prairie preservation efforts by The Nature Conservancy and other organizations will continue. Additional prairie units in the Midwest are being acquired and protected. However, methods for defining what parts of the ecosystem have been protected and what parts remain unprotected vary from state to state and in general remain primitive, unorganized, or local in scope.

Therefore, it is urged that the assembled expertise of the North American Prairie Conference address this challenge. This hierarchy will guide the future actions of The Nature Conservancy and other preservation programs in their selection of future prairie preserves. As a result the entire ecosystem will be ultimately represented in a set of protected prairies.

Terms like dry-mesic and wet prairies are used to describe differences between prairies. For example, the Wisconsin Scientific Areas Program uses the terms dry, dry-mesic, mesic, wet-mesic, and wet prairie. The Illinois Natural Areas Inventory uses these descriptions and adds eighteen additional prairie types including five for sand prairie, three for gravel prairie, five for dolomite prairie, and four for hill prairie. Some work has been done on correlating prairies to soil types. Mark Heitlinger (personal communication) has developed a system for our Minnesota Chapter that documents which prairie types are missing. This system is being used as one criterion in selecting new prairies for preservation. Some prairies are selected for preservation because they provide habitat for rare flora or fauna. Sometimes we select prairies simply because they are long distances from the nearest prairie preserves. These criteria are valid, but are they adequate to ensure that the results represent the entire ecosystem? No. Heitlinger believes that ideally we need a classification system based on biological features, principally the presence or absence of certain plants, in addition to physical features such as moisture, aspect, bedrock, and soil type.

A sound tallgrass prairie classification system would have several important benefits to preservation efforts. Foremost, it would be a major tool guiding the search for missing portions of the protected prairie ecosystem. Second, it would enable prairie preservationists to make their case more effective when seeking private or public resources for the acquisition of rare unprotected ecotypes. Third, it could become a framework for designating a comprehensive system of tallgrass prairies.

Unprotected prairies in several midwestern states are quite likely to be significantly different from any protected prairies. Unfortunately, the resources have not been available to acquire them. By demonstrating that these prairies represent the only opportunity to save a certain ecotype in the United States, the potential for public or private interest and support increases significantly. For the same reasons, compelling and documented arguments are frequently needed to maintain existing preserves. The Nature Conservancy prairie preserves are frequently threatened by developmental pressures. At times it is difficult to convince utility companies, taxing authorities, and elected officials that a preserve is more than locally significant. Giving national stature to areas provides an added layer of protection. For example, a prairie designated as a "North American Prairie Ecosystem Preserve" representing the best example of an ecotype in a recognized classification system would be much more defensible.

It is not entirely clear who would be best equipped to implement these suggestions. The development of a classification system is the work of prairie scientists. The creation of such a classification and a designation program for prairie ecosystem preserves could conceivably be accomplished by a standing committee of this conference. Alternatively, it could be a special portion of the National Natural Landmark program administered now by the Heritage Conservation and Recreation Service.

Your reactions and ideas on how such a classification system can be developed would be appreciated. Perhaps one exists and needs only to be more widely recognized. Assuming that such a classification system exists, your response to the concept that representative ecotypes should be preserved would be welcomed.

PRAIRIE HERITAGE APPRECIATION PROGRAM, A DIFFERENT PRESERVATION APPROACH, IN BOONE COUNTY, ILLINOIS

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During the past decade interest in the prairie and associated phenomena has grown from a mild, matter-of-fact awareness to a blossoming consciousness of prairie aesthetics, history, and usefulness. Following close behind is the realization of the need for protection and preservation of existing prairie stands which are so rapidly disappearing.

The frustration felt when witnessing a formerly healthy and valuable prairie site being destroyed or seriously degraded because of mismanagement, bulldozing, or over-collecting is indeed hard to describe. This feeling may be intensified when attempting to convince a landowner or agency that the area should be protected. When thwarted with the possible expenses which may be incurred through leases, attorneys' fees, and licenses, sentiments are strong. After alternatives have been explored, one concludes public agencies are the most effective long-range vehicle for conserving or preserving prairies on a local level. Occasionally, some corporations or nonprofit agencies may be the better choice, but generally public agencies have more potential.

It should be determined if an interested agency can properly administer a number of small scattered prairie sites. Unfortunately, most remaining sites are in this category. Very few quick solutions exist; however, a number of alternatives are available.

The Boone County Prairie Heritage Appreciation Program (PHAP) is a result of some alternative thinking by the Boone County Conservation District. It is designed as an attempt at "a method" and should not be considered the only method possible, and as an effort to bypass and supplement the normal legal and administrative difficulties incurred by preservation through purchase or lease. The plan of PHAP is to involve directly the general public through private ownership. In this way the owner retains complete control and is committed to preserving one of our country's great natural heritages. Generally, benefits are received with a very low investment, if any. This program becomes a vehicle through which an agency can offer technical and educational assistance, and it can function as a seed source for expansion projects. Therefore, PHAP can function as an expert liaison with other agencies in developing insight and understanding about prairie species and their identification, purpose, origin, and proper management. Once initiated an effective program can expand to encompass nonprivate lands and businesses. If a highly significant site is discovered, the process of preservation reverts to more permanent arrangements through leases or purchases. In the interim, a great deal of interest, understanding, and exploration has been generated.

The program's initial contact generally arises from a request by a landowner for technical assistance about a possible existing prairie or a desire to enter into a "prairie restoration" project such as an alternative cover for a lawn. District personnel usually do not make the initial contact with the landowner unless a prairie remnant already exists on the land. However, general discussion at the local coffee shop is often a good beginning. Once a request is made, a district staff member visits the landowner. A discussion about the resources the district can provide and the landowner's objectives is conducted. At this time, the landowner is given a packet containing a number of pamphlets which the landowner may read later.

Following the initial contact, a site inspection is made to determine the value of the existing prairie and the requirements for a new planting, if necessary. The landowner should be encouraged to participate in the site inspection which can be used as an educational opportunity. Rarely, the order of the initial contact and the site inspection is reversed, but only under special circumstances.

Consultation with the landowner is generally the next step. It may take a number of sessions before the landowner is confident about moving ahead. During this period, signing an agreement with PHAP is encouraged.

With this authorization the landowner is committed to (1) preserving the prairie site for three consecutive years, (2) following the technical advice given by the district, and (3) giving the district the right to collect seeds or use the site for educational and promotional reasons. These rights are exercised with the landowner's consent. This approach presents few problems because of the friendly consultation atmosphere which preceded the official confirmation. Without such a confirmation, the area is not listed and little further assistance is offered. Exceptions are made if the site is of significant quality or special interest. The real work begins following a sign-up.

The district is committed by this agreement to give technical advice, post the property, and provide liaison with public agencies. The posting sign is 18" x 14" and neatly silk-screened with dark green lettering on a heavy white polyethylene sheet. This sign reads "BOONE COUNTY PRAIRIE HERITAGE APPRECIATION PROGRAM. This area is part of a county-wide cooperative program designed to promote, preserve and protect those small patches of remaining or re-established Prairie Grasslands once so extensive in Boone County. In Cooperation with BOONE COUNTY CONSERVATION DISTRICT, 547-7935." Most landowners are hesitant to post a sign, but the pleasing appearance of the sign and the reference for additional information seems to reduce any concerns of potential disturbance to the landowner. Up to this point, the program is conducted on a friendly basis with no legal restraints. However, if care and management will be taken over by the district then a "garden-easement" or some such similar legal arrangement is made.

Technical assistance will probably include composing a management plan for each site along with periodic checks and discussions. Once a site plan is in order and the management processes are operating, a visit is made to the local "weed commissioner." The PHAP effort may seem useless since it is of short duration and with no legal binds. However, this program does build understanding and cooperation between the private and public sectors. Positive benefits of such a program will be the increased awareness of the prairie, its value, and hopefully its continued existance.

Since its inception in August 1977, the Boone County PHAP system now includes nine privately owned restoration sites, one management agreement, two garden leases, and a gift containing one of the three remaining natural prairie sites in this county. As a result of PHAP, 80 percent of the significant prairie remnants of this county are now under management and community interest is growing.

LIVING WITH THE NATIVES

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Loess bluffs along the Missouri River have been plowed and planted in corn. Without the original sod crown, the soil has eroded. Wild fires have been stopped and scrub timber has encroached on the bluff's steep sides. Consequently, prairie has been relegated to the area between farm and forest. Little original cover has survived and it is in danger of being overprotected or undermanaged. Areas that are representative of the loess bluff/prairie ecology have been identified. Proper management procedures are being applied and developed for those bluffs owned by the Missouri Department of Conservation. Other bluffs are being plowed, overgrazed, or excavated for landfill. Most undisturbed bluff prairies owned by the department could use a good burning. Prairie fires hold shrubs in check and reduce dead grass buildup that could slowly suppress forbs and grasses. Privately owned bluff prairies are endangered and should be studied before they are destroyed. Prairies are not being created currently, but with hard work, sweat, foresight, and study, reestablishment of prairies is possible. To restore a true prairie will take at least 10,000 years; we can begin now whether on a 16 ha (40 acres) tract or in our own backyards.

My experience with reestablishing native grasses began in 1972 when we purchased 13 ha (30 acres) with bluff area located north of St. Joseph, Missouri. The tops of the hills had been intensively farmed and the hillsides were overgrown with greenbriar, wild grape, gray dogwood, and assorted brush species. Old cropland was attacked first. Initially, four test plots were planted with little bluestem, big bluestem, Indian grass, and buffalo grass. We also planted 223 sq m (2400 sq ft) with a mixture of the remaining seed.

The first spring and summer seasons were discouraging. Foxtail went on the rampage and bindweed carpeted the ground with pretty white flowers. After checking with the Missouri Department of Conservation, we contacted Jim Wilson, a prairie expert from Polk, Nebraska. He sent a bundle of prairie propagation leaflets. We followed these suggestions:

1. Mow according to the height of the grass desired, i.e., if you want buffalo grass, mow 100-150 mm (3 inches).
2. Prevent "weed" seed production. Clip individual "weeds" or use herbicides.
3. Do not fertilize.
4. Do not water.
5. Be very patient.

After the first frost, individual prairie plants could be seen that were previously concealed by "weeds."

The following spring was dry. The "weed" competitors did not survive. It was strange to see a prairie plant dwarf a foxtail. The few sunflowers or lambsquarters growing in our plots were stunted. If a dandelion would poke above the buffalo grass you could almost watch it die. In contrast, native forbs thrived. Purple prairie clover, black-eyed susan, and round-headed lespedeza came back, occupying a nitch within the prairie plant system.

Since our test plots were successful, we landscaped around our house with native prairie plants. Our lawn is a buffalo grass — blue gramma mixture. Sideoats gramma, little bluestem, and other taller grasses were sown in odd areas where it was difficult to mow. The easy maintenance and subtle beauty have made the initial effort worthwhile.

Many methods can be used to plant seeds. A rake or hand cultivator works best on areas with limited accessibility. A rotary tiller can be used for appropriately sized plots. For large acreages, it is more practical to plow, disk, harrow, and seed with a native grass drill. The ground must be worked several times in the spring to kill the sprouting "weeds." It should not be worked too deep, and the seed covered at a depth of 8 mm (0.32 inch) or less. After planting the ground should be packed as hard as possible.

In light loess soil, the following method of planting has been most successful. On odd areas, trails, or hogback ridges, scratch or lightly stir the surface with a rototiller. This procedure should be done in April, May, and early June. Broadcast the seed after the third preparation, and then rototill the area again to cover the seed. Do not dig deeper than 30 mm (1.2 inches) on any tilling so that the firm subsoil required by the sprouting grasses is preserved. After the last tilling, pack the ground with a lawn tractor, automobile, or your feet.

Now you must manage the area for prairie plants, not foxtails. Let everything in the area grow until it gets knee high. Mow with a rotary or shredder type mower to clip the seed heads off the "weeds," but leave the tender young prairie plant shoots. Repeat this procedure whenever the "weeds" start to produce seed heads, about once every six weeks in a hot dry summer. After the first hard frost, cut everything down to 75-100 mm (3-4 inches) high. The following June, watch out for the "weed" seed heads. High mow them once and then let the plot alone. The native prairie plants should take over and crowd out the undesirable species. When mowing, cut as finely as possible to prevent covering the struggling natives.

Buy your seed from a reputable dealer. Make sure the analysis tag is on the seed sack. Remember that PLS means pure live seed which is the percentage of the seed that will grow. Pure live seed is calculated by multiplying the percentage of actual seed in the sample (excluding stems, chaff, dust, or sand) times the germination rate. Only seed with a labelled PLS value should be purchased. Often a 50 lb sack of bulk seed will contain only 24 lb of pure live seed. The difference is significant at $8.50/lb.

Obtain as much information as possible about growing natives in your locale. Before planting native plants, determine the result that you expect. If a highly manicured lawn, like a golf course is desired, think again. If low maintenance is preferred, you should go the native route. A lot of work must be invested initially, but in the end you will have a tract of unusual beauty.

In the spring of 1978 we planted 10 acres (4 ha) in native plants in Worth County, northern Missouri. In this cattle country if crops other than alfalfa, fescue, corn, or beans are not planted, it is not known there anymore. A 17-year-old neighbor asked, "Why?" The Conservation Department biologist with me pointed out a glacial erractic and said, "We thought that stone was lonesome. The stone and the bluestem were brought here at about the same time, and we thought it was time for a reunion."

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CRITERIA FOR INTRODUCTION OF SPECIES TO NATURAL AREAS

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Introduction of species to natural areas involves numerous variables and may produce both positive and negative long- or short-term results. Consideration of variables and predicted results prior to introduction of any species will increase the chances of a beneficial effect upon the natural area. Factors to be considered prior to introduction of a species include the reason for introduction, the former presence or absence of a species, the potential for successful establishment and reproduction of the species, the effect of the species upon the community, and the source of the genetic material. Maintenance of accurate records is necessary to interpret the results of introduction.

The Severson Dells Environmental Education Center is a preserve of 148 ha (370 acres) in northern Illinois. The primary goal of all activity at Severson Dells is preservation of the natural area. Part of this preservation involves restoration of the original species and communities which were once present but were degraded or eradicated by human activities. One facet of restoration, the introduction of species, involves many variables. A great deal of harm can be done to a natural area, on a minor or major scale, by premature species introduction without researching the possible effects of the species upon the receiving environment.

PROBLEMS

Many problems can arise when introducing a species into a natural area, for example:

1. A species which may be native to surrounding areas may *not* be native to the specific site into which it is introduced. If that is the case, then the introduction results not in the restoration of the original landscape but in the creation of a facsimile of that landscape. In an area being preserved as a research area, or as a living memorial of the land prior to intensive settlement, adding species which did not originally occur at the site results in a loss of integrity of the area as a whole. As remnant natural areas become fewer, it becomes increasingly important to preserve the individual communities intact for research, preservation, and community integrity.
2. A risk of disturbing the gene pool exists by bringing in different genetic stock. Introduction of an overvigorous ecotype or genotype may cause the decline of the native ecotype or genotype. A foreign genotype of a species may hybridize with a closely related species, forming a hybrid swarm, and thereby alter the genetic makeup of the related species.
3. An introduced species may influence the natural successional pattern. It may affect the speed of succession, or promote or hinder the growth of one or more species which in turn influences the rate of succession.
4. An introduced species may significantly affect other members of the community, thus creating an imbalance. For example, a species may upset established food webs or become so successfully established that it outcompetes other species.
5. An introduced species may bring disease pathogens into the community.

To prevent or reduce the risk of damage due to ignorant introduction of species and to increase the chances of a beneficial effect upon the natural area, guidelines were established which apply to all species, both plant and animal, introduced into Severson Dells. Not a single individual of any species is introduced except as defined by these guidelines and as part of a management program. Introduction refers both to bringing in a species from outside the preserve as well as to the intentional movement of a species from one part of the preserve to another, whether for protection of the species or expansion of a plant community.

The following guidelines form a policy which outlines why, when, and how a species may be introduced into Severson Dells. The policy consists of four parts: reasons for introduction, criteria for introduction, methods of obtention and introduction, and maintenance of records.

REASONS FOR INTRODUCTION

At Severson Dells only native species may be introduced as part of a restoration program to create a natural-appearing community as similar to presettlement conditions as possible. Species may be introduced only for the purposes listed below:

1. Increase the internal diversity of a community, particularly in degraded communities where some species have been eradicated.
2. Increase the stability of a community.
3. Upgrade and/or maintain a community in a healthy balanced condition.
4. Maintain a rare or endangered species as a viable part of a community.

CRITERIA FOR INTRODUCTION

Five determinations are made prior to introduction of any species. The results of these determinations decide whether a species should or should not be introduced. These five determinations constitute a very broad dictum and precise answers are difficult to obtain. However, as much as possible, the effects of introduction are studied prior to the actual introduction to alleviate or prevent any potential problems. The results of these five determinations provide a basis for determining the advisability of the species introduction. If the expected results of introduction imply a deterimental effect on the quality or condition of the ecosystem, the species should not be introduced without giving serious consideration to the value of the expected benefits versus the anticipated deterimental effects. The expected outcome of introduction should result in an overall improvement or upgrading of the community and ecosystem and an increase in its resemblance to the original community.

1. Determine if the species or subspecies was once native to the proposed area of introduction or to the near environs. Information can be obtained from the original land surveys, although only the dominant species tended to be recorded, from previous surveys of the flora and fauna of the area, by looking at natural or historical distribution patterns, by observing remnant virgin communities, and by researching the literature for distributional information and for species associations.
2. Determine why the species is not currently present. This absence might be due to habitat degradation, pollution, overpredation, or loss of a pollinator or prey species. The reason for the species absence must be determined prior to reintroduction of that species. If the factors responsible for the original demise of the species are still present, little benefit will be involved in reintroduction.
3. Determine if conditions are suitable for successful establishment of the species. If they are not, determine how they can be made suitable, and how this situation will affect other species and surrounding communities. Any intentional change in the environment must be preceded by an understanding of the effects of the change upon all, or as many, parts of the environment as can be reasonably determined.

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4. Determine if the species will be able to maintain itself and reproduce successfully or oversuccessfully in the area of introduction. If the species is unable to reproduce, then there is considerable question as to the advisability of introducing it, as it will be only a transient visitor rather than a viable member of the community. On the other hand, the species may reproduce so successfully that it overruns the community. Observing the results of introduction of the species into similar areas may assist in determining the reproductive capacity of the species at the particular site under consideration.
5. Determine how the introduction of the species will affect the ecosystem into which it is introduced, what the short- and long-term effects will be, and what the effects will be on other communities.

METHODS OF OBTENTION AND INTRODUCTION

In order to preserve as much of the original genotypic composition of the community as possible and to ensure minimal disturbance to the community, species are obtained and introduced in the following manner:

1. Species are obtained from locations as close to the area of introduction as possible to preserve genotype. At Severson Dells all material is sought from within a 8 km (5 mile) radius of the preserve, although this is not an ironclad rule as certain species may no longer be present within this limited area. In general, asexual propagation of a species is discouraged because of the lack of genetic mixing, but this method is considered preferable to obtaining material from a more distant source.
2. Species are obtained from locations as similar to the area of introduction as possible to preserve ecotype.
3. Species are introduced into suitable habitat as quickly and carefully as possible to ensure their optimal survival.
4. Species are introduced in as natural a manner as possible, duplicating the natural associations and distribution patterns of the original community.
5. Species are introduced with minimal disturbance resulting to the new habitat.

MAINTENANCE OF RECORDS

Maintenance of accurate, precise, and complete records is essential for interpretation of the results of introduction. These records include information about the following: where and when the species was obtained; where, when, and how the species was introduced; the survival and reproduction of the species after introduction; the impact of the species on the ecosystem and community; and any other information useful to analysis of the results of introduction.

The four-part policy described above was developed as part of a management plan for Severson Dells. This policy was designed to both assist and improve efforts at re-creating or restoring the original landscape and to reduce negative effects resulting from the introduction of species into the preserve. The philosophy behind this policy is that restoration of a community should be as accurate and complete as possible, resulting in the creation of a true community with only the original species present and interacting, rather than in an inaccurate facsimile of that community.

PRAIRIE RESTORATION IN NORTH-CENTRAL MISSOURI

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It is generally accepted that tallgrass prairie communities in the form of open prairies and savannas were present in central Missouri at the time of settlement by Europeans (Carpenter, 1940; Kuchler, 1965; Livingston and Shreve, 1921; Shantz and Zon, 1924; Schoolcraft, 1819). Presently, only a few, small, scattered tracts of virgin prairie exist in central Missouri. This paper details the initial attempt of the U.S. Forest Service to reestablish a mixture of native warm-season grasses and forbs on the open lands of the Cedar Creek District of the Mark Twain National Forest.

The Cedar Creek Ranger District is comprised of approximately 5300 ha (13,000 acres), of which 2225 ha (5500 acres) are classified as open or semiopen (nontimbered). Public lands are intermingled with private lands located north of the Missouri River in portions of Boone and Callaway Counties. These Forest Service-administered lands, once under private ownership, have an adverse history of severe depletion and erosion of soils. Abuse resulted from intensive cultivation of row crops and severe overgrazing in the 1930's. The majority of open lands are presently in permanent, cool-season grass pastures consisting of tall fescue *(Festuca arundinacea)* and Kentucky bluegrass *(Poa pratensis)*.

In accordance with a new management plan for the Cedar Creek District (U.S. Forest Service, 1975), it was determined that open lands with soils of prairie-forest transition origin should be converted from introduced domestic grasses to native prairie species. It is generally accepted that diverse native species of grasses and forbs constitute much higher quality wildlife habitat than a nondiverse, introduced monoculture of a cool-season grass, such as fescue. It is the intent of the Forest Service to provide high quality wildlife habitat; however, it is believed that the use of herbivores, such as cattle, to manipulate and maintain native prairie vegetation is as important an ecological process as the use of prescribed fire. It is relatively easy to establish a monoculture of warm-season grasses. On the other hand, it is difficult, if not impossible, to re-create a true prairie with a diverse composition of species on either a large or small scale basis. Given the ecological constraints by which the Forest Service must abide, the techniques described in this paper represent the known state-of-the-art for establishing native grasses and forbs on a large-scale basis.

MATERIALS AND METHODS

Plantings were made in Mexico Silt Loam, Keswick Silt Loam, and Hatton Silt Loam soils. These soils are characterized by a control section that is classified as being fine-textured (having more than 35 percent clay-sized particles) resulting in very low fertility and high susceptibility to erosion.

Equipment used for planting in both 1977 and 1978 was a Truax rangeland drill equipped with large and small seed boxes, double-disc furrow openers, depth bands and positive wheel-type packers, pulled by a tractor. Drill rows were spaced 20 cm (8 inches) apart with the drill being 2.2 m (7.3 ft) wide. One ha (just less than 2 acres) per hour could be seeded with this drill.

Type of seedbed preparation varied somewhat by field and year. In 1977 preparation consisted principally of deep plowing of a cover crop established the previous year and spraying with 2-4D, a preemergent herbicide, before planting into cover crop stubble residue. In 1978 seedbed preparation consisted principally of (1) deep plowing of cool-season pastures the previous fall, (2) disking twice during the following spring with a tandam disk, (3) harrowing once, and (4) disking a third time. Before drilling operations began, a Brillion cultipactor was used to produce a firm and level seedbed. Seeding depth was 0-1.25 cm (0-0.5 inches) in 1977 and 0.40-1.25 cm (0.16-0.5 inches) in 1978.

The 1977 plantings were started 20 May and extended into mid-June. In 1978 planting was begun 3 June and completed by 7 July. Wet field conditions prevented starting earlier than June in 1978. In 1977 fields totaling 45 ha (110 acres) were seeded to warm-season grasses. Species planted and pure live seed (PLS) rates are listed in Table 1. Bulk rates varied because of differences in purity and germination rate. In 1978 fields totaling 69 ha (171 acres) were seeded to warm-season grasses and also forbs. Species planted and PLS for grasses are listed in Table 1. Bulk rates varied from 16 to 20 kg/ha (14.5 to 18 lbs/acre) because of differences in purity and germination rate of large, fluffy seed. Pure live seed rates for forbs are not known; however, species and bulk rates are listed in Table 2. Evaluation is needed to determine exact kg/ha of PLS forb seed needed in prairie plantings.

Legume forb seeds were inoculated with species specific inoculants before being mixed with other forb seed. The seeds of *Amorpha canescens, Ambrosia psilostachya, Lespedeza capitata, Desmanthus illinoensis, Helianthus maximilianii, Cassia fasciculata,* and *Petalostemum purpureum,* were mixed in a ratio with *Panicum virgatum* to produce the various seeding rates listed in Table 2. Seeds of *Silphium laciniatum* were hand-mixed with large, bulky seed and placed in large seedbox of Truax drill.

Soil samples and subsequent analysis were obtained for all pastures. The 1978 plantings were fertilized with P&K and limed to bring all fields to recommended soil test. Nitrogen fertilizer, at a rate of 34-45 kg/ha (30-40 lbs/acre) was also applied to two fields that exhibited uniform seedling distribution 4-6 weeks after planting when the seedling height was about 7.6-15 cm (3-6 inches).

RESULTS AND DISCUSSION

Reestablishment success has been defined by various authors ranging from 1 seedling/m² to 20 seedlings/m². The U.S. Forest Service goal or guide for establishment success is to refine and develop planting technique to the degree that uniform grazeable stands of native grasses and forbs can be consistently produced by the second grazing season. In Kansas it was shown that native species with 10-20 plants/m² were ready to be grazed the second growing season unless stand development was delayed by excessive weed competition or drought (Launchbaugh and Owensby, 1970).

Using 20 plants/m² as an indicator, overall 1977 establishment attempts have not met with much success. In the fall of 1977 density of seedlings were fewer than 1 plant/m², except in isolated instances, and in some cases fewer than 1 plant/ha. Observation of these plantings in August 1978 indicated that densities of seedlings had not changed.

Failure of the seedlings to emerge has been attributed to soil crusting, and alternate wetting and drying (Cook et al., 1979). In 1977 it appeared that ground conditions contributed to a general lack of seed germination. Seedbed moisture seemed to have been inadequate. Plantings were made into dry surface soil. Immediately after plowing, a short summer drought ensued, resulting in death of some seedlings. Lack of adequate seedbed preparation also probably contributed to poor planting success in 1977. Rough seedbed conditions resulted in uneven planting depths ranging from bare surface to 1.25 cm (0-0.5 inches) below the surface. Undesirable plant competition was a severe problem in some 1977 plantings. The spraying of weedy fields with 2-4D had little effect on successful establishment of young seedlings, either before or after planting.

Establishment success of 1978 seedlings are judged as very good. Grasses that were seeded in early June varied from 18 to 60 cm (0.59-1.9 ft) in height as of 60 days since planting. Evaluation of fields by plant counts show that an average of 115 or more plants (grasses)/m² (10.7/ft²) were established in all but one field (percent species composition for grasses is listed in Table 1). It appears that techniques described for 1978 seedbed preparation contributed greatly to establishment success. Drilling in topsoil that was extremely fine and powder-like produced the most uniform and consistent stands.

Evaluation of forb germination shows an average of 34 seedlings/ha for Illinois bundleflower and 8 seedlings/ha for partridge-pea. Although these two species are the only forbs planted that have germinated in measurable quantities, seedlings of purple prairie clover, maximillian sunflower, and western ragweed have been identified. Several years evaluation may be needed to determine exact composition and seeding rate needed for forb establishment.

To date, undesirable plant competition has not been a severe problem with 1978 plantings. Moisture conditions were much better in 1978 than in 1977. As shown in other cases (Lauchbaugh and Owensby, 1970), average depth to moist soil at planting time appears to be indicative of success. Soils were moistened to within 2.5 cm (1 inch) below the surface in the majority of fields planted in 1978. In 1977 seed was placed almost entirely in dry soil.

Mixed opinion of researchers on the use of nitrogen prevails in establishment of native grasses. Recommendations for use range from no use to restrictive use. The success of nitrogen fertilization of

Table 1. Species of grasses seeded with pure live seed rates (PLS) for 1977 and 1978, and initial seeding composition (percent) of native grasses seeded in 1978.

	PLS 1977 (kg/ha)	PLS 1978 (kg/ha)	Composition 1978 (%)
Andropogon gerardii (big bluestem)	1.58	3.35	22
A. scoparius (little bluestem)	1.58	2.25	19
Sorghastrum nutans (Indian grass)	1.90	2.25	15
Panicum virgatum (switch grass)	1.68	1.50-2.25	34
Bouteloua curtipendula (sideoats grama)		1.15	10
Total	6.67	9-10	100

Table 2. Species of forbs seeded with bulk rates for 1978.

	Gm (bulk)/ha
Amorpha canescens (leadplant)	35
Ambrosia psilostachya (western ragweed)	91
Lespedeza capitata (roundheaded lespedeza)	42
Desmanthus illinoensis (Illinois bundleflower)	200
Helianthus maximilianii (maximilian sunflower)	35
Cassia fasciculata (showy partridgepea)	42
Silphium laciniatum (compass-plant)	7
Petalostemum purpureum (purple prairieclover)	7
Total	459

newly seeded stands of native grasses appears linked to initial stand uniformity and seedling growth stage at time of application. It is apparent that 1978 plantings fertilized with nitrogen responded vigorously. Cool-season grasses and broadleaves, which were in a semidormant stage of growth, were easily outperformed by the new seedlings.

SUMMARY

In years of normal spring precipitation, seedings of native grasses should be attempted between 15 May to 15 June on upland sites. In years of abnormally high amounts of spring moisture, plantings may be attempted well into July with good success. Good subsoil moisture conditions and periodic summer rains can ensure success of late plantings in central Missouri. However, it is normal for central Missouri to experience a 4-6 week drought, such as occurred in 1977, during the early to midsummer period.

Large scale seeding of prairie forbs and grasses can be successfully conducted. It appears that proper seedbed preparation, combined with adequate moisture conditions and a knowledge of local plant phenology, contributed greatly to successful establishment in central Missouri. Continued studies are needed to develop better techniques of seeding grasses and forbs on large scale basis.

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REESTABLISHMENT OF NATIVE GRASSES BY THE CORPS OF ENGINEERS ON PROJECT LANDS IN THE SOUTHWESTERN DIVISION AREA

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Within the past few years, the Corps of Engineers has encouraged establishment of native vegetation on its project lands primarily for the following reasons: (1) The use of native vegetation is more compatible with the natural type recreation facilities provided by the Corps. (2) Native plants are usually better adapted to the sometimes harsh growing conditions which are available and, thus, are more economical to establish and maintain.

The Southwestern Division lies geographically in the middle of the southern part of the United States and includes all of Oklahoma, most of Texas and New Mexico, southeastern Colorado, southwestern Arkansas, and southern Missouri and Kansas. It encompasses parts of the Gulf Coastal Plain, the Ozark Plateaus, the central Lowlands Plains, the southern Rocky Mountains, and the semiarid desert areas of southwestern Texas and southern New Mexico. Average rainfall can vary from 142 cm (56 inches) in Arkansas to 20 cm (8 inches) in localized areas of New Mexico and Colorado. In 1976, 81 major projects were in operation in the division involving approximately 809,200 ha (2,000,000 acres) of land and water with the majority of projects concentrated in the eastern half of the division.

A statement contained in the 1973 *Environmental Program*, perhaps best expresses the policy of the Corps of Engineers regarding development of national resources in its care: "In recognition of the highly complex relationship between nature and man, we will encourage and support efforts to bring the best existing ecological knowledge and insights to bear on the planning, development and management of the Nation's water and related resources." This policy was reinforced in a 1976 letter from the Chief of Engineers to the Divisions: "We must do everything reasonably possible to preserve, conserve, enhance, maintain and restore the natural environmental resources of this country and create new opportunities for the American people to use and enjoy them." The Southwestern Division continues to stress environmental quality, particularly regarding the use of native plants. Our policy is that native plants should be used wherever practical to include landscaping project buildings and recreational developments, reestablishing vegetative cover on disturbed areas, and managing project lands.

EXAMPLES OF SOUTHWESTERN DIVISION PROJECTS ON WHICH NATIVE VEGETATION IS BEING ESTABLISHED

The largest restoration effort accomplished by the Albuquerque District was in 1977 at Cochiti Lake where native or adapted grasses were planted in 243 ha (over 600 acres) of borrow pits, waste clay mounds, haul roads, and road cuts. Completed in 1975, Cochiti Lake is located on the Rio Grande River in north-central New Mexico near the city of Santa Fe; it provides flood control, sediment retention, and recreation. The retaining embankment is over 8 km (5 miles) long and required over 38 million m^3 (50 million yd^3) of earth fill. Over 405 ha (1,000 acres) of land from the reserved area were cleared and excavated to supply this huge quantity of earth. The borrow areas were relatively flat, extensive floors with side slopes ranging from 2.5 to about 3 on 1. The length of the side slopes ranged from about 7.6 to 61 m (25 to 200 ft). The waste clay mounds could be more appropriately described as a series of small hills covering about 61 ha (150 acres). The soils of this area are characterized by a thin mantle of sandy loam and silty clay loam underlain by a narrow band of caliche which is underlain by a thick layer of terrace sands and gravels. However, as a result of side slope shaping, moving borrow materials, and road shaping, the side slopes and bottom were left as a mixture of these heterogenous materials.

This fill was primarily taken from the reservoir area which was characterized by grassy, relatively flat mesa land, and gently rolling hills. The vegetative cover of this area was sparse to moderately dense concentration of predominantly short grasses such as blue grama *(Bouteloua gracilis)*, black grama *(B. eriopoda)*, side-oats grama *(B. curtipendula)*, galleta *(Hilaria jamesii)*, and muhly *(Muhlenbergia* spp.*)*. Shrubs such as broom snakeweed *(Gutierrizea sarothrae)*, various species of cacti *(Opuntia* spp.*)*, and yucca *(Yucca* spp.*)* were widely dispersed throughout this grassland association.

In developing a suitable restoration plan, a number of factors were considered; including soil fertility and pH, native or adapted grass species suitable to climatic and edaphic conditions, planting methods, and angle and conditions of side slopes. Because two years had elapsed since construction was completed, erosion was progressing rapidly. Only those areas above the level of the 5-year-frequency pool were selected for restoration because of the frequency of inundation at lower elevations. In the arid Southwest, perhaps the most important aspect of restoration is the timing of the planting operation which must be accomplished immediately before the summer rainy season begins. If planting is finished too early, then an isolated rainstorm can germinate the seed without sustaining rain, the seedlings will wither and die in scorching 32-38°C (90-100°F) temperatures. Since approximately 50 percent of 20.3 cm (8 inch) annual precipitation here falls from July through September, planting was done between 15 June and 1 August.

Different seeding rates were used for level terrain and steep side slopes. The seeding rate for nearly level land was 25^{16} of pure live seed (PLS)/ft^2 and 35^{16} PLS/ft^2 of slope. More seed was applied to slopes because of loss from erosion. With the exception of Indian ricegrass, all the selected grasses are warm-season grasses such as sand dropseed, Indian ricegrass, sideoats grama, and blue grama which are native to New Mexico. Two other species of plants were used: weeping lovegrass, an exotic species that has performed well in the Southwest, and yellow sweet clover, a nitrogen-fixing species that was inoculated prior to seeding. With time the populations of yellow sweet clover will decrease and the populations of the warm-season grasses will increase. Selection of the species mixture for the existing soil and climatic conditions, and the quantity of seed necessary to establish a good stand of vegetation is critical. Overseeding may produce a stand of seedlings so thick that individual plants compete with each other for moisture.

Prior to the seeding operation, a level seedbed was prepared. The soil was scarified to a depth of 10-13 cm (4-5 inches) by disking or in the case of hard-packed haul roads by a spike-tooth harrow. It was necessary to apply a nitrogen fertilizer before seeding to improve fertility. The soils throughout much of the severely disturbed areas were low in fertility and have a fairly high pH.

The seed was planted by a rangeland drill which is adapted to moderately rocky terrain. Following the seeding operation, native hay mulch was blown over the seeded area at an application rate of 1 ton/ha (2.5 tons/acre). The mulch was then anchored in the grounds to form a soil binding mulch. The entire area was fenced to prohibit grazing.

Results

Shortly after completing the seeding operation, the seasonal rains came and they were generally adequate. However, some erosion damage did occur following the first storm when 4.4 cm (1.75 inches) of rain fell. The mulch application significantly reduced erosion of soil and seed; it probably saved the entire seeding operation. At the end of the first growing season, much of the area exhibited fair to good growth, but some large sections had little or no growth. This poor growth was partly attributable to erosional damage where mulch was improperly anchored. Some areas were also very sandy and may not have retained sufficient moisture. Ponding in some portions of the borrow pit rotted the seed. On less disturbed areas such as roads, the results were very good and some sections closely resembled the surrounding undisturbed native grassy areas.

In the spring of 1978, following a winter with above normal precipitation, the soil moisture level was high and a significant portion of the area became covered with cheat grass *(Bromus secalinus)*, a species introduced with the native hay mulch and yellow sweet clover. Cheat grass, a cool-weather grass, stops growing in the summer, but here it served to stabilize the soil. The planted grass species, being warm-season grasses, had not yet sprouted in significant numbers. The series of large waste clay hills exhibited very good results. By August of 1978 it was too early to ascertain how well the planted grass was becoming established. The waste clay hills, one large borrow area, and almost all haul roads appeared to be developing well yet two smaller borrow areas were progressing slowly. Areas with little or no growth improved following seasonal rains. Nevertheless, it is believed that the grasses in successful areas, along with natural seeding from adjacent undisturbed grassland, will invade these sparse areas so that all of the disturbed areas will eventually have cover.

DEVELOPMENT OF MARSH AND UPLAND HABITAT PLANT COMMUNITIES ON BOLIVAR PENINSULA, GALVESTON BAY, TEXAS

In March 1975 a two and a half year field study was initiated to determine the feasibility and impact of developing marsh and upland plant communities on dredged material. The investigation was conducted as part of the Corps of Engineers Dredged Material Research Program managed by the Waterways Experiment Station, Vicksburg, Mississippi. The Galveston District provided construction, maintenance, and logistical support.

The climate is warm and humid with an average annual precipitation of 1.07 m (42 inches) and mean temperatures ranging from a daily low of 3.9°C (39°F) in winter to a daily high of 33.9°C (93°F) in summer. Water levels are between 0.36 and 0.85 m (-1.2 and +2.8 ft) MSL 98 percent of the time. The study area is a 1.2 ha (2.9 acre) site near the western end of Bolivar Peninsula, exposed to Galveston Bay on the north and to Bolivar Peninsula on the south. Soil materials on the project site were 88 percent or more sand and of low fertility. They were obtained from maintenance dredging in the nearby Gulf Intercoastal Waterway. This process is required at approximately two year intervals; the most recent maintenance was in August 1974.

After the site was inventoried for existing flora and fauna and characteristics of dredged material, it was prepared for planting. Existing vegetation was cleared and the site was graded to improve uniformity. A primary sandbag dike was constructed offshore to dissipate wave energies. Secondary sandbag dikes were also provided with open spaces to provide circulation. A fence was constructed around the perimeter to exclude goats and other animals.

The site was divided into intertidal and upland zones, each with its own experimental design. The species selected were based on the earlier inventory. The intertidal site was divided into three tiers, based on elevation. The periods of time the tiers were inundated during the growing season were 80-93 percent for the lower, 9-80 percent for the intermediate, and 1-9 percent for the upper. Within each tier smooth cordgrass *(Spartina alterniflora)* and saltmeadow cordgrass *(S. patens)* were established by 30 different treatment combinations such as sprigging, seeding, or no planting, and fertilization at different levels or no fertilization. In addition, two pairs of plots were established outside the dike and two pairs were established just inside the dike to provide an evaluation of dike effectiveness. Both species of cordgrass were used in these plots.

The upland portion was designed to examine survival and growth of three vegetational forms: trees, shrubs, and grasses. The trees selected were sand pine *(Pinus clausa)*, live oak *(Quercus virginiana)*, and salt cedar *(Tamarix gallica)*. The shrubs were southern waxmyrtle *(Myrica cerifera)*, gulf croton *(Croton punctatus)*, and winged sumac *(Rhus copallina)*. The grasses were coastal bermuda grass *(Cynodes dactylon* var. *alecia)*, bitter panicum *(Panicum amarum)*, and bluestem *(Andropogon perangustatus)*.

Intertidal Zone Results

Smooth cordgrass survived and grew best at lower elevations 0.06-0.21 m (0.2-0.7 ft) about MSL where tidal inundation occurred during 69-87 percent of the growing season. Saltmeadow cordgrass performed best in the upper intertidal zone, above 0.36 m (1.2 feet) MSL. Both species tended to produce more biomass at the lowest elevations they could tolerate. This production may indicate a response to a greater availability of nutrients at lower elevations. A zone of poor survival and growth was evident for both species near mean high water. Other studies on the east and west coasts suggest that this zone is caused by salt accumulation where the evaporative concentration of salts exceeds leaching. Sprigging proved to be much more reliable than seeding. Fertilization did not clearly affect survival, growth, or seed production in the intertidal zone. The sandbag dike was effective in stabilizing waves. Plantings outside the dike were poorer in survival and growth than those inside the dike. Survival rates are not available.

Upland Zone Results

Variation in elevation appeared to be related to the success of most species in the upland zone. The plants that performed poorly in low, wet soils included coastal bermuda grass, bitter panicum, and Gulf croton. In contrast, salt cedar and sand pine performed poorly on the higher drier soil. The species most tolerant to variation in elevation and moisture were live oak, winged sumac, and waxmyrtle. Bluestem transplants performed poorly over the entire site although they grew naturally in the adjacent area, perhaps indicating that transplanting is a poor method for propagating this species. The survival of wax myrtle and height growth of sand pine were increased by fertilization, but no other effects were observed among other tree and shrub species. Average percentages of plants surviving on the upland site were live oak (96.5), bitter panicum (84.7), coastal bermuda grass (81.3), winged sumac (66.0), southern waxmyrtle (62.9), sand pine (31.9), salt cedar (28.9), Gulf croton (22.2), and bluestem (5.4).

Conclusions

This study indicates that both smooth cordgrass and saltmeadow cordgrass can be artifically established in the intertidal zone on dredged material. Smooth cordgrass can be established below mean high water, while saltmeadow cordgrass should be planted in periodically inundated areas above mean high water. Both smooth and saltmeadow cordgrass are most successfully introduced by transplanting. Fertilization does not appear to significantly affect growth in the intertidal zone.

Planting upland areas with grasses, shrubs, and trees was partially successful, depending on species and soil moisture. Upland species that generally performed best were coastal bermuda grass, bitter panicum, live oak, winged sumac, and waxmyrtle.

FORT WORTH DISTRICT

The Fort Worth District has seeded a total of 1043 ha (2577 acres) in native grasses. At O.C. Fisher Lake, near San Angelo, Texas, for example, 486 ha (1200 acres) were planted with a mixture consisting of plains bristlegrass, green sprangletop, switchgrass, and one of the gramas. It was necessary to root plow and rake dense stands of mesquite on part of the area before seeding.

At the Waco Lake project, near Waco, Texas, project personnel used prairie sod from an adjacent air field that was being renovated to reestablish 2 ha (5 acres) of prairie grass on project lands. The principal species included were big bluestem, little bluestem, Indian grass, switchgrass, and associated forbs. In addition to the reestablishment of new sod, the District conducts practices designed to encourage and preserve existing stands of native plants. This procedure mainly involves control of overgrazing and wildfire.

On the Benbrook Lake project, adjacent to Fort Worth, Texas, project personnel have encouraged the development of over 40 ha (100 acres) of native herbaceous plants. The establishment techniques used were control of overgrazing and delay of mowing until after the plants seeded. The species composition varies from one place to another, but includes bluebonnet, Indian paintbrush, prairie verbena, Maximilian sunflower, Texas blue thistle, and gay feather.

TULSA DISTRICT

The Tulsa District effort toward reestablishing native vegetation is concentrated primarily in three areas: restoration of range lands, management of forbs, and revegetation of sites disturbed by project construction. Range lands at such projects as John Redmond Lake, central Kansas, are being restored to their former prairie plant species compositions, primarily by controlling cattle grazing and by selective prescribed burning. During 1977 these techniques were used to improve over 809 ha (2000 acres) of grasslands at John Redmond Lake alone. The native flowering plant program has become a favorite with the visiting public. Generally, the management techniques involve establishment of relatively small plots by seeding and deferring mowing on these areas to allow for reseeding. Prescribed burning is sometimes used. The revegetation of disturbed areas is usually accomplished cooperatively with the Soil Conservation Service. The typical practices used include erosion control structures, seedbed preparation, seeding, and tree planting. The primary emphasis here is erosion control; however, native plants are used wherever possible.

SUMMARY

The primary mission of the Corps is to provide flood control, navigation, recreation opportunities, water supply storage, fish and wildlife habitat, and hydroelectric power generation for the benefit of the public. We recognize and accept our responsibility to exercise good stewardship on lands associated with our projects. It is our goal to maintain a balanced environment in all management activities.

WARM-SEASON GRASS ESTABLISHMENT ON MINE SPOIL IN KENTUCKY

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With the increasing dependence on coal to fill this country's energy needs in the future, thousands of acres are being stripped every year to recover coal. Coupled with this operation is the pressure to protect the remaining natural resources in the coal-producing areas. Strip-mining creates large areas denuded of vegetation, which, if left unstabilized, will generate large quantities of silt; thus, streams and rivers downstream from the mining area are being polluted. Plants that provide cover quickly and maintain an adequate stand indefinitely need to be established on these strip-mined soils.

In addition to newly created, mined land, thousands of acres of abandoned mined land exist that also need reclamation. Revegetation on these areas is usually difficult because the topsoil or other soil material suitable for plant growth was not retained. The remaining material is very rocky and clayey, making seeding and establishment almost impossible.

Mined land should be planted with species that not only stabilize the soil but also have economic value. Since the passage of the Surface Mining and Reclamation Act of 1971, much of the approximately 117,450 ha (280,000 acres) on which permits for mining were issued in Kentucky has been returned to a condition that could support hayland or pasture (Ky. Dept. Nat. Resources and Environ. Protection, Div. of Reclamation, personal communication). However, the species generally used to reclaim this land were either not suited for or had limited value for hay and pasture during the summer months. Plant species are needed that (1) provide sufficient cover on mine spoil to meet state specifications, (2) are suitable for hay or pasture, and (3) provide forage through the summer months.

In response to these needs, the Environmental Protection Agency funded a study by the Soil Conservation Service that would (1) compare the performance of several warm-season grasses, seeded alone or with legumes, with the species commonly used for mine spoil revegetation, (2) evaluate several different methods of establishing these grasses, and (3) determine the forage yield and quality of the warm-season grasses and grass-legume mixtures. The first two objectives are reported on in this paper.

METHODS

Study sites of identical size were established in the eastern and western Kentucky coal fields in April 1976. The differences in soils, climate, and types of mining were the reasons for establishing two study sites. The western Kentucky site is located near Central City, Muhlenberg County, on the Vogue mine of Peabody Coal Company. The soils in this area are formed from sandstone and shales, with a thin loess cap. The growing season averages 180-185 days and annual rainfall distribution is divided equally between the first and last six months. The summers tend to be hotter and dryer than eastern Kentucky. The pH of the mine spoil was 5.6, but lime was applied to raise it to 6.5. The eastern Kentucky site is about 24 km (15 miles) from Jackson, Breathitt County, on the Press Howard Fork mine operated by Falcon Coal Company. Soils in this area are shallow, residual ones formed in acid sandstone and calcareous shale. About 45 percent of the annual rainfall accumulates in the first six months. Summers are hot, but generally moisture is available. The pH of the spoil was 6.6; therefore, no lime was applied.

Mining methods vary between the two areas. In western Kentucky, area strip-mining is the predominate type of surface mining. During reclamation the spoil is placed so that the land could be used for pasture or hayland. In eastern Kentucky, the trend is toward mountaintop removal mining. In this method, the entire coal seam is exposed by removing the peak of the mountain. This procedure creates large, relatively flat areas that could be suitable for pasture or hayland.

The study sites at each location were chosen so that both had approximately the same aspect, drainage pattern, and amount of relief. The study uses a split plot design, with three replications. Each replication is 24.2 m x 106.7 m (80 ft x 352 ft). The five establishment methods are each 4.8 m (16 ft) wide and run the length of the replication. The eight seeding mixtures are each 13.3 m (44 ft) long and run with the width of the replication. This divides the replication into 40, 4.8 m x 13.3 m (16 ft x 44 ft) plots, each containing a different seeding mixture-establishment method combination.

Eight species or cultivars were used at both study sites; they are listed below with references:

Festuca arundinacea Schreb 'Ky-31' tall fescue	Hitchcock, 1950
Panicum virgatum L. 'Blackwell' switchgrass	Hitchcock, 1950
Andropogon gerardii Vitman 'Kaw' big bluestem	Hitchcock, 1950
Andropogon caucasicus Trin. Caucasian bluestem	Hitchcock, 1936
Sorghastrum nutans (L.) Nash 'Cheyenne' Indiangrass	Hitchcock, 1950
Coronilla varia L. 'Chemung' crownvetch	Gleason and Cronquist, 1963
Lespedeza cuneata (Dumont) G. Don 'Interstate' sericea lespedezea	Gleason and Conquist, 1963
Lespedeza cuneata 'Appalow' sericea lespedeza, a prostrate cultivar	Gleason and Cronquist, 1963

Eight different seeding mixtures were used at both study areas with varying seedjng rates for Pure Live Seed (PLS): 'Kaw' big bluestem (16.9 kg PLS/ha), 'Cheyenne' Indiangrass (16.9 kg PLS/ha), 'Blackwell' switchgrass (11.1 kg PLS/ha), 'Chemung' crownvetch (22.5 kg PLS/ha), Caucasian bluestem (22.5 kg PLS/ha), 'Blackwell' switchgrass (11.1 kg PLS/ha) and 'Interstate' sericea lespedeza (33.75 kg PLS/ha), 'KY-31' tall fescue (33.75 kg PLS/ha) and 'Interstate' sericea lespedeza (33.75 kg PLS/ha), and Caucasian bluestem (22.5 kg PLS/ha) and 'Appalow' sericea lespedeza (33.75 kg PLS/ha).

Five different establishment methods were evaluated for each species or species mixture. Seed was broadcasted with straw (4500 kg/ha), woodbark (255 m^3/ha), or without mulch. Seed was drilled with straw (4500 kg/ha) or no mulch. Stand counts at the sixtieth day, and the one hundred and twentieth day for each seeding mixture and establishment methods in both studies were taken in 1976. Two observers each made counts in three randomly selected 25 cm x 25 cm (10 in x 10 in) plots within every seeding mixture and establishment method subplot. In the autumn of 1977, when stands were at their peak, two observers estimated the percentage of plant cover in each plot.

RESULTS

Data from the 120-day stand count (Table 1) show that some species sown alone can become established as well as a standard reclamation mixture of tall fescue-sericea lespedeza, and others cannot. Caucasian bluestem, whether seeded alone or in a mixture with 'Appalow' sericea lespedeza, produced good stands. The presence or absence of mulch was not critical in stand establishment for any species. Many unmulched plots had better stands than the mulched plots.

The data on percent cover (Tables 2 and 3) are in four columns. The column headed "all" gives the percent ground cover due to seeded species plus unseeded species or "weeds." The columns headed "unseeded," "grass," and "legume" show the percent of total ground cover that is provided by "weeds," seeded grass, and seeded legume, respectively.

The data show that some of the warm-season grasses produce stands as good or better than the standard tall fescue-sericea lespedeza mixture, and some do not. Caucasian bluestem gave the best results in stand establishment. Whether seeded alone or in a mixture with 'Appalow' sericea lespedeza, this grass species was the most consistent in establishing stands that met the reclamation standard of 70 percent cover for permanent vegetation. In 1976 in Eastern Kentucky (Table 2), Caucasian bluestem seeded alone and the Caucasian bluestem-'Appalow' sericea lespedeza mixture both had adequate cover under three different establishment methods. Tall fescue-'Interstate' sericea lespedeza met the reclamation standard under all five establishment methods. In 1977 at the same location (Table 3), three different treatments of Caucasian bluestem gave adequate cover, as did four different treatments of the Caucasian bluestem-'Appalow' sericea lespedeza mixture. Again, all five treatments of tall fescue-'Interstate' sericea lespedeza met the reclamation standard. No plots of big bluestem, Indiangrass, or switchgrass met the standard.

Establishment methods also affected the amount of cover produced. More successful plots were established with broadcast seeding and woodbark mulch than with any other establishment method. Fifteen plots met the reclamation standard for percent cover in both 1976 and 1977. In both years, five of these plots were established by the above method. The next most successful establishment methods were seed drilled without mulch and seed broadcast without mulch. Both of these methods produced three plots that met the standard in both 1976 and 1977. The plots mulched with woodbark have a better stand of the seeded species, and fewer "weeds" or unseeded species, than the plots mulched with straw. The fewest successful plots were produced when seed was broadcast with straw mulch or seed was drilled with straw mulch.

SUMMARY

Some warm-season grasses will establish stands on mine spoil that are equal to stands obtained with plants commonly used for mine spoil reclamation, and some will not. Caucasian bluestem seeded alone, the Caucasian bluestem-'Appalow' sericea lespedeza mixture, and the switchgrass-'Interstate' sericea lespedeza mixture produced stands as good as the tall fescue-'Interstate' sericea lespedeza standard; however, the warm-season grass seedings were not successful under as many different establishment methods as were the standard mixture seedings. Neither big bluestem, Indiangrass, nor switchgrass seeded alone produced adequate stands. Stands of the warm-season grasses improved in the second year. Establishment methods can affect the stand of seeded species. Woodbark mulch on a broadcast seeding was the most effective. The plots mulched with straw had a greater percent of total cover from "weeds" and unseeded species than did the plots with woodbark mulch or without mulch.

If the forage quality of the warm-season grasses grown on these sites is found to be acceptable, we will have more plant species which can both stabilize and provide an economic return from the growing acreage of strip-mined land.

Table 1. Eastern (E) and western (W) Kentucky 120-day stand count given in plants/m^2 for species seeded alone and in mixture. Values are the average of three replications.

	Seed Broadcasted						Seed Drilled			
	Woodbark Mulch		Straw Mulch		No Mulch		Straw Mulch		No Mulch	
	E	W	E	W	E	W	E	W	E	W
Seeded Alone										
Big bluestem	81	105	27	110	31	71	25	135	49	95
Indian grass	92	150	52	76	97	59	76	100	64	105
Switch grass	53	32	56	44	86	37	57	33	63	60
Crownvetch	107	75	69	129	70	47	49	79	57	95
Caucasian bluestem	252	257	175	260	342	254	132	241	281	422
Seeded in Mixture										
'Interstate' sericea lespedeza & switch grass	77/163	40/169	46/44	44/36	27/27	52/60	29/44	60/40	51/18	76/15
'Interstate' sericea lespedeza & 'KY-31' tall fescue	236/84	221/49	172/73	181/24	134/55	129/25	132/173	220/41	158/56	155/52
'Appalow' sericea lespedeza & Caucasian bluestem	186/92	260/98	256/110	196/60	292/63	319/30	191/45	203/42	298/48	160/15

Table 2. Percent cover and stand composition, eastern (E) and western (W) Kentucky, in October 1976.

	Seed Broadcasted																							
	Woodbark Mulch								Straw Mulch								No Mulch							
	Percent Cover								Percent Cover								Percent Cover							
	All		Unseeded		Grass		Legume		All		Unseeded		Grass		Legume		All		Unseeded		Grass		Legume	
	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
Seeded Alone																								
Big bluestem	80	42	47	28	53	72			92	55	94	44	6	56			42	40	69	46	31	54		
Indian grass	80	52	72	54	28	46			86	56	87	82	13	18			69	39	79	87	21	13		
Switch grass	73	38	58	15	42	85			92	54	90	72	10	28			60	32	40	19	60	81		
Crownvetch	88	78	17	17			83	83	95	73	55	21			45	79	69	28	21	22			79	78
Caucasian bluestem	84	68	7	12	93	88			83	78	53	39	47	61			94	55	6	16	94	84		
Seeded in Mixture																								
'Interstate' sericea lespedeza & switch grass	85	54	25	14	63	24	12	66	88	59	83	65	11	19	6	16	43	38	21	17	42	66	37	17
'Interstate' sericea lespedeza & 'KY-31' tall fescue	96	59	4	4	58	58	38	38	96	64	5	8	80	85	15	7	98	44	7	12	83	86	10	2
'Appalow' sericea lespedeza & Caucasian bluestem	90	62	12	16	20	62	68	12	94	66	38	38	15	49	47	13	93	67	7	26	12	70	81	4

	Seed Drilled															
	Straw Mulch								No Mulch							
	Percent Cover								Percent Cover							
	All		Unseeded		Grass		Legume		All		Unseeded		Grass		Legume	
	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
Seeded Alone																
Big bluestem	86	59	93	52	8	49			50	29	75	44	25	56		
Indian grass	94	57	85	81	15	19			64	55	86	86	14	14		
Switch grass	83	56	83	66	17	34			57	35	19	16	81	84		
Crownvetch	84	67	50	31			50	69	70	46	23	32			77	68
Caucausian bluestem	78	56	66	31	34	69			81	55	15	8	85	92		
Seeded in Mixture																
'Interstate' sericea lespedeza & switch grass	83	61	79	30	13	49	8	21	69	50	23	12	41	83	36	5
'Interstate' sericea lespedeza & 'KY-31' tall fescue	94	81	8	8	83	85	9	7	85	47	6	6	88	83	6	11
'Appalow' sericea lespedeza & Caucasian bluestem	90	66	48	44	15	49	37	7	83	69	8	39	11	59	81	2

Table 3. Percent cover and stand composition, eastern (E) and western (W) Kentucky, in October 1977.

	Woodbark Mulch Percent Cover								Seed Broadcasted Straw Mulch Percent Cover								No Mulch Percent Cover							
	All		Unseeded		Grass		Legume		All		Unseeded		Grass		Legume		All		Unseeded		Grass		Legume	
	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
Seeded Alone																								
Big bluestem	91	64	60	12	40	88			87	76	86	14	14	86			87	59	80	23	20	77		
Indian grass	86	68	39	15	61	86			77	62	71	41	29	59			80	50	68	48	32	52		
Switch grass	92	64	49	8	51	92			83	59	73	22	27	78			90	55	58	22	42	78		
Crownvetch	92	55	38	29			62	71	96	63	35	29			65	71	79	22	50	71			50	29
Caucasian bluestem	93	83	12	6	88	94			80	82	37	11	63	89			99	56	9	15	91	85		
Seeded in Mixture																								
'Interstate' sericea lespedeza & switch grass	97	65	15	6	25	53	60	41	83	63	37	13	22	71	41	16	87	59	50	10	22	87	28	3
'Interstate sericea lespedeza & 'KY- 31' tall fescue									96	59	4	4	58	58	38	38								
96	64	5	8	80	85	15	7	98									44							
7	12	83	86	10	2																			
'Appalow' sericea lespedeza & Caucasian bluestem	98	69	10	6	51	64	39	30	85	71	30	11	39	66	31	23	96	67	13	12	58	78	29	10

	Seed Drilled Straw Mulch Percent Cover								Seed Drilled No Mulch Percent Cover							
	All		Unseeded		Grass		Legume		All		Unseeded		Grass		Legume	
	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
Seeded Alone																
Big bluestem	88	74	92	22	8	78			89	43	91	40	9	60		
Indian grass	84	68	73	24	27	76			87	58	85	36	15	64		
Switch grass	82	65	59	24	41	76			93	67	58	12	42	88		
Crownvetch	87	65	56	35			44	65	88	52	70	44			30	56
Caucausian bluestem	78	72	22	11	78	89			92	58	15	15	85	85		
Seeded in Mixture																
'Interstate' sericea lespedeza & switch grass	86	68	44	9	22	66	34	25	92	66	38	12	29	85	33	3
'Interstate' sericea les-edeza & 'KY-31' tall fescue	94	67	4	7	73	73	23	20	93	50	5	12	80	81	15	7
'Appalow' sericea lespedeza & Caucasian bluestem	87	73	21	21	48	65	31	19	93	59	15	23	60	68	25	9

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A QUALITY ANALYSIS TECHNIQUE FOR WISCONSIN GRASSLANDS

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Site analysis is the process of examining the resources of an area to determine their suitabilities for various uses. Before decisions can be made regarding the acquisition, development, or management of a site, a site analysis should be performed by landscape architects, planners, and conservationists in order to understand the effect on the resources to be impacted. The requirement for the preparation of Environmental Impact Statements under the National Environmental Policy Act (1969) and similar state laws has made such evaulations a necessity in many instances. Although standardized analysis systems for soil and topography have been well established largely through the efforts of the Soil Conservation Service, no parallel system has been developed for vegetation.

An effective vegetational evaluation system should include ratings for both the existing qualities of a site in terms of proposed uses and the potential for damage by each use. Many vegetational rating systems have been advanced in recent years; none are completely satisfactory. The majority are attempts to evaluate plant communities for specific uses such as preservation (Fosberg, 1967; Tubbs and Blackwood, 1971; Helliwell, 1973; Peterken, 1974; Tans, 1974; Gelbach, 1975; Wright, 1977) or wildlife habitat (Stocker et al., 1977). These studies evaluate vegetation on the basis of various criteria such as "rarity," "diversity," or "naturalness," but little consensus exists about the measurement and evaluation of these factors or about the combination of these criteria. More importantly, the issue of use-sensitivity is not addressed. A vast literature is available which documents the effects of specific impacts such as trampling, grazing, and air pollution on specific sites, but few attempts have been made at rating potential impact. Some analyses have been reported which rank plant communities according to their relative sensitivities to specific types of impact (Smith et al., 1975; Cooper et al., 1976); they either compare one community type with another or early successional stages with later ones. Other systems are intended as general checklists for evaluating type and extent of environmental damage (Leopold et al., 1971). All of these impact evaluating techniques are either too restrictive or so general that they fail to yield useful predictive information for site analysis.

This paper presents a technique for evaluating the quality of plant communities, grasslands in particular, designed specifically for use in site analysis. This technique expands those described above because (1) the degree to which vegetational features enhance a use as well as the potential for damage by that use is considered, (2) it can be used to evaluate a site in terms of a number of different uses, and (3) the ratings rely on quantitative data in an attempt to make them as objective as possible.

GRASSLAND QUALITY ASSESSMENTS

Description of Quality Analysis Technique

The Grassland Quality Assessment considers five uses which may occur in grassland areas without destroying them: natural areas (scientific research and preservation), education, nonmotorized recreation (hiking and skiing), motorized recreation (snowmobiling and trail biking), and hunting. These categories associate activities which have similar resource requirements and produce similar impacts; therefore, they may be assessed in the same way. For each use-category, the technique compares the site under investigation with quality standards expressed in terms of measurable features or test statistics. The values of these test statistics are ranked on a relative scale from 1 to 5, low quality to high quality respectively. Each is independently weighted according to its relative importance in measuring overall quality; a high weight indicates high importance. The sum of the weights of all the measures in the analysis is 100.

A suitability score for each test statistic is then calculated by multiplying its weight by the rank resulting from the assessment. The sum of all of the individual suitability scores represents the quality rating for the site:

$$\text{Test Statistic Rank x Weight} = \text{Suitability Score}$$
$$\Sigma \text{ Suitability Scores} = \text{Quality Ratings}$$

Ratings may range from 100 to 500. A low quality site would have ranks of 1 or 2 for all the assessment test statistics, and a resultant quality rating of 100 or 200. A site of high quality on the other hand would have ranks of 4 or 5 for all measures, and a quality rating between 400 and 500.

Quality Standards and Test Statistics

Table 1 presents the criteria which evaluate grasslands in terms of each of the five use-categories and the test statistics which measure these quality standards. Two general types of criteria are employed. The first attempts to judge the biological features of a particular site; the second estimates human-related features.

Biological Features

The biological features are evaluated with data from field studies using species presence/absence information from 25 uniformly distributed 1-m² circular quadrats. The data are gathered during a site visit in midsummer. The test statistics are all designed to use information gathered in this manner.

Species Diversity. This standard represents the concept that the variety of species present at a site is important. Several different measures of diversity exist. The measure chosen for this analysis is perhaps the simplest: the number of species occurring in the 25, 1-m² quadrat analysis.

Naturalness. This standard identifies plant communities which are least affected by modern civilization; hence, they are "natural."

1. Resemblance to presettlement vegetation. This test statistic measures naturalness by comparing the species in the quadrat sample with a list of prevalent species for that community type (Curtis, 1959). Prevalent species are those most likely to be encountered in any given undisturbed example of that type. Thus, the number of prevalents in the sample is an indication of the degree of resemblance to natural vegetation.
2. Lack of "detrimental" disturbance. Another criterion is that no obvious cultural disturbance is evident. This standard is measured by using indicator species: exotics which are usually not present in a community unless trampling or grazing, for example, has occurred. Two test statistics can be applied. The first, Percent Exotic Species, expresses the percentage of all quadrats containing at least one exotic species. The second measure, Percent of Quadrats with Exotics, indicates the extent of disturbance.

Game Potential. One standard for quality hunting involves the ability of a site to support game species. This concept is difficult to reduce to simple measurable features because it involves many habitat factors such as food, shelter, and predation. For purposes of this analysis a single measure was devised: a generalized habitat rating which compares different community types such as dry prairie, wet prairie, and shrubby oldfield in terms of their game potential.

Human-Related Features

These features are evaluated using the botanical quadrat data described above as well as information gleaned from maps or aerial photographs.

Ease of Use. Several measures evaluate different facets of this quality standard. Two refer to nonvegetative features of the site. Percent Slope indicates the relative steepness of the topography; it evaluates both the physical difficulty of using the site and the likelihood of erosion hazards. Soil Texture is a measure of compaction problems. The third test statistic, Percent Quadrats with Noxious Species, indicates the relative abundance of harmful plants such as poison ivy or nettle. The fourth measure, Suitability Rating, is an attempt to rate the damage potential of different sites. It considers such points as rarity, resiliency, and ability to recover in assessing damage potential. In general, wet areas are considered more sensitive than dry ones, and native communities more sensitive than those dominated by nonindigenous species, for instance.

Accessibility. This standard measures the distances between the site and possible users such as schools and residential areas.

Demand. Measuring demand involves calculating the number of potential users within a reasonable distance to the site.

Scenic Quality. Scenic quality can be evaluated in numerous ways. This analysis considers the presence or absence of surface water, its extent, and the nature of the topography. The presence of water and varied topography increases the scenic values in this analysis.

Nuisance Value. This standard measures the distance between the site and population centers in which people might be offended by the proposed use.

Once the quality criteria and test statistics are established for each analysis, ranks and weights need to be determined. Ranks are assigned to possible test statistic values utilizing figures derived from studies of sites of known quality. The ranks assigned to the botanical statistics are based on information gathered by Curtis (1959). In studying Wisconsin's undisturbed grasslands, Curtis (1959) compiled species density figures for different types of prairies which represent the average number of species on a site. These figures are used to set the lower limit of the highest rank (5). The limits of the other two ranks are set so as to divide the remainder of the range equally. For example, the species density for dry prairie is listed as 47; thus the ranks are the following:

Possible Scores	Rank
< 24	1
24-46	3
$\geqslant 47$	5

Similarly ranks for the "naturalness" measures are calculated using figures from Curtis (1959). The ranks for the game potential test statistic represent educated opinion.

The ranks for the test statistics for the human-related features are based on recreation statistics from the Wisconsin Department of Natural Resources, and the work of the Battelle Columbus Laboratories (Norbert et al., 1972). Again, ranks are established by using figures for sites of established quality.

Weights for all tested statistics are assigned to reflect the relative importance of the statistics in determing quality. These weights are based on expert opinion.

NATURAL AREAS ASSESSMENT

In order to illustrate the grassland analysis technique, consider the example of an evaluation of a dry prairie in terms of Natural Area Quality. The complete assessment form is shown in Table 2.

The assessment is based on the assumptions that (1) natural areas are plant communities which have retained their pristine characteristics and, therefore, their quality is dependent on the degree to which they have remained undisturbed by modern civilization, (2) there is a desire to preserve as many different species as possible, and (3) the use of a site as a natural area results in no appreciable impact to the vegetation.

Table 1. Biological features (species diversity, naturalness, and game potential) and human-related features (ease of use, accessibility, size, demand, nuisance value, and scenic qualities) are criteria which evaluate grasslands in terms of their test statistics and five use-categories.

Test Statistics	Use-categories: Natural Areas	Education	Nonmotorized Recreation	Motorized Recreation	Hunting
Species diversity					
Number of native species	x	x	x		
Naturalness					
Number of prevalent species	x				
Percent exotic species	x	x			
Percent quadrats with exotics	x	x			
Game potential					
General habitat rating					x
Ease of use					
Suitability rating		x	x		
Percent quadrats with noxious species		x	x		
Percent slope		x		x	
Soil texture			x	x	
Size				x	
Accessibility					
Average distance to schools within 24 km (15 mile) radius		x			
Size					
Minimum size				x	
Demand					
Number of schools within 24 km (15 mile) radius		x			
Population within one hour's driving time			x	x	
Hunters/acre of public hunting grounds in county					x
Nuisance value					
Population within 3.2 km (2 mile) radius				x	
Scenic qualities					
Surface water			x		
Relief and topographic character			x		

The criteria and test statistics used in the analysis reflect these quality standards. Four measures are used: one reflects diversity and three measure naturalness. Ranks are assigned so that areas with many native, prevalent species and few exotics receive high ratings. The weights indicate that measures of disturbance are considered most important (Percent Exotic Species and Percent Quadrats with Exotics) while diversity and resemblance to presettlement vegetation are less important.

Similar Natural Areas Assessments exist for other grassland communities; they differ in the ranks given to ranges of values for the diversity and prevalent species test statistics. These differences occur because the data collected by Curtis (1959) vary from wet to dry prairies. Table 3 indicates the nature of these differences.

CONCLUSIONS

The assessment procedure described here provides a relatively objective system for determining the quality of the grassland vegetation of different sites in terms of a variety of uses. It can compare the relative merits of different areas so that the best use for a site or the best site for a use can be identified. Although the technique is specifically designed for Wisconsin, it can be readily modified for other areas by adjusting the quality standards to reflect desired levels of diversity.

This technique can aid prairie preservation efforts by providing a standardized evaluation system that ranks areas on a vegetative quality basis so that priorities can be more readily determined. It can identify areas that may be of inferior natural area quality, but have good recreational potential; consequently, uses that might otherwise damage a high quality natural area can be directed to the alternate sites.

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Table 2. Natural areas assessment for dry grassland.

Criteria	Test Statistic	Possible Value	Rank	Weight
Species diversity	Number of native species	< 24	1	
		24-46	3	20
		≥ 47	5	
Naturalness	Number of prevalent species	< 12	1	
		12-23	3	25
		≥ 24	5	
	Percent of exotic species	> 10	1	
		5-10	3	30
		< 5	5	
	Percent of quadrats with exotics	61-100	1	
		31-60	3	25
		≤ 30	5	

Table 3. Ranks for diversity and prevalent species statistics.

	Number of Native Species per Community	Number of Prevalent Species per Community	Rank
Dry prairie	< 24	< 12	1
	24-46	12-23	3
	≥ 47	≥ 24	5
Dry-mesic prairie	< 27	< 13	1
	27-54	13-24	3
	≥ 55	≥ 25	5
Mesic prairie	< 27	< 13	1
	27-54	13-24	3
	≥ 55	≥ 25	5
Wet-mesic prairie	< 31	< 17	1
	31-61	17-34	3
	≥ 62	≥ 35	5
Wet prairie	< 22	< 11	1
	22-43	11-21	3
	≥ 44	≥ 22	5

GRAZING AS A FACTOR IN THE DECLINE OF ILLINOIS HILL PRAIRIES

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The hill prairies of Illinois have long been noted by botanists, but it was not until the early 1900's that these prairies were described in detail. Hus (1908) wrote of the grazed bluff hillsides near Collinsville dominated by bluegrass and prairie species; Vestal and Bartholomew (1941) described the hardiness of hill prairie grasses being grazed. Later, Evers (1955) wrote the first comprehensive annotated list of hill prairie locations, species composition, and grazing ecology for the Illinois prairie.

An examination of 446 hill prairies in 1976-1977 during the Illinois Natural Areas Inventory noted that only 127 of these prairies, many less than 0.4 ha in size, were relatively undisturbed by grazing. This paper compares the effect of grazing on the frequency of plants in both grazed and ungrazed hill prairies.

DESCRIPTION OF STUDY AREA

To complete this study two ungrazed prairies, Fults and French Village, of very high natural quality were surveyed. The Fults prairie is part of the Fults Hill Prairie Nature Preserve. This 16 ha prairie is located about 1.6 km east of the town of Fults, Monroe County, Secton 27, T4S, R10W. The grazed counterpart of the Fults prairie totals 12 ha. It is located about 2 km to the northwest of the nature preserve. Both prairies are on a deep mantle of loess atop limestone cliffs nearly 60 m high. The 0.8 ha French Village hill prairie is located on the bluff on the southwestern edge of French Village, St. Clair County, Section 24, T2N, R9W. The 0.6 ha grazed counterpart is located about 2.5 km to the northeast, along Route 157. Both of these prairies are on loess caps more than 16 m deep and are without an accompanying cliff. According to their owners, both disturbed prairies have been grazed by cattle for 35-50 years.

METHODS

The method of site location and specification is patterned after the Wisconsin thin soil prairie study by Dix (1959). Pairs of grazed and ungrazed prairies are selected which have similar soils, slope, and exposure, which are not more than 0.4 km from each other. A maximum distance of 2.5 km is the criterion used for the present study because the soil, species composition, exposure, and slope are similar in both study areas.

Species frequency is determined by using 30, 0.25 m^2 circular plots randomly spaced along transects paced up the slopes of the prairies. This method yields frequencies similar to the 86 percent for dominant species suggested by Curtis and McIntosh (1950).

The total frequency decrease (tfd) defines the actual or total percent decrease in frequency of a species that is effected by grazing. Quantities in the first equation are the ungrazed frequency of a species (uf), the grazed frequency of a species (gf), and the frequency difference of a species (fd). The tfd is determined by using the following formulas:

$$uf - gf = fd$$
$$fd/uf = tfd$$

The tfd is figured only for native species with an ungrazed frequency of 10 percent or greater, as these are considered the dominants of the prairie community. The tfd suggests the severity of frequency decrease of a species in both ungrazed and grazed prairies. Scientific names of plants are according to Mohlenbrock (1975).

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RESULTS AND DISCUSSION

A total of 97 species were recorded in the ungrazed prairies and 67 species in the grazed prairies at both study areas. Of the 97 species total in the ungrazed prairies, 89 of them (87 percent) are native prairie species. In the plots sampled in the ungrazed prairies, the native species composition was 40 of the 43 species recorded (93 percent). In contrast, only 37 of the 67 species total (55 percent) in the grazed prairies were native. In the plots sampled in the grazed prairies, the native species composition was 26 of the 43 species recorded (67 percent). The difference in the two percentages from the plots sampled is 26 percent which suggests that the loss of native species is apparently related to grazing.

Only the species with a frequency of 10 percent or greater in the samples are recorded in Table 1. These species are divided into three groups based on their change in frequency apparently because of grazing. The first group, plants that dominate the ungrazed hill prairies, decreased in frequency apparently because of grazing; the second group, plants with only minor frequency changes, were 3 percent or lower; the final group, nearly all alien species, increased in frequency or were favored by grazing.

Bouteloua curtipendula and *Sorghastrum nutans*, two of the three dominant prairie grasses, decreased in frequency in the grazed stands. The tfd of *B. curtipendula* was 84 and 83 respectively, at the Fults and French Village study areas (Table 1). *Sorghastrum nutans* had a tfd of 74 and 90, respectively at Fults and French Village. A tfd of 90-100 suggests a nearly complete eradication of a dominant native species from the prairie apparently because of grazing. The situation where no plants of a particular species were recorded for the grazed prairie is indicated by a tfd of 100. Some doubt may be expressed for those species with these numbers because they may not have originally occurred in the grazed prairie. In both of the grazed prairies studied, however, native species with a tfd of 100 were in adjacent prairies and fence rows where grazing pressures were considerably reduced. In contrast, *Schizachyrium scoparium*, the dominant prairie grass, had little or no change in frequency (Table 1), even though a decrease in the size and vigor of the clumps was observed.

The tfd's of prairie forbs and shrubs also decreased. *Petalostemum purpureum* decreased by 68 and by 90, respectively at Fults and French Village. Other species with a tfd of 60 or more are *Aster patens*, *Houstonia nigricans*, *Lespedeza capitata*, *Euphorbia corollata*, *Echinacea pallida*, and *Ceanothus americana*.

All of the species in the third group had frequency increases, the highest being 70 percent. The alien species were either completely nonexistant or in only small naturally disturbed areas in the ungrazed prairies, and thus were not sampled (Table 1). They are included in the table as being observed.

Poa pratensis increased in frequency to 60 and 70 percent, respectively at Fults and French Village. Other alien forbs show increases of frequency of 10 percent or more are *Melilotus alba*, *M. officinalis*, *Erigeron canadensis*, *Geranium carolinianum*, and *Cirsium vulgare*. *Juniperus virginiana* and *Lonicera japonica* were the only two woody species that increased in the sample.

The results suggest a decline of the climax vegetation in the ungrazed prairies towards a more weedy composition when extensive grazing occurs. The dominant prairie grasses, *Bouteloua curtipendula* and *Sorghastrum nutans*, drastically decreased in frequency, and are replaced by *Poa pratensis*. Also, prairie forbs such as *Petalostemum purpureum*, *Euphorbia corollata*, *Lespedeza capitata*, *Echinacea pallida*, and *Aster sericeus* are among those species apparently affected by grazing. Under these conditions, weedy species such as *Melilotus alba*, *M. officinalis*, and *Erigeron canadensis* successfully compete with the declining native plants.

Similar results were reported in grazed prairies by Daubenmire (1940), Drew (1947), Kelting (1954), Evers (1955), and Dix (1959).

The different frequencies of the species observed in the grazed prairies probably involved several factors. The act of grazing, including both foraging and trampling, probably increases soil compaction, decreases soil moisture, opens areas for secondary succession, reduces seed source, and eliminates cover of protective microhabitats necessary for the survival of some prairie forbs. The reduction of some species is undoubtedly caused by selective browsing because of plant height and palatability (Daubenmire, 1940; Drew, 1947). Kucera (1956) stated that cool-season species such as *Poa pratensis* complete their growing season before grazing is started and allow better competition with species that do not mature until later in the growing season. Domestic foragers tend to use the same browsing trail repeatedly, consequently, bare terraces eventually form which erode or form loess slumps. These areas are prime sites for invading species.

Juniperus virginiana and *Lonicera japonica* are common woody species that occur on the grazed hill prairies. Some grazed prairies observed were nearly completely covered by *J. virginiana*. This type of coverage eventually shades out any remaining prairie species. Other woody species that encroach hill prairies are *Cornus drummondii* C.A. Mey, *Rhus glabra* L., and *Robinia pseudoacacia* L.

SUMMARY

The midgrass prairies that occupy the loess caps above the bluffs of the major river valleys in Illinois are the least disturbed prairies left in the prairie state. With the advent of wire fencing and changes in agricultural land uses, hill prairies became natural pastures for domestic livestock. The examination of 445 hill prairies along 384 km of river bluffs during the Illinois Natural Areas Inventory reveals the extensiveness of this grazing. Only 13 percent of the original 1,050 ha of hill prairies surveyed remained relatively undisturbed by grazing. Sampling of hill prairies with a history of prolonged grazing shows sharp reductions in native species, frequencies, and diversity. Conservative prairie species declined or disappeared completely while alien grasses and forbs readily replaced them. Encroachment by *Juniperus virginiana* and other woody species increased to the exclusion of prairie vegetation in heavily grazed hill prairies. Loess slumps and erosion patterns also increased with repetitious grazing.

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Table 1. Frequencies of species from ungrazed (uf) and grazed (gf) sample areas of Fults and French Village hill prairies and calculated total frequency decreases (tfd) for native prairie species only and are arranged in three groups according to changes in frequency: decreased, more or less constant, and increased for all species. Names of alien species are preceded by a single asterisk (*) A double asterisk (**) indicates that the species occurs in the prairie indicated but was absent from the quadrats.

	Fults			French Village		
	uf	gf	tfd	uf	gf	tfd
Decreased frequency						
Bouteloua curtipendula (Michx.) Torr.	63	10	84	40	7	83
Sorghastrum nutans (L.) Nash	50	13	74	17	**	90
Petalostemum purpureum (Vent.) Rybd.	50	16	68	27	**	90
Aster patens Ait.	40	**	90	13		100
Houstonia nigricans (Lam.) Fern.	37	**	90	53	20	62
Lespedeza capitata Michx.	37	7	81	**		100
Aster sericeus Vent.	20		100	33		100
Euphorbia corollata L.	16		100	23		100
Echinacea pallida (Nutt.) Nutt.	13		100	57		100
Solidago rigida L.	10		100	40		100
Ceanothus americanus L.	16		100	**		100
Phlox bifida Beck	13		100	23		100
More or less constant frequency						
Schizachyrium scoparium (Michx.) Nash	100	100		100	97	
Brickellia eupatoriodes (L.) Shinners	3	**		7	**	
Lithospermum canescens (Michx.) Lehm.	3	3		10	7	
Increased frequency						
**Poa pratensis* L.	**	60		**	70	
**Melilotus alba* Desr.	**	20		**	23	
**Melilotus officinalis* (L.) Lam.		36			**	
Erigeron canadensis L.	**	23			27	
Aster azureus Lindl.		20		**	10	
**Geranium carolinianum* L.		16			**	
**Verbascum blattaria* L.		13			**	
**Cirsium vulgare* (Savi) Tenore		13			**	
Juniperus virginiana L.	**	10		**	3	
**Viola rafinesquii* Greene		10			**	
Hedeoma hispida Pursh.		10				
**Lonicera japonica* Thunb.		10				
**Tridens flavus* (L.) Hitchc.		**			10	
**Plantago aristata* Michx.	**	**		**	10	

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ALLELOPATHIC ASSOCIATIONS AND THEIR EFFECT ON NATIVE LEGUMES

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South Dakota is an agricultural state with large areas of native range and grasslands. The quality of the rangeland is largely determined by the particular species growing on it. Growth of these plants in turn is determined by factors such as competition for moisture, nutrients, and light; grazing pressure; and chemical interactions between plants. The role of biological nitrogen fixation by cultivated legumes is known (Erdman, 1959), but the part native legumes play in the maintenance of soil nitrogen in grasslands is yet to be determined. Little doubt exists that the native legumes have an influence on soil nitrogen in the grassland and rangelands.

Chemical interactions among plants in determining the composition of plant species in a community are known to be a major factor and in many cases, may outweigh such factors as moisture, nutrients, or light between plants (DelMoral and Gates, 1971). However, relatively little is known about the presence and influence of these allelopathic-producing species in native prairies of South Dakota and their influence on native legumes of the prairie. This research was initiated to study the abundance of allelopathic-producing plants and their influence on the abundance of native legumes on the Ordway Prairie, a tract of land newly acquired by The Nature Conservancy near Leola in northeastern South Dakota (Hertz, 1976).

MATERIALS AND METHODS

A search of the literature was conducted to determine those species of plants known to produce allelopathic substances. This list was compared to the species on the Ordway Prairie (Hertz, 1976). Species that produce allelopathic substances were studied by returning to Hertz's study sites and locating the nearest plant of the species to be studied. Upon locating a known allelopathic-producing plant and using it as the center of a 1-m diameter circle, the number of other allelopathic plants, and the total number of different species were counted. When possible, two or three such samples were taken in the vicinity of each collection site to obtain data from low-lying areas or tops of slopes. The data were used to determine the presence, density, and frequency of these plant species. The study was conducted from 14 July 1977 to 3 August 1977.

Shave and Pengra (1974) compiled a list of legumes and other nitrogen-fixing plants native to South Dakota. The presence, frequency, and density of nitrogen-fixing species were determined from the above samples and in locations where nitrogen-fixing species had been collected by Hertz. Sampling procedures were the same as above. Least squares analysis of variance (Steel and Torrie, 1960) was used to determine if a relationship existed between the native legumes and those plants known to have allelopathic effects.

RESULTS

On the Ordway Preserve eleven species are known to be allelopathic. Of these, eight were studied in detail (Table 1); the other three species were rare and were not found on the preserve at the time of this study. *Ambrosia psilostachya* was the most abundant and most widespread followed by *Chenopodium album* and *Bromus inermis* (Table 1). These species were in high numbers in areas of extensive disturbance such as near roadsides, gates, watering sites, car trails, ranch houses, and in plowed fields. *Ambrosia psilostachya* and *Chenopodium album* were also widely scattered over the prairie. *Bromus inermis* had the greatest density followed by *Agropyron repens* and *Mentha arvensis*.

A comparison of the list of nitrogen-fixing plants native to South Dakota compiled by Shave and Pengra (1974) with the species listed by Hertz (1976) showed that *Amorpha canescens, Astragalus agrestis, A. crassicarpus, A. flexuosus, A. gilvilflorus, Elaeagnus angustifolia, Glycyrrhiza lepidota, Lotus purshianus, Oxytropis lambertii, Petalostemum candidum, P. occidentale, P. purpureum, Psoralea agrophylla, P. esculenta,* and *Vicia americana* are on the Ordway Prairie. Only five of these were in the study plots of allelopathic-producing species. *Amorpha canescens* had the greatest density where collected, followed by *Glycyrrhiza lepidota* and *Psoralea agrophylla* (Table 2). The most frequently encountered species in areas where allelopathic-producing plants were collected was *Psoralea agrophylla* followed by *Lotus purshianus*. This phenomenon could be because these two species were the most common nitrogen-fixing plants on the entire prairie, or because they are the nitrogen-fixing species which are least sensitive to the allelopathic effects of plants studied. *Amorpha canescens, Glychyrrhiza lepidota,* and *Petalostemum purpureum* had high densities in the nitrogen-fixing plots but relatively low densities in the allelopathic plots.

A least squares analysis of variance was conducted to determine the effects on the total number of plants, and the total number of species near the allelopathic-producing plants and the nitrogen-fixing plants. A significant difference exists in the number of plants/plot between each of the allelopathic-producing species and nitrogen-fixing species but not between the allelopathic plots and the nitrogen-fixing plots (Table 3). The allelopathic substances do not appear to reduce the total number of plants growing within 1m.

No significant difference is evident in the total number of species/plot within the allelopathic plots or the nitrogen-fixing plots, but a significant reduction (0.01 level) in the total number of species in allelopathic plots exists compared to that of nitrogen-fixing plots. The allelopathic-producing plants do not reduce the total number of

Table 1. Frequency and density of allelopathic-producing species on the Ordway Prairie, August 1976.

	Frequency (%) in Nitrogen-fixing Plots	Density (%) in Allelopathic Plots	Density (%) in Nitrogen-fixing Plots
Ambrosia psilostachya	53.53	11.08	2.03
Chenopodium album	30.30	13.77	1.78
Bromus inermis	5.05	49.37	1.27
Agropyron repens	4.04	24.20	0.21
Artemisia absinthium	3.03	6.18	0.02
Mentha arvensis	0	16.77	0
Erigeron strigosus	0	4.09	0
Helianthus annuus	0	1.28	0

Table 2. Frequency and density of nitrogen-fixing species on the Ordway Prairie, August 1976.

	Frequency (%) in Allelopathic Plots	Density (%) in Nitrogen-fixing Plots	Density (%) in Allelopathic Plots
Psoralea argophylla	28.57	3.45	0.51
Lotus purshianus	18.36	2.64	1.62
Petalostemum purpureum	12.24	2.57	0.02
Amorpha canescens	10.20	6.83	0.22
Glycyrrhiza lepidota	5.10	5.58	0.09

Table 3. Least squares analysis of variance of plants and species per plot for allelopathic-producing and nitrogen-fixing species. Theoretical sampling distribution of variance ratios are given in columns labeled "F."

	Plants/Plot	F	Species/Plot	F
Allelopathic-producing species vs. nitrogen-fixing species		0		9.708[1]
Allelopathic-producing species	207.95	3.956[1]	7.53	1.595
Nitrogen-fixing species	171.17	3.568[1]	8.86	0.559

[1]Significant difference at the .01 level.

plants, but they are associated with a fewer number of plant species growing within a sampling area.

SUMMARY

Most of the allelopathic species are nonindigenous plants and "weedy" species. These species appeared to be more frequent near roadsides, along fences, and at gates in highly disturbed areas. The walk-on policy that is now being enforced on the preserve may help reduce the total number of man-disturbed areas. Reducing the number of cattle and the frequency of grazing in each pasture may lessen the amount of disturbance along fences, at gates, and at watering sites.

The data suggest that the allelopathic-producing plants reduce the total number of species but not the total density of plants growing near them. A reduction of allelopathic plants may increase the total diversity of plant species on the preserve. The data indicate that the nitrogen-fixing plants are of value because of the greater number of species growing near them. Any management practices that will increase the number of nitrogen-fixing plants may be beneficial in increasing the total number of species on the preserve.

ACKNOWLEDGEMENTS

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SEED VIABILITY AND SEEDLING VIGOR IN SELECTED PRAIRIE PLANTS

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The tallgrass prairie as mapped by Weaver and Clements (1938) does not exist in Montana; however, on ideal sites small isolated stands of prairie species occur. These stands are unique because they are on the margin of their range, of scattered occurrence, and of very limited extent. Concern for the continued existence of tall prairie species within southeastern Montana is spurred by the encroachment of surface coal mines and the number of stands already lost to all types of land disturbance. We would suspect that the reestablishment of species on the margin of their range would be very difficult due to the loss of many special microsites through soil and subsoil redistribution and new topographic characteristics concomitant with strip mine reclamation processes.

The use of indigenous species is required by law in Montana, but the biological characteristics of southeastern Montana ecotypes are unknown. Because of this concern for restoration of prairie species to strip mine reclamation lands, a project was begun in 1975 to evaluate seed and seedling biology for a large number of indigenous plant species. The objective of the research was to improve the potential for restoring each species into its original habitat. We are also concerned with the possibility that some species, due to very narrow site requirements, may not be capable of reestablishment.

METHODS

Seed collections were made from an area of the Fort Union Basin roughly outlined by Decker, Colstrip, and Alzada, Montana, and Gillette and Sheridan, Wyoming. Species from which seeds were collected included *Andropogon gerardii* Vitman, *Andropogon hallii* Hack., *Elymus canadensis* L., *Dalea enneandra* Nutt., *Ratibida columnifera* (Nutt.) Wooton & Standl., *Panicum virgatum* L., *Schizachyrium scoparium* Nash., *Spartina pectinata* Link, and *Sporobolus cryptandrus* (Torr.) A. Gray. One to several seed sources were obtained and seeds were stored in paper bags under dark conditions, 20° C. Of the species collected *Andropogon gerardii, A. hallii, Dalea enneandra, Panicum virgatum,* and *Spartina pectinata* are very limited in their distribution; the remainder of species are of common occurrence.

Seed Viability

To determine germination requirements seeds were placed on moist cellulose, treated with Captan fungicide (N-((trichlorometh)thio)-4-Cyclohexene-1, 2-dicarboximide), and germinated in darkness at 5, 10, 15, 20, 25, and 30°C with and without 5°C cold 1, 2, or 3 month stratification. Four replicates of 25 seeds each were used per treatment. Germination was checked every 2 days for a 30-day period. Germination rate (days to 50 percent of final total germination) and total germination were calculated. All comparisons were made using a pairwide t-test.

Seedling Vigor

The seedling vigor of each prairie plant was tested by setting up probable field conditions: an early spring rain saturating the soil followed by a drought during the crucial period of seedling establishment. A control with adequate soil moisture was also included.

A loam topsoil screened through a 5-mm mesh was loosely packed into 500 or 700 ml root trainer columns, then saturated to field capacity (moisture content of 37.4 percent). Following optimal pretreatment freshly germinated seeds were transplanted into the rooting columns. Equal-aged individuals were utilized to eliminate variables caused by factors other than those being tested. Each set of seedlings for a particular species was tested over a 4-week period. Two treatments were applied: (1) control—soils kept moist throughout 4 weeks (continuous wet cycle) and (2) moisture stress—soils allowed to dry, no additional watering (drying cycle). Depending upon the species, eight to sixteen replicates were utilized for each treatment with additional replicates included to determine the weekly gravimetric soil moisture content.

The experiment was conducted under 25°C greenhouse conditions with a 16-hour light period. Measurements of the "above ground" growth or the photosynthetic area were taken each week. At the end of the fourth week "below ground" measurements were made after soil had been washed from the root systems. Mean, standard deviation, t-test for two means, skewness, and kurtosis values were computed for the above measurements.

RESULTS

Seed Viability

Analysis of the germination data for the nine species yields no apparent response patterns, rather each species is unique when all factors are considered (Table 1). On a factor by factor basis some groups are discernable. *Andropogon gerardii, A. hallii,* and *Schizachyrium scoparium* have rather long afterripening requirements compared to the other species. Under very specific conditions cold stratification promoted germination in all of the grasses, but the two forbs showed no consistent effect or showed germination inhibition. Only in *Sporobolus cryptandrus* was long stratification period a required prerequisite to germination. Both *Andropogon gerardii* and *A. hallii* germinated very poorly when stratification exceeded 30 days. All species germinated rapidly except *Elymus canadensis* which was the last to initiate germination and had the lowest overall germination rate.

Most significant results are those dealing with the temperature requirements. For germination of *Sporobolus cryptandrus* very strict temperature requirements (30-20°C alternating) coupled with afterripening and stratification prerequisites indicate consistent establishment is not to be expected with artificial propagation. *Spartina pectinata* also conforms to this rather restricted pattern. Others such as *Andropogon hallii, Ratibida columnifera,* and *Dalea enneandra* have rather broad requirements for temperature as well as pretreatments. These last three species plus *Panicum virgatum* all consistently yielded what can be termed satisfactory germination. On the other hand, *Andropogon gerardii, Elymus canadensis, Schizachyrium scoparium,* and *Sporobolus cryptandrus* were all inconsistent in germination response and were especially variable under suboptimal conditions. From a germination standpoint those species which germinate well, even under suboptimal conditions, should be the best for initial as well as follow-up regeneration in radically altered habitats.

Seedling Vigor

Marked differences were apparent in both intraspecific and interspecific reactions to the moisture stress conditions applied in this experiment. On an intraspecific level, generally four types of seedling vigor responses occurred when compared to controls.

Very High Seedling Vigor

The response of *Dalea enneandra* was characterized by no significant difference between the control and moisture stress groups (Table 2) with slightly increased growth under stress conditions (Fig. 1).

Table 1. Germination characteristics of some indigenous plants of southeastern Montana.

	Seed Fill	After Ripening (months)	5°C Stratification Effects on Germination	Germination Rate	Range in Germination Percent at Optimum Temperature (%)	Optimum Germination Temperature (°C)
Andropogon gerardii	Fair	12	30 days promoted 60 days eliminated	Medium 4/4[1] at stratification & 30°C	12-94	Stratification followed by 25° or 30°
A. hallii	Good	12	30 days promoted 90 days inhibited	Rapid 2/2[1] at 30°C	68-93	10° to 30°, 30°-20°, or 20°-5°
Dalea enneandra	Excellent	2	Variable	Rapid 2/2[1] at 20°C	62-91	20°, 30°, 30°-20°, 20°-5°, or stratification followed by 10°, 20°, or 30°
Elymus canadensis	Good	1	Develops short inhibition period	Slow 5/10[1] at 20°C	60-99	20° or 20°-5°
Panicum virgatum	Good	3	Promoted except in older seed	Medium 1/4[1] at stratification & 20°C	70-90	20° or 30°-20°
Ratibida columnifera	Excellent	2	Older seed inhibited	Rapid 2/2[1] at 20°C	80-99	20° or 30°
Schizachyrium scoparium	Poor	10	30-60 days required	Slow 4/6[1] at stratification & 30°C	85-98	Stratification followed by 20°, 30°, or 30°-20°
Spartina pectinata	Excellent	4	Promoted	Rapid 1/2[1] at stratification & 30°-20°C	70-91	20°, 30°, or 20°-5°
Sporobolus cryptandrus	Excellent	6	60 days required	Rapid 2/2[1] at stratification & 30°-20°C	90-99	30°-20°

[1]Days to initial germination/days to 50 percent of final total germination.

Under the moisture stress treatment, both above and below ground tissue displayed insignificant signs of stress at the end of 4 weeks (Table 2). This stress suggests very low requirements for additional water during initial establishment and excellent potential for vigorous establishment during dessicative periods of 4 weeks or more.

High Seedling Vigor

Panicum virgatum, Spartina pectinata, Andropogon hallii, and *Elymus canadensis* exhibited high seedling vigor in both the control and moisture stress treatments (Table 2). However, a reduction in growth under moisture stress did occur (Fig. 2) though no signs of stress were evident at the end of the 4-week dessicative period. Data indicate a high potential for survival under moisture stress conditions of 4 weeks or longer.

Relatively Low Seedling Vigor

Ratibida columnifera, Andropogon gerardii, and *Schizachyrium scoparium* showed a significant reduction in both above and below ground growth with increasing moisture stress when compared to their control (Table 2, Fig. 3). Additional water would be necessary for continued stable growth at the end of 2 weeks; therefore, the potential for vigorous establishment during a 4-week drought for these species is comparatively low (Fig. 3).

Very Low Seedling Vigor

Sporobolus cryptandrus exhibited great variance between the control and moisture stress treatments (Table 2, Fig. 4). Photosynthetic and root tissue were necrotic and suberized at the end of 3 weeks indicating high requirements for additional water and very poor potential for establishment during a dessicative period beyond 2 weeks.

Interspecific comparisons are compiled in Table 2 with six main factors averaged to determine a survival index (Column 18) of the nine species tested. This index indicates the following arrangement of seedling vigor response during moisture stress on a relative basis: excellent *(Panicum virgatum, Elymus canadensis,* and *Andropogon hallii)*, good *(Dalea enneandra* and *Spartina pectinata)*, moderate *(Ratibida columnifera)*, poor *(Andropogon gerardii)*, and very poor *(Schizachyrium scoparium* and *Sporobolus cryptandrus)*.

CONCLUSIONS

Andropogon gerardii appears to have a low potential for reestablishment on disturbed areas based on low and variable germination, low probability of optimal germination temperatures occurring naturally, and poor seedling vigor. Best establishment should be expected from seeds over 1 year old; McWilliams (1950) found seeds reached peak germination at 4 years for a North Dakota seed source. Also, seed lots should be checked for high seed fill and vigor. Planting appears to be best in spring when soil temperature is cool but with a high probability of significant warming in 30 days or less. Maintenance of good soil moisture conditions appears to be necessary.

Andropogon hallii possesses many characteristics indicating high reestablishment potential. These characteristics are good seed fill, a broad range of optimal germination temperatures, pronounced seed vigor, and high seedling vigor even with soil drought. High seed vigor was also reported by Tolstead (1941). We found seeds should be afterripened for at least 1 year and it may retain high germination up to 7 years (McWilliams, 1950). Planting appears to be best anytime in the spring.

Dalea enneandra has excellent potential for reestablishment on disturbed land. We found high seed fill, vigorous seed germination at a wide range of temperatures, and excellent seedling vigor with strong resistance to soil drought. Consistently high losses of seedlings immediately after germination, however, pose a problem. Plantings should be successful both in the fall and spring.

Elymus canadensis possesses excellent seedling vigor; however, it was slow to germinate being quite variable in total germination and somewhat restricted in its germination requirements. Germination was generally high; a result also obtained by Greene and Curtis (1950) and McWilliams (1950). McWilliams also noted that germination re-

Table 2. Interspecific ranking of species based on seedling growth characteristics as an index to their potential survival under moisture stress conditions. Rankings are based only on moisture stress data except columns 2, 6, and 11 which have been adjusted to a control before interspecific comparisons were made. All rankings are derived from measurements at the end of four weeks except columns 1, 16, 17, and 18.

	1 Initial Establishment	2 Variation of Reaction-Control v.s. Moisture Stress	3 Cumulative Leaf-Stem Length	4 Plant Height	5 Above Ground Biomass	6 Above Ground Biomass Control vs. Moisture Stress	7 Above Ground Growth Vigor	8 Composite Above Ground Rating (Average of Columns 3,4,5,6, & 7)	9 Primary Root Length	10 Below Ground Biomass	11 Below Ground Biomass Control vs. Moisture Stress	12 Below Ground Growth Vigor	13 Composite Below Ground Rating (Average of Columns 9,10,11, & 12)	14 Total Biomass of Control	15 Final Establishment	16 Soil Moisture Utilization Index	17 Potential for Extended Stress Periods	18 Survival Index (Average of Columns 2, 8, 13, 15, 16, & 17)
Andropogon gerardii	5	3	3	3	2	2	2	2.4	3	2	2	2	2.2	2	5	3	1	2.6
A. hallii	5	3	5	4			4	4.3	4			4	4.0	3	5	5	4	4.0
Dalea enneandra	2	3	5	3	5	5	5	4.6	5	5	4	4	4.5	3	2	4	5	3.8
Elymus canadensis	5	5	5	5	3	4	3	4.0	4	3	5	3	3.8	5	5		3	4.1
Panicum virgatum	5	3	5	5	5	2	5	4.4	5	5	5	5	5.0	5	5	4	5	4.4
Ratibida columnifera	5	3	2	2	3	1	4	2.4	5	2	3	4	3.5	5	4	5	3	3.5
Schizachyrium scoparium	5	3	2	2	2	1	2	1.8	3	2	1	3	2.2	4	2	2	1	1.8
Spartina pectinata	3	3	5	5	4	5	4	4.6	5	5	5	3	4.5	4	3	4	4	3.7
Sporobolus cryptandrus	5	3	1	1	1		1	1.0	1	1		1	1.0		4	1	1	1.7

Ranking by column number

1. Percent survival after 1 week of growth: 1 = 0-24 percent, 2 = 25-49 percent, 3 =50-74 percent, 4 =75-99 percent, and 5 = 100 percent.
2. Average of greatest root and shoot variance expressed by skewness and kurtosis values: 1 = highly significant**, 3 = significant difference at 95 percent*, and 5 = not significant (NS).
3. 1 = 0-24 mm, 2 = 25-49 mm, 3 = 50-74 mm, 4 = 75-99 mm, and 5 = 100+ mm.
4. 1 = 0-9 mg, 2 = 10-24 mg, 3 = 25-49 mg, 4 = 50-74 mg, and 5 = 75-100+ mg.
5. 1 = 0-0.9 mg, 2 = 1-2.9 mg, 3 = 3-4.9 mg, 4 = 5-5.9 mg, and 5 = 6-10+ mg.
6. Significant difference at 95 percent*, highly significant**, not significant (NS), and magnitude of calculated t value (t' = 2.6-2.56): 1 = **/6-10+, 2 = **/3.5-5.9, 3 = */2.51-3.49, 4 = NS/2-2.5, and 5 = NS/1.99-0.5.
7. Visual: 1 = necrotic, 2 = chlorotic and wilted, 3 = stable, 4 = moderate, and 5 = vigorous.
8. Composite average.
9. 1 = 0-24 mm, 2 = 25-49 mm, 3 = 50-74 mm, 4 = 75-99 mm, and 5 = 100-150+ mm.
10. 1 = 0-0.9 mg, 2 = 1-2.9 mg, 3 = 3-4.9 mg, 4 = 5-5.9 mg, and 5 = 6-10+ mg.
11. Significant difference at 95 percent*, highly significant**, not significant (NS), and magnitude of calculated t value (t' = 2.16-3.35): 1 = **/6+, 2 = **/3.5-5.9, 3 = */2.51-3.49, 4 = NS/2-2.5, and 5 = NS/1.99-0.5.
12. Visual: 1 = suberized "brittle," 2 = dehydrated, 3 = stable, 4 = moderate, and 5 = vigorous.
13. Composite average.
14. 1 = 1 mg, 2 = 1-4.9 mg, 3 = 5-9.9 mg, 4 = 10-14.9 mg, and 5 = 15-20+ mg.
15. Percent survival after 4 weeks of growth which includes loss after initial establishment and loss due to moisture stress: 1 0-24 percent, 2 = 25-49 percent, 3 = 50-74 percent, 4 = 75-99 percent, and 5 = 100 percent.
16. Percent H_2O used weeks active growth: 1 = very poor, 2 = poor, 3 = moderate, 4 = good, and 5 = excellent.
17. Visual: 1 = very poor, 2 = poor, 3 = moderate, 4 = good, and 5 = excellent.
18. 1 = very poor, 2 = poor, 3 = moderate, 4 = good, and 5 = excellent.

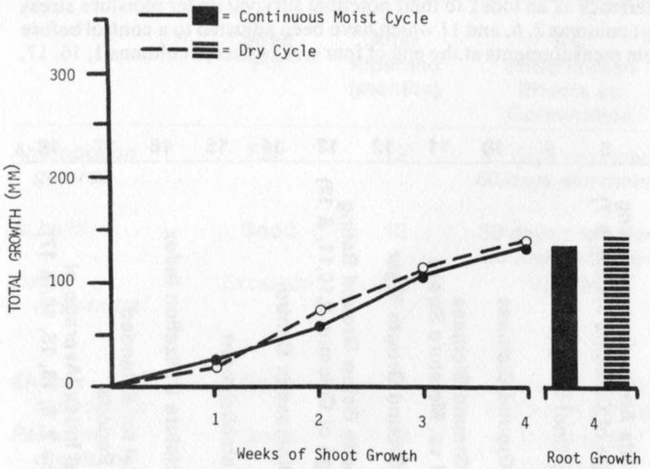

Figure 1. *Dalea enneandra*. Mean cumulative shoot and primary root growth at the end of four weeks.

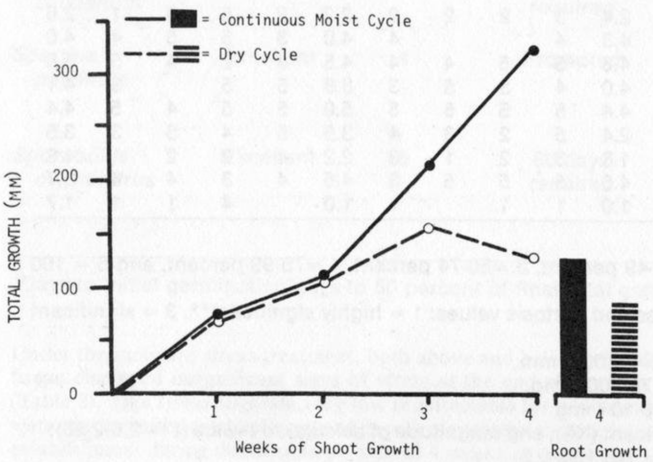

Figure 2. *Elymus canadensis*. Mean cumulative shoot and primary root growth at the end of four weeks.

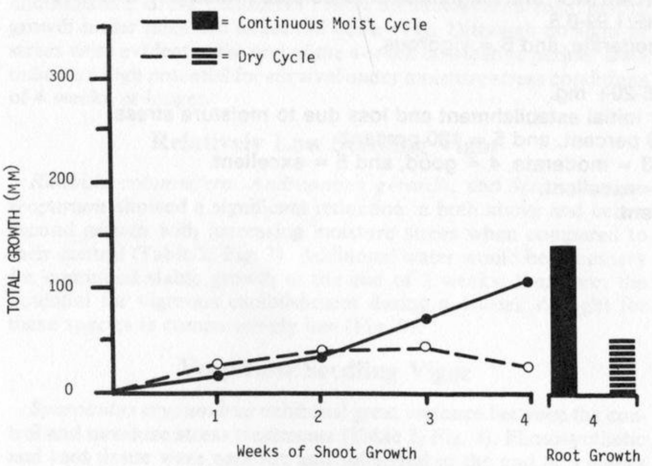

Figure 3. *Schizachyrium scoparium*. Mean cumulative shoot and primary root growth at the end of four weeks.

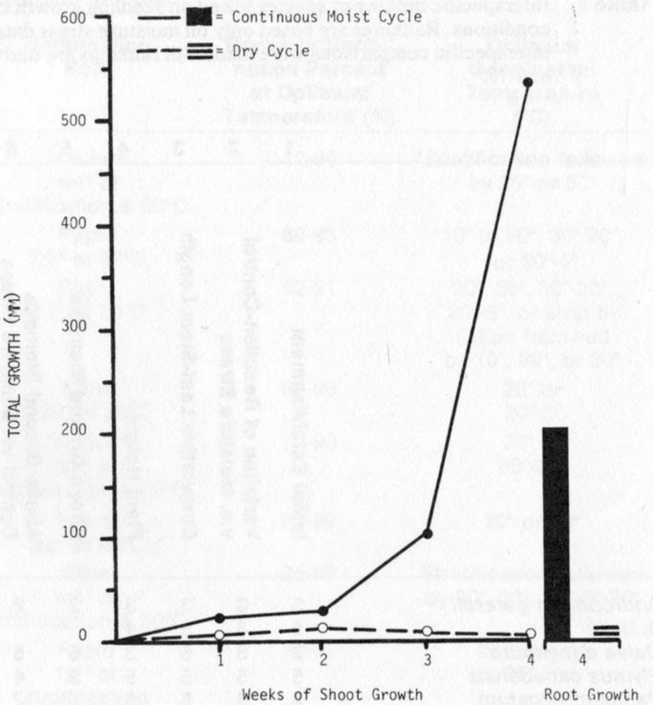

Figure 4. *Sporobolus cryptandrus*. Mean cumulative shoot and primary root growth at the end of four weeks.

mained high up through 3 years of seed age. Spring planting in warm moist soil appears to be best due to an inhibition period developed from cold stratification. Additional soil moisture appears necessary after 3 weeks of growth to maintain maximum seedling vigor.

Panicum virgatum germinated well and exhibited exceptional seedling vigor, although with moisture stress shoot growth was reduced. It should do well in reestablishment efforts. Limitations appear to be a slower rate of germination and high germination temperature requirements. We found both a shorter afterripening period and higher germination than did McWilliams (1950) and Robocker et al. (1953). Our results indicate both fall and spring planting should be acceptable.

Ratibida columnifera appears to possess only moderate potential for reestablishment. Sorensen and Holden (1974) were able to obtain germination only by puncture of the seed coat; however, we consistently obtained high germination without doing so. Although Jacobsen (1974) rated both seedling vigor and seed quality as excellent we rank seedling vigor as only moderate. Seed quality and production, however, was high for our seed sources. Afterripening and stratification response indicate both fall and spring plantings of new seed would be acceptable. Jacobsen (1974) indicated spring planting was required.

Schizachyrium scoparium appears to possess very poor seed and seedling vigor. Although we obtained very high germination from seedlots roughly 1 year old, McWilliams (1950) found peak germination in seeds 7-8 years of age. Coukos (1944) found dormancy began to break at 18 months for Missouri seed while ours required only 10 months for complete dormancy breaking. Fall planting of seed a year or more old appears best based on our data.

Spartina pectinata seed germinated rapidly and seedlings grew vigorously, even under soil moisture stress, to 4 weeks of age. The main limiting factor was early seedling mortality. Our data indicate that fall planting would be the most successful.

Sporobolus cryptandrus would not be expected to do well in reestablishment efforts. Seed required stratification, as reported by Tolstead (1941) and Toole (1941), and restricted temperatures to germinate. Seedlings were of very low vigor and required constant high soil moisture. Our results suggest fall planting as being the best possible procedure.

Sporobolus cryptandrus may be a problem species in reestablishment, but we suspect other factors compensate for those limitations observed in the laboratory experiments. For example, excellent seed production and seed quality increase its probability of success as evidenced by field observation.

We foresee considerable difficulty in reestablishment of *Andropogon gerardii* and *Schizachyrium scoparium* on disturbed lands by direct seeding. The problems we observed may be overcome by use of adaptable varieties as Wilson (1972) tentatively recommended or by ecotypic selection of native materials. An alternative would be propagation of seedlings which Nuzzo (1976) found successful on Wisconsin roadsides. Based on species-site relationships both *Andropogon hallii* and *Dalea enneandra* show good potential for use on uplands, while *Panicum virgatum*, *Elymus canadensis*, and *Spartina pectinata* show good potential for swale sites.

SUMMARY

Tallgrass prairie species are present in isolated stands in southeastern Montana. A number of such stands have already been lost through surface coal mining activities and those remaining are endangered by the expanding industry. Wherever possible, destruction must be prevented, and, in addition, the tallgrass prairie species must be reestablished on mined lands. Reestablishment requires an understanding of their regeneration characteristics, particularly seed vitality and seedling vigor.

Nine common tallgrass prairie species were studied and their seed vitality and seedling vigor determined. Five of these species are very limited in their distribution though they are frequently abundant in small localized stands. Seed germination rate and total was measured at temperatures ranging from 5° to 30°C with and without preceding stratification. Seedlings were also grown under artificial drought conditions to determine root and shoot response.

Andropogon gerardii and *Schizachyrium scoparium* both possess poor seed viability and poor seedling vigor. Considerable difficulty is foreseen in reestablishment on coal mine spoils. *Sporobolus cryptandrus* possesses very low seedling vigor under moisture stress conditions. Therefore reestablishment would be strongly moisture dependent. Mediocre establishment would be expected from *Ratibida columnifera* since germination and seedling vigor are only fair under stress conditions. Reestablishment of *Dalea enneandra* and *Spartina pectinata* is expected to be limited only by early seedling mortality. Vigor of seed and seedlings appears quite high. *Elymus canadensis* should reestablish well, however limitations in germination and an apparent necessity for fair moisture conditions may give poor results in some years. Both *Panicum virgatum* and *Andropogon hallii* possess excellent seed and seedling vigor. Reestablishment is expected to be consistantly successful.

Since some species possess inherent reestablishment difficulties, well-designed studies are needed to select the adaptable genotypes for perpetuation of the species on the reclaimed coal mines in southeastern Montana.

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NATIVE FORB SEED PRODUCTION

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As more conservationists in prairie states attempt large-scale prairie restorations, the question has become "Where can I get native wildflower seed and how much does it cost?" Before an answer to that question becomes available, we must learn how to manage uniform stands of single species for seed production.

Over the past ten years, the Soil Conservation Service (SCS) has cooperated with state universities and agencies in investigating the potential of using wildflowers in conservation plantings. The work of the Manhattan Plant Materials Center (PMC) has been documented by Jacobson (1975), Dickerson and Hadle (1977), and Salac et al. (1978). To provide seed for evaluation and testing of Kansas ecotypes, small-scale seed production was started. We have now had experience in large-scale mechanical planting and harvesting seeds of *Petalostemum, Salvia, Echinacea, Ratibida, Liatris, Asclepias, Heliopsis, Helianthus, Lespedeza,* and *Desmanthus.* Small-scale harvests have been made of *Silphium, Penstemon,* and *Baptisia.* Other genera have been studied but are not beyond the single-row, hand-maintenance stage.

According to unpublished SCS records for Kansas, an average of 16,843 ha (41,600 acres) per year have been seeded with native grasses since 1946 (Soil Conservation Service, 1946-1977). Forb seeding amounting to 37,800 kilograms (assuming 2.28 bulk kilograms/ha or 2 lb/acre average rate) could have been included in the grass mixes. To provide this amount of forb seed, hit-and-miss field harvesting operations would not have sufficed.

Growing and harvesting forbs requires more attention than the native grasses because of different sizes of plants and wide range in growth requirements. Species such as purple prairie clover *(Petalostemum purpureum)* and butterfly milkweed *(Asclepias tuberosa)* are injured by damping-off and root rot fungi. Shell-leaf penstemon *(Penstemon grandiflorus)* and Illinois bundleflower *(Desmanthus illinoiensis)* are both short-lived in solid stands for reasons that are unknown. Harvesting of Maximilian sunflower *(Helianthus maximilianii)* requires height reduction to avoid seed loss by the combine. Many insects are associated with the life cycles of forbs as pollinators and predators. The wind-pollinated grasses do not have such extensive differences in management requirements. Though most species of forbs grown at Manhattan PMC require specific care during part of their life cycle, all share some common management practices. In discussing this management, we are reporting techniques used on our Haynie very fine sandy loam and Eudora silt loam soils (Jantz et al., 1975). Both are deep, well-drained soils suited to most crops.

FIELD ESTABLISHMENT

Site preparation is more important with forbs than with grasses because we do not have a suitable herbicide for removing grasses from broadleaf plantings. These plantings should be made on a well prepared, weed-free seedbed. Fallowing for the two preceding growing seasons is highly desirable for weed control and the breakdown of herbicide residue. Perennial weeds, especially rhizomatous ones, are very difficult to control in a stand of forbs. Control before planting is far preferable for species such as bermudagrass *(Cynodon dactylon),* yellow nutsedge *(Cyperus esculentus),* and field bindweed *(Convolvulus arvensis).*

Soil tests should be made to establish levels of available macronutrients, pH, and organic matter. Moderate levels of available phosphorus (28.5 kg/ha or 25 lb/acre) and potassium (171 kg/ha or 150 lb/acre) are desirable, while low levels of nitrogen (10 ppm or less of nitrate and ammonia) are advisable to reduce the potential for disease. Soil pH should be in the range of 6-7 to approximate the native condition. Damping-off may be reduced by maintaining a pH on the low end of this range. The organic matter content of the soil should be maintained by growing green manure crops during the years between forb crops. Reduction of the soil organic matter may occur because of the yearly removal of the forb crop residue. However, this removal is prudent to reduce insect and disease buildup. We have no experience to date with respect to micronutrient level requirements for forb seed production.

Optimum plant densities for maximum seed production have not been established. Future work may include such studies, but for now we are using 100 pure live seed/m (30 pure live seed/foot) as a target seeding rate. We suspect that very dense plant populations are conducive to disease and lower seed yield.

Whether spring- or fall-planted, all species may require irrigation to initiate timely germination if a dry winter and spring occur (Table 1). Almost all spring plantings are irrigated during the summer while fall-planted species must be irrigated only under very dry conditions. As implied earlier, soil moisture conditions are critical for prairie clovers during germination. Since damping-off organisms readily attack the new seedlings, irrigation should be avoided between the onset of germination and the 5- or 6-leaf stage. Morning watering is recommended and is practiced in tree nurseries where damping-off is a common problem (Williams and Hanks, 1976). Butterfly milkweed and Illinois bundleflower may also be vulnerable to overwatering. A 0.1 ha field of butterfly milkweed was lost to root rot during the third growing season, 1977, which was very wet. A 3-year-old stand of bundleflower failed to emerge during the spring of 1978. Sunflower heliopsis *(Heliopsis helianthoides)* wilts at the onset of dry weather but recovers well if promptly irrigated.

Slow seedling development prolongs the period of susceptibility to stress and greater injury is likely from insects, disease, water, wind, and cultivation. A correlation exists between seedling vigor and time until the first seed harvest is realized. Species with low seedling vigor such as butterfly milkweed, echinacea *(Echinacea* spp.), roundhead lespedeza *(Lespedeza capitata),* Stueve's lespedeza *(L. stuevei),* liatris *(Liatris* spp.), the prairie clovers *(Petalostemum* spp.), and grayhead prairieconeflower *(Ratibida pinnata)* do not produce seed during the establishment year (Table 1). In contrast, Illinois bundleflower, Maximilian sunflower, and pitcher sage *(Salvia pitcheri)* have good seedling vigor and often produce their best seed crops during the first year.

The mature size of most of the species in Table 1 precludes mechanical cultivation with standard farm equipment past the eighth week of the growing season during postestablishment years. The high cost of hand labor makes the use of selective preemergent herbicides attractive. At the present time no herbicides are registered for use in native forb seed production, but some are registered for use on broad-leaved herbaceous plants such as vegetables and soybeans. In a 4-year study (unpublished data) carried out at the Manhattan PMC in cooperation with Dr. Charles Long, assistant professor of ornamental horticulture, Kansas State University, three commonly used chemicals were determined to be compatible with selected native forb species at certain rates. When the forb crop is completely dormant, winter annuals such as henbit *(Lamium amplexicaule)* and evening primrose *(Oenothera biennis)* can be controlled with contact herbicides.

Fire is not useful for removing the forb residue because it is insufficient for burning. With some species a slow fire might carry through the stand, but a slow fire can result in damage by generating hotter soil temperatures. Anderson et al. (1970) related vegetative composition changes to timing of fire in the tallgrass prairie where late burns reduced the number of forbs. No work has been reported relating fire effects on single species stands. Mowing and baling of the crop residue in early spring reduces the number of harmful organisms that have overwintered in the stems and leaves. This method is preferred, but some species do not have sufficient residue for baling by spring; Stueve's lespedeza and butterfly milkweed are in this group. Spring baling is preferred because it allows the residue to remain as cover through the winter. In some years Maximilian sunflower residue is coarse enough to cause problems with baling. Shredding the stems with a rotory mower and rototilling the stubble in both fall and spring have been satisfactory at Manhattan PMC, but these techniques may not work in drier locations where decomposition would be slower.

HARVESTING

Harvesting forb seed with a combine requires the same equipment and knowledge of the crop as grass seed. The range in seed sizes if not textures is greater for the forbs than for the grasses (Fig. 1). Combine settings that apply to Allis-Chalmers-72 and John Deere-45 combines[1] are listed in Table 2. We view these settings as a starting point, and each year's crop requires some fine tuning. Pickup guards are useful with most crops and necessary with those that lodge, such as gayfeather.

One of the most challenging aspects of harvesting native forbs is timing the harvest. Butterfly milkweed must be combined when the seed turns a uniform dark brown inside the pods which are still green. The seed pods dry and split within a few days after seed turns brown

[1]Trade names are used solely to provide specific information. Mention of a trade name does not constitute a guarantee of the product by the U.S. Department of Agriculture nor does it imply an endorsement by the Department over comparable products that are not named.

Table 1. Forb culture in solid stands.

	Seeding Date	Planting Depth (mm)	Row Spacing (m)	Seedling Development	Size 1st Year (m)	Years To Maturity	Size 2nd Year (m)	Dormancy Period	Stand Longevity (years)
Asclepias tuberosa	May	6	0.6-1.0	Slow	0.2-0.3	2	0.6-0.8	Oct-May	3
Desmanthus illinoensis	May	12	0.8-1.0	Moderate	1.3	1	1.3-1.5	Oct-Apr	3
Echinacea pallida/E. angustifolia	Nov	12	0.8-1.0	Slow	0.1-0.3	2-3	0.6-1.0	None	5+
Helianthus maximilianii	May	12	1.8-2.6	Rapid	2.0-2.6	1	2.6-3.9	Nov-Apr	5+
Heliopsis helianthoides	Mar	6	0.8-1.0	Rapid	1.3	1	1.3-1.5	Oct-Apr	5+
Lespedeza capitata	May	12	0.6-1.0	Slow	0.1-0.5	2	0.6-1.0	Oct-May	5+
L. stuevei	Jun	6	0.3-0.6	Slow	0.1-0.3	2	0.3-0.5	Oct-May	5+
Liatris pycnostachya	Mar	6	1.0-1.2	Slow	0.1-0.3	2	1.1-1.7	Oct-Apr	5+
Petalostemum purpureum	Apr	12	0.8-1.0	Slow	0.1-0.3	2	0.6-1.0	Oct-Apr	5+
Ratibida pinnata	Apr	12	0.8-1.0	Moderate	0.3-0.4	2	1.0-1.3	Nov-Apr	5+
Salvia pitcheri	Apr	12	0.8-1.0	Rapid	1.0-1.3	1	1.1-1.4	Nov-Apr	5+

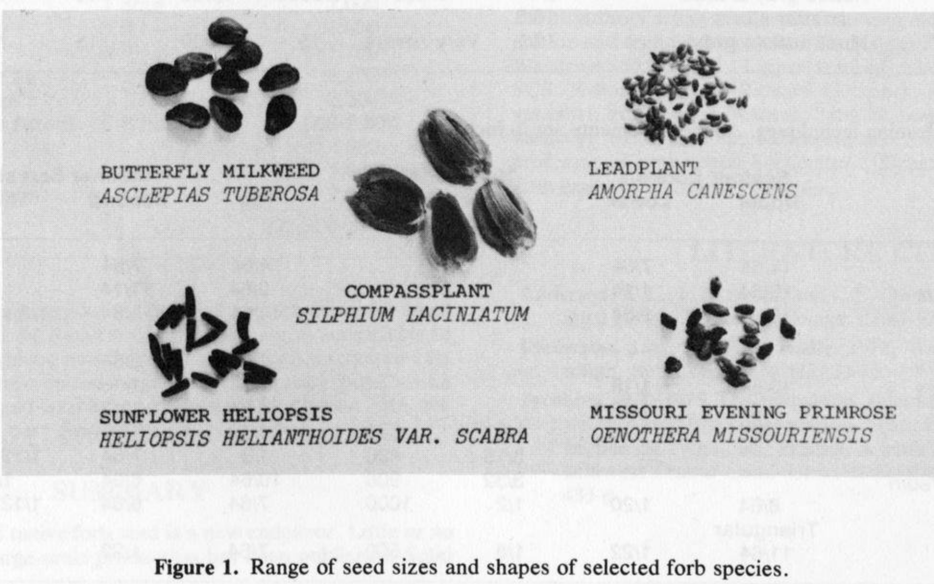

Figure 1. Range of seed sizes and shapes of selected forb species.

and the recoverable yield drops rapidly with time because the seed becomes airborne inside the machine and floats away. Maximilian sunflower maturity coincides with average first frost at Manhattan PMC. After frost, seed loss can occur rapidly because of wind shatter or large flocks of migrating birds. Failure to conduct a height-reducing mowing, about June 1, results in the sunflower becoming too tall and in excessive shatter loss during combining. Pitcher sage shatters immediately upon ripening if there is even a moderate breeze. Delay of a day will allow the crop to be lost, so very close observation is necessary.

Grayhead prairie coneflower and echinacea are examples of easily harvested forbs. Combining should be delayed until seed shatter begins, then rapidly executed. Failure to wait for seed shattering to begin allows a high percentage of the very hard seedheads to pass through the combine without being separated from the stems and knocked apart.

Drying the harvested crop requires artificial methods at Manhattan PMC. The seed is sacked in burlap bags and immediately placed on a drying apparatus that forces heated air (40°C) through the bags. Typical drying times are given in Table 2. Seed can also be dried by spreading it on a dry concrete floor and stirring two or more times a day, but this method takes longer.

SEED CLEANING

Forb seed can be cleaned with a hammer mill and a two-screen fanning mill provided that a wide assortment of screen opening sizes and shapes are available. A general scalping operation is advisable before hammer milling. When harvesting is well-timed and the combine properly set, hammer milling is unnecessary for six of the eleven crops listed in Table 3. The screen sizes listed in Table 3 are to be used as a guide. Yearly fluctuations in seed size, trashiness, weed populations, and harvest precision will require changes in screen selection. The range of seed yield and quality of 11 forb species grown at Manhattan are listed in Table 4. These data were obtained under the rigorous cleanliness standards associated with foundation seed production. Some seed was sacrificed during the weeding, combining, and cleaning procedures that could have been retained at other levels of production.

EQUIPMENT AND LABOR NEEDS

The basic equipment required for handling forb seed production is given in Table 5. The area that can be maintained in forb seed production with this equipment will vary with the crops grown and the

Table 2. Forb seed harvest techniques.

	Harvest	Harvest Date	Shattering	Concave Clearance (mm)	Cylinder (rpm)	Air Intake Open (%)	Pickup Guards Needed	Forced Air Drying Time at 40°C (hr)
Asclepias tuberosa	Pods green & seed brown, firm	8/25	Severe	12	900	0	No	24
Desmanthus illinoensis	Legumes black & splitting	8/15	Trace	10	1,000	50	No	24
Echinacea pallida/ E. angustifolia	Head dry & seed shatter starts	8-20	Trace	12	1,600	15	Yes	20
Helianthus maximilianii	Head dry	11/1	Severe	12-15	1,100	25	No	15
Heliopsis helianthoides	Majority of heads brown	8/19-9/7	Severe	12	1,100	15	No	24
Lespedeza capitata	Head brown	11/1	Trace	8	1,000	25	Yes	15
L. stuevei	Legumes brown & seed firm	10/18	Moderate	6	1,200	15	No	15
Liatris pycnostachya	Spikes tan & seed firm	10/5	Severe	15	800	0	Yes	10
Petalostemum purpureum	Head gray & seed firm	7/21-8/11	Moderate	18	450	15	Yes	15
Ratibida pinnata	Heads gray & seed shatter starts	9/1-10/8	Trace	Closed	1,100	15	No	10
Salvia pitcheri	Most nutlets gray	10/1	Very severe	15	800	15	No	15

Table 3. Forb seed cleaning techniques. All measurements are in inches.

	Scalper Screens Upper	Scalper Screens Lower	Hammer Mill Screen Size	Hammer Mill Rpm	Cleaner Screens Top	Cleaner Screens Second	Cleaner Screens Third	Cleaner Screens Fourth
Asclepias tuberosa	14/64	7/64			14/64	7/64		
Desmanthus illinoensis	10/64	1/14			9/64	1/14		
Echinacea pallida/ E. angustifolia	10/64	9/64			10/64	9/64	1/2 x 1/16	1/2 x 1/2
Helianthus maximilianii					7/64	6/64	1/12	1/22
Heliopsis helianthoides	10/64	1/18			1/8	1/16		
Lespedeza capitata	6/64	1/25			6/64	1/12		
L. stuevei	6/64	1/20	1/8	800	1/12	1/20		
Liatris pycnostachya			3/16	400	1/8	7/64	1/12 x 1/2	1/22
Petalostemum purpureum			3/32	900	10/64	6/64	1/14	1/25
Ratibida pinnata	8/64	1/20	1/2	1000	7/64	6/64	1/12 x 1/2	1/22
Salvia pitcheri	Triangular 11/64	1/22	1/8	500	7/64	1/22		

Table 4. Seed yield and quality.

Species	Year	Yield (kg/ha)	Germination (%)	Hard Seed (%)	Purity (% by wt.)	Inert (% by wt.)	Other Crop & Weed Seed (% by wt.)	Notes
Ascelpias tuberosa	76	81	57	0	86	14	0	Stand destroyed by root rot.
Desmanthus illinoensis	75	645	55	36	99	1	0	
	76	391	12	0	100	0	0	
	77	829	29	41	99	1	0	
Echinacea pallida/ E. angustifolia	76	242	0	0	96	4	0	Seed testing procedure for germination not yet accurate. Field experience indicates higher actual germination rates.
	77	201	24	0	96	4	0	
Helianthus maximilianii	75	113	85	0	96	4	0	
	76	168	72	0	97	3	0	
	77	147	75	0	98	2	0	
Heliopsis helianthoides	75	155	30	0	98	2	0	Germination test procedures inaccurate.
	76	78	50	0	90	10	0	
	77	242	51	0	96	4	0	
Lespedeza capitata	75	59	37	50	97	3	0	
	76	96	55	36	100	0	0	
L. stuevei	75	93	18	59	97	3	0	
	76	161	24	23	100	0	0	
	77	60						Seed test not obtained.
Liatris pycnostachya	75	31	83	0	98	2	0	
	76	200	63	0	89	11	0	
	77	149	60	0	94	6	0	
Petalostemum purpureum	75	14	27	60	99	1	0	
	76	333	53	42	100	0	0	
	77	190	37	50	99	1	0	
Ratibida pinnata	75	55	97	0	90	10	0	
	76	116	90	0	82	18	0	
	77	75	86	0	98	2	0	
Salvia pitcheri	76	296	31	0	99	1	0	Germination test procedures inaccurate. Seed lost to wind shatter.
	77	13	33	0	99	1	0	

Table 5. Equipment needs for wildflower seed production.

	Size	Approximate Cost Retail (1978)
Tractor, with 3 pt. hitch	40 hp	$10,500
Disc, tandem	10 ft	1,300
Harrow, spike tooth	10 ft	750
Rototiller, p.t.o.	2 row	3,000
Planter, unit (flex)	2 row	950
Cultivator	2 row	1,000
Sprayer, 3 pt. hitch	100 gal	1,000
Pipe, irrigation	1 acre	1,000
Spreader, fertilizer	8 ft	1,500
Mower, sickle-bar	6 ft	1,700
Baler, square, wire tie		5,400
Hay rake, windrower		2,000
Combine, pull-type (used)	6 ft head	1,000-2,000
Bags, containers		500
Hammer mill		1,000
Fanning mill, 2-screen		2,000
	Total	$33,600-$34,600

experience of the seed producer. Because requirements for hand labor are greatest during the year of establishment, it is desirable to establish only two or three new fields each year. Labor requirements will also depend on the crop and the grower's experience, but 12-16 ha (30-40 acres) of new and established plantings at Manhattan PMC will keep a crew of four busy from March to November.

SUMMARY

The production of native forb seed is a new endeavor. Little or no previous work on large-scale production has been published. Solid stands of native forbs are inviting to insects and disease organisms. Large variations in growth and harvest requirements between species challenge the seed producer to adapt management schemes to individual species. Special attention to site preparation, weed control, water management, and the proper stage of maturity at harvest time will pay off with satisfactory yields. Equipment and manpower requirements are significant, however, and production costs for amateur growers may exceed purchase costs as commercial seed producers increase their output.

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SEED CONDITIONING AND GERMINATION OF NEW JERSEY TEA, *CEANOTHUS AMERICANUS* (RHAMNACEAE)

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With an increased effort to restore the plant diversity that once characterized the North American Prairie, it has become increasingly apparent that certain species are more difficult to establish than others, and more information is needed to determine the factors involved in seed conditioning, germination, and establishment of the more difficult prairie forbs. New Jersey tea, *Ceanothus americanus* L., has been one of these more difficult species. Widely distributed throughout the eastern tallgrass prairie region in dry to mesic prairie habitats and open woods, this low profile, woody shrub is a quality prairie plant. The plant exhibits a lustrous green foliage, very showy white flowers, and it provides important browse for deer and seeds for other wildlife species.

Western species of *Ceanothus* are important components of interior and coastal chaparral and are important deer browse on both summer and winter ranges (Leopold et al., 1951; Taylor, 1956). *Ceanothus americanus* is used in horticulture as a rootstock for grafting other *Ceanothus* species (Hartman and Kester, 1975). The genus *Ceanothus* contains some of the relatively few nonleguminous species which have nitrogen-fixing bacteria associated with their root systems (Delwiche et al., 1965).

Investigations on different species of *Ceanothus* of the western chaparral have been done by Quick (1935, 1961) and Hadley (1961). Radwan and Crouch (1977) have done a careful study on redstem ceanothus. In their study they determined that germination of *Ceanothus* seeds was usually restricted by a hard and impervious (to water) seed coat, which could be overcome by hot or boiling water treatments. Some species also required cold-damp conditioning to break dormancy and achieve maximum germination. In the present study a series of tests were conducted on *C. americanus* to determine the best method for achieving maximum germination of this species.

MATERIALS AND METHODS

Twenty-one different treatment tests and one control test were conducted and compared. The tests were set up to examine the effects of fire, scarification, boiling water, hot water soak, cold-damp stratification, and gibberellic acid soak, in addition to several different durations and combinations of the various treatments. Also, concentrated sulfuric acid was used to treat some lots of seeds, yielding sporadic and very inconclusive results that are not presented in this paper.

Seeds were obtained in September from prairie remnants in Mercer County, Illinois. All seeds were collected by hand, air-dried, and hand-separated from seed pods and chaff. Seeds were stored dry at room temperature until they were used.

After preliminary testing, viability was determined using a cold water sink-float test. It was found that when *Ceanothus americanus* seeds were stirred into a container of water at room temperature, some of them sank to the bottom, while others floated on top. Germination tests were conducted on seeds which floated and seeds which sank. No germination was observed in the seeds which floated while germination did occur among the seeds which sank. This result provided an easy method of separating viable and nonviable seed for further testing. All final tests were conducted using seeds which sank when stirred in water.

Seeds to be exposed to fire were scattered on moist soil in wooden flats and covered with 2 cm of prairie grass straw. The straw was ignited, and allowed to burn until all combustible material was consumed. A thin layer of soil was then spread over the seeds and ashes. Scarification was accomplished by placing seeds on a sheet of sandpaper and gently scratching them with a sanding block.

Two methods of testing seeds with hot water were used in the study. In the hot water soak method, 1 liter of water was heated to selected temperatures, seeds were dropped into the water, and the water allowed to cool to room temperature. In the boiling water treatment, seeds were poured into vigorously boiling water. After various periods of boiling, the seeds were cooled quickly by pouring them into a container of cold water. Seeds were then removed from the water, drained, and planted.

Seeds to be cold-damp stratified were counted out in various lots, mixed with 50 ml of moist sterile sand, placed in small polyethylene bags, and refrigerated in an environmental chamber at 1-2° C for 10 weeks.

Seeds were treated with varying concentrations of gibberellic acid by placing the individual lots of seeds in test tubes, and covering them with 3-4 ml of gibberellic acid. All the gibberellic acid tests were previously treated by boiling in water for 1 minute. The seeds in the test tubes were placed in the dark and left to soak for 24-48 hours. Gibberellic acid concentrations of 50, 100, and 200 ppm were used.

With the exception of the fire test, all seed germination tests were carried out in plastic flats. The potting soil used was a commercial mixture called Redi Earth produced by Terra Lite. Each flat was filled with 3 cm of potting soil. The seeds were scattered on the soil, covered with 3 mm of soil, and gently watered. Flats were maintained in a greenhouse from November to March. Controls consisted of untreated seed planted in the same way as the treatment tests. The soil was kept moist throughout the study. Flats were checked daily and seedlings were recorded when they first came through the soil. Germination flats were observed up to 12 weeks although most of the germination occurred within 25-30 days with little change thereafter.

Statistical analyses included the calculation of decimal percentages, standard deviations of these percentages

$$s = \sqrt{\frac{p\,(1-p)}{n}}$$

and comparisons of percentages of two large samples by calculation of d values

$$d = \frac{p_1 - p_2}{\sqrt{p\,(1-p)\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where a value of d greater than 2.58 indicates significant difference at the 0.01 level (Roland, 1973; Hoel, 1971). Sample sizes for the various test lots included 100 or 200 seeds per test. Certain tests in similar treatment categories are combined into common or combined percentages.

$$p = \frac{p_1 + p_2 + \ldots}{n_1 + n_2 + \ldots}$$

for more meaningful comparisons of the various treatment categories.

RESULTS AND DISCUSSION

Preliminary testing and experimentation determined a cold water sink-float viability test for *Ceanothus americanus* seeds. None of the floating seeds germinated during this study. Of the total seeds counted in these tests, 18 percent sank. This value can be considered the viability percentage for the particular year the seeds were produced and would probably vary from year to year, depending upon conditions during seed production and maturation. All the test treatments were run using the seeds that sank.

Table 1 presents germination percentages and the standard deviations for all test treatments and the control. In addition, selected d values are calculated to determine significance levels of certain differences. Figure 1 presents these data graphically, including ± twice the standard deviation. Table 2 and Figure 2 present similar data for combined tests in similar treatment categories.

A maximum germination of 70 percent occurred with a boiling water treatment of 1.5 minutes followed by cold-damp stratification of 10 weeks. The control test with no conditioning at all produced only 7 percent germination. The fire test (9 percent germination) had no statistically significant effect on germination when compared with the control (d = 0.61). Scarification had a definite effect on germination yielding 30 percent.

Hot water soak of 70° C and 80° C had a limited effect on germination (13-15 percent) when compared to the control and was significant at the 0.05 level (d = 2.28) but not at the 0.01 level (Table 2 and Figure 2). Hot water soak of 90° C had a significant effect on germination (d = 2.74) and raised germination to 27 percent, which is comparable to the boiling water treatments. Boiling water is an important and easy method of seed treatment with this species. Different test lots were boiled 0.5-7 minutes. The boiling water tests that lasted 0.5-6 minutes were rather similar, producing a minimum of 24 percent at 2 minutes and a maximum of 35 percent at 0.5 minutes. The difference between these two percentages was significant at the 0.05 level but not at the 0.01 level (d = 2.52). The average or combined percentage for all the boiling water tests up to 5 minutes was 31 percent (Table 2). At 7 minutes of boiling water treatment, no germination was observed thus setting an upper limit for this treatment at which the destruction of the embryo occurred in all seeds tested. The lower limit at which the seed coat was not altered sufficiently to overcome seed coat impermeability is indicated by the 70° C and 80° C hot water tests where only 13-15 percent germination resulted. Boiling water treatments appear to be very similar to scarification, producing almost identical germination of 30 percent. These results suggest the important role of seed coat impermeability in *C. americanus* dormancy which both these treatments overcome.

Cold-damp stratification both with and without boiling water treatment was tested in this species. Maximum germination of 70 percent was achieved with boiling water 1.5 minutes followed by 10 weeks of cold-damp conditioning. An additional test of 0.5 minutes of boiling water and 10 weeks of stratification yielded a similar high germination of 63 percent. Stratification alone yielded only 28 percent germination (Fig. 1, Table 1), which was comparable to boiling water alone.

Gibberellic acid soak combined with a boiling water treatment of 1 minute did not improve germination, yielding germinations of from 17

Table 1. Germination results of all treatment tests on *Ceanothus americanus* seeds.

	Sample Size	Number Germinated	Percent Germination	Standard Deviation	
Control	200	14	0.070	±0.018	d
Burned	100	9	0.090	±0.029	0.61
Scarified	100	30	0.300	±0.046	
Boiling water					d
0.5 min	200	71	0.355	±0.034	0.95
1.0 min	200	67	0.335	±0.033	d
1.5 min	200	67	0.335	±0.033	2.52
2.0 min	200	48	0.240	±0.030	
3.0 min	200	52	0.260	±0.031	
5.0 min	200	63	0.315	±0.033	
7.0 min	200	0		±0.033	
Hot water					
70°C	100	15	0.150	±0.036	
80°C	100	13	0.130	±0.034	
90°C	100	27	0.270	±0.044	
Cold-damp stratified, 10 wk					
No boiling water	200	56	0.280	±0.032	
Boiling water, 0.5 min	200	126	0.630	±0.034	
Boiling water, 1.5 min	200	140	0.700	±0.032	
Gibberellic acid, 24 hr + boiling water, 1 min					
50 ppm	100	25	0.250	±0.043	
100 pmm	100	21	0.210	±0.041	
200 pmm	100	20	0.200	±0.040	
Gibberellic acid, 48 hr + boiling water, 1 min					
50 ppm	100	24	0.240	±0.043	
100 ppm	100	22	0.220	±0.041	
200 ppm	100	17	0.170	±0.038	

to 25 percent. Soaking seeds in 50, 100, and 200 gibberellic acid ppm for 24-48 hours did not increase the germination percentage. When the combined germination of 21 percent for all gibberellic acid tests was compared to the combined germination for boiling water tests (d = 4.12, Table 2), there was a significant difference at the 0.01 level indicating a possible suppression of germination by gibberellic acid. Radwan (1977) used potassium gibberelate (K-GA_3) to replace cold-damp conditioning in his studies on redstem ceanothus (*Ceanothus sanguineus*). Radwan obtained high germination when he combined K-GA_3 with a boiling water treatment. Gibberellic acid may not produce the same effect as K-GA_3, or there may be species differences in germination response to treatments with these kinds of compounds.

The results of this study indicate that a boiling water treatment of 1-2 minutes followed by at least two months of cold-damp stratification at 1-2° C will yield good germination of 70 percent in *C. americanus*. Scarification may accomplish the same effect on the seed coat as boiling water but is harsher and less practical. Quick and Quick (1961) indicated that scarification or boiling water treatments are necessary to alter the seed coat and allow the seed to imbibe water. Without imbibition, after-ripening cannot occur. Quick (1935), Quick and Quick (1961), Radwan (1977), and Hartman (1975) all found that many other species of *Ceanothus* required a combination of cold-damp conditioning and boiling water or scarification to achieve maximum germination. *Ceanothus americanus* seems to follow this pattern rather closely.

In establishing prairie it is not only important to achieve high germination percentages but also a rapid rate of germination. Those seedlings which become established quickly and early the first year of a restoration project can better compete with the "weedy" annuals that are so prevalent in the early stages of succession. Figure 3 presents selected germination tests plotted against time. Most seeds in this study germinated within 25 days from the time of planting, but the most rapid rate of germination was achieved in the tests that combined cold-damp stratification and boiling water. Seeds in these tests germinated within 13 days or about two-thirds the time taken for seeds to germinate in the other tests. Even the seeds that were given only a stratification treatment began to germinate about a week earlier than seeds given the other treatments (Fig. 3).

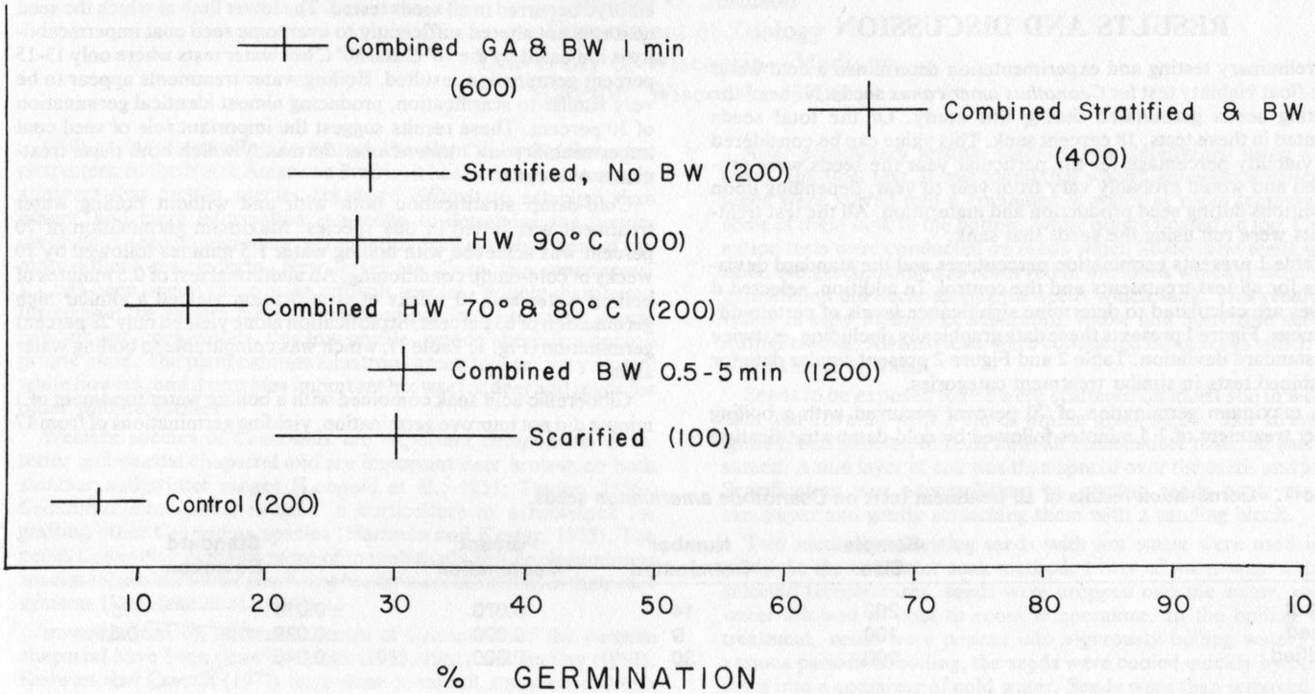

Figure 1. Percent germinations of all test treatments of *Ceanothus americanus*. Horizontal lines indicate twice the standard deviation on either side of the percent. GA = gibberellic acid; BW = boiling water; HW = hot water. (Numbers in parentheses indicate sample size or number of seeds tested.)

Table 2. Germination results of combined treatment categories compared to the control and some individual treatment tests.

	Sample Size	Number Germinated	Percent Germination		Standard Deviation		
Control	200	14	0.070	d	±0.018		d
Combined boiling water, 0.5-5 min	1200	368	0.307	2.28	±0.013		6.97
Combined hot water, 70° and 80°C	200	28	0.140	d	±0.024		
Hot water, 90°C	100	27	0.270	2.74	±0.044	d	d
Cold damp stratified						0.77	4.12
No boiling water	200	56	0.280		±0.032		
Combined boiling water, 0.5-1.5 min	400	266	0.665		±0.023		
Combined concentrations gibberellic acid, 24 hr + boiling water, 1 min	300	66	0.220		±0.024		
Combined concentrations gibberellic acid, 48 hr + boiling water, 1 min	300	63	0.210		±0.023		
Combined gibberellic acid tests	600	129	0.215		±0.017		

Once germination has occurred and the seedlings have developed a few leaves, they are easily transplanted bare-rooted from the flats into cups or pots with very little mortality. After the plants have grown for one to two months they can be readily transplanted into the prairie; prairie; young plants should be protected from deer and rabbits. Also, treated seeds can be sown directly into restoration sites along with appropriate mixtures of forbs and prairie grasses. *Ceanothus americanus* is an outstanding, quality prairie forb that can be established easily if the seeds are viable and properly conditioned.

SUMMARY

An investigation of seed conditioning and germination was conducted on the woody prairie shrub, *Ceanothus americanus*. A variety of seed treatments were tested including fire, scarification, boiling water, hot water soak, cold-damp stratification, gibberellic acid soak, and different durations and combinations of the various treatments. A cold water sink-float test determined that only seeds that sank were viable. Maximum germination of 70 percent resulted from boiling water 1.5 minutes followed by 10 weeks of cold-damp stratification. Stratification alone, boiling water alone (up to 5 minutes), and scarification alone all produce about the same germination (28-30 percent). Seeds boiled for 7 minutes produced no germination. Hot water soak at 70° and 80° C resulted in a slight increase over the control while a 90° C soak was comparable to boiling water (27 percent). Gibberellic acid has little effect on germination and may, in fact, suppress the effects of boiling water. Fire, as tested in this study, had no significant effect over the control. Three to four weeks were needed to determine maximum germination percentages for most of the tests. Stratification produced the most rapid rate of germination (10-14 days).

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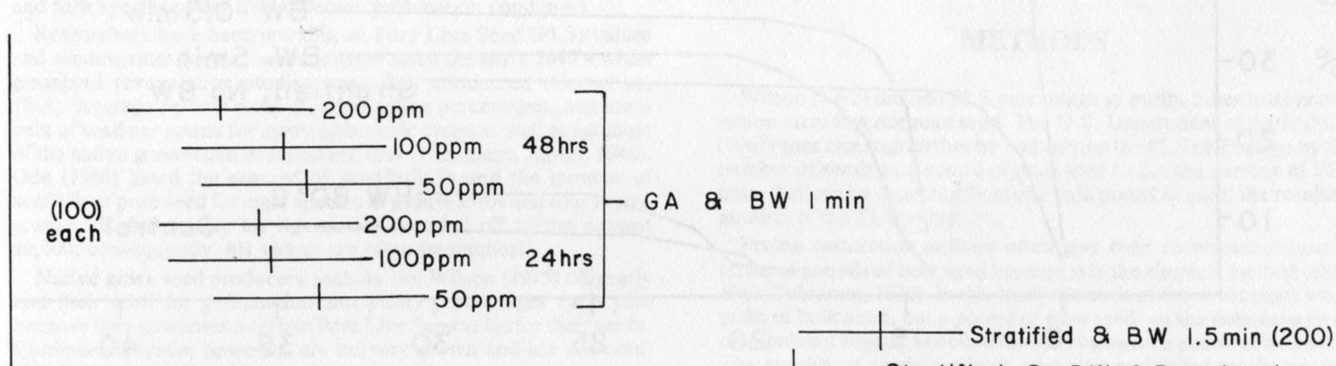

Figure 2. Combined percentage germinations of selected test categories of *Ceanothus americanus* compared against each other and the control test. Horizontal lines indicate twice the standard deviation of either side of the percent. GA = gibberellic acid; BW = boiling water; HW = hot water. (Numbers in parentheses indicate sample size or number of seeds tested.)

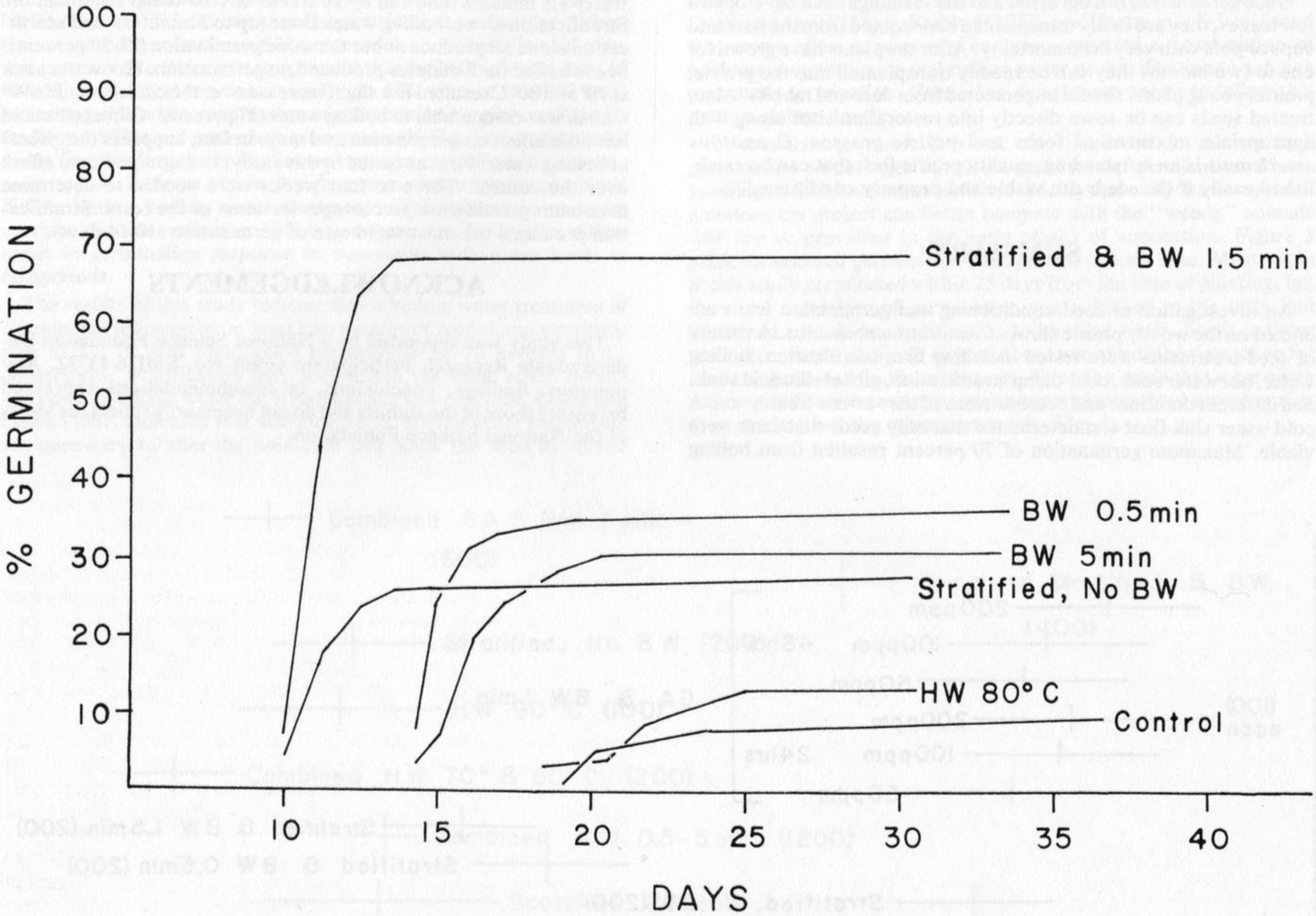

Figure 3. Germination percentage of *Ceanothus americanus* plotted against time (days) for selected test treatments and the control.

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GERMINATION STUDIES AND PURITY DETERMINATIONS ON NATIVE WISCONSIN PRAIRIE SEEDS

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One of the problems commonly faced by those interested in starting prairie plants from wild-collected seed is determining what percentage of a given amount of bulk seed can be expected to grow. This knowledge can help the prairie planner to accurately formulate seed mixtures that will produce the desired species ratios and reduce seed wastage from overplanting. Many variables are involved in this exercise, such as, the viability of the seed, the microclimate of the growth environment, predation of seed, and inter- and intraspecific competitive effects. This paper is an attempt to determine the germination percentages (Pure Live Seed values) of some native Wisconsin grass and forb species under four different germination conditions.

Researchers have been working on Pure Live Seed (PLS) values and seeding rates for the native grasses since the early 1940's when grassland revegetation studies were first conducted (Cornelius, 1944). Average percent purities, germination percentages, and numbers of seed per pound for many agronomic crops as well as for most of the native grasses can be found in *Grass* (U.S. Dept. Agric., 1948). Ode (1968) listed the percent of seed/bulk lb and the number of seeds/lb of pure seed for eight species of prairie forbs and four native grasses. Unfortunately his figures are rounded off to the nearest 10,000; consequently, his values are often impractical.

Native grass seed producers such as Jim Wilson (1975) diligently test their seed for germination and purity percentages each year because they guarantee a certain Pure Live Seed value for their seeds. Commercial seeds, however, are nursery grown and are not completely representative of the wild grass seed.

The Association of Official Seed Analysts (1978) described specific germination and testing procedures for twelve common prairie grass species, but only about six genera of prairie forbs are listed as general testing categories. So a starting place has been defined for developing a range of Pure Live Seed values for the most popular species of native grasses, but similar procedures have not been developed for species of native forbs.

The four germination conditions chosen for study represent those most commonly used and one variation (3): (1) petri dishes in a growth chamber with controlled temperature and light conditions (Mitchell, 1926; Salac and Hesse, 1975); (2) petri dishes at room temperatures (Griswold, 1936); (3) petri dishes in a greenhouse; and (4) flats of soil in a greenhouse (Blake, 1935; Greene and Curtis, 1950; Christiansen and Landers, 1966).

METHODS

Wilson (1972) defined PLS percentage as purity times total germination including dormant seed. The U.S. Department of Agriculture (1967) goes one step further by multiplying the PLS percentage by the number of seeds in a pound of pure seed to get the number of PLS units that can be expected from one bulk pound of seed: the resulting number is the PLS value.

Prairie restoration authors often give their recommendations in terms of pounds of bulk seed because it is the simplest method (Ode, 1968; Schramm, 1970). In this study the basis of the seed counts was a gram of bulk seed, not a pound of pure seed, so the data have to be manipulated slightly to obtain the PLS value for a pound of bulk seed. The number of seeds per bulk gram was multiplied by the percent germination and by 453.59 g/lb to obtain a PLS value for one bulk pound. The purity percentage was not used directly, but it is implied by using the actual number of seeds in a bulk gram. Pure Live Seed values for a gram of bulk seed are presented in Tables 1 and 5.

Table 1. Seed counts, purity percentages, and ranges of pure live seed (PLS) values.

	Number of Seeds/ Bulk g	Purity (%)/ Bulk g	Number of Seeds/ Pure g	Range of 1977 Germination Percentages	Range of PLS/ Bulk g	Range of PLS/ Bulk lb
Amorpha canescens	293	95	308	48-92	141-270	63,793-122,270
Coreopsis palmata	275	45	611	6-16	17-44	7,484-19,958
Lespedeza capitata	135	40	338	4-34	5-46	2,449-20,820
Liatris aspera	327	40	818	8-52	26-170	11,866-77,128
Monarda fistulosa	290	10	2,900	0-34	0-99	0-44,724
Petalostemum purpureum	506	97	522	0	0	0
Ratibida pinnata	780	50	1,560	4-40	31-312	14,152-141,520
Rudbeckia hirta	723	10	7,230	0-38	0-275	0-124,619
Solidago nemoralis	589	10	5,890	4-50	24-295	10,687-133,582
S. rigida	955	60	1,592	0-26	0-248	0-112,626
Tradescantia ohiensis	40	20	200	2-16	1-6	363-2,903
Andropogon gerardii		32	364	12-26		19,800-42,900
A. scoparius		81	573	20-58		52,000-150,800
Bouteloua curtipendula		70	421	20-30		38,200-57,300
Elymus canadensis	173	55	315	0-4	0-7	0-3,139
Sorghastrum nutans		87	386	8-36		14,000-63,000
Stipa spartea	48	85	56	0-12	0-6	0-2,613

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All of the forb seeds as well as the *Elymus canadensis* and *Stipa spartea* seeds were collected from local wild seed sources. *Andropogon gerardii, A. scoparius, Bouteloua curtipendula,* and *Sorghastrum nutans* seeds were purchased from Wilson Seed Farms, Polk, Nebraska, in the spring of 1976.

Paper bags of prairie seed were stored dry on an unheated porch from the time of collection in the fall and early winter until January. In January 1977 the seed bags were transferred to a controlled cold room kept at approximately 2-4.5 ° C and 50 percent relative humidity. The seeds were stored continuously under these conditions until they were used for experiments in both 1977 and 1978. The 1977 tests were therefore on seeds less than one year old and the 1978 tests were on seeds over one year old. The legumes were neither scarified nor inoculated.

Rock (1974) reported that many seeds can be cold, dry stratified to eliminate the danger of premature germination in warm weather before seeds are planted. Cold, dry stratification was used in this project since the planting time of the test seeds was uncertain and any seeds that might have germinated during storage would have been wasted.

Each sample of seeds used in the germination tests was selected as randomly as possible from the seed lot. The sample consisted of 50 seeds for each species per test, either spread in separate petri dishes lined with filter paper substrates or planted in separate rows in flats. Since the supply of *Stipa spartea* and *Tradescantia ohiensis* seed was quite limited, some seed samples of these species contained only 25 seeds/test. All petri dishes were watered as necessary with distilled water.

Germination was checked and recorded every other day. Germinated seedlings were usually not removed from the petri dishes until they became overcrowded or started to mold. Mold was not usually a major problem; windblown seeds, such as, *Liatris aspera* and *Solidago* spp., molded more readily than seeds which are enclosed by their flower parts, for example, *Monarda fistulosa*.

Emergence of the radicle was the criterion for germination in the petri dish tests. Ballard (1966) pointed out, however, that emergence of the radicle may result from cell elongation not true mitotic cell division. Thus, such a "seedling" may not be capable of actually forming a normal plant. The Association of Official Seed Analysts (1978:29) defined germination "as the emergence and development from the seed embryo of those essential structures which . . . are indicative of the ability to produce a normal plant under favorable conditions." Using this definition, the author estimates that less than one in a thousand embryos with an emerged radicle failed to develop beyond the root tip emergence stage into a normal seedling during these experiments.

All four germination experiments in both years were conducted at approximately the same time. These experiments were originally planned for a two-month period, but some of the growth chamber tests were interrupted after only one month. Therefore, Table 2 presents the one month results for all the germination experiments although most of the tests were actually conducted for two months.

Growth Chamber Tests

Growth chamber tests were first started in the early spring of 1976 in a botany department growth chamber. Mitchell (1926) used a temperature range of 20-25 ° C in her germination experiments. Other workers suggested the following alternating temperature ranges as optimum for germination of native prairie seed: usually 20-30 ° C or 15-35 ° C (Association of Official Seed Analysts, 1978) or 19-33 ° C (Salac and Hesse, 1975). Ballard (1966) stated that when a single constant temperature is employed the optimum for most grasses lies in the 15-25 ° C range, but it is higher in the Andropogoneae and Chlorideae where the optimum may be in the 30-35 ° C range.

The growth chamber did not allow for fluctuating temperatures so it was set at 20 ° C constant temperature, and a 12-hour daily photoperiod from both fluorescent and incandescent lights was used. The conditions were chosen because of the above recommendations and because they approximated the early spring conditions in Wisconsin. These conditions are probably optimal for only a small group of species, but they are probably not so severe as to actually inhibit any species that were tested.

Room Temperature Tests

In 1977 the room temperature petri dish tests were conducted in the fall and early winter when daily room temperatures ranged from a low of 12 ° C to an occasional high of 26 ° C. The average temperature was 22.6 ° C. The 1978 tests were run in the spring and early summer when room temperatures varied from a low of 19 ° C to an occasional high of 35.5 ° C and averaged 26.6 ° C.

Greenhouse Flat and Petri Dish Tests

Seed samples were tested concurrently in both petri dishes and plastic greenhouse flats. In 1977 the soil mix in the flats consisted of a commercial greenhouse starter mix and loamy black soil. In 1978 the commercial mix was unavailable so sand was mixed with the loamy soil. Eight or nine species were sown in rows in each flat approxi-

Table 2. Germination percentages and ranges for selected lots of prairie seed. Slash marks indicate replications.

	Growth Chamber		Room Temperature		Greenhouse Flats		Greenhouse Petri Dish		Germination Ranges	
	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
Amorpha canescens	86	54/90	92/92	60/56	74/48	58/42	84.0	54.0	48-92	42-90
Coreopsis palmata	8	26/18	6/10	16/30	6/6	8/4	16.0	8.0	6-16	4-30
Lespedeza capitata	34	12/18	14	16/12	8/4	12/22	18.0	18.0	4-34	12-22
Liatris aspera	52	28/32	32/32	32/32	8/8	10/22	28.0	48.0	8-52	10-48
Monarda fistulosa	34	40/26	22	46/36	10/0	4/4	26.0	34.0	0-34	4-46
Petalostemum purpureum	0	0/0	0	0/0	0/0	0/0	0	0	0	0
Ratibida pinnata	22	48/50	40/24	48/24	0/4	28/30	38.0	54.0	4-40	24-54
Rudbeckia hirta	18	30/38	4	26/28	0/0	24/10	38.0	36.0	0-38	10-38
Solidago nemoralis	50	36/25	46	52/42	6/4	4/0	46.0	36.0	4-50	0-52
S. rigida	14	26/20	10/4	32/10	0/0	2/2	26.0	16.0	0-26	2-32
Tradescantia ohiensis (25 seeds/test 1978)	2	12/4		20/16.0	4.0/4	0/0	16.0	4.0	2-16	0-20
Andropogon gerardii	26	18/12	14	10/20	20/22	8/14	12.0	8.0	12-26	8-20
A. scoparius	20	50/64	22	42/34	46/48	54/56	58.0	48.0	20-58	34-64
Bouteloua curtipendula	30	26/24	22	28/30	20/22	30/18	30.0	34.0	20-30	18-34
Elymus canadensis	0	0/38	2	12/2	4/2	12/4	0	0	0-4	0-38
Sorghastrum nutans	8	48/34	10	24/18	8/8	14/22	36.0	26.0	8-36	22-48
Stipa spartea (25 seeds/test)	0	0/0	0	0/0	12/0	16/8	8.0	0.0	0-12	0-16
Average percent germination/species	23.8	27.9	20.4	25.1	11.9	15.9	28.2	24.9		

mately 0.64 cm deep and lightly watered. Each seed sample was replicated twice in the flats and once in the greenhouse petri dish on filter paper.

The flats were placed on a bench while the petri dishes were set on the ground between the benches since constant direct sunlight tended to dry out the dishes very quickly. Air and soil temperatures were recorded every time the seed samples were watered. In 1977 the air temperature ranged from 21-26 ° C, averaging 22.7 ° C, while the soil temperatures were slightly cooler at 20-23 ° C, averaging 21.6 ° C. In the warmer 1978 tests, the air temperature ranged from 20.5-43 ° C, averaging 33.8°C, while the soil temperatures were from 18-39° C. averaging 30.9°C.

Purity Determinations and Seed Counts

Seeds used in these tests were collected as cleanly as possible in the field to reduce the amount of hand cleaning needed later. No mechanical cleaning was done.

All seeds were separated as completely as possible from the chaff which consisted of bracts, dried flower parts, receptacles, and short pieces of stem. Any seed that was totally shattered or eaten by insects was included with the chaff although partially damaged or immature seeds were counted. Since it is very difficult to remove the pappi from species of *Liatris* and *Solidago* without crushing their seed, these fluffy appendages were included with the seed weight.

The chaff portion was almost always heavier than the seed portion so the chaff was weighed. This chaff weight was subtracted from the total weight to give a purity percentage. After the chaff was removed, the number of seeds in each gram sample was counted.

The Association of Official Seed Analysts (1978) recommended various weight samples for different sizes of seed. Since their recommendations are incomplete regarding prairie species, a uniform 1-g sample was randomly selected from the seed lot of each species for the purity determinations.

The number of seeds/pure g for the four purchased grass species was obtained from *Grass* (U.S. Dept. Agric., 1948), while the purity percentages were obtained from the grass seed certification tags attached to the packages. The number of seeds/bulk g was not counted for these four grasses so the PLS values were based on the number of seeds in a pure pound: 165,000 for *Andropogon geradii; 260,000 for A. scoparius;* 191,000 for *Bouteloua curtipendula;* and 175,000 for *Sorghastrum nutans*.

RESULTS AND DISCUSSION

The results of the germination tests conducted under four different testing conditions are compared in Table 2. In terms of the total number of seeds germinated in both years, the greenhouse conditions produced both the highest germination percentage in the petri dishes and the lowest germination percentage in the flats of soil. When the two years are considered separately, in 1977 the greenhouse petri dishes had the highest average germination/species, 28.2 percent, but in 1978 the growth chamber had the greatest average germination/species, 27.9 percent. In both years, the greenhouse flats had the lowest germination averages, 11.9 percent in 1977 and 15.9 percent in 1978.

Based on all average germination percentages, the seed used in 1978 which had been stored continuously cold and dry since harvest in late 1976 had higher germination under three of the four testing conditions than did the 1977 samples of the same seed lots. Only in the greenhouse petri dish tests did the 1978 samples not germinate as well as the previous year.

The warmer temperatures for the 1978 room temperature and greenhouse flat tests may be one reason for the better germination of the older seed, but warmer temperatures fail to explain the better 1978 germination under the constant growth chamber conditions. Increased after-ripening of the seed, and therefore, a reduction in dormancy, as well as increased temperatures are probably both responsible for the higher 1978 germination percentages.

This trend of increased germination in 1978 was probably negated in the greenhouse petri dishes by the higher soil and air temperatures. Rock (1974) stated that soil temperatures above 21 ° C can cause seeds to lose the advantage of stratification and return them to dormancy. Since both soil and air temperatures were considerably above 21 ° C in 1978, the higher temperatures could have inhibited further germination by sending some seeds back into dormancy. In this study, the optimum germination temperatures based on the highest percent germination, seem to be 21-26 ° C. Therefore, the temperatures in the 1978 petri dish tests were probably above the optimum germination temperatures for many prairie species.

The low germination in the flats may have been due to high soil temperatures alone or to a combination of several factors. During the high temperatures, the soil surface of the flats tended to dry out and crust over, therefore seedling emergence was more difficult for species with small or less vigorous seedlings. All seeds were approximately 0.64 cm deep, but this depth may have been too great for species with small seeds or those species requiring light to germinate. Mitchell (1926) found that light had a beneficial effect on the germination of *Solidago nemoralis,* but that light had no marked effect on the germination of *Rudbeckia hirta*. Lack of light was therefore probably the reason *Solidago nemoralis* germinated so poorly in the flats, only 0-6 percent, and this species exhibited the widest range in germination percentages of any species tested, 0-52 percent for both years. Greene and Curtis (1950) had low germination, 0-2 percent for *S. nemoralis* in their flats, but they did not discuss the reason(s) for such a low percentage.

Liatris aspera, Ratibida pinnata, and *Solidago rigida* are species common to both this study, and to studies conducted by Greene and Curtis (1950), and by Christiansen and Landers (1966). Greene and Curtis (1950) had a germination percentage of 60 for *Ratibida pinnata* while Christiansen and Landers (1966) had a germination percentage of 70 for the same species. In this study, *R. pinnata* had an average germination of only 2 percent in 1977 and 29 percent in 1978 in the flats.

The researchers (Greene and Curtis, 1959; Christiansen and Landers, 1966) who used flats to study germination of prairie species planted their seed in the fall and then brought the flats into the greenhouse in the spring to germinate. Their flat experiments were conducted at early spring temperatures on seeds that had been in the soil for some time. It is postulated that the high temperatures of the soil in this study could have either sent the seed back into dormancy or dried out the soil so much that seeds could not imbibe the water required for germination.

Three major plant families were represented in this germination study: Fabaceae, Compositae, and Gramineae (Table 3). Although the legumes were neither scarified or inoculated, they exhibited extremes in germination under all of the different germination conditions. *Amorpha canescens* had the highest germination percentage of any species tested, 92 percent in 1977 and 90 percent in 1978. *Petalos-*

Table 3. Average percent germination by major plant families.

	Growth Chamber		Room Temperature		Greenhouse Flats		Greenhouse Petri Dish	
	1977	1978	1977	1978	1977	1978	1977	1978
Fabaceae	40	29	35	24	22	22	34	24
Compositae	27	32	22	31	4	12	35	34
Gramineae	14	26	12	18	18	21	24	19
Pioneer forbs*	25	22	19	35	2	17	34	41

**Monarda fistulosa, Ratibida pinnata,* and *Rudbeckia hirta.*

temum purpureum had the lowest germination, 0 percent in all cases. *Amorpha canescens* and *Lespedeza capitata* had the highest 1977 germination percentages in the growth chamber, at room temperatures, and in the flats. The Compositae had the best germination percentage of 1978 under all but the greenhouse flat condition where they had low average germination of only 4 percent in 1977 and 12 percent in 1978.

Compared to the legumes and composites, the grasses had the poorest average germination percentages under all testing conditions in both years except in the flats of soil where they had better average germination than the composites. Only two species had their highest germination percentages occur in the flats: 4 percent for *Elymus canadensis* in 1977 and 12 percent in 1978, and 16 percent for *Stipa spartea* in both 1977 and 1978. The germination percentage for the grasses increased from 1977 to 1978 in all conditions except the greenhouse petri dishes where the temperatures may have been too high, as mentioned earlier. This trend is consistent with the findings of Coukos (1944) who reported on the increased germination of grass seeds caused by after-ripening occurring over a period of several years. The four species of nursery-grown grasses from Wilson Seed Farms had higher germination percentages than the species of grasses from more variable, less viable wild-collected seeds.

Monarda fistulosa, Ratibida pinnata, and *Rudbeckia hirta* are species that are commonly considered to be pioneer species. They had their highest average percent germination under the warmest conditions in the greenhouse petri dishes: 34 percent in 1977 and 41 percent in 1978.

Table 1 combines the information gained from the above germination studies with seed counts and purity percentages to determine a range of PLS values for the 17 prairie species tested. The 1977 germination ranges were used for convenience, the 1978 ranges are equally applicable.

Some of the PLS value ranges are quite wide. Three composites had the widest range: *Ratibida pinnata* had the widest range from 14,152 to 141,520 PLS/bulk lb, closely followed by *Solidago nemoralis* (10,687-133,582) and *Rudbeckia hirta* (0-124,619). The narrowest ranges were for *Tradescantia ohioensis* (363-2,903), *Elymus canadensis* (0-3,139), and *Stipa spartea* (0-2,613); these species had low seed counts in addition to low germination percentages. No reason is known for the total lack of germination of *Petalostemum purpureum*.

As discussed earlier, the results from the greenhouse flat tests were lower than the germination percentages of the three other methods used in this study and those reported in the literature. Eliminating the greenhouse flat results would tend to increase the low end of the germination percentage range, and this would result in a narrow range and would thereby make the data more useful. Table 4 represents the narrowed PLS value ranges that result from eliminating the flat germination percentages except for *Elymus canadensis* and *Stipa spartea* which had some of their highest germination in the flats.

CONCLUSIONS

Based on all the number of seedlings produced, the greenhouse conditions gave both the highest and the lowest germination percentages. In 1977 the greenhouse petri dishes gave the highest germination percentages at air temperatures of 21-26° C, while in 1978 the constant temperature growth chamber results were higher, due probably to excessively high temperatures in the greenhouse of up to 43° C.

Greenhouse flat tests had the lowest germination of any germination condition tested in any year. This low germination percentage could have been due to high soil temperatures returning the seed to dormancy or inhibiting imbibition by the seeds, the soil surface drying out and crusting over, too deep planting of the seed, or lack of light on the seeds.

The seeds tested in 1978, then more than one-year old, had higher germination in three of the four testing conditions than the same seed when less than one-year old. Warmer temperatures and increased after-ripening of the seed are both probable causes of the increased germination in 1978.

The Fabaceae had the highest germination percentage of the three major plant families in 1977, but the Compositae had the highest overall germination in 1978. The species of commercially grown grass seeds had higher germination than species of the wild-collected grass seeds.

The germination percentages from the four germination testing conditions were combined with seed counts and purity determinations to calculate Pure Live Seed value ranges for the 17 species of prairie seeds tested. In order to narrow somewhat the wide range of PLS values, the results from the greenhouse flats were eliminated from the germination ranges since their germination percentages seemed unreliably low in comparison with the other testing conditions and other researchers.

Although some of the PLS ranges are still wide perhaps due to the natural variability of the seeds and the small size of the samples tested, the PLS values presented here should provide an initial framework for establishing a more consistent, reliable PLS value range for species of wild-collected seeds.

Table 4. Narrowed pure live seed values (PLS) ranges for selected prairie seed lots.

	Number of Seeds/ Bulk g	Average Germination Percentages 1977 Range	1978 Range	Range of PLS/ Bulk lb 1977 Range	1978 Range
Amorpha canescens	293	84-92	54-72	111,638-122,270	71,767-95,689
Coreopsis palmata	275	8-16	8-23	9,979-19,958	9,979-28,690
Lespedeza capitata	135	14-34	14-18	8,573-20,820	8,573-11,022
Liatris aspera	327	28-52	30-48	41,531-77,128	44,497-71,195
Monarda fistulosa	290	22-34	33-41	28,939-44,724	43,409-53,932
Petalostemum purpureum	506	0	0	0	0
Ratibida pinnata	780	22-38	36-54	77,836-134,444	127,368-191,052
Rudbeckia hirta	723	4-38	27-36	13,118-124,619	88,545-118,060
Solidago nemoralis	589	46-50	31-47	122,896-133,582	82,821-125,567
S. rigida	955	7-26	16-23	30,322-112,626	69,309-99,631
Tradescantia ohiensis	40	2-16	4-18	363-2,903	726-3,266
Andropogon gerardii		12-26	8-15	19,800-42,900	13,200-24,750
A. scoparius		20-58	38-57	52,000-150,800	98,800-148,200
Bouteloua curtipendula		22-30	25-34	42,020-57,300	47,750-64,940
Elymus canadensis	173	0-3	0-19	0-2,354	0-14,910
Sorghastrum nutans		8-36	21-41	14,000-63,000	36,750-71,750
Stipa spartea	48	0-8	0-12	0-1,742	0-2,613

Table 5. Additional seed count and percent purity averages and their ranges.

	Number of Samples	Number of Seeds/ Bulk g		Percent Purity/ Bulk g	
		Average	Range	Average	Range
Amorpha canescens	8	346.1	293-412	90.5	80-97
Anemone patens	4	477.0	404-583	100.0	
Artemisia ludoviciana	1	3,641.0		70.0	
Asclepias incarnata	1	57.0		40.0	
A. verticillata	2	226.0	212-240	30.0	25-35
Baptisia leucantha	2	65.5	51-80	72.5	45-100
Coreopsis palmata	4	456.3	275-818	51.2	30-100
Echinacea pallida	1	100.0		22.0	
E. purpurea	3	121.0	106-146	31.7	30-35
Eryngium yuccifolium	1	201.0		60.0	
Elymus canadensis	8	183.8	78-362	69.4	55-80
Euphorbia corollata	1	76.0		25.0	
Gentiana andrewsii	1	21,900.0		100.0	
Lespedeza capitata	8	89.1	51-135	24.4	10-40
Liatris aspera	6	302.7	184-391	45.0	25-55
L. cylindracea	3	200.7	164-258	55.0	50-60
Monarda fistulosa	3	448.7	290-718	15.0	10-25
Panicum virgatum	1	461.0		75.0	
Petalostemum candidum	5	646.6	613-705	95.8	90-100
P. purpureum	5	583.6	506-655	94.8	90-97
Phlox pilosa	1	262.0		20.0	
Potentilla simplex	1	4,303.0		100.0	
Ratibida pinnata	4	708.0	564-780	36.2	25-50
Rudbeckia hirta	2	893.0	723-1,063	12.5	10-15
R. subtomentosa	1	533.0		20.0	
Silphium integrifolium	1	74.0		50.0	
S. laciniatum	1	15.0		20.0	
S. terebinthinaceum	4	42.5	35-50	38.7	15-70
Solidago nemoralis	3	1,166.7	589-1,487	18.3	10-25
S. rigida	4	822.8	596-1,090	55.0	40-70
S. speciosa	3	2,049.0	1,888-2,268	45.0	35-50
Sporobolus heterolepis	5	528.4	399-699	83.0	80-90
Stipa spartea	2	36.5	25-48	57.5	30-85
Tradescantia ohiensis	4	40.8	20-58	20.0	10-25

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FLOWERING PATTERNS AND PRODUCTION ON A CENTRAL OKLAHOMA GRASSLAND

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Phenological studies of tallgrass prairies have been generally limited to selected species with emphasis placed on the grasses (Benedict, 1940; Olmsted, 1944; Larsen, 1947; Rice, 1950; McMillan, 1959; Ahshapanek, 1962). Less attention has been given to community phenological response to variation in environmental conditions during the growing season or along geographical gradients. In this study community flowering patterns and green biomass production are used to determine how the phenology of an Oklahoma tallgrass prairie was modified in response to environmental conditions during the growing season. To understand how flowering patterns differ at the extreme ends of a north-south gradient within the tallgrass prairie, seasonal variation in flowering patterns for an Oklahoma prairie are compared with a Wisconsin tallgrass prairie site.

DESCRIPTION OF STUDY SITES

The Oklahoma study site is located 16 km north of Oklahoma City. Tallgrass prairie species dominated the vegetation, but the site is located within a narrow transition zone separating the former tallgrass prairie from the post and blackjack oak dominated Cross Timbers to the east (Duck and Fletcher, 1943). The study site had never been plowed, but it had been grazed and cut for native hay. However, the site was undisturbed five years prior to the current study.

The Wisconsin site is the Curtis Prairie at the University of Wisconsin—Madison Arboretum, an artifically established tallgrass prairie containing a diverse mixture of prairie species (Cottam and Wilson, 1966; Anderson, 1972). Restoration of the Curtis Prairie began in 1935; however, the prairie contains many exotics that undoubtedly dominated in many areas at the time (1950-1951) the flowering data were collected. The Wisconsin site was used because of the availability of the data from the Arboretum's records and because it also occurs in a prairie-forest border region but at the extreme northern edge of the tallgrass prairie.

METHODS

Oklahoma Site

The composition of the vegetation on the Oklahoma site was determined using the line transect method. Plant cover touching the line or projecting above or below it was recorded to the nearest 2.5 cm on 7 and 9 September 1974. A total of 125 m of line was sampled. The length of each species' intercept was expressed as a percent of the total length of the line. Nomenclature follows Waterfall (1969).

Flowering data were obtained from a 1.9 ha area over which was superimposed a grid of sampling points. The grid consisted of ten lines, 15 m apart, each with ten points also located at 15 m intervals. At intervals of approximately 7-10 days, from 15 March to 25 November 1974, the ten lines were traversed and species in flower were recorded. Above ground living plant tissue, green biomass, was harvested in ten randomly located quadrats (25 cm x 25 cm) at about monthly intervals beginning in late May and continuing through early September. Living biomass was oven-dried at 70° C for 48 hours and weighed. To determine sample adequacy a standard error of the mean was calculated and expressed as a percent of the mean for each sampling date.

Wisconsin Site

From the Arboretum's records, blooming dates for 127 species were available for 1950 and 1951. These data were collected by the late John T. Curtis or his student from selected phenological stations. Information about the criteria used in selecting the stations or the frequency at which observations were made was not available. However, based on the beginning and ending dates of flowering for the species, it is apparent that observations were made at least once a week from late April through October. From these data the number of species in flower during 5-day intervals from late April through October was tabulated for the 2-year period.

RESULTS

The dominant species on the Oklahoma site was little bluestem (*Schizachyrium scoparium = Andropogon scoparius*) with 84.9 percent cover as measured by the line transect method (Table 1). Other important species, but each with less than 4 percent cover, were heath aster (*Aster ericoides*), Scribner's panic grass (*Panicum scribnerianum*), blazing-star (*Liatris punctata*), tick-trefoil (*Desmodium sessilifolium*), and old-field goldenrod (*Solidago nemoralis*).

The number of species in flower at each observation date for the Oklahoma site is shown and compared with the number of species in flower during 5-day intervals on the Curtis Prairie (Fig. 1a). The Oklahoma prairie has two periods of maximum flowering, one occurring in late May and early June, and the other in early September. In contrast the Wisconsin site has a single period of maximum flowering occurring in early to mid-August.

For the Oklahoma site the results suggest that two periods occur during the growing season when the "optimum time for flowering" of many species overlap. The number of species in flower per month is plotted with the long-term average monthly rainfall for Edmond, Oklahoma, located 6-miles (9.6 km) to the south (Fig. 1b). Both of the flowering peaks are associated with high monthly rainfall. The depression in flowering occurring in midsummer is associated with the low rainfall during July and early August, a pattern typical of central Oklahoma.

The average number of species in flower per month plotted over the average monthly rainfall (March-November) yields a nearly linear relationship ($r^2 = .64$, $p < .01$); only the month of August has a substantial departure from the linear trend (Fig. 1d). August has more species in flower than would be predicted from its rainfall. An examination of the distribution of rainfall received during 24-hour periods revealed that during the study year an increase in the number of species in flower occurred in early August, even though substantial rainfall did not occur until later in the month.

The flowering pattern for a tallgrass prairie site near Stillwater, Oklahoma, is shown in Figure 2, adapted from Mueller (1964). Percent gravimetric soil moisture in the upper 15 cm of soil and monthly precipitation is also shown. In Mueller's study rainfall was above a 62 year average for July (67 mm versus 96 mm) and 50 mm below the 62 year average for May and June. However, the bimodal flowering pattern is still evident, with a marked decline in flowering during July in spite of relatively heavy rainfall. The soil moisture curve shows a continual depletion of moisture from April through August. Recharge of the upper layers does not begin until September when cooler temperatures prevail. The number of species in flower increases in August even though soil moisture is at its lowest levels.

Our results, as well as those of Mueller (1964), suggest that during early August plants may not be responding to moisture to initiate flowering but perhaps to the more reliable environmental cue, photoperiod. The relationship between the average number of species in flower per month and midmonth day length for the Oklahoma site is shown in Figure 1c. The number of species in flower increases with increasing photoperid through June, decline markedly in July, and

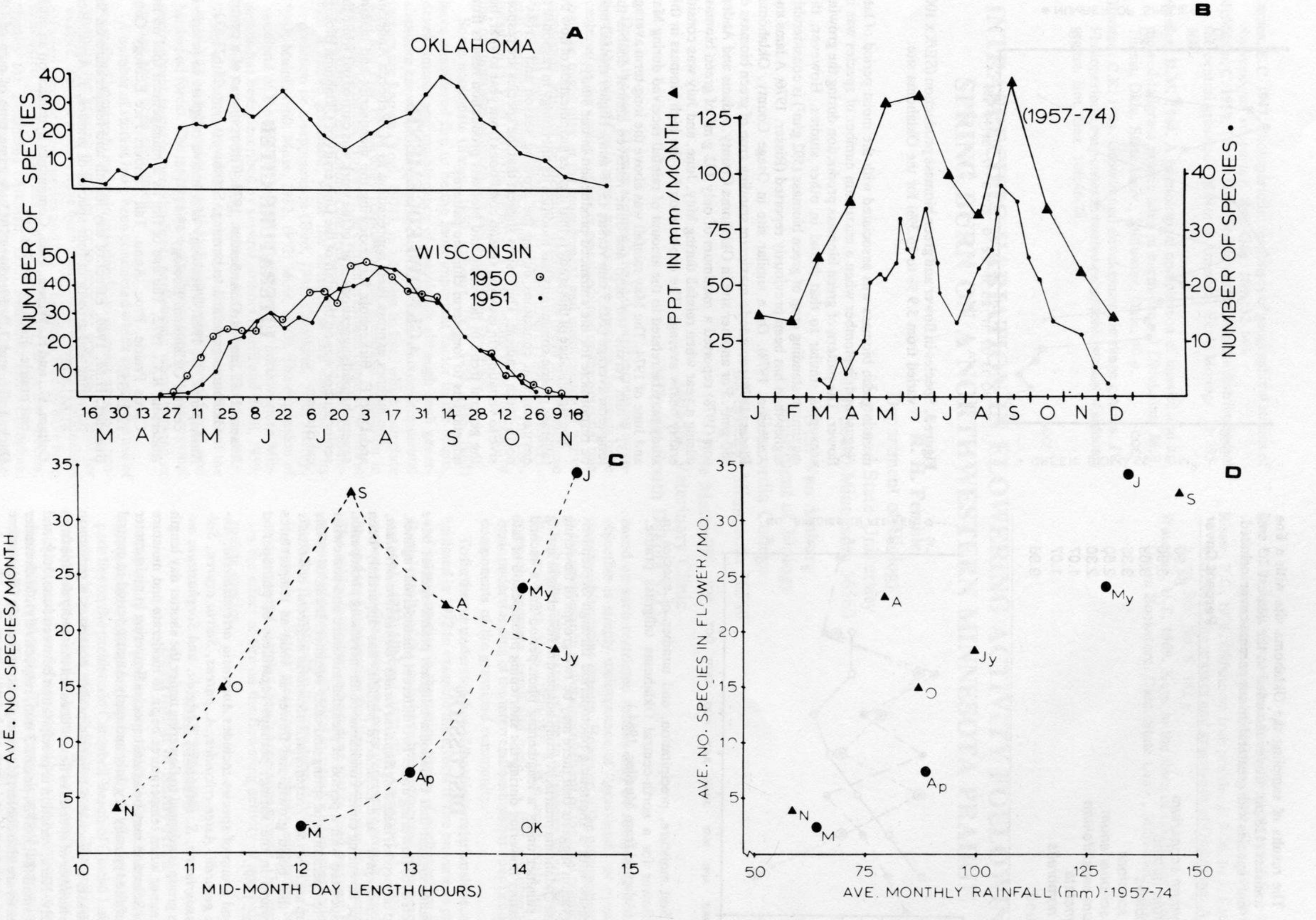

Figure 1A. Comparison of number of species in flower for Oklahoma and Wisconsin tallgrass prairies. **1B.** Comparison of the average number of species in flower per month in an Oklahoma tallgrass prairie and average monthly rainfall (based on an 18-year record). **1C.** Relationship between the average number of species in flower/month and the mid-month day length for the Oklahoma site. **1D.** Relationship between average number of species in flower/month and average monthly rainfall (March-November).

Table 1. The results of sampling the Oklahoma site with a line transect (125 m). Cover recorded to the nearest 2.5 cm, only species with greater than one percent cover included.

	Percent Cover
Schizachyrium scoparium	84.90
Sorghastrum nutans	3.96
Aster ericoides	3.63
Solidago speciosa	3.33
Panicum scribnerianum	2.50
Desmodium sessilifolium	2.30
Liatris punctata	1.07
Solidago nemoralis	1.07
Bare ground	9.96

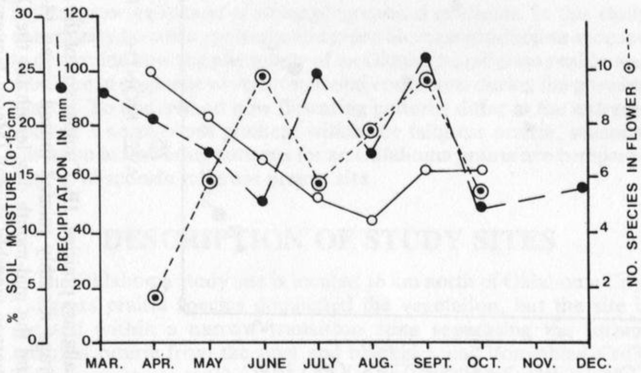

Figure 2. Soil moisture, precipitation, and number of species in flower for a north-central Oklahoma tallgrass prairie. (Adapted from Mueller, 1964.)

then increases with a shortening photoperiod through September. This observation suggests that there may be two groups of flowering plants in the Oklahoma prairie. A group adapted to flowering in spring and early summer under a lengthening photoperiod and a second group initiating flowering during the shortening photoperiod of late summer.

DISCUSSION

The results suggest that Oklahoma tallgrass prairie species have been selected for flowering under two different photoperiod regimes. One group of species, including *Baptisia viridis*, *Oenothera serrulata*, *Sabatia campestris*, and *Echinacea pallida*, has apparently been selected for flowering under conditions of an increasing photoperiod that is associated with a period of plentiful moisture and somewhat moderate temperatures of spring and early summer. Included in this early group are *Hedyotis crassifolia*, *Antennaria neglecta*, and *Oxalis violaceae* that begin growth and flower as soon as temperatures become warm in the spring, perhaps regardless of photoperiod (McMillan, 1959).

A second group of species includes *Ambrosia artemisiifolia*, *Andropogon gerardii*, *Aster ericoides*, *A. patens*, *Salvia azurea*, *Solidago missouriensis*, *S. nemoralis*, *S. rigida*, and *Sorghastrum nutans*. This group is adapted to flowering under the shorter day length of late summer when temperatures begin to moderate and moisture increases. Selection may be against species flowering in midsummer because of the typically dry July and early August period in central Oklahoma.

In contrast, a Wisconsin tallgrass prairie possesses a pattern in which the number of species in flower does not markedly decline from June to July. Here, variation in precipitation between June, July, and August is small (84.5, 87.3, and 82.3 mm, respectively). Midsummer temperatures are also cooler; for example, average July temperature at Madison is 22.3° C and at Oklahoma City, 27.7° C.

The two periods of peak flowering in Oklahoma were associated with times of relatively high rainfall (Fig. 3), but only a small incre-

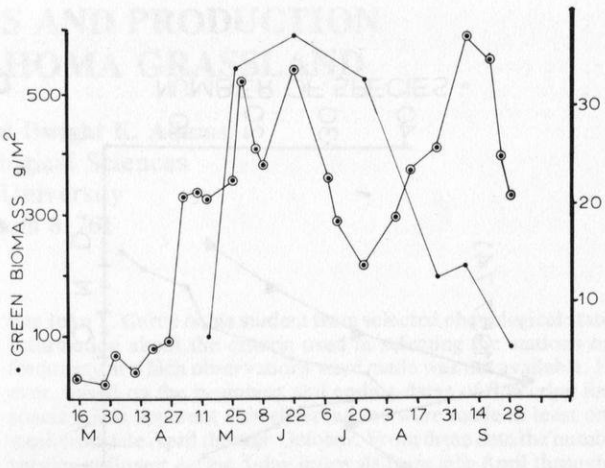

Figure 3. Species in flower and green biomass production (SE/$\bar{x}$ x 100 varied from 5.9 % to 26.3%) for the Oklahoma site.

ment in green biomass was associated with the moist period of late August and September when a maximum number of species was in flower. The pattern of green biomass production during the growing season is similar to that found in other studies. However, the maximum standing crop of green biomass (592 g/m^2) is considerably higher than has been previously reported (Risser, 1976; Adams and Anderson, 1978). On a similar site in Osage County, Oklahoma, Risser (1976) recorded a maximum standing crop of green biomass of 380 g/m^2. For another site in Oklahoma County, Adams and Anderson (1978) reported a maximum of only 132 g/m^2 of green biomass during a year when rainfall during May, June, and July was considerably below average. The explanation for the high biomass in this study may be related to the amount of rainfall received during May and June of 1974. The May rainfall was above the long-term average (131.5 mm versus 160 mm) and June received almost double the long-term average (205.7 mm versus 131.8 mm). Higher rainfall may be responsible for the enhanced production in our study.

The significance of this study is that it gives an indication of how the tallgrass prairie community has modified its phenology in response to environmental conditions during the growing season and across a north-south gradient. The results suggest that the species are responsive to variations in growing season conditions from year to year, but the general trend in flowering and biomass production results from adaptations to long-term climatic patterns.

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INTRASPECIFIC VARIATION IN FLOWERING ACTIVITY FOLLOWING A SPRING BURN ON A NORTHWESTERN MINNESOTA PRAIRIE

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During the past 20 years ecologists have devoted increasing attention to the role of fire in native grassland ecosystems. Interests have centered on the ecology of fire in grasslands and on the potential role that fire might play in the management and maintenance of native grasslands. Much of the literature dealing with fire in North American grasslands has been summarized by Daubenmire (1968) and by several contributing authors in Kozlowski and Ahlgren (1974). The contribution by Vogl (1974) in the latter is outstanding in its coverage of the relationships between fire and grassland vegetation.

Some ecologists (Sauer, 1950; Stewart, 1951, 1955, 1956, 1963) have considered fire to be the most important factor in the origin, development, and maintenance of grasslands although such generalizations are without supporting evidence. Numerous environmental factors are known (Vogl, 1974), in addition to fire, which correlate with and may be partially responsible for grassland vegetation in particular localities. However, in certain grassland types as well as in the grassland-forest ecotones the presence of periodic fires can maintain a native grassland, while the absence of fire can lead to its degradation or disappearance (Bird, 1961; Coupland, 1950; Jeffrey, 1961; Maini, 1960; Moss, 1932, 1952; Muir, 1965). The expansion of woodland at the expense of native grassland in northwestern Minnesota has been described by several authors (Buell and Buell, 1959; Buell and Facey, 1960; Ewing, 1924; Svedarsky and Buckley, 1975; Tester and Marshall, 1962). At the time of European settlement the vegetation on this region included tallgrass prairie, boreal forest, and hardwood forest. The maintenance of tallgrass prairie in this regional environment requires periodic fires, particularly where mowing or grazing have been eliminated.

A number of studies have been conducted which support the use of prescribed burning to maintain grasslands, to increase grassland productivity for grazing purposes, or to improve grassland habitat for wildlife. Yet few studies have been done concerning the relationships between specific plant species and fire. When such studies have been conducted, the emphasis has generally been on only a few species, usually the dominants (Aikman, 1955; Blaisdell, 1953; Cornelius, 1950; Curtis and Partch, 1948, 1950; Dix, 1960; Dix and Butler, 1954; Dokken and Hulbert, 1978; Ehrenreich, 1959; Ehrenreich and Aikman, 1957, 1963; Hadley and Kieckhefer, 1963; Hill and Platt, 1975; Koelling and Kucera, 1965; Kucera and Ehrenreich, 1962; Old, 1969; Olson, 1975; Robocker and Miller, 1955). Burning prescriptions based on such restricted studies may be acceptable if the primary objective is simply maintenance of "grassland" or even grassland dominated by native grasses. However, if the management objective is the maintenance and/or improvement of the total prairie community, then the relationship of fire to all species should be considered. We agree with Vogl (1974:181) that a need exists for "vigorous research programs, small and large . . . that will objectively seek basic understanding of the interrelationships between fire and various components of the grassland community."

To further an understanding of these interrelationships, a study was initiated in 1972 to examine the effects of fire on various prairie plant and animal species in the prairie region of northwestern Minnesota. Partial results of the study have been presented elsewhere (Harmoning et al., 1973; Hibbard, 1972; Van Amburg et al., 1981). The plant responses to fire considered were vegetative growth, flowering activity, and seed germination, but the emphasis was on flowering activity. The ability to flower and produce viable seed may not be the best measure of potential ecological success for all species under all conditions, but it is critical for the long-term survival of most. In addition, it is probably a better measure of a plant's adaptation to the total environmental complex than is vegetative growth. This report discusses the effect of fire on the flowering activity of approximately 100 prairie species.

METHODS

Description of Study Area

The study was conducted at Buffalo River State Park located in northwestern Minnesota approximately 21 km east of Moorhead. The park lies on the prehistoric Campbell Beach of Glacial Lake Agassiz, a lake which existed some 10,000 years ago. The soils are predominantly loams and sandy loams. The regional climate is subhumid, midcontinental, and characterized by wide variations in temperature from summer to winter. The average length of the growing season is about 120 days. The mean annual precipitation is about 450 mm, about 75 percent of which falls during the period of April through September.

The park is located about 40 km west of the prairie-forest ecotone. Within the park the presettlement vegetation was a mosaic of tallgrass prairie and gallery forest (Marschner, 1974). Presently, about 400 hectares are within the park boundaries; approximately one-third is woodland associated with the Buffalo River. The wooded portion has been in public ownership for more than 40 years. The remainder of the park is grassland, most of which has been acquired within the last 15 years. Prior to acquisition, the grassland areas had been used for various purposes including grazing, native hay production, and sod production. Part of the grassland may also have been disturbed by cultivation. After acquisition by the state and until 1972, no attempt was made to manage the grassland areas in the park. As a result, by 1972 much of the grassland area in the park was dominated by *Poa* sp., both *P. pratensis* and *P. compressa,* and *Bromus inermis* with extensive stands of *Symphoricarpos occidentalis,* expanding groves of *Populus tremuloides,* and, on wetter sites, brush-prairie dominated by *Cornus stolonifera* and *Salix* sp. Seedlings of *Fraxinus pennsylvanica, Acer negundo,* and *Ulmus siberica* were established in scattered localities in the "prairie" areas of the park.

In the spring of 1972, prescription burning was introduced for the first time in the park as a prairie management tool. The first burn was conducted on the second of May on an overcast day with high humidity, wet to damp soil, and almost no wind. A back-fire was used on the north edge of the burn to establish a fire break. A head-fire was used to burn the remainder of the tract. The burn covered an area of approximately 55 ha. The area burned included various local site types ranging from relatively dry prairie on a 20° south-facing slope near the Buffalo River to wet prairie with standing water during much of the growing season. Past histories of these sites also varied from undisturbed to cultivated.

Sampling Techniques

Prior to the initial burning treatment a control strip which included five of the site types was established along the north edge of the burn. Five pairs of 50 × 50 m plots were located along the control strip, each pair on a different site type. An additional pair of 25 × 25 m plots were established near the south edge of the burn. The plots were subdivided into 25 subplots of equal area. Data for most of the species was gathered from 25 one square meter quadrats each of which was located in the center of one of the subplots. Low density species were counted throughout the entire plot.

Data were gathered on a total of 116 species representing 34 families of vascular plants. Of these, some index of flowering activity was obtained for nearly 100 species. The nature of the index varied with the species. Where it was relatively easy to determine what constituted an individual, the total number of flowering plants per unit area was measured. In other cases, flowering stems or flowering culms were counted. Since fire does affect the phenological activity of many plant species (Ehrenreich and Aikman, 1963) counts were repeated to correspond with peak flowering activity on burned and unburned sites for each species. Some species reached their flowering peak on burned plots as much as two weeks earlier than on unburned ones.

RESULTS

A species by species comparison for each pair of plots was made using a chi-square technique. The results are presented in Table 1. Each of the six columns in the table correspond to one of the six site types examined. All vascular plant species encountered in one or both of the paired plots for a particular site have had their flowering index calculated. The species have been arranged alphabetically by genus. A chi-square value in a particular column after a species name indicates that the species was present in one or both of the paired plots on that site type. Species whose flowering activity was stimulated by fire are indicated by a plus sign (+) following the chi-square value. Species which showed decreased flowering activity after the spring burn are indicated by a minus sign (-) following the chi-square value.

DISCUSSION

One of the most visible effects of the spring burn was the increase in flowering activity of many prairie species on the burned sites. Intraspecific differences in flowering activity on burned versus unburned plots were apparent early in the summer in such species as *Galium boreale* and *Hypoxis hirsuta* and were still apparent through the fall flowering period for such species as *Aster ericoides* and *Andropogon gerardii*. Indications that fire affects flowering activity in some species is well known. Increased numbers of inflorescences in graminoid species have been reported for *Andropogon gerardii* (Aikman, 1955; Cornelius, 1950; Curtis and Partch, 1948, 1950; Dix and Butler, 1954; Ehrenreich and Aikman, 1957, 1963; Kucera and Ehrenreich, 1962; Old, 1969; Olson, 1975), *Andropogon scoparius* (Aikman, 1955; Cornelius, 1950; Dix and Butler, 1954; Ehrenreich and Aikman, 1957, 1963; Kucera and Ehrenreich, 1962; Old, 1969; Olson, 1975), *Agropyron trachycaulum* (Ehrenreich and Aikman, 1963), *Agrostis stolonifera* (Ehrenreich and Aikman, 1963), *Bouteloua curtipendula* (Cornelius, 1950), *Koeleria cristata* (Ehrenreich and Aikman, 1963), *Muhlenbergia* sp. (Ehrenreich and Aikman, 1963), *Panicum virgatum* (Cornelius, 1950; Old, 1969; Olson, 1975), *Sporobolus heterolepis* (Aikman, 1955; Dix and Butler, 1954; Ehrenreich and Aikman, 1957, 1963), and *Carex* sp. (Ehrenreich and Aikman, 1957, 1963). Grasses in which flowering activity has been reported to decrease after burning include *Stipa comata, Stipa viridula,* and *Agropyron smithii* (Dix, 1960). A decrease in the vegetative growth and often, but not always, flowering activity of cool-season species such as *Poa pratensis* and *Bromus inermis* following fire is well known (Aldous, 1934; Curtis and Partch, 1948; Ehrenreich and Aikman, 1963; Hadley and Kieckhefer, 1963; Hill and Platt, 1975; Old, 1969; Olson, 1975). Flower stalk production of *Elymus canadensis,* a cool-season species, has been reported to increase after fire in Iowa (Aikman, 1955) although the total numbers of plants per unit area decreased after a fire in Wisconsin (Robocker and Miller, 1955). The flowering activity of *Sorghastrum nutans* has been reported to increase with fire in Missouri (Kucera and Ehrenreich, 1962), Iowa (Aikman, 1955; Ehrenreich and Aikman, 1957, 1963), and Illinois (Old, 1969), but it is reported to decrease in Wisconsin (Dix and Butler, 1954). Little information is in the literature on any response of prairie forbs to fire. Ehrenreich and Aikman (1963:125) examined the effect of fire on the flowering activity of several prairie forbs and concluded that "generally native prairie plants produced more flowers and taller flowering stalks on burned than on unburned areas." Exceptions, however, included *Achillea millefolium* ssp. *lanulosa* and *Lithospermum canescens.* After an early spring burn in Wisconsin, Curtis and Partch (1948) observed a decline in the number of flowering plants of *Echinacea pallida* and an increase in numbers of *Liatris aspera* and *Solidago ridiga;* no mention is made of differences in flowering activity. They observed no effect from fire on original numbers of *Baptisia leucantha* or *Eryngium yuccifolium.* Following a lightning-caused spring fire in the Nebraska Sand Hills, Wolfe (1973) observed (1) an increase in total numbers of plants in *Kuhnia eupatorioides, Petalostemum villosum, Sideranthus spinulosus,* and *Solidago missouriensis;* (2) a decrease in numbers of *Chenopodium leptophyllum, Commelina virginica, Lepidium* sp., *Lithospermum* sp., *Plantago purshii,* and *Ratibida columnaris;* and (3) no change in numbers of *Ambrosia psilostachya, Euphorbia missurica, Helianthus laetiflorus,* and *Physalis heterophylla.*

With the exception of *Sorghastrum nutans,* a differential intraspecific response to fire in prairie species has not generally been noted in the literature. Still Olson (1975) reported intraspecific variation in flowering activity of several native grasses in response to prescribed burning at different times of the year. Our observations support Olson's conclusion that the time of burning is critical in determining the nature of a particular species' response to fire. However, we have also learned that considerable intraspecific variability exists in response to any single fire depending on local site conditions.

For example, *Andropogon gerardii* produced significantly more flowering culms following fire on the south-facing slope where it was restricted to the lower half of the slope, on a nearly level mesic site in disturbed prairie, and in the depression site, but no significant difference was apparent in flower stalk production on the level, mesic undisturbed prairie site or the wet-mesic disturbed prairie site. A differential response with a different pattern was shown by *A. scoparius.* This species produced more flowering culms following fire on all but the level, mesic upland prairie site. *Bouteloua curtipendula* was stimulated on the driest site but inhibited on one mesic upland site. No significant difference was noted on the other mesic upland site where *B. curtipendula* also occurred. *Poa* sp., including both *P. pratensis* and *P. compressa,* were significantly inhibited by fire on the driest site, showed no significant differences on a mesic upland site, and were stimulated on all other sites where they occurred.

Differential intraspecific response to fire depending on local site conditions were noted for most of the species encountered in this

Table 1. Flowering response to a prescribed spring burn on a (1) dry-mesic south-facing slope site in undisturbed prairie, (2) nearly level mesic site in a badly disturbed prairie, (3) level mesic site in undisturbed prairie, (4) gently sloping to nearly level mesic site in undisturbed prairie, (5) level wet-mesic site in badly disturbed prairie, and (6) wet swale site in undisturbed prairie. The numbers shown are chi-square values ($X^2_{.05} = 3.84$ for df = 1). A plus sign (+) following the chi-square value indicates stimulation of flowering activity and a minus sign (−) indicates inhibition of flowering activity. Species were absent from those sites where no chi-square value appears.

	Site Types					
	1	2	3	4	5	6
Agropyron trachycaulum		1.3(+)	0	0.5(+)	9.1(+)	0.8(−)
Agrostis stolonifera		8.5(+)		0		13.1(−)
Allium stellatum	0		2.3(+)	0.5(+)		
Amorpha canescens	0.2(+)				0	
Andropogon gerardii	25.7(+)	10.1(+)	3.1(+)	0.5(+)	2.6(+)	53.8(+)
A. scoparius	359.4(+)		0.9(+)	439.7(+)	46.0(+)	16.1(+)
Anemone candensis			4.9(−)			100.0(+)
A. cylindrica			0			
Apocynum sibiricum		0.5(+)				
Artemisia ludoviciana	0.1(+)		0	0		
Asclepias syriaca		0				
A. verticillata					0	
Aster ericoides	14.7(+)	14.7(−)	81.5(+)	0.1(+)	23.3(+)	5.7(+)
A. laevis	4.4(−)	23.0(−)	3.4(+)	5.7(+)		
A. ptarmicoides				40.0(+)		
Astragalus agrestis	3.2(−)		2.3(+)	0.5(+)	0	
Bouteloua curtipendula	70.3(+)		10.6(−)	0.1(+)		
B. gracilis	7.1(+)					
Bromus inermis		6.8(−)	0		0	
Campanula rotundifolia	0					
Calamagrostis inexpansa					8.4(+)	13.8(+)
C. neglecta				0.1(+)		
Carex sp.		11.5(+)				0.5(−)
Chrysopsis villosa	3.2(+)					
Cirsium arvense		0			2.4(−)	
Convolvulus sepium		50.2(+)				
Conyza canadensis	0					
Cornus stolonifera		0			0	
Echinacea pallida	201.5(+)					
Erigeron philadelphicus		0		0.5(+)		
Galium boreale	0	15.1(+)	45.4(+)		72.6(+)	
Gentiana andrewsii				0		15.4(+)
Gerardia tenuifolia		0				
Helianthus laetiflorus			0		0.2(+)	
Helianthus maximilianii				6.1(−)	0.1(−)	59.3(+)
Hordeum jubatum						0
Hypoxis hirsuta				125.2(+)		115.6(+)
Iva xanthifolia					0.5(+)	
Juncus balticus					3.2(+)	5.9(+)
Lactuca pulchella	0				12.9(−)	
Lathyrus palustris						0
Liatris aspera	0.9(−)		2.9(+)			
L. punctata	211.2(+)					
L. pycnostachya					9.1(−)	0
Lithospermum canescens			4.1(+)			
Lysimachia ciliata		1.3(+)				
Medicago lupulina			20.0(+)	387.0(+)		0
M. sativa			1.3(−)			
Melilotus alba	0	0		10.1(+)		
M. officinalis				6.8(−)		
Muhlenbergia richardsonis					1.6(−)	69.1(+)
Oenothera biennis					0	
Oxalis violacea	0		4.2(−)			
Panicum virgatum		1.3(+)	1.5(+)	2.8(+)		10.6(−)
Petalostemum candidum			0			
P. purpureum	0.2(+)		4.3(+)	1.1(+)	4.2(+)	
Poa sp.	121.4(−)	27.8(+)	13.4(+)	0.3(+)	52.4(+)	3.9(+)
Polygonum natans						0
Potentilla arguta					2.2(+)	
Prenanthes racemosa			0	0.2(+)	6.8(+)	4.2(+)
Psoralea argophylla	62.9(+)		16.0(+)	1.8(−)	6.1(+)	
P. esculenta	4.9(+)					
Pycnanthemum virginianum		7.1(−)			19.1(−)	0.5(−)
Ratibida columnifera			0.5(−)	0.5(+)		
Rosa suffulta			0			0
Rumex crispus		10.6(+)			0.2(+)	
Senecio aureus						9.1(+)

Table 1. (cont.) Flowering response to a prescribed spring burn on a (1) dry-mesic south-facing slope site in undisturbed prairie, (2) nearly level mesic site in a badly disturbed prairie, (3) level mesic site in undisturbed prairie, (4) gently sloping to nearly level mesic site in undisturbed prairie, (5) level wet-mesic site in badly disturbed prairie, and (6) wet swale site in undisturbed prairie. The numbers shown are chi-square values ($X^2_{.05} = 3.84$ for df = 1). A plus sign (+) following the chi-square value indicates stimulation of flowering activity and a minus sign (−) indicates inhibition of flowering activity. Species were absent from those sites where no chi-square value appears.

	Site Types					
	1	2	3	4	5	6
Setaria viridis		19.1(+)	0	1.5(+)	1.3(+)	
Sisyrinchium angustifolium			0.5(−)	4.8(+)		6.3(+)
Sium suave						1.8(+)
Solidago canadensis	0	6.4(−)	0.6(+)	5.8(+)	5.1(+)	59.4(+)
S. missouriensis		2.2(+)				
S. rigida		0	0	0		
Sonchus arvensis				0	7.7(+)	0.5(+)
Sorghastrum nutans	0				1.1(+)	25.0(+)
Spartina pectinata				0		8.1(+)
Spiranthes cernua		0				
Sporobolus heterolepis	7.1(+)	4.2(+)		120.0(+)		0.5(+)
Stipa spartea			4.2(+)	1.3(+)		
Thalictrum dasycarpum					0.5(−)	
Tragopogon dubius	0					
Trifolium pratense		0				
T. repens				0.5(+)		
Verbena hastata		5.1(+)		10.0(−)		0.1(+)
V. urticifolia					0	
Vernonia fasciculata						2.4(+)
Vicia americana	0					
Zizia aptera			0		4.2(+)	1.3(+)
Z. aurea					3.2(+)	9.1(+)
Zygadenus elegans						0.5(−)

study. Dokken and Hulbert (1978), and Robocker and Miller (1955) reported similar patterns for several species although their studies were restricted to a comparison of only two site types and they did not differentiate between flowering and vegetative stem production. Wolfe (1973) also reported a differential intraspecific response with variations in local site conditions for four forbs, *Helianthus petiolaris*, *Amaranthus* sp., *Froelickia floridana*, and *Liatris punctata*, in the Nebraska Sand Hills. Again, no attempt was made to differentiate between flowering and vegetative responses. The only known study where the relationship between local site conditions, fire and flowering activity has been noted and discussed is that of Zedler and Loucks (1969). They described definite intraspecific differences in the flowering response of *Poa pratensis* and *Andropogon scoparius* to fire depending on local site conditions. *Andropogon scoparius* was not always stimulated by fire nor was *Poa pratensis* always suppressed. In fact on the wetter sites, *Poa pratensis* produced more flower stalks after burning. This result is inconsistent with the general observation that warm-season native grasses are stimulated by fire while cool-season species are inhibited. Our data is consistent with that of Zedler and Loucks (1969) for both *Poa* sp. and *Andropogon scoparius*, at least with regard to their intraspecific variation in flowering response to a single burn. More importantly, our observations suggest that such variability is the rule rather than the exception for most prairie species. The only species which showed no variability were *Convolvulus sepium*, *Bouteloua gracilis*, *Echinaea pallida*, *Hypoxis hirsuta*, *Liatris punctata*, *Lithospermum cancescens*, *Senecio aureus*, and *Psoralea esculenta*. These species were all restricted to single site types and in all cases their flowering activity was stimulated by fire. Significantly, no species in our study showed a reduced flowering response on all sites where it occurred after the spring burn.

Although intraspecific variability in flowering response to fire is clearly the rule for most prairie species, the explanation for such patterns is less obvious. Several factors which may be responsible for increased flowering activity following fire have been suggested in the literature. Of these, stimulation of flowering due to the direct heat of fire is considered of doubtful significance (Curtis and Partch, 1950; Ehrenreich and Aikman, 1963). Most authors seem to agree that the primary factor responsible for increased flowering activity after burning is the simple physical removal of litter and standing dead stems by fire (Curtis and Partch, 1950; Ehrenreich and Aikman, 1957, 1963; Old, 1969). This removal of litter allows for higher temperatures and increased light intensities near the soil surface early in the growing season which results in increased rates of vegetative growth in the spring. Ehrenreich and Aikman (1963) suggested that greater growth in the spring would allow for more carbohydrate production which in turn could induce the differentiation and growth of flower stalks (Loomis, 1953). If the latter is correct, then any change which results in increased vegetative growth should lead to increased flowering activity.

Some evidence exists that the addition of nutrient-rich ash may have a limited effect, but ash has not generally been considered a major factor in the flowering response (Burton, 1944; Curtis and Partch, 1950; Ehrenreich and Aikman, 1963; Old, 1969). Significant increases in flowering activity have, however, been obtained with nitrogen fertilizer (Burton, 1944; Aldous, 1932; Old, 1969). Old (1969) believes that the removal of litter produces a more favorable microenvironment for microbial activity which in turn increases nitrogen levels. Microbial activity may also be affected by pH which is higher on burned areas (Ehrenreich and Aikman, 1963; Old, 1969).

Competition has also been considered to play a role in flowering activity (Curtis and Partch, 1948; Hill and Platt, 1975; Old, 1969). Old (1969) stated that in the absence of fire, competition from cool-season species such as *Poa pratensis* and *Bromus inermis* contributes to the reduction in flowering of warm-season species. By reducing the abundance of cool-season species, fire results in improved plant growth conditions for the warm-season natives. With increased vegetative growth early in the year, more flowering activity is evident as the season progresses.

If, as the literature implies, the major factors affecting flowering activity are the presence or absence of litter and the degree of competition from cool-season species, a partial explanation for the differential intraspecific responses observed in our study may be available. One of the observations made immediately after our initial burn was the lack of uniformity of litter removal by the fire. On the drier sites the litter was almost completely consumed, but in the wetter depressions considerable litter remained after the fire. If litter removal is the key to stimulating flowering activity, it would seem that nonuniform litter removal would result in nonuniform flowering activity. On sites where the litter was completely removed, the flowering activity of warm-season species might be greater than on those sites where considerable litter was left after the fire. If competition is involved a similar pattern should develop on the drier sites where fire does more damage to cool-season species (Zedler and Loucks, 1969), one might expect increased flowering of warm-season species. On those sites where cool-season species are not harmed, a reduction in flowering activity of warm-season species might be expected.

While the flowering responses of some of the species in our study more or less agree with this expected pattern, many do not and the reasons are not clear at this time. Daubenmire (1968) mentioned the possibility of ecotypic differentiation in prairie species in response to different fire frequencies. Ecotypic differentiation in response to different regional climates has been described for several prairie grasses (McMillan, 1959), but no studies are known to have been conducted on possible ecotypic differentiation in response to different fire regimes. Studies which examine the possibility of local ecotypic differentiation in response to different site conditions have not been carried out even though local ecotypic variation is known to play a role in some vegetational patterns (Bradshaw and Snaydon, 1959; Briggs, 1962). Perhaps some of the observed intraspecific variation in flowering response is related to local ecotypic variation in prairie species.

Regardless of the explanation, the fact remains that while no prairie species seems consistently vulnerable to the detrimental effects of prescribed burning, the intraspecific response of each species is far from uniform. In fact, it appears that fire may actually favor an increased diversity in the prairie as a whole by favoring some species on certain sites and others as site conditions change. Hill and Platt (1975) suggested that periodic burning results in a temporal resonance between prairie dominated by warm-season (C_4) species and cool-season (C_3) species. Our data suggests that the degree of resonance may be as much a function of local site differences as frequency of burning.

SUMMARY

Prescription burning was introduced in 1972 as a tallgrass prairie management and restoration technique at Buffalo River State Park in northwestern Minnesota. During the growing season following the initial spring burn, records were kept of the flowering response of more than 100 species. Burned and control plots were located on six different site types ranging from a wet depression to a dry, south-facing slope. Many of the species studied occurred on more than one site and their flowering response to fire often varied significantly with site type. The results of the study suggest that the effects of prescribed burning in the tallgrass prairie are dependent on the specific site conditions present.

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RESPONSE OF ARTHROPODS TO A SPRING BURN OF A TALLGRASS PRAIRIE IN NORTHWESTERN MINNESOTA

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The use of fire as a tool in the management of forest and grassland ecosystems has acquired an impressive acceptance within the past decade. A large amount of literature has been generated by numerous studies, usually concerning the response of vegetation to fire (Daubenmire, 1968; Kozlowski and Ahlgren, 1974). Relatively few studies have examined the effect of burning upon other components of the ecosystem such as the soil flora and fauna, or above ground arthropods. Literature becomes even more scant when considering a particular type of ecosystem or geographical area (Vogl, 1974). It is likely that the ecosystem itself and/or the geographical area, including the response of the vegetation, are important in determining how burning will affect all components of an ecosystem. The purpose of this study was to determine the response of arthropod populations to a single spring burn on a tallgrass prairie.

METHODS

The study site was located within Buffalo River State Park, Clay County, Minnesota. A parcel of approximately 55 ha of level to gently rolling tallgrass prairie was burned on 2 May 1972. An 11 ha control strip (100 m x 1080 m) along the north edge of the site was unburned. Five pairs of 50 m x 50 m plots along the border of the burned and control area were established. An additional pair of plots (25 m x 25 m) along the south border of the burn was also established to include a site with a steep south-facing slope. The location of each pair was based on site characteristics, with each pair being judged floristically homogeneous. Response of the vegetation and a more thorough description of the study area is reported in a separate paper (Pemble et al., 1981).

All collections of arthropods were made within the plots. The sampling period of 15 weeks was from 3 May through 9 August. Sweep net collections of five equally spaced passes down each plot were conducted weekly. Each plot received an equal number of sweeps. Net collections were placed in cyanide jars until they were sorted and identified.

Litter and soil arthropods were sampled by using a device that extracted a core 10 cm in diameter and 15 cm deep (727.5 cm^3). Three of these core samples were taken each week from all plots on the same day during the sampling period. The core samples were located randomly by gridding the plots. Organisms within these samples were extracted by the Berlese funnel method.

All specimens collected were mounted on pins, slides, or preserved in alcohol and identified to order or family. Only adult specimens were identified. Identification below the family level was not attempted due to the large number of specimens and the need for many specialists. All specimens are held as a permanent collection in the Concordia College Biology Department Museum, Moorhead, Minnesota. Specialists interested in any of the taxa represented in the data are invited to use this collection to make more precise identifications.

The data were originally separated according to plots. This resulted in small numbers of many of the taxa. Therefore, data were combined into two categories: burned and unburned. Chi square analysis of each taxon was used to determine if significant differences in populations existed between the burned and unburned treatments.

RESULTS AND DISCUSSION

The numbers of each taxon and the distribution between treatments are given in Table 1. Calculation of the chi square value was based on the assumption that equal numbers of a taxon would occur on each treatment. A significant departure from the expected value indicated a response to burning. Several taxa were discovered to differ significantly from the expected value.

Two groups, mites and ticks, within the Order Acari showed an opposite response to burning. Mite populations on the burned plots were greater than on unburned plots. Pomeroy and Rwakaikara (1975) have reported a similar response in burning East African grasslands. Mites are an extremely diverse group with many scavengers that feed on detritus. Since spring burning stimulates root growth (Dahlman and Kucera, 1965), increased levels of detritus may account for the larger mite populations on the burned plots (Lussenhop, 1976). These results also indicate that the fire had little or no direct affect upon the soil fauna. This is probably to be expected since fire in grasslands does not usually penetrate the soil or elevate subsurface soil temperatures to lethal levels (Vogl, 1974).

Ticks were more numerous on the unburned plots. All of the ticks collected were the genus *Dermacentor*, a common vertebrate parasite. This genus is usually more common in areas of brush, dense vegetation, and litter. Burning destroys this type of habitat and reduces the tick population.

Collembola are considered to be an important group of the soil/litter fauna, often second in abundance only to mites. One family in this order, Sminthuridae, occurred in significantly greater numbers on the unburned plots. The raw data show this response occurred some 45 days after the burn. Samples taken at the time of the burn through 41 days after the burn show total springtails to be nearly equal in abundance on control and burn plots (Fig. 1). Forty-one days after the burn collembolan populations began increasing on both treatments. However, the numbers of springtails on the burned plots soon reached a maximum and began a slow decline, while those on the unburned plots continued to increase. Pomeroy and Rwakaikara (1975) reported collembolans to decrease on areas subjected to two burns per year and theorized that drying of the soil was the cause. The decline of collembolans on the burned plots did occur at a time in the growing season when moisture can become limiting. Removal of litter, a darkened surface, and increased insolation cause an increase in soil temperature, greater evaporation rate, and reduction in soil moisture on burned sites (Old, 1969). Soil samples taken 72 days after the burn showed the soil moisture in the top 15 cm to be higher in the control plots on all sites (Fig. 2). Such a decrease of soil moisture on the burned plots may account for the decrease of collembolans.

Six families within the Order Coleoptera exhibited a response to burning. The families Carabidae, Coccinellidae, and Staphylinidae, generally considered predacious, were significantly more abundant on the burned plots. Meloidae, with herbivorous adults, were also more numerous on burned plots. Tester and Marshall (1961) suggested that greater Coleoptera populations are associated with sparse litter but drew no conclusions. Nagel (1973) noted these same taxa to have a greater frequency on a burned true prairie site. Response of these taxa would seem to indicate that burning produces a more suitable habitat. In the case of predators, more prey may be available. The adults of Meloidae often feed on pollen. The vegetative response of greater flower production on burned plots (Pemble et al., 1981) may explain the higher numbers of Meloidae on these plots. Cantharidae and Elateridae were more numerous on unburned plots.

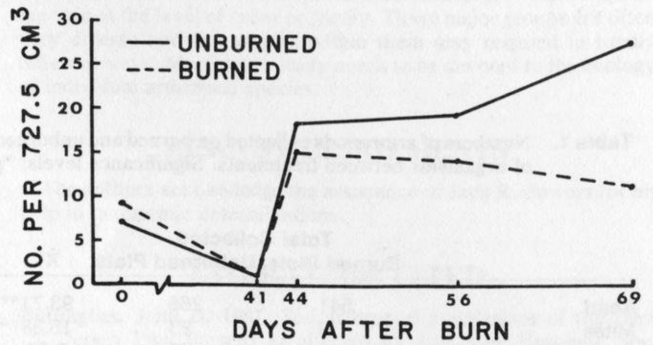

Figure 1. Numbers of collembolans per volume of soil on burned and unburned control plots at selected time intervals after the burn.

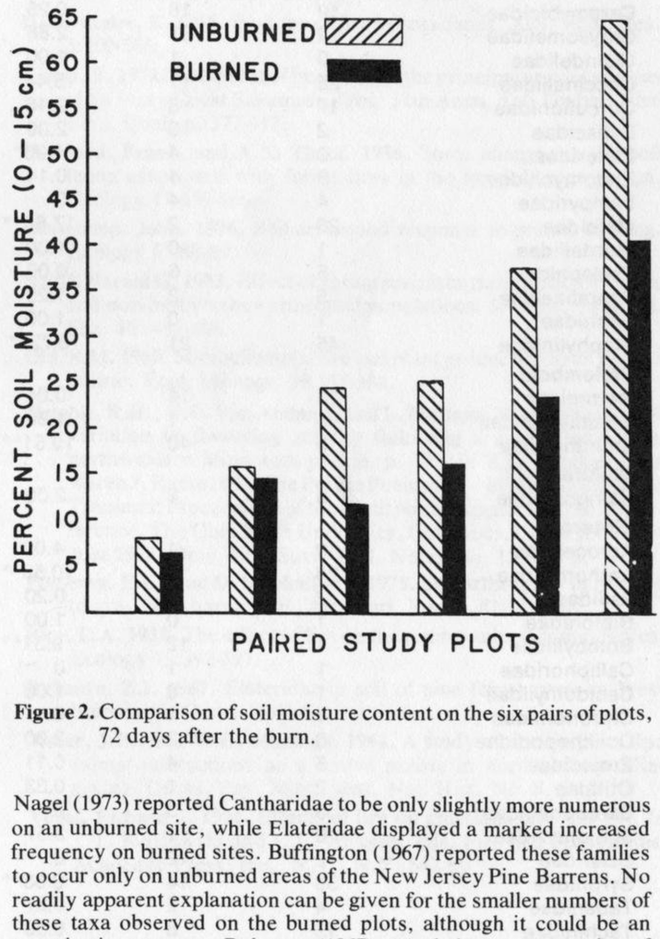

Figure 2. Comparison of soil moisture content on the six pairs of plots, 72 days after the burn.

Nagel (1973) reported Cantharidae to be only slightly more numerous on an unburned site, while Elateridae displayed a marked increased frequency on burned sites. Buffington (1967) reported these families to occur only on unburned areas of the New Jersey Pine Barrens. No readily apparent explanation can be given for the smaller numbers of these taxa observed on the burned plots, although it could be an organismic response. Rubzova (1967) stated that some species of Elateridae were restricted to burned areas while others were more numerous on unburned land.

The Order Diptera is represented by a relatively large number of families in the grassland fauna. Two dipteran families, Acroceridae and Bombyliidae, had significantly larger numbers in the unburned plots. The Acroceridae are generally considered to be rather rare. Little is known about the life histories of either family. Two other dipteran families, Anthomyiidae and Syrphidae, were in greater numbers in the burned plots. Many of the Anthomyiidae are herbivorous, the larvae being root maggots and leaf miners. Increased vegetative production may explain their higher population in the burned plots. Syrphidae are often aggregated about flowers. Increased flower production could have caused increased numbers of Syrphidae on the burned plots.

Table 1. Numbers of arthropods collected on burned and unburned plots. Chi square values computed assuming an expected equal distribution of organisms between treatments. Significance levels: *$p < 0.05$; ** $p < 0.01$.

	Total Collected Burned Plots	Total Collected Unburned Plots	X^2
Acari	541	266	93.71**
Mites	3	23	15.38**
Ticks (Ixodidae)	41	46	0.29
Pseudoscorpionida	0	1	1.00
Spirobolida	4	0	4.00*
Coleoptera			
Cantharidae	0	7	7.00**
Carabidae	11	1	8.33**
Ceramybicidae	19	16	0.26
Chrysomelidae	19	31	2.88
Cicindelidae	0	1	1.00
Coccinellidae	25	11	5.44*
Curculionidae	17	9	2.46
Dytiscidae	2	0	2.00
Elateridae	0	4	4.00*
Endomychidae	3	4	0.14
Lampyridae	4	4	0
Meloidae	23	2	17.64**
Mordellidae	1	0	1.00
Pselaphidae	5	6	0.09
Scarabaeidae	5	2	1.29
Silphidae	1	0	1.00
Staphylinidae	45	21	8.73**
Collembola			
Isotomidae	13	14	0.04
Entomybryiidae	4	1	1.80
Sminthuridae	9	40	19.61**
Diplura			
Campodeidae	0	2	2.00
Diptera			
Acroceridae	0	4	4.00*
Anthomyiidae	29	9	10.53**
Asilidae	2	3	0.20
Bibionidae	1	0	1.00
Bombyliidae	1	12	9.31**
Calliphoridae	1	1	0
Cecidomyiidae	1	0	1.00
Chironomidae	1	0	1.00
Dolichopodidae	0	2	2.00
Empididae	5	4	0.11
Otitidae	2	1	0.33
Sarcophagidae	3	3	0
Schiomyzidae	6	1	3.57
Sciaridae	2	2	0
Syrphidae	36	14	9.68**
Tabanidae	4	2	0.67
Tachinidae	12	8	0.80
Tipulidae	1	2	0.33
Ephemeroptera	1	0	1.00
Hemiptera			
Coreidae	0	1	1.00
Lygaeidae	2	0	2.00
Miridae	23	18	0.61
Nabidae	1	2	0.33
Pentatomidae	7	8	0.07
Phymatidae	0	3	3.00
Reduviidae	0	1	1.00
Homoptera			
Aphidae	11	20	2.61
Cicadellidae	66	51	1.92
Delphacidae	19	6	6.76**
Dictyopharidae	5	7	0.33
Margarodidae	2	3	0.20
Membracidae	2	4	0.67
Psyllidae	10	4	2.57
Hymenoptera			
Andrenidae	5	3	0.50
Apidae	12	20	2.00
Braconidae	3	3	0
Chalcidoidea	1	0	1.00
Cynipoidea	1	0	1.00
Formicidae	47	95	16.23
Halictidae	10	5	1.67
Ichneumonidae	11	5	2.25
Megachilidae	2	1	0.33
Sphecidae	23	9	6.13*
Tenthredinidae	3	1	1.00
Tiphiidae	0	2	2.00
Vespidae	1	0	1.00
Lepidoptera			
Ctenuchidae	0	3	3.00
Danaidae	15	5	5.00*
Gelechiidae	3	9	3.00
Hesperiidae	3	4	0.14
Lycaenidae	1	1	0
Noctuidae	5	9	1.14
Nymphalidae	17	8	3.24
Papilionidae	5	1	2.67
Pieridae	14	29	5.23*
Satyridae	27	32	0.42
Lithobiomorpha	0	1	1.00
Neuroptera			
Chrysopidae	3	4	0.14
Mantispidae	1	11	8.33**
Odonata			
Aeshnidae	2	3	0.20
Coenagrionidae	8	6	0.29
Libellulidae	22	17	0.64
Orthoptera			
Acrididae	22	16	0.95
Gryllidae	3	0	3.00
Tetrigidae	1	0	1.00
Tettigoniidae	0	4	4.00*
Plecoptera	1	0	1.00
Protura			
Eosentomidae	0	1	1.00
Thysanoptera			
Phloeothripidae	12	22	2.94
Thripidae	2	1	0.33

Delphacidae was the only family of Homoptera to show a significant response to burning. Larger numbers of this family were on the burned plots. Delphacidae is a family of planthoppers (Fulgoroidea) which feed on plant juices. Very likely the new vigorous growth on the burned areas provided better feeding habitat and greater reproduction. Cancelado and Yonke (1970) have reported more numerous catches of planthoppers on a burned prairie in Missouri. They concluded that spring burning had an effect upon populations of several Homoptera and Hemiptera. We did not find any response of Hemiptera to burning.

The combined data in Table 1 indicate that ant (Formicidae) populations were smaller on the burned plots. The raw data, however, give reason to doubt any real difference. The populations were nearly equal in all samples except one from an unburned plot which had a very high number. Exclusion of this sample would reduce the chi square value to nonsignificance. Buffington (1967) noted ants to be more numerous on unburned sites, although less severely affected by burning than other arthropods. Nagel (1973) stated that foliage ants were only slightly more abundant on a burned site. Rice (1932) reported ant populations to be over one-third higher following burning of an Illinois prairie.

Sphecidae, solitary predacious wasps, were significantly more abundant in the burned plots. The adults are often on flowers, which may account for this response. More available prey species, such as the Delphacidae, may also be involved.

Two families of Lepidoptera responded to the burn. Danaidae was more numerous on burned areas and Pieridae more abundant than on unburned plots. Reasons for these responses are obscure.

Mantispidae occurred in significantly greater numbers on unburned plots. Mantidflies are predaceous and prey availability could have affected their abundance.

Only one family of grasshoppers, Tettigoniidae, differed from the expected distribution, being more numerous on the unburned plots. Tester and Marshall (1961) indicated that grasshoppers were more abundant where there is a light to moderate cover of litter. Above or below this optimum the habitat is less desirable. The amount of litter on the control plots could have been nearer the optimum accounting for the higher populations on these areas. Several studies have shown grasshopper populations to increase after fire (Nagel, 1973; Tester and Marshall, 1961; Rice, 1932). Gillon (1971) has stated that grasshopper species differ in response to burning, with some being unaffected and others greatly decreased.

Spirobolida (millipedes) were in greater numbers on the burned plots. This result is unexpected and contradicts previous studies (Heyward and Tissot, 1936; Rice, 1932).

SUMMARY

The response of arthropod populations to a spring burn of a northwestern Minnesota tallgrass prairie showed that eleven taxa had significantly larger populations on the burned sites, whereas ten taxa had greater populations on unburned plots. Seventy-five taxa exhibited no changes in population size after burning. One might generally conclude from this study that prairie athropod populations are adapted to fire.

In most cases it is very difficult, or even impossible, to determine the cause of an arthropod population response to burning. Such responses would occur at the species level, however, we are examining taxa at the level of order or family. These major groups are often very diverse and the species within them may respond in totally different ways. Much more study needs to be devoted to the ecology of individual arthropod species.

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INTERACTIONS BETWEEN THE PRAIRIE GARTER SNAKE (*Thamnophis radix*) AND THE COMMON GARTER SNAKE (*T. sirtalis*) IN KILLDEER PLAINS, WYANDOT COUNTY, OHIO

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This paper is a progress report on a two-year study begun in March 1978 on the status of the prairie garter snake or eastern plains garter snake, *Thamnophis radix*, in Wyandot County, Ohio. This species is listed as endangered in Ohio (Ohio Div. Wildl., 1976) because of its very restricted distribution and unique association with relict wet prairie. Our eventual goals are an evaluation of the present distribution, habitat associations, and management practices affecting *T. radix*. This report is an evaluation of the potential for interspecific competition between *T. radix* and its close relative, *T. sirtalis*, the common garter snake, at the Killdeer Plains Wildlife Area.

Thamnophis sirtalis has the widest distribution of any reptile in North America, while *T. radix* is principally found in the Great Plains (Conant, 1975; see our Fig. 1). Considerable overlap exists in the ranges of the two species, a phenomenon common in garter snakes. *Thamnophis radix* is notable due to the presence of disjunct populations in relict prairie outliers in Ohio, Missouri, Indiana, and Arkansas (Fig. 1). This species is a good example among vertebrates for the Prairie Peninsula concept of Transeau (1935; Smith, 1957). This garter snake was first reported in Ohio in 1945, based upon specimens from Wyandot and Marion Counties (Conant, Thomas, and Rausch, 1945) and in 1958 it was reported in Crawford County (Adler, 1958). These localities are in or close to an area that "was once the most extensive single wet prairie area in Ohio" (Conant et al., 1945:63; see our Fig. 2).

Both species live in open, moist habitats although *T. sirtalis* is common in a wider variety of habitats than *T. radix* (Conant, 1951). The two species are similar in size, general habits, and food preferences (Conant, 1951), and both were recorded from Killdeer Plains in the original description (Conant et al., 1945). Our preliminary study at Killdeer Plains in 1977 revealed both species to be syntopic or commonly occurring together in the same local area (Rivas, 1964). The general similarity of the species and their syntopy indicate possible competition for resources. Such competition was not an issue in earlier studies of *T. radix*. In Illinois only 1.8 percent of the garter snakes collected were *T. sirtalis* and none were located a second time (Seibert and Hagen, 1947); in Colorado only one specimen of *T. elegans* was reported in a two-year study of *T. radix* (Bauerle, 1972). In Minnesota at the prairie forest ecotone, *T. radix* occurred only in the prairie, while *T. sirtalis* was rare there but common in forested areas (Jordan, 1967). Hart (1975) compared niche attributes of *T. sirtalis* and *T. radix* in allopatry and sympatry in Manitoba. *Thamnophis sirtalis* had a lower average field body temperature than *T. radix*, and Hart considered this parameter, as well as habitat type, to be factors contributing to "niche discrimination" between the two species. Unfortunately, he did not clearly define his use of the term sympatry (versus syntopy); hence the exact nature of ecological interactions of the two species in Manitoba remains unclear.

The present nature of the ecological interactions of *T. radix* and *T. sirtalis* must be understood and evaluated before further management decisions can be made. This study evaluates (1) the degree to which the two species show niche overlap, (2) the present population dynamics of the two species, and (3) the estimated resource limits relative to snake densities.

STUDY AREA

Killdeer Plains Wildlife Area, Wyandot County, is a 3448.8 ha (8622 acres) area administered by the Ohio Department of Natural Resources. The principal species for which the area is managed is the Canada goose *(Branta canadensis)*, however, other species of wildlife are maintained in the area for sportsmen and nonconsumptive wildlife use. Approximately 40 percent of the area is in open grassland, 25 percent in crops, and the remaining area about equally divided between woodlands and water surface of ponds, marshes, and a reservoir.

Within Killdeer Plains Wildlife Area four sites were initially surveyed for garter snakes in the spring. At two of these sites only *Thamnophis sirtalis* was located but in such low frequencies as to be unproductive for our study. At two other sites both species were present and one of these, an area of grassland of approximately 20 ha adjacent to the wildlife area headquarters and pond number six, Prairie Slough Pond (Fig. 3), was chosen for an intensive study in 1978. The area is still being surveyed to locate sites where each species occurs by itself for future comparisons. All areas where garter snakes have been located are similar in that they border upon ponds with riparian vegetation, are low-lying grasslands with poorly drained soils with high (60-70 percent) clay content (Steiger, 1978, personal communication), and include prairie plants, such as big bluestem, blazing-star, and prairie-dock. All sites surveyed are bordered by drainage ditches and were once, but no longer, subjected to tile drainage.

In the spring the low-lying grasslands are inundated by water, often 10 cm (2.54 inches) above the substrate surface. By midsummer the water table has receded up to several meters below the surface and the soil is dry, cracked, and very hard.

Other species of snakes known from Killdeer Plains include the massasauga rattlesnake *(Sistrurus catenatus)*, the common water snake *(Natrix sipedon)*, the brown snake *(Storeria dekayi)*, and the smooth green snake *(Opheodrys vernalis)*. None of these species are as commonly seen as the garter snakes, and all are quite different from the garter snakes in general habits, food consumed, or body size.

FIELD METHODS

Field observations and hand capture of snakes were performed once each week from March through July 1978. A mark-recapture technique for successive sampling (Schumacher and Eschmayer, 1943) was used in conjunction with a ventral scale marking technique (Brown and Parker, 1976). Upon capture, the snakes were marked and the following information recorded:

1. Cloacal and ambient temperatures. Ambient temperature was taken at and 1.5 m (5 ft) above the substrate surface where the snake was collected. A Schulteiss quick-registering thermometer was used for temperature readings, and only body temperatures obtained within 5-10 sec were recorded.
2. Snout to vent and total body lengths.

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3. Sex and reproductive condition (if female).
4. Food by forcing regurgitations of recently swallowed meals.
5. Scale and color pattern to identify possible hybrids.
6. Time of day.
7. General habitat associations.
8. Description of behavior before capture.
9. Two compass headings from the point of capture were taken to standard points on the periphery of the study sites to evaluate movement upon recapture.

Most snakes were caught while basking or mating. As the summer progressed it became more difficult to catch the snakes as they rapidly fled through very tall vegetation.

MATERIALS AND METHODS FOR STUDY OF EVAPORATIVE WATER LOSS

Specimens of *Thamnophis radix* and *T. sirtalis,* collected in early June, were kept at 22° C with a 12-hr photoperiod centered at 1300 hr (EST). Water was provided freely and no feeding occurred prior to testing. Tests were run for periods between 1.5 and 2.5 hr during the time between 0800 and 2100 hr. Five specimens of each species were tested and most tests were repeated once but never in the same day. The desiccation system used was similar to those described by Claussen (1969), Elick and Sealander (1972), and Gans et al. (1968). The snakes and postchamber tubes of drierite were weighed on a Mettler PN1210 open pan balance accurate to 0.01 gm before and after each run.

NICHE OVERLAP

General Habitat

The close association of *Thamnophis radix* with wet prairie led Conant et al. (1945) to consider it restricted to the Killdeer or Sandusky Plains area of Ohio, even though the area has been greatly altered by agriculture. In contrast, *T. sirtalis* is common in various habitats in Ohio and populations occur throughout Ohio in open, as well as forested areas (Conant, 1951).

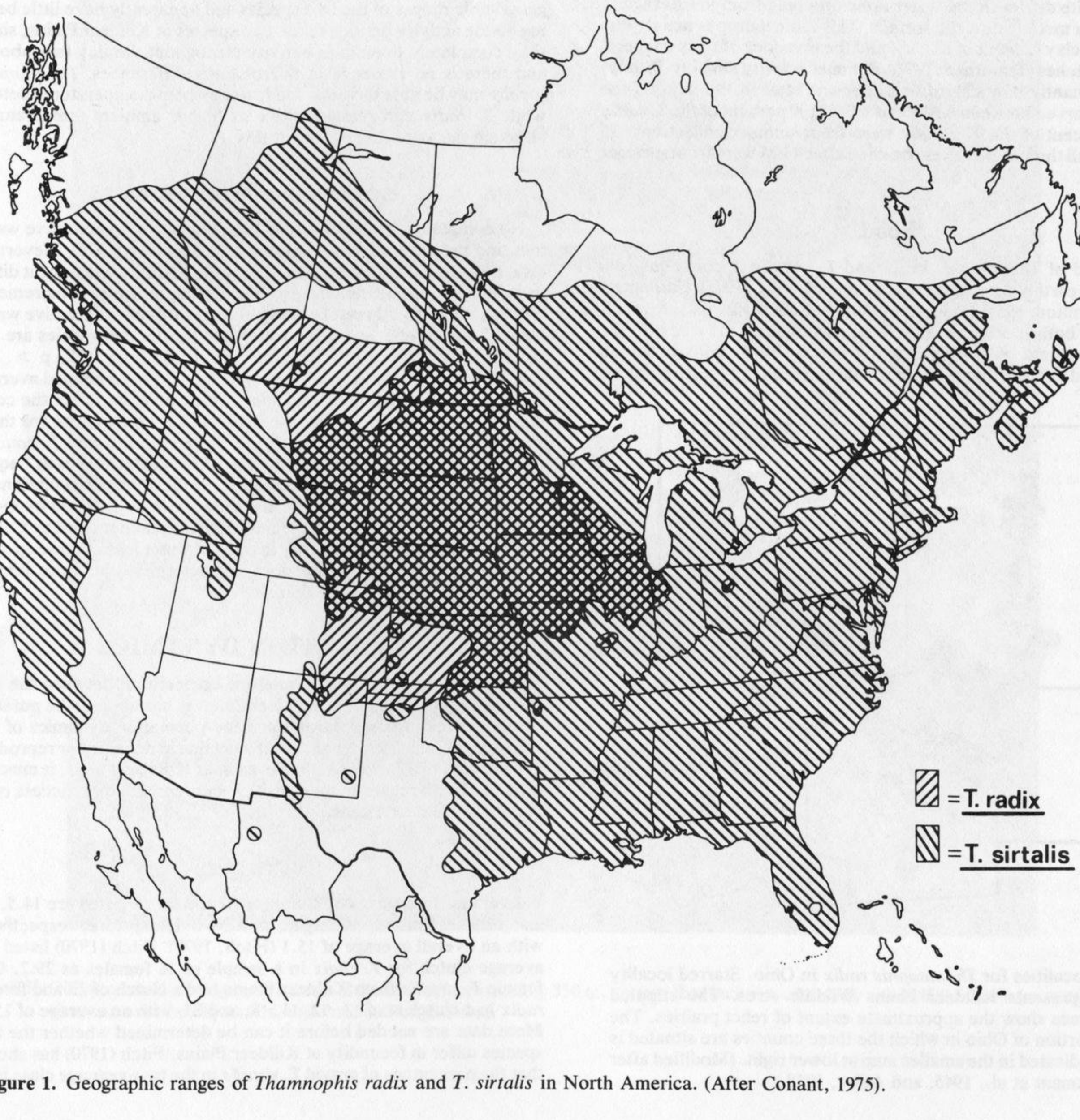

Figure 1. Geographic ranges of *Thamnophis radix* and *T. sirtalis* in North America. (After Conant, 1975).

Hibernation and Copulation

In 1978 both species were first found emergent from hibernation in the first week of April. When approached both species commonly sought refuge down the holes of crayfish *(Falicambarus fodiens)* which probably serve as sites of hibernation (Carpenter, 1952b; Neil, 1951). Both species could be collected in the same fields and were observed in copulating groups within 20 m of one another. No mixed pairs were observed copulating and no hybrids were identified by color or scale count. Premating isolation may be accomplished by species specific pheromonal cues which may explain the apparent lack of hybrids (Ford, 1978).

Activity and Movements

No significant difference ($X^2 = 5.898$, df = 10, $p > .05$; Snedecor and Cochran, 1967) was noted in the daily activity patterns of the two species for the entire study period (Table 1). Daily activity in the spring (31 March-20 May) is principally restricted to midday when temperatures are at their highest; between 1 and 3 PM, 88 percent and 86 percent of the *Thamnophis radix* and *T. sirtalis*, respectively, were caught or observed. Spring activity occurs principally in the low-lying grasslands in which the snakes emerged from hibernation while summer activity centers in drainage ditches and the riparian vegetation surrounding ponds. Toward the end of May, the hibernation sites became quite dry, with the water table dropping from the surface to more than a meter below the surface. This radical drop is mainly due to the high clay content of the soil and the presence of the peripheral drainage ditches (Trautman, 1977). Summer activity (26 May-18 July) is predominantly bimodal, both earlier and later in the day. Of the snakes observed between 8 AM and 1 PM, 100 percent of the *T. radix* and 96 percent of the *T. sirtalis* were from summer collections; 75 percent of all the garter snakes obtained after 4 PM were from summer collections.

Food

The food of *Thamnophis radix* and *T. sirtalis* is commonly described as earthworms and frogs (Conant, 1951, 1975; Carpenter, 1952a; Hamilton, 1951; Foquette, 1954). At Killdeer Plains the principal food of both species appears to be earthworms and frogs. In the spring 10 percent of *T. sirtalis* and 7 percent of *T. radix* collected regurgitated only earthworms. In the summer the only regurgitations were frogs (young *Rana pipiens*, snout-vent length 30-50 mm). In the laboratory both species readily take earthworms and frogs. Hart (1975) reported the major food regurgitated to be frogs (especially *R. pipiens)* with no significant differences between the species.

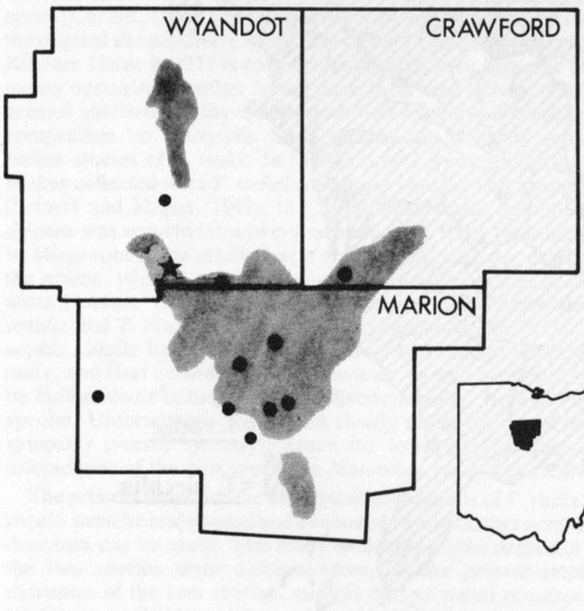

Figure 2. Localities for *Thamnophis radix* in Ohio. Starred locality represents Killdeer Plains Wildlife Area. The stippled areas show the approximate extent of relict prairies. The portion of Ohio in which the three counties are situated is indicated in the smaller map at lower right. (Modified after Conant et al., 1945, and Adler, 1958.)

Thermobiology

All snakes collected in the field had their body temperatures recorded immediately by placing the bulb of a Schulteiss quick-registering thermometer into the cloaca. Subsequent substrate surface temperatures where the snakes were collected were recorded. Sixty-five specimens of *Thamnophis radix* and thirty-six of *T. sirtalis* were collected. The average field body temperature values (averages followed by 95 percent confidence interval limits) of 65 for *T. radix* (27.9° C ± .91) and 36 for *T. sirtalis* (26.1° C ± 1.45) closely overlap (Fig. 4). Hart (1975) found approximately a two-degree difference in the body temperatures of these species in Manitoba. He attributed the lower average body temperature of *T. sirtalis* to its lower albedo and concomitant higher warming rate. Hart stressed this temperature difference in his evaluation of the potential for interspecific competition. However, such a small difference should not be too quickly asserted as a critical factor in expiaining differences in the distributions of these two species. At present field body temperature comparisons point more to the similarities of these two species. Such small differences may not be biologically significant in much of the geographic ranges of the two species and apparently have little bearing on the activity periods of the two species at Killdeer Plains, since they completely overlap in activity throughout the day (see above) and there is no evidence of microhabitat differences. *Thamnophis sirtalis* may be able to withstand lower ambient temperatures better, while *T. radix* can remain active at higher ambient temperatures although our data do not reflect this.

Evaporative Water Loss

No complete correlation exists between rate of evaporative water loss and habitat preferences (Elick and Selander, 1972). Nevertheless, the possibility that *Thamnophis radix* and *T. sirtalis* might differ in habitat requirements because of differing moisture requirements was evaluated by laboratory study of their rates of evaporative water loss. The rates of evaporative water loss for the two species are not significantly different (Wilcoxon rank test, $T_1 = 125$, $p > .05$; Snedecor and Cochran, 1967; see our Fig. 5). The combined average for both species was 3.70 mg/gm/hr. This rate is less than the combined average obtained by Cohen (1975) of 6.12 mg/gm/hr for three species of garter snake (*T. cyrtopsis, T. marcianus,* and *T. couchi*) from the southwest. Cohen categorized these garter snakes as "aquatic." These results and our observations of the habitat associations of *T. radix* and *T. sirtalis* indicate that they are less restricted by moisture considerations than the species of garter snake studied by Cohen (1975). Moreover, the similarity in rates of water loss of these species indicate that moisture alone does not determine the more limited distribution of *T. radix* in Ohio.

POPULATION DYNAMICS

Our concern with the potential for competition between the two species of garter snakes at Killdeer Plains is based upon the possible consequences of competition upon the population dynamics of the endangered prairie garter snake. If a decline in densities or reproductive success of *Thamnophis radix* exist at Killdeer Plains, it must be evaluated with regard to the densities and reproductive success of *T. sirtalis* at Killdeer Plains.

Clutch Size

Average clutch sizes of *Thamnophis sirtalis* reported are 14.5, 18, and 12.9 in Kansas, Michigan, and New Hampshire, respectively with an overall average of 15.1 (Fitch, 1970). Fitch (1970) listed the average clutch for *T. radix* in a sample of 16 females as 29.2. One female *T. sirtalis* from Killdeer Plains had a clutch of 15 and five *T. radix* had clutches of 11, 12, 13, 18, and 25, with an average of 15.8. More data are needed before it can be determined whether the two species differ in fecundity at Killdeer Plains. Fitch (1970) has shown that the percentage of gravid *T. sirtalis* in the two-year age class is 42

Figure 3. Oblique aerial photograph from an altitude of approximately 350 m, or area that includes our study site at Killdeer Plains Wildlife Area, showing area headquarters and Prairie Slough Pond.

Table 1. Daily activity data by hourly intervals for *Thamnophis radix* and *T. sirtalis* at study site in Killdeer Plains, 31 March through 18 July 1978.

Hour of Day	Number of Snakes Observed *T. radix*	*T. sirtalis*
8-9 a.m.	4	3
9-10	9	8
10-11	7	5
11-12	4	5
12-1 p.m.	5	4
1-2	11	6
2-3	16	19
3-4	1	4
4-5	6	3
5-6	1	1
6-7	1	0
Totals	65	58

percent and increases to 100 percent by the six-year age class. *Thamnophis sirtalis* in Kansas and data on *T. melanogaster* (Tyning, 1977) indicate that clutch size increases with body size. Hence, age specific fecundities should be evaluated at Killdeer Plains in the future. Garter snakes held in the laboratory gave birth to young in the first two weeks of August, but newborns were rarely observed in the field.

Size-Age Classes and Mortality

The ranges in body lengths of *Thamnophis radix* and *T. sirtalis* captured are 400-750 mm and 350-700 mm, respectively. In both species maximum male body length is smaller than for females, as has been reported in earlier studies (Carpenter, 1952a, b; Fitch, 1965). Size-age classes are not easily separable at this time and the sex ratios of both species approach one to one, although more data are required before certainty.

Turner (1977:218-221) reviewed the literature on mortality in snakes and discussed the inconsistencies in prenatal data and the shortcomings of survival estimates. Most workers (Turner, 1977) agree that the majority of mortality is prenatal or within the first months of life, including hibernation. No estimates of mortality were made in this study.

Seibert (1950) estimated a mortality rate of 20 percent for *T. radix* in Illinois, however, Seibert and Hagan (1947:19) stated that "no safe approximation of this figure [mortality rate] can be derived" from their data. At Killdeer Plains few garter snakes are seen dead on the road, but approximately 5 percent of the snakes observed had been chopped up in mowing operations employed to improve the grazing area for Canada geese.

Population Density

Density estimates for the two species at our study site (Fig. 3) are based on data collected from 31 March to 18 July 1978. Sixty-six individuals of *Thamnophis radix* and thirty-one of *T. sirtalis* were marked during this time and the recapture rates were 11 percent and 29 percent, respectively. The absolute population estimates and their 95 percent confidence limits are 219.6 ± 64.6 and 58 ± 21.2 for *T. radix* and *T. sirtalis*, respectively. To compare these values with earlier studies, the population estimates were transformed to densities per hectare (Turner, 1977). Only the area in which snakes were collected has been used in this estimate. Our total study site was approximately 20 ha, but snakes were only collected in 4.3 ha of this area. Using only this collected area, we estimate 51 and 14 individuals/ha for *T. radix* and *T. sirtalis*, respectively.

Earlier density estimates for *T. sirtalis* are similar: 11 snakes/ha in Kansas (Fitch, 1965) and 24 snakes/ha in Michigan (Carpenter, 1952a). However, earlier density estimates for *T. radix* are much higher than the present estimate of 51 individuals/ha: 320 individuals/ha in Colorado (Bauerle, 1972) and 845 individuals/ha in a landfill near Chicago (Seibert, 1950). The lack of confidence limits for these estimates and the various techniques used for estimation make comparisons difficult.

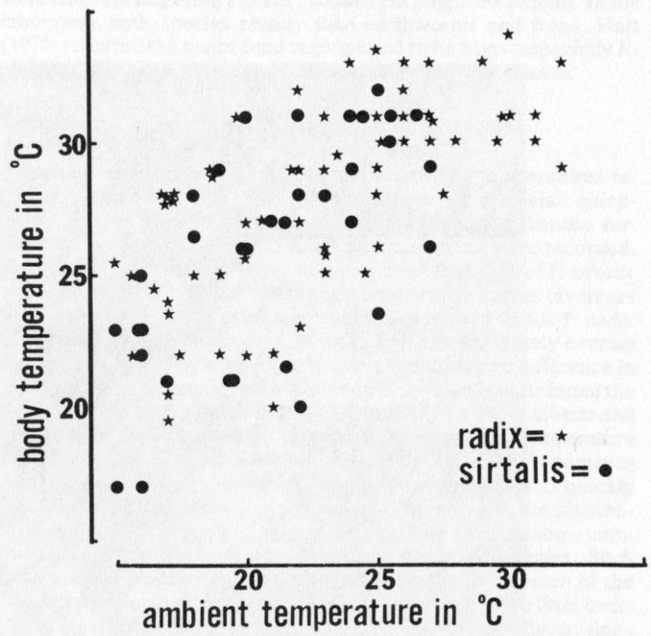

Figure 4. Relation of cloacal body temperatures to ambient substrate surface temperatures of specimens of *Thamnophis radix* and *T. sirtalis* recorded at study site in Killdeer Plains.

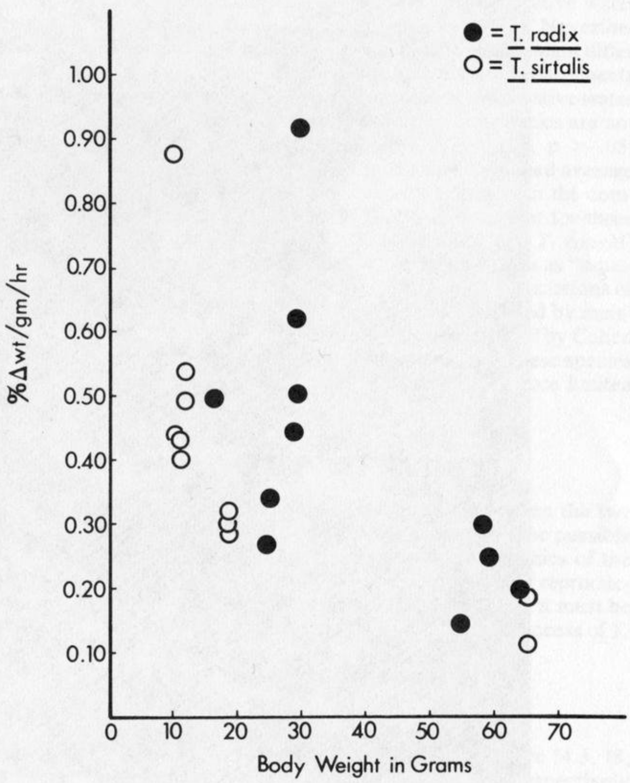

Figure 5. Relation of percent weight loss/mg/hr to body weights of *Thamnophis radix* and *T. sirtalis*.

RESOURCE LIMITS

Predator and Prey Biomass

Frog (*Rana pipiens*, young of the year) and earthworm population biomass values were obtained for comparison to a biomass estimate of the garter snakes/ha. Transects of pond periphery and riparian vegetation gave an average value of 104 frogs/ha; at an average weight of 10 gm/frog this gives 1.04 kgm of frogs/ha. Earthworm biomass estimates were unsuccessfully attempted using the formaldehyde method (Edwards and Lofty, 1977). We have, therefore, taken the average biomass value of earthworms/ha from 17 earlier studies of "arable land, pastures and orchards" summarized by Edwards and Lofty (1977: Table 5) as 883 kgm/ha (over 3 million worms/ha). However, the high clay content of the soils and the radical seasonal changes in soil moisture at Killdeer Plains indicate that earthworm densities here may be lower than average. Therefore, we conservatively assume the earthworm biomass at Killdeer to be one-half the average value or 441.5 kgm/ha.

Bauerle (1972) gave the average weight of *Thamnophis radix* as 39 gm. Using this value to estimate the total biomass for both species at Killdeer Plains (65 snakes/ha) gives 2.6 kgm/ha of garter snakes. The total biomass of principal prey, frogs and worms, is 451.9 kgm/ha. By this method the predator-prey ratio by biomass would be 1 to 167. Schoener (1977) stressed the low energetic requirements of reptiles in general, and he mentioned estimates of minimal energetic requirements for snakes of 1.25-3 times the body weight per year. Bauerle (1972) came to the same conclusion in his study in Colorado; however, a number of mathematical errors appear to have been made in his energetic analysis. Given the low predator-prey ratio estimate for Killdeer Plains and the relatively low energetic requirements of snakes in general, it seems unlikely that prey are a limiting resource for the present population of garter snakes at Killdeer Plains.

Habitat

Because *Thamnophis sirtalis* occurs throughout Ohio, the available habitat at Killdeer Plains is not at issue for this species. *Thamnophis radix* is restricted to this relict prairie region; hence, the available habitat for this species is central to an understanding of its future status. Because both species are at reasonably high population levels, for snakes, we assume that habitat is not at present a limiting resource with regard to relative densities at Killdeer Plains. The density estimates of 320 snakes/ha (Bauerle, 1972) and 845 snakes/ha (Seibert, 1950; Turner, 1977) for *T. radix* in Colorado and Illinois indicate that much higher relative densities could be reached at Killdeer Plains.

The planting of crops at Killdeer Plains is considered advantageous to a variety of wildlife as well as to local farmers. On the basis of the present year's crop rotations at Killdeer Plains, approximately 25 percent of the area is being farmed. Fortunately, the Ohio Department of Natural Resources has required that agriculturally modified areas be widely dispersed throughout the area; hence, no major barriers are impeding the movements and spread of populations of the prairie garter snake within Killdeer Plains. Approximately 40 percent of the area is classified as open grassland, but the actual habitat available to garter snakes fluctuates seasonally primarily as a function of water content in soils, which in turn affects the distribution of the main prey types.

One factor that further reduces available habitat at Killdeer Plains is the mowing of open grassland to improve the grazing area for Canada geese. While such mowing appears to have only a limited mortality effect, it does leave grassland unsuitable to the snakes since such areas dry out very quickly. The combined effects of mowing and progressive drying of the soils with the onset of summer results in the concentration of garter snakes near ponds and drainage ditches.

SUMMARY

Our preliminary data indicate the *Thamnophis radix* and *T. sirtalis* show extensive niche overlap at Killdeer Plains with regard to habitat use, hibernation sites, time of copulation, activity and movements, food, thermobiology, and moisture requirements. The data available on population dynamics indicate that the two species differ considerably in densities with 51 individuals/ha for *T. radix* and 14/ha for *T. sirtalis;* however, the resource base on which they depend appears to be ample for their support. Moreover, the total population density of garter snakes estimated for our study area is much lower, 65 snakes/ha, than the density estimates for *T. radix* at other localities, 320 and 845 snakes/ha, indicating that even higher densities might be supportable at Killdeer Plains. The lower estimate for *T. radix* at Killdeer Plains may partially be due to the generally marginal quality of habitat for disjunct or peripheral populations or the effects of general habitat deterioration of the wet prairies in Ohio (Trautman, 1977).

In the general context of competition, this study reveals that, while competition cannot and probably never will be ruled out, the present resource base appears capable of supporting the present density of garter snakes even though the two species show extensive niche overlap.

ACKNOWLEDGEMENTS

Our research is supported by the Ohio Department of Natural Resources, Division of Wildlife, and the Ohio Biological Survey. We thank Denis Case, Robert Sturgeon, and Charles C. King for their assistance and encouragement throughout our studies. Robert Beaman did the laboratory study of evaporative water loss and assisted with air transportation over our study sites. Jody Grenga prepared the illustrations and Sheldon Lustick permitted us to use his physiological facilities. Roger Thoma identified the crayfish and William Carr assisted with local plant identifications. Many individuals assisted in the field work: W. Bolin, J. Goldman, W. Kasson, W. Nichols, A. Penniman, D. Reaver, L. Reichenbach, D. Thompson, and R. Vlasik. Finally, J.F. Downhower and L.A. Dalrymple discussed the research procedures with us at length. We thank these people for their assistance and interest.

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SIGNIFICANCE OF NATIVE PRAIRIE TO GREATER PRAIRIE CHICKEN *(TYMPANUCHUS CUPIDO PINNATUS)* SURVIVAL IN MISSOURI

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The greater prairie chicken *(Tympanuchus cupido pinnatus)*, a product of the primeval tallgrass prairie ecosystem, reached its fullest potential in the dawn of settlement which had modified the land of grass with islands of grain crops. Until then, the prairie chicken had been dependent for some diversity in its habitat and for grain on Indian tribes who tilled crops. Today, only splintered remnants of the native tallgrass prairie remain in a land of grain lightly populated with prairie chickens. The new caretakers of the land since settlement have been both the giver and taker, creating optimum habitat then destroying it.

The vital role of grassland in prairie chicken ecology has been documented state by state. Hamerstrom et al. (1957:84, 87) concluded that "total grassland appears to be a rough index to habitat quality in that the densest populations are shown to be those areas which are 55-60 percent grassland . . . To save the prairie chicken, grasslands must be preserved and managed for them. There are no substitutes." Certainly, the native tallgrass prairie has filled the role as primary grassland habitat for the prairie chicken in the pre- and postsettlement eras, but the destruction of native prairie continues. Can the prairie chicken survive?

HISTORY OF PRAIRIE CHICKEN SURVIVAL

Originally about ten states in the eastern range of the prairie chicken supported substantial populations of prairie chickens for hunting year-round (Christisen, 1969). Much of this area became the heart of the cornbelt. Millions of acres of native grass prairies are now gone, sunk beneath a sea of corn and soybeans! Bread basket monoculture does not produce prairie chickens because the birds do not live by grain alone.

Iowa, Indiana, Ohio, Kentucky, and Arkansas no longer have prairie chicken populations. Only five states have enough breeding stock to maintain at least a flock or more of chickens as museum species. Survival of the birds in Michigan's alien habitat is on a precarious year-to-year basis. More birds exist in Illinois, but suitable, domestic-crop habitat offers a narrow survival base. Wisconsin probably has a chance of keeping a small population in newly created habitat converted from marshes. Minnesota and Missouri have remnants of the original native tallgrass prairie habitat, good residual populations of prairie chickens, and bright hopes for maintenance of the species.

The western habitat represents both ends of the habitat spectrum—the good and the bad, the original and the new land. Baker (1953:10) surmised that originally" the greater prairie chicken did not occur further west than the middle of Kansas and that the bird did not occur in impressively large numbers." Changes in land-use occurred and the prairie chicken extended its range in the Dakotas, Nebraska, and Kansas and into Colorado in the wake of pioneer agriculture as native eastern prairies were converted to corn and small grain. One author (Anonymous, 1953:8) observed:

> When the proportion of grassland [in North Dakota] was about 20 to 80, the pinnate [prairie chicken] moved in and began to increase . . . As the proportion of grain to grass . . . tipped over the other way . . . the pinnate could find plenty of food but no nesting cover . . . or escape cover. He was literally plowed out of house and home.

Mohler (1944:8) stated that "the breeding and nesting habits of this species require extensive grassland and the disappearance of the native prairie through cultivation was responsible for the eviction of the prairie chicken from eastern Nebraska many years ago." According to Baker (1953:12), "The disappearance of the greater prairie chicken from eastern Kansas is attributable to the reduction of native grasslands by plowing . . . where the greater prairie chicken now occurs in eastern Kansas, grasslands always have been at least as extensive as at present."

The drier climate of the mid- and shortgrass country has deficiencies too, in both food and cover. The extensive range lands are virtually without grain, and the dry land farming and irrigated areas have little grass. The new land is only a substitute for a range diminished and marginal for prairie chickens.

Only four states have prairie chicken hunting seasons. In South Dakota and Nebraska, they coincide with the sharp-tailed grouse seasons as a pragmatic accommodation for hunters. In Kansas and Oklahoma, which rank first and second in total bird harvest and have larger acreages of native tallgrass prairie, they are featured seasons.

Only the adaptiveness of the prairie chicken has permitted it to survive in marginal and hostile environments whether in the intensively tilled, original, eastern range or in the adopted, arid, western range, both bereft of tallgrass prairies. Where native tallgrass prairies have been plowed under, the greater prairie chickens are gone or their numbers are severely reduced to fewer than a thousand birds. In contrast, where these native prairies still occur prairie chicken populations are in the thousands and even offer huntable populations.

MISSOURI NATIVE PRAIRIES

The higher population densities in Missouri are associated with the remaining native tallgrass prairies. Arthaud (1970) identified 33 percent of his 44 sq km (16 sq miles) study area in St. Clair County as native prairie with 7.3 cocks per sq km (19 cocks per sq mile). Drobney (1973) classified 56 percent of his study area of nearly 13 sq km (5 sq miles) in Benton County as native prairie with 10.4 cocks per sq km (27 cocks per sq mile). However, the presence of a tract of native prairie does not necessarily guarantee a prairie chicken population. To be a productive habitat, native prairie must be in sufficient quantity, of good quality, and of widespread distribution.

Character and Use

The basic components of Missouri's native prairies are the warm-season native grasses, particularly little bluestem *(Andropogon scoparius)*, big bluestem *(A. gerardii)*, Indian grass *(Sorghastrum nutans)*, and switchgrass *(Panicum virgatum)*. These grass species are the ones of substance which are attractive to and functional for prairie chickens (Christisen, 1972a). The structural strength and clump effect of these grasses give optimum shelter for nesting, brood-rearing, and roosting without impairing movement at the ground level. The high diversity of plant species in the prairies, well over 200 grasses, sedges, and forbs, provides an enriched habitat for prairie chickens.

Physical characteristics of prairies alone do not spell survival for prairie chickens. Use or management of the prairies sets them apart from domestic grasslands and permits prairie chickens to prosper.

The native prairies have never offered the forage tonnage potential of legumes, such as alfalfa or red clover, or even of the introduced cool-season grasses. However, prairies are drought-tolerant and offer weight-gaining forage for livestock through the hot summers in Missouri. Properly managed, native prairies are pastured during the warm-season months and hayed before August but after completion of the nesting season. When hayed in July, sufficient time remains for regrowth before winter. As a result of these practices, the native prairies offer better cover for prairie chickens and other wildlife. Most important, less disturbance to prairie chickens during incubation and brood-rearing occurs.

High arching grasses provide nesting cover which is vital to the safety of the incubating hen and a successful hatch. The clump growth form of the native grasses, such as, the bluestems and Indiangrass, and many of the larger forbs projecting above the native prairie are well-suited for nest cover. Drobney (1973) found that 60 percent (21) of all nests located in his study area were on native prairies and that little bluestem occurred at all but three of the nest sites. Only four of twenty-three nests were established in cover heights of less than 20.54 cm (10 inches).

Sufficient roost cover of good quality is equally important because the need is year-round. I observed that prairie chickens use cover of varying heights, but the 16.5-38 cm (8-15 inch) cover probably receives the greatest use. The shorter cover is used more often during mild weather, whereas the taller cover is sought during severe conditions. Good quality cover gives protection by retention of its upright growth form and structure despite inclement weather. Not all pasture grasses have this characteristic. The forbs in the prairie often help support the grasses and vice versa.

Prairie pastures accounted for 85 percent of the roost observations (1,180) made by Drobney (1973). About 75 percent of the roosts were in cover 16.5-90 cm (8-36 inches) high and 25 percent in 10-16.5 cm (4-8 inch). Roost forms were more abundant on the unmowed portions of a west-central Missouri prairie than on the mowed portions (Hurd and Christisen, 1975). A roost survey conducted in March for five successive years on a 72 ha (180 acre) parcel of Taberville Prairie in St. Clair County showed a range of 0-27.5 roosts/ha (0-11 roosts/acre) on meadows hayed the previous year but totaled 5-295 roosts/ha (2-118 roosts/acre) on uncut meadows (Christisen, 1963-1967). More often about 15 roosts/ha (6 roosts/acre) occurred on cut meadows and 125-188 roosts/ha (50-75 roosts/acre) on the uncut. Some 200 prairie chickens wintered on Taberville Prairie at the time. Prairie chickens may roost in the same locality of a meadow or field on successive nights but apparently not on the identical roost site. Schwartz (1945:70) observed "most flocks seem to use the same field night after night . . . Some flocks . . . move about regularly . . . apparently having no fixed roosting site."

Significance to Prairie Chicken Survival

The plow first started turning Missouri prairie sod about 1819 (McKinley, 1960) and most of the glaciated prairies of northern Missouri were soon growing other crops. Bennitt and Nagel (1937) noted widespread decrease of suitable range north of the Missouri River. Prairie chickens lingered until the mid-1950's in a habitat including Kentucky blue grass *(Poa pratensis)*, red top *(Agrostis alba)*, and timothy *(Phleum pratense)*. But the intensity of farming after World War II changed the habitat even more and most of the prairie chickens disappeared, leaving only the populations tied to the nonglaciated prairies of southwestern Missouri (Fig. 1). As late as 1946 about 6,000 ha (150,000 acres) of native prairie existed in southwestern Missouri. Again in recent years, the lucrative grain sales abroad and soaring land prices prompted more rapid conversion of prairies to cash crops. Presently, no more than 3,000 ha (75,000 acres) of native tallgrass prairie remain, but it is the core of the prairie chicken habitat in a tall fescue *(Festuca elatior arundinacea)* world.

Since these bits of the original productive habitat remain, it was logical to base a survival plan for greater prairie chicken on preservation of some tracts of native prairie, as "the fortunes of the chicken are linked with the fate of the native prairies" (Nagel, 1970:82). A checkerboard plan of acquiring parcels of native prairies specifically for prairie chickens was envisioned for southwestern Missouri (Christisen, 1963) after the 672 ha (1680 acre) Taberville Prairie, St. Clair County, and 34 ha (85 acre) Milo Prairie, Vernon County, were acquired in 1959-1960.

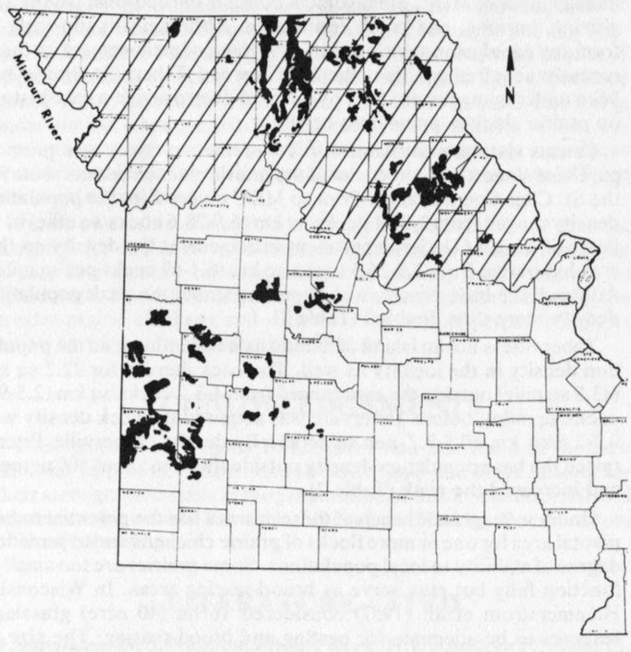

Figure 1. Distribution of the greater prairie chicken (*Tympanunchus cupido pinnatus*) in Missouri. Their range in 1940 is indicated by the dark shading (Schwartz, 1945:29). Since the 1950's the range above the Missouri River has been marginal to unoccupied as shown by the slashed area. Below the Missouri River, the 1940 range is still occupied today. (Information for base map obtained from the Missouri State Planning Board.)

Funds were inadequate to continue the program of prairie acquisition, and nearly ten years elapsed before it resumed. In the interim, interest in the preservation of prairies had become a concern of citizens (Christisen, 1967). The Missouri Prairie Foundation, newly formed in 1966, and The Nature Conservancy both began acquiring native tallgrass prairies in 1968 and 1971, respectively. The Missouri Prairie Foundation urged that conservation organizations acquire 6,800 ha (17,000 acres) of native prairie by 1987 (Christisen, 1972b). In a more recent development, the voters of Missouri amended the State Constitution to permit the Department of Conservation to collect a one-eighth of one percent sales tax beginning 1 July 1977. This Design for Conservation earmarked a large proportion of the monies derived from the sales tax for land acquisition. Prairies were included in this design program, and four tracts (194 ha, 486 acres) were acquired in the first year.

The Nature Conservancy has acquired 1,245 ha (3,112 acres) of prairie in eleven tracts, the Missouri Department of Conservation (MDC) has purchased 789 ha (1,972 acres) in seven tracts, and the Missouri Prairie Foundation has bought 258 ha (645 acres) in six tracts. Together, these three organizations have been able to acquire 2,292 ha (5,729 acres) of tallgrass native prairies for the public in 20 units (Toney, 1977; see my Fig. 2).

Obviously the checkerboard or satellite system of native prairie is beginning to take shape, although the reasons for acquiring prairies have gone beyond the original one of prairie chicken sanctuaries. Each prairie acquired has a unique combination of features and plants, yet all have certain similarities consistent with native prairie communities. Considerable variation occurs in the use of these prairies by prairie chickens because of topography, soils, past land-use, size, cover pattern, and current range of the species. With better management these utilization differences will probably decrease.

Presently, six of twenty prairies in public ownership are probably not used by prairie chickens. Booming grounds or leks were on or within a 0.8 km (0.5 mile) of 13 prairies in 1977 (Christisen, 1977). The number of cocks credited to the prairie sanctuaries was small with the exception of Taberville. Not more than four booming grounds nor more than 31 cocks were on or within 0.8 km (0.5 mi) of the prairies (Table 1).

These prairies are either currently, or eventually will be, under the management of MDC. Management consists of rotational haying and grazing, burning, and brush eradication. Although it is too early to form any conclusions about the effectiveness of management on these recently acquired prairies, the MDC-owned Taberville Prairie has been under management for 17 years and does provide a case history on prairie chicken population behavior.

Census data are available for Taberville several years prior to purchase since it was a segment of the prairie chicken census route for the St. Clair County range. Prior to MDC ownership, the population density ranged from 2.6-11 cocks/sq km (6.9-28.6 cocks/sq mile) in 11 years of census. Under department management the density on this area has varied from 2.3-26.5 cocks/sq km (6.1-69 cocks per sq mile). Although the base density was about the same, the peak population density more than doubled (Table 2).

Taberville is not an island of habitat as it has influenced the population density in the locality as well. The cock density for 22.2 sq km (13.8 sq mile) outside the area ranged from 1-3.7 cocks/sq km (2.5-9.7 cocks/sq mile); before Taberville was acquired the cock density was 0.2-2.8/sq km (0.5-7.2 per sq mile). Evidently, Taberville Prairie raised the base population density outside the area about 500 percent and increased the peak (Table 2).

Under management, each of these prairies has the potential to be a pivotal area for one or more flocks of prairie chickens and to provide a degree of stability to local populations. Some prairies are too small to function fully but may serve as brood-rearing areas. In Wisconsin, Hammerstrom et al. (1957) considered 16 ha (40 acre) grassland reserves to be adequate for nesting and brood-rearing. The size of these 20 prairies varies from 15-544 ha (37-1,360 acres) and will benefit prairie chickens in varying degrees.

Arthaud (1968:117), in a study of prairie chicken populations and land-use in southwestern Missouri concluded that a refuge "could not be less than 256 ha (640 acres) if it were to support prairie chickens independently of adjacent land." He found that 800 ha (2,000 acres) of grassland supported 13 booming grounds and calculated that at least 64 ha (160 acres) of grassland suitable for nest-brood cover would support a small booming ground population. Drobney (1973), in a study of habitat in central Missouri, noted that nests were localized around the booming grounds where adequate cover was available. Only five of the twenty public prairies had booming grounds in 1977.

Encouraging booming grounds on these prairies nearby would include providing cover for nesting and brood-rearing, and protecting the ground from mechanical disturbances; consequently, the aesthetic value of the prairie would be enhanced. Each prairie acquired has one or more potential sites for booming grounds. In two instances, booming grounds have been moved onto prairie preserves from outside the boundaries as result of cover changes within.

Presently, the twenty prairies acquired represent about thirteen localities and of these nine have resident flocks of prairie chickens. Random acquisition of these tracts has created a natural scatter pattern; however, the density is lighter than that prescribed by Hamerstrom et al. (1957) for the domesticated grasslands of Wiscon-

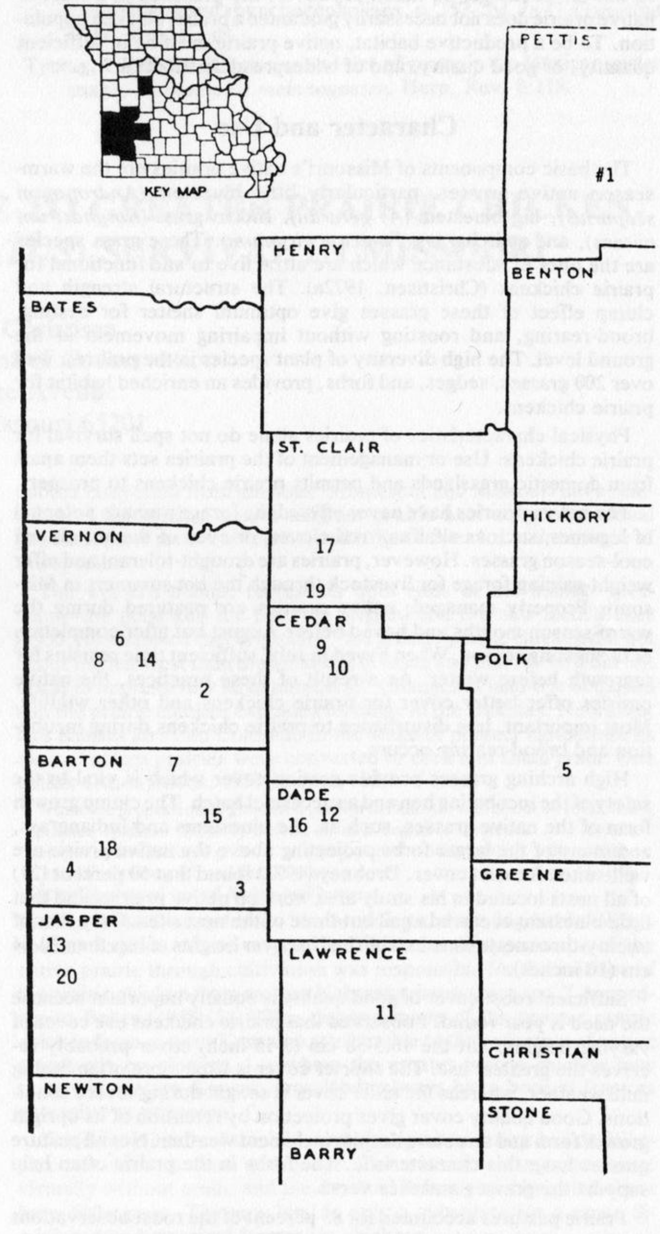

Figure 2. Public prairies of western Missouri: (1) Friendly, (2) Gayfeather, (3) Golden, (4) HunKah, (5) La Petite Gemme, (6) Little Osage, (7) McNary Tract, (8) Milo, (9) Mo-Ko, (10) Monegaw's, (11) Mount Vernon, (12) Niwathe, (13) Opolis, (14) Osage, (15) Pawhuska, (16) Penn Sylvania, (17) Taberville, (18) Tzi-sho, (19) Wah'Koh-Tah, and (20) Wa-Sha-She.

Table 1. 1977 prairie chicken census on public prairie preserves in Missouri. Numbers preceding names of prairies correspond to the numbers used in the map of prairies in Missouri (Fig. 2). Data are presented on the number of booming grounds (BG) and on the number of males on the booming grounds (M).

	Hectares (acres)	On Prairie Area		Within 0.8 km (0.5 miles) of Prairie Area		Total	
		BG	M	BG	M	BG	M
1—Friendly, Pettis County	64.0 (40)	0	0	2	14	2	14
2—Gayfeather, Vernon County	121.6 (76)	0	0	0	0	0	0
3—Golden, Barton County	512.0 (320)	1	1+	3	22	4	23
4—Hunka, Barton County	256.0 (160)	0	0	1	1	1	1
5—La Petite Gemme, Polk County	592.0 (37)	0	0	0	0	0	0
6—Little Osage, Vernon County	128.0 (80)	0	0	0	0	0	0
7—McNary Tract, Barton County	256.0 (160)	0	0	0	0	0	0
8—Milo, Vernon County	136.0 (85)	0	0	1[1]	2[1]	—	—
9—Mo-Ko, Cedar County	672.0 (420)	1	7	1	2	2	9
10—Monegaw's, Cedar County	432.0 (270)	0	0	1	2	1	2
11—Mount Vernon, Lawrence County	64.0 (40)	0	0	0	0	0	0
12—Niwathe, Dade County	384.0 (240)	0	0	2	14	2	14
13—Opolis, Jasper County	96.0 (60)	0	0	1	10	1	10
14—Osage, Vernon County	1920.0 (1200)	1	2	2	24	3	26
15—Pawhuska, Barton County	123.2 (77)	0	0	0	0	0	0
16—Penn Sylvania, Dade County	256.0 (160)	0	0	1	3	1	3
17—Taberville, St. Clair County	2176.0 (1360)	3	92	4	50	7	142
18—Tzi-sho, Barton County	384.0 (240)	0	0	1	31	1	31
19—Wah'Kon-Tah, St. Clair County	1024.0 (640)	0	0	1	6	1	6
20—Wa-Sha-She, Jasper County	256.0 (160)	1	21	0	0	1	21

[1] Included in Osage Prairie

Table 2. Annual male populations and densities of prairie chickens in Taberville Prairie (6.825 sq km or 2.625 sq miles) and adjacent private lands (35.475 sq km or 13.875 sq miles).

	Taberville		Outside Taberville	
	Total	per sq km (sq mile)	Total	per sq km (sq mile)
1945	36	35.62 (13.7)	100	18.72 (7.2)
1946	22	21.84 (8.4)	68	12.74 (4.9)
1947	18	19.94 (6.9)	94	17.68 (6.8)
1948				
1949	37	36.66 (14.1)	7	1.30 (0.5)
1950				
1951				
1952	53	52.52 (20.2)	56	10.40 (4.0)
1953	68	67.34 (25.9)	58	10.92 (4.2)
1954				
1955	40	39.52 (15.2)	52	9.88 (3.8)
1956	74	73.32 (28.2)	34	6.50 (2.5)
1957	75	74.36 (28.6)	76	14.30 (5.5)
1958	35	34.58 (13.3)	36	6.76 (2.6)
1959	37	36.66 (14.1)	45	8.32 (3.2)
1960	36	35.62 (13.7)	45	8.32 (3.2)
1961	28	27.82 (10.7)	41	7.80 (3.0)
1962	23	22.88 (8.8)	63	11.70 (4.5)
1963	16	15.86 (6.1)	64	11.96 (4.6)
1964	20	19.76 (7.6)	93	17.42 (6.7)
1965	46	45.50 (17.5)	60	11.18 (4.3)
1966	119	117.78 (45.3)	128	23.92 (9.2)
1967	181	17.94 (69.0)	133	24.96 (9.6)
1968	74	73.32 (28.2)	135	23.92 (9.7)
1969	71	70.46 (27.1)	97	18.20 (7.0)
1970	40	39.52 (15.2)	99	18.46 (7.1)
1971	43	42.64 (16.4)	102	19.24 (7.4)
1972	45	44.46 (17.1)	65	12.22 (4.7)
1973	57	54.86 (21.1)	61	11.44 (4.4)
1974	80	79.30 (30.5)	34	6.50 (2.5)
1975	39	38.74 (14.9)	67	12.48 (4.8)
1976	57	54.86 (21.7)	81	15.06 (5.8)
1977	92	91.00 (35.0)	68	12.74 (4.9)

sin. Although not all of these prairies are most effectively located with respect to prairie chicken flocks, this density deficiency may be overcome with the acquisition of more prairies.

SUMMARY

Taberville Prairie, a pioneer of prairie preservation, has been a success for prairie chickens. Birds in this locality were recipients of management benefits before The Nature Conservancy and the Missouri Foundation Prairie began acquiring prairies. Now the habitat of prairie chickens is being preserved and managed. The experience gained from Taberville would seem to predict success elsewhere under similar management. Undoubtedly, a few prairies will be exceptions for various reasons. Modification in management techniques or additional lands for management may bring success even to these few problem prairies.

Public ownership of a network of native prairies holds the greatest potential for the survival of prairie chickens in Missouri into the twenty-first century because habitat on private land continues to deteriorate. The native tallgrass prairies is the requisite habitat for the greater prairie chickens and without it the task of perpetuating this native species is immeasureably difficult.

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COVER USE BY RADIO-TAGGED ATTWATER'S PRAIRIE CHICKEN (*TYMPANUCHUS CUPIDO ATTWATERI*) IN GULF COASTAL PRAIRIE OF TEXAS

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The Attwater's prairie chicken (*Tympanuchus cupido attwateri*) is a member of the grouse family, Tetraonidae. The distribution of this subspecies of the greater prairie chicken (*T. c. pinnatus*) is now limited to remnant areas of the Texas Gulf Coastal Prairie. Attwater's prairie chicken once occurred throughout the coastal tallgrass prairies of southwestern Louisiana and southeastern Texas (Lehmann, 1941). Between 1937 (Lehmann, 1941) and 1976 (Brownlee, 1977), the population decreased from 8,700 to an estimated 2,088 birds. The major cause of this decline was habitat loss due to urban sprawl, brush invasion, and conversion of native prairie into agronomic units. Long-term survival of the Attwater's prairie chicken is directly related to habitat preservation and management. However, successful management programs are dependent on a thorough understanding of the dynamic relationship between this subspecies and its environment. It is not enough to recognize that prairie chickens require grassland. Stands of grass vary in character and those required by the prairie chicken must be identified if effective management of the species is to be undertaken. To understand better the habitat requirements of the Attwater's prairie chicken, location data from a radio telemetry study conducted in Refugio County, Texas, were analyzed to determine cover usage.

STUDY AREA

This study was conducted in Refugio County, 29 km northeast of Refugio, Texas. Most of the study area was within the borders of the 6,400 ha Lake Pasture of the O'Connor Brothers' Riverside Ranch which has been described by Cogar et al. (1977). They estimated 250-300 prairie chickens occupied this pasture during the study with 15 and 18 booming grounds utilized by displaying males during 1976 and 1977, respectively.

METHODS AND MATERIALS

Field work began in January 1976 and continued to September 1977. The study area was divided into eight major cover types by Cogar et al. (1977) on the basis of visually dominant plant species. In addition, they recognized artificially maintained areas as a distinct cover type. Cover height, visual obstruction, and visual dominance of species were recorded during these seasons: spring-nesting, brooding, fall-booming, and winter-booming (Cogar et al., 1977).

Attwater's prairie chickens were live-trapped to attach leg bands and radio transmitters. Such radio-tagged birds were located daily at randomly selected times to determine cover use. Nests were located by following radio-tagged hens to their nests and by chance sightings on the study area.

Cover type preference indices (PI) were determined by dividing the percentage of bird locations in a specific cover type by the percentage of the study area covered by that type (Robel et al., 1970). A PI value greater than 1 indicated use greater than expected; a value less than 1 indicated use less than expected; and a value of 1 indicated a cover type was used in proportion to its abundance on the study area.

RESULTS

The percent of the study area occupied by the eight major cover types and the visually dominant plant species within each type were presented by Cogar et al. (1977). They noted that the clumped midgrass cover type occupied the largest portion of the study area and the spiny aster type the least. The tallest and most dense cover type was the cordgrass while the hardpan type was least dense and shortest.

A total of 90 Attwater's prairie chickens was trapped on the study area, 56 males and 34 females. Twenty-four males and thirty-two females were radio-tagged. A total of 3,434 individual locations was determined, 1,678 and 1,756 for males and females, respectively.

During this study, 19 nests were located on or within 0.1 km of the study area (Fig. 1). Thirteen of these were located in the clumped midgrass cover type and six nests were in the unclumped midgrass cover type.

Five radio-tagged hens with broods were radio-tracked during the study and twenty non-radio-tagged hens with broods were also observed (Fig. 1). All broods younger than five weeks were observed in the clumped midgrass cover type. In addition to the use of the clumped midgrass cover type, older broods were also observed in artificially maintained areas associated with the clumped midgrass cover type.

The spiny aster, transition, and clumped midgrass areas were selected by females during the winter booming season (Table 1). Females also selected spiny aster and clumped midgrass areas during the nesting season. Males selected the spiny aster cover during the brooding and winter-booming seasons. Pooled male and female data indicated selection of the spiny aster cover type during the brooding and the winter-booming seasons. The seasonal use of the eight cover types by the chickens was not correlated solely with visual obstruction or cover height.

Cover type preference indices indicated that a positive selection of the clumped midgrass cover type occurred throughout the year (Table 1). Male preference indices for clumped midgrass cover type varied

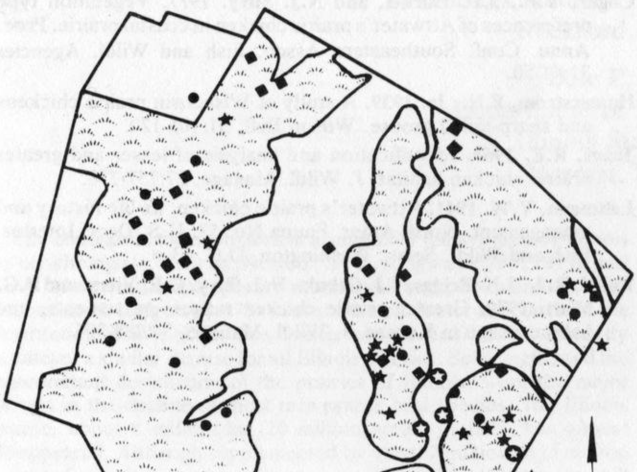

Figure 1. The location of nest sites, brood observations and booming grounds showing their association with midgrass areas of the Lake Pasture, River Branch, Refugio County, Texas. (After Cogar et al., 1977.)

from 2.7 during the winter-booming season to 2.9 during the spring-nesting season. Female preference for clumped midgrass ranged from 2.51 during the winter-booming season to 2.9 during both the spring-nesting and brooding seasons. Pooled cover preferences for male and female birds showed positive selection for clumped midgrass to be greatest during the brooding season (PI = 3.00) and least during the winter-blooming season (PI = 2.62).

DISCUSSION

In an earlier report of vegetation use by Attwater's prairie chickens, we analyzed data obtained from general observations of chickens on our study area (Cogar et al., 1977). In the present study, we used data from radio-tagged birds taken daily at random times.

For the present study, radio telemetry data revealed that the Attwater's prairie chickens substantially used only one of the eight major cover types present. In addition, artifically maintained areas were also extensively used. Cogar et al. (1977) indicated that the use of artificially maintained areas was somewhat restricted as they were used only if they adjoined either the clumped midgrass or transitional cover types.

The clumped midgrass with a visual obstruction index of 2.22 and 2.98, and a mean cover height of 49.2 and 48.3 cm during the spring-nesting and brooding seasons, respectively, appeared to offer cover of the correct density and height for nests and young broods (Cogar et al., 1977). These results are in agreement with findings by Chamrad and Dodd (1972), Jones (1963), and Hamerstrom (1939). Once broods became older, they were observed more in the artificially maintained areas of the Lake Pasture which were associated with clumped midgrass areas (Fig. 1). As noted by Cogar et al. (1977), broods here were easier to observe due to the mown vegetation; however, these areas also provided good sites for dusting, avoidance of wet vegetation, and feeding.

Of the eight cover types on the study area, clumped midgrass provided the highest cover preference index, averaging 2.82 for all seasons. Cogar et al. (1977) observed that the clumped distribution of the vegetation within this type plus the cover density and height must be favorable to the Attwater's prairie chicken. No correlation existed between visual obstruction or height of cover with the differential seasonal use of the eight cover types by chickens. Robel et al. (1970) noted that factors such as site, slope, food availability, and location as well as density probably influence habitat usage of greater prairie chickens in Kansas. Neither cover height nor the combination of cover height and obstruction could be used to separate cover use when analyzed on a seasonal or annual basis. Both of these factors appeared important; however, our data suggest cover height may be more important than visual obstruction. It appeared that if the mean height of the cover exceeded 55 cm the habitat became unfavorable for Attwater's prairie chicken use. During our study, this factor would eliminate chicken use of the balsamscale, cordgrass, and rattlebrush cover types. The wetness of the latter two areas appears to preclude their use by the prairie chickens on the study area.

The clumped midgrass cover type had a greater interspersion of cover heights than did the unclumped midgrass or transitional areas. Cogar et al. (1977) quantitatively demonstrated this difference and noted that the variation in height was due to variations in soil topog-

Table 1. Cover type preferences indices (percent of bird locations within a cover type/percent cover type within study area) by season, calculated from 3,434 nonbooming and nonartificially maintained area locations of radio-tagged Attwater's prairie chickens in the Lake Pasture, O'Conner Brother's Riverside Ranch, Refugio County, Texas. Preference indices are presented for males (M) and females (F), and data are pooled (P) for both males and females.

	Preference Indices											
	Nesting Season			Brooding Season			Fall Booming			Winter Booming		
	M	F	P	M	F	P	M	F	P	M	F	P
Spiny aster	0.50	1.05	0.82	2.00	0.90	1.60	0.22	0.81	0.51	1.23	2.74	1.90
Cordgrass	0	0	0	0	0	0	0	0	0	0	0	0
Transition	0	0.02	0	0.15	0.10	0.14	0.14	0.30	0.22	0.94	1.34	0.64
Rattlebush	0.30	0	0.12	0	0.20	0.07	0.11	0.20	0.16	0	0.04	0.02
Balsamscale	0	0	0	0	0	0	0	0	0	0	0	0
Hardpan	0.22	0.03	0.11	0.02	0	0.01	0.33	0.30	0.30	0.48	0.03	0.30
Unclumped	0.05	0	0.02	0	0	0	0.06	0	0.03	0	0	0
Clumped	2.90	2.90	2.83	2.80	2.90	3.00	2.80	2.71	2.73	2.70	2.51	2.62

raphy and the clumped nature of the vegetation. According to Lehmann (1941), the best natural habitat for Attwater's prairie chicken was native coastal prairie in which the soil topography caused vegetational diversity. He indicated that when properly managed these grasslands satisfied every known requirement of the Attwater's prairie chicken. We support his recommendation that management for this subspecies should be directed toward improvement of the native coastal prairie.

CONCLUSIONS

During January 1976 through August 1977, a study of Attwater's prairie chicken yielded 3,434 radio telemetry locations of activities. Results of an earlier observational study of Attwater's prairie chicken (Cogar et al., 1977) were similar to the present findings, and the same general conclusions seem appropriate. Analysis of the radio telemetry data as to cover use provided the following conclusions:

1. Radio telemetry locations of Attwater's prairie chicken indicated that the chickens preferred only one of eight major cover types on the study area, the clumped midgrass cover type.
2. Areas of clumped midgrass which were utilized by Attwater's prairie chicken contained an interspersion of open, low vegetation with taller, more dense vegetation. Cover height appeared more important than cover density although interspersion of cover height and soil moisture also influenced use of areas.
3. The creation of artificial openings by the presence of roads and mown areas appeared beneficial to the Attwater's prairie chicken on this study site.
4. The protection and proper management of native Gulf Coastal Prairie seemed to be the key factor in maintaining a viable Attwater's prairie chicken population.
5. This radio telemetry study verifies that data consisting of numerous visual observations can produce valid habitat use information.

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Greater Prairie Chicken Cock

Greater prairie chicken cock in courtship display. (Photograph by Don Wooldridge, courtesy of D. M. Christisen and the Missouri Dept. Conserv.)

THREATENED, ENDANGERED, AND EXTIRPATED BIRDS OF ILLINOIS PRAIRIES

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The contrast between historical accounts of the avifauna of Illinois by ornithologists, such as, Nelson (1876), Ridgway (1889, 1895), and Cory (1909), and contemporary accounts of bird populations is well-documented. Ridgway (1873) wrote of the character and, later, of the destruction (1889), of the Fox Prairie and its bird life. He correctly predicted a similar demise for all Illinois prairies. Settlement, and the concomitant destruction of the prairies of Illinois, were the major factors in the decline of most rare prairie bird species. The Illinois prairie, about 8 million ha (20 million acres) in 1800, has almost disappeared. Although supplemented by about 2 million ha (5 million acres) of substitute prairie of pasture and hayfields, this amount still represents a 75 percent decrease in habitat for prairie species. Recent loss of this artificial habitat has continued as pasture, which constituted over 2.4 million ha (6 million acres) in 1907, had dropped 67 percent by 1957 (Graber and Graber, 1963). As a result, relatively few tracts of prairie or substitute prairie are large enough to support the larger territorial prairie species remaining in Illinois. Smaller existing tracts may be too isolated to be repopulated if nesting species fail to return; thus, a biogeographical island results.

PROCEDURES

A provisional list of endangered Illinois birds was compiled by the Illinois Nature Preserves Commission (INPC) in 1971. In 1976 in cooperation with the Department of Conservation, Illinois Natural History Survey, Illinois State Museum, and various universities, the INPC published an interim list of 143 endangered, vulnerable, and rare vertebrates of Illinois (Thom, 1977).

In 1977 the Natural Land Institute received a Joyce Foundation grant to compile information about and to determine the status of Illinois' threatened and endangered vascular plant and vertebrate species. This project included a museum search, literature review, interviews, and field investigations. A series of workshops was held with specialists to review and augment the information previously gathered, and to make recommendations on management and protection. Criteria used at the endangered bird workshop in establishing the bird species list included naturally low populations; decreasing populations; and rare, vulnerable, or disappearing habitat. State endangered species were defined as those being in danger of extirpation as breeding species in Illinois, while state threatened species were considered likely to become endangered species.

The list resulting from the bird workshop was recommended to the Illinois Endangered Species Protection Board, which has authority to determine state endangered species. After receiving public comment, this board published a list of 72 endangered and threatened vertebrates of Illinois (Kenney, 1978). Ten endangered and two threatened avian species of the Illinois prairie were included. At least four prairie bird species have been extirpated.

We considered birds to be prairie species if the literature or observer noted that they nest in grassland or savanna communities. Some species that may occur within prairie regions are not included because an aquatic habitat is a requirement for nesting and foraging.

Scientific names follow those of the American Ornithologists' Union (1957). General range distribution and habitat are from Bull and Farrand (1977). More detailed Illinois distribution is from Bohlen (1978). Illinois counties are delineated in Figure 1.

STATE THREATENED SPECIES

Loggerhead Shrike *(Lanius ludovicianus)*

This shrike is a common permanent resident in the southern third of Illinois, although current nesting records are rare. It is an occasional summer resident in the central and northern counties. Prior to 1900 this species had a state-wide distribution, adapting primarily to osage orange hedgerows for nesting and feeding. With the elimination of hedgerows, the central and northern Illinois populations began to decline in the 1950's and have almost disappeared (Graber et al., 1973).

Early accounts of this shrike (Ridgway, 1889) indicated that it preferred open areas with thorn trees, such as honey locust, wild crabapple, and the then common hedgerows. Most of the recent nests in central and northern Illinois have been in osage orange trees. In the south, red cedar trees and rose bushes may also be used (Graber et al., 1973).

The decline of the loggerhead shrike in the northern two-thirds of Illinois is partially due to hedgerow removal, but a very rapid decline occurred from 1957 to 1965 from unknown causes. No current sign of recovery is evident (Graber et al., 1973). Until the cause for the decline in shrike populations is discovered, few management recommendations can be made. Hedgerows and other plant species with thorns provide nesting and foraging habitat.

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Brewer's Blackbird *(Euphagus cyanocephalus)*

This species occurs as a locally uncommon summer resident in northeastern Illinois in Lake and, possibly, Cook Counties. Stephney and Power (1973) cited nesting only as far east as the Red River valley in western Minnesota before 1900. The Minnesota population then increased and expanded eastward into cleared forest land. Woodruff (1907) reported this species as a rare visitor in the Chicago area; nesting was first noted there in 1928 (Ford, 1956).

Brewer's blackbird now nests near Lake Michigan in prairie and disturbed habitat. Protection from human disturbance and maintenance of natural prairie near the lakeshore seem to be the only immediate needs for this peripheral species.

Henslow's Sparrow *(Ammodramus henslowii)*

At present, this species is a very local summer resident in northern and central Illinois counties and a very rare summer resident in the south. Ridgway (1895) indicated that this sparrow formerly was exceedingly common or even abundant in Illinois, and noted its occurrence in Fox Prairie, east-central Illinois (Ridgway, 1873). Henslow's sparrow probably nested state-wide in prairie where shrubs or tallgrasses provided singing perches. It now also nests in fields with dense ground cover.

Figure 1. Illinois counties.

Destruction of prairie nesting habitat seems to be the cause for the decline of this sparrow. Many nesting sites are in unprotected successional fields in the Chicago region. Safeguarding prairie nesting sites and maintaining cover through the nesting season are critical, as well as maintaining fallow fields in the proper stages of succession. Because of cover requirements, burning programs could prohibit or delay nesting.

STATE ENDANGERED SPECIES

American Bittern *(Botaurus lentiginosus)*

At present in Illinois, the American bittern is a rare summer resident. Breeding may occur in large marshes in Fulton, Grundy, Cook, and Lake Counties, and possibly in marshes along the major rivers (Graber et al., 1978). This species is a regular summer resident at Goose Lake Prairie, Grundy County (Birkenholz, 1975). Presumably, this bittern once nested in wet prairies and marshes throughout Illinois. Old records (Cory, 1909; Nelson, 1876) noted that this species was a common summer resident in northern Illinois. Ford (1956) still considered the species abundant in northeastern Illinois.

The American bittern generally inhabits lake edges and brackish and freshwater marshes. Specific information from Illinois is scarce. Beecher (1942) recorded a nest located just above the water level in cat-tails, bulrushes, and sedges at a marsh edge. Nesting has also been noted at woodland ponds (Graber et al., 1978).

This solitary and secretive bittern has a large territory and low population density. The nesting population has declined with the destruction of prairie and marsh habitat. Until more is known about this species' ecology, management recommendations are the preservation of large tracts of prairie wetlands and marshes, as well as protection from human disturbance.

Swainson's Hawk *(Buteo swainsoni)*

Swainson's hawk is now a rare, local summer resident in northeastern Illinois. The species probably occurred locally in the northern two-thirds of Illinois where habitat was available. Ridgway (1889) recorded this hawk at Fox Prairie, Richland County. Nesting occurred in northern Illinois in Winnebago and Boone Counties until the mid-1960's, and was last documented in Kane County in 1974 (Keir, 1976).

Nesting requirements are not well-known in Illinois for this species. Swainson's hawk probably forages in prairies or open fields, and has recently been noted to nest in bur oak woodlands. Breeding at the eastern limits of its range in Illinois, this hawk now appears to be a sporadic and declining species. Protection of nesting birds from human disturbance is critical because nest desertion, which has been observed in Illinois (Keir, 1976), can be frequent.

Marsh Hawk *(Circus cyaneus)*

Now an occasional summer resident throughout Illinois, the marsh hawk or northern harrier probably was once distributed nearly state-wide in suitable marsh and prairie sites. Recent breeding sites are in north-central Illinois in LaSalle County and Goose Lake Prairie State Park, Grundy County (Birkenholz, 1977).

As a breeding species, the marsh hawk has declined to an extremely low population level because of destruction of grassland nesting habitat. Preservation of large areas of this habitat are essential for this species. Research on nesting behavior in relation to prairie management is needed.

Greater Prairie Chicken *(Tympanuchus cupido)*

This prairie chicken occurred in tallgrass prairie throughout the northern two-thirds of Illinois. The population reached a peak about 1860 as the birds extended their range into areas of cleared forest. With increased intensity of farming and hunting, the Illinois population then began a severe decline that paralleled the destruction of prairie habitat. This species is now a rare and local permanent resident in south-central Illinois, with remnant flocks of fewer than 300 birds in Jasper, Marion, Washington, and Wayne Counties where

1978 booming ground counts consisted of 124 cocks (Westemeier, 1978). It is rare and local at present despite absence of hunting pressure.

Sanderson et al. (1973) provided an account of status of the greater prairie chicken in Illinois. The species uses intensively managed nonindigenous grassland on preserves where reseeding and burning produce optimum nesting habitat. Species of native grasses are being reintroduced into sanctuaries and managed with burning. Well-drained, open booming grounds are critical for the mating of this species.

In northern and central Illinois, competition from the introduced ring-necked pheasant will probably prevent reestablishment of the greater prairie chicken. On the prairie chicken preserves, predators, booming ground harassment, and nest parasitism from released private game farm pheasants are a continual threat.

Yellow Rail *(Coturnicops noveboracensis)*

In Illinois the yellow rail is a rare summer resident in the northern counties. No current nesting sites are documented. Nelson (1876) reported this rail to be "not very rare" in northeastern Illinois and he cited a collection of eggs from Winnebago County. Woodruff (1896) reported it as quite common in Cook County. This species was probably present throughout northern Illinois in suitable habitat: its secretive nature may explain the lack of sightings. Marshes, wet prairies, and sedge meadows with good nesting cover probably serve as habitat for this species.

Illinois is at the southern limit of the breeding range of the Yellow Rail. Rare since 1900 because of loss of habitat, continued wetland destruction should further decrease the population of this rail. General management suggestions include the protection and proper management of wetland habitat in northern Illinois.

Black Rail *(Laterallus jamaicensis)*

The Black Rail appears to be a rare summer resident in the central and northern counties. No current nesting sites are known, probably because of its secretive nature and rarity, and little information is available on its former distribution. Although seldom observed, it probably inhabited marshes throughout central and northern Illinois. Nelson (1876) cited a nest in marshes of the Calumet River, Cook County, and Musselman (1937) banded young in Adams County in 1932 and 1936. Bohlen (1976) reported a possible nesting in Mason County during June 1975.

Sighting and nesting records for this elusive rail are so rare that little is known of its status. Destruction of marsh habitat probably decreased its population size and may continue. Until more is known about the nesting ecology of this species, management recommendations can only include the protection of wet prairie and sedge meadow nesting habitat.

Upland Sandpiper *(Bartramia longicauda)*

This species remains a summer resident in Illinois. The few current nesting records are from at least nine counties throughout the state. The species has apparently recovered from near extirpation, but its population level is low compared to early records (Graber and Graber, 1963).

Graber and Graber (1963) recorded greatest densities of this sandpiper in pasture and hay fields, especially red clover. Birkenholz (1975) observed nesting in bluegrass rather than prairie tallgrasses at Goose Lake Prairie. However, late spring burns and drought allowed this species to use areas of tallgrass in 1976 (Kleen, 1978).

Disappearance of habitat contributed to its current status, and preservation and management of existing habitat is critical for this species. Late prescribed burning which allows nesting in low cover areas, and the maintenance of pasture and hay fields may increase habitat.

Short-eared Owl *(Asio flammeus)*

This owl is a rare summer resident in central and northern Illinois. Recent nesting locations are in Grundy County at Goose Lake Prairie and in Lake County, Cory (1909) indicated that this species nested in Cook County while Ford (1956) emphasized erratic nesting. Nesting may have formerly occurred sporadically across the northern half of Illinois in appropriate habitat. Apparently, wintering birds have always been locally common.

The short-eared owl nests on the ground in freshwater and saltwater marshes, open grasslands, prairies, and dunes. It probably nests in wet prairie in Illinois (Birkenholz, 1975). Wintering populations may use old fields and abandoned pastures. They often roost in pines in open areas.

Destruction of prairie nesting habitat probably has been the primary factor in the population decline of this owl. Low nesting populations and erratic nesting behavior make its presence unpredictable even in suitable habitat. Preservation and management of large tracts of prairie and marsh habitat seem essential for this species. Protection from disturbance for wintering populations is also necessary.

Bachman's Sparrow *(Aimophila aestivalis)*

Bachman's sparrow is now restricted to southern Illinois where it is a rare summer resident. Observations were made in Johnson, Pope, and Jackson Counties from 1972 through 1975 (Bohlen, 1978), but no current nesting sites are known. Bachman's sparrow may have had a nearly state-wide distribution. Cory (1909) indicated that this species occurred in habitat in the southern and central portion of the state. Ford (1956) reported it as a very rare summer resident in the Chicago region.

Ridgway (1895:280) gave "oak-wood sparrow" as a popular synonym for Bachman's sparrow and described appropriate habitat: "emphatically a bird of open oak woods . . . with grass immediately adjoining . . . but neglected fields, grown up to weeds, and in which old dead trees are left standing, are also its favorite haunt." This statement indicates that even before 1900 the species occupied its current habitat of old fields with trees or shrubs and a grass understory.

Bachman's sparrow breeds at the northwestern limits of its range in Illinois and may never have been abundant. Since 1900 it has declined and disappeared from northern Illinois and, now, rarely occupies old fields in southern Illinois. The survival of Bachman's sparrow in Illinois may depend upon burning of savanna or barren remnants, and control of old field succession.

STATE EXTIRPATED SPECIES

Sharp-tailed Grouse *(Pediocetes phasianellus)*

Kennicott (1855) reported this northwestern grassland species as formerly common in Cook County. Nelson (1876) indicated that the last record was a covey of 14 birds taken with prairie chickens near Waukegan, Lake County, in 1863 or 1864. Ridgway (1895) cited an older report for northeastern Illinois that described hunting grouse and noted their association with bur oak, the characteristic savanna vegetation of that region. The cause of decline is unknown; however, hunting, as with the prairie chicken, may have been a factor.

Whooping Crane *(Grus americana)*

Kennicott (1855) reported that the whooping crane was exceedingly rare, but once common in Cook County. Nelson (1876) stated that it was formerly an abundant migrant but "now" of rare occurrence except along the Illinois River and thinly settled portions of the state, and that a few pairs still bred in the large marshes in central Illinois. Parmalee (1958) referred to archaeological records of this species from sites in Peoria and Jackson Counties. This reference suggests a possible state-wide occurrence. The whooping crane now nests in northern bogs and winters in coastal prairies. Little is known of its habitat in Illinois. It apparently occurred where large prairies and marshes were present, probably in the northern two-thirds of the state. Intolerant of human presence, the whooping crane began to disappear even before destruction of its habitat.

Sandhill Crane *(Grus canadensis)*

Parmalee (1958) referred to archaeological specimens from midden refuse throughout Illinois. Kennicott (1855) reported the sandhill crane had been abundant but was disappearing with settlement in Illinois. Nelson (1876) indicated it was formerly abundant on all large marshes, but by then it was breeding only in a few sites in the center of the state. Thus, even before 1900 this species was disappearing. Nelson (1876) and Cory (1909) referred to nesting in marshes. Ridgway (1895) noted that the sandhill crane fed more in meadows and prairies; it nested sometimes in marshes, but often on dry spots, suggesting the prairie border of marshes. Like the whooping crane, this species is relatively intolerant of human populations and apparently began to disappear long before actual destruction of its habitat.

Swallow-tailed Kite *(Elanoides forticatus)*

The inclusion of this species is based on a few accounts prior to 1900. The swallow-tailed kite was described by Kennicott (1855) as rare but formerly common in Cook County, and "still found in the middle of the state." Nelson (1876) cited its decline in northeastern Illinois, noting only "two or three instances of its occurrence within the last twenty years." Ridgway (1889) recorded it from east-central Illinois, Richland County. It may have occurred throughout the state but disappeared with settlement. Ridgway (1889) described this kite and the Mississippi kite as feeding on insects over clearings in Fox Prairie, Richland County. No nesting accounts are available.

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SOIL LOSS AND THE SEARCH FOR A PERMANENT AGRICULTURE

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This paper has been published elsewhere and the references are listed below:

Jackson, Wes. 1978. Towards a sustainable agriculture. Not Man Apart 8(15):4-6.

__________. 1979. Soil loss and the search for a sustainable agriculture, p. 243-254. *In* Wes Jackson. Man and the environment. William C. Brown and Co. Publishers, Dubuque, Iowa. 363 p.

United States of America

Map of the political divisions of the United States. (Elbert L. Little, Jr., 1971, Atlas of the United States trees, Vol. I, Conifers and important hardwoods, For. Serv., U.S. Dept. Agric., Misc. Publ. No. 1146, U.S. Gov. Printing Office, Washington, D.C., Base Map 2-N.)

ABSTRACTS OF PAPERS NOT SUBMITTED

4. COMPASS-PLANT *(SILPHIUM LACINIATUM)* IN OHIO: ITS HISTORIC AND PRESENT-DAY DISTRIBUTION. Allison W. Cusick, Ohio Department of Natural Resources, Division of Natural Areas, Columbus, OH

Compass-plant *(Silphium laciniatum)* seems always to have been a rarity in Ohio, restricted to the fringes of the Prairie Peninsula and to prairie outliers in the Eastern Deciduous Forest Region. It was last reported from Franklin and Summit Counties in 1935 and 1938, respectively. A recent record from Erie County, 1966, is from a site now destroyed. Today it is known only from a single station in Lawrence County. It occurs on a lightly-grazed slope with other prairie species in a small opening surrounded by typical deciduous forest. The opening seems to be maintained by the grazing and by the periodic slumping of the unstable, clayey substrate. This site, then, is closely related to other pockets of prairie species found on calcareous or neutral soils on the Appalachian Plateau, such as the Buffalo Beats in Athens County. A study of the common prairie-dock *(Silphium terebinthinaceum)* in Marion County revealed genetic introgression with compass-plant, although no specimens of *Silphium laciniatum* itself could be located. This is the only evidence of compass-plant's occurrence in the heart of Ohio's Prairie Peninsula.

8. APPROACHES TO THE DESIGN OF SMALL PRAIRIE PLANTINGS. Evelyn A. Howell & Darrel Morrison, Department of Landscape Architecture, University of Wisconsin, Madison, WI

Prairie plantings on small sites of one acre or less are generally of two forms: (1) Gardens in which prairie species are used individually and (2) Attempts to represent the prairie community. It is the latter approach which is the subject of this paper.

In botanical terms a plant community is an aggregation of species growing together in a given place at a given time; in design terms a community is the assemblage of design elements such as color or texture which characterize the botanical community. This aesthetic "essence" of a community can be approximated in planting design by either (1) an exact replication of a natural prototype, or (2) by a simplified stylization which keeps the major design elements without including all the botanical elements of the prototype.

On a small site the first approach results in the re-creation of a small portion of a prairie community. The number of species used, the pattern of placement, and the species associations are the same as those found in a selected sample plot. The aesthetic experience is that of a close, detailed examination.

The second approach might result in a capsulization of a broad prairie expanse in a small area. When viewed from a distance, the fine textures of the prairie grasses merge to form a green background which visually filters and refines the coarser textured and brilliantly colored forbs. This effect can be achieved in a small space with a short viewing distance by simplifying the number of species planted and by choosing a predominance of finer-textured species, e.g. by using a ratio of 90% "background" grasses to 10% "accent" forbs.

Either approach is a valid community design. Each provides the potential of experiencing some aspect of the prairie landscape in a limited space.

11. RESTORATION AND MANAGEMENT OF THE ARMAND BAYOU PRAIRIE. Cameron Munroe, Armand Bayou Nature Center, Houston, TX

The Coastal Prairie Association is a unique grassland community of Texas that is rapidly diminishing. On the site of Armand Bayou Nature Center, in Harris County, are the remains of part of the Coastal Prairie Association. There are two plots, 486 acres and 509 acres, in poor and fair condition, respectively. Due to overgrazing and control of fire, the major grass species and prairie plants have diminished and the prairie has been invaded by *Baccharis halimifolia, Sapium sebiferum* and less desirable grass species. The 486-acre plot will be burned in the summer of 1978 to eradicate the brush, and the native grasses will be reintroduced by broadcast seeding. The 509-acre plot will be burned in the winter of 1979 to maintain and encourage the already established grasses and remove invading brush. The grasses will be managed with annual haying and maintenance burns every third winter. Ten (10) acres of each plot will remain as controls.

12. RESTORING PRAIRIES AS AN EDUCATIONAL TOOL. Robert F. Horlock, St. Charles High School, St. Charles, IL

At St. Charles High School, St. Charles, Illinois, students have been involved in a prairie restoration for the past six years. Approximately 200 high school students have contributed their time to the restoration, which has reached a size of about 30,000 square feet, with close to 130 species of native prairie plants having been introduced by hand planting, and subsequent weeding of the planting. What students gain from their participation in the project is highly variable, depending primarily on the degree of their activity in the project. They do not gain any academic credit for their work. However, it is obvious that there is an educational "gain" from even a modest involvement. They gain a practical insight into plant classification and physiology. By virtue of being instructed as to what plants occur in particular habitat types, they gain some practical experience in the dynamics of ecology. Ecological principles such as competition and succession are demonstrated to the students by the population changes that occur in the plots for which they are responsible. Horticultural practices are demonstrated in the collection and stratification of seeds, the planting of the seeds in individual pots, the care of the seedlings, the field planting, and the weeding of the planting. They are introduced, by experience, to some of the principles of grassland management. Among the less tangible but equally important virtues to be learned from the students' involvement in the project are a deeper sense of and respect for living organisms, a sense of the agrarian heritage of our nation, and a sense of pride at having made a lasting contribution to the cause of conservation in their own community.

13. SHEYENNE NATIONAL GRASSLAND IN NORTH DAKOTA — FROM SAND TO GRASS AND MORE. Dale F. Shanholtzer, U.S. Forest Service, Sheyenne National Grassland, Lisbon, ND

The Sheyenne National Grassland is located in Ransom and Richland Counties, North Dakota. Much of this land was originally homesteaded, plowed, and farmed. However, much of it was sub-marginal farmland and serious wind erosion occurred during the great drought of the 1930's. Under provisions of Title III, Bankhead-Jones Farm Tenant Act, the Federal Government began a land acquisition program with the ultimate aim of demonstrating and promoting grassland agriculture. Administration of these lands was transferred to the Forest Service in 1954.

Nearly all the depleted farmland has been revegetated with native species, range improvements have been constructed, and livestock herds have been established. A cooperative grazing association has been established and a grazing agreement, which specifies rules of management, has been negotiated between the Grazing Association and the Forest Service. The Association Board of Directors, elected by the membership, and Forest Service personnel work together in promoting full development of potential and existing grazing lands.

In the past the major land use practices have historically centered around livestock. However, currently, recreation, wildlife and water demands are creating new impacts upon the grazing resource.

The range resource program on the Sheyenne National Grassland is somewhat unusual. Annual grassland burning and mowing practices are utilized to make lowland grasses palatable for livestock use. Rotation grazing systems are integrated with twice-over pasture use to properly utilize the available forage.

The needs of the greater prairie chicken are incorporated into the range grazing systems to promote a steady increase in the prairie chicken population.

15. THE ORIGIN AND ECOLOGY OF OHIO'S BOGS AND FENS. Guy Denny, Ohio Department of Natural Resources, Division of Natural Areas, Columbus, OH

Ohio's acid peat bogs and alkaline marl bogs or fens have an origin dating back to Wisconsinan glaciation. As the climate warmed and the glacier made a final northerly retreat, the extensive band of boreal vegetation along the margin of the ice sheet also retreated, recolonizing the newly exposed glacial soils and countless lakes and ponds left behind the melting ice.

Although both acid bogs and fens share a glacial origin and may even share a few of the same floristic components, they are physically and botanically two separate and distinctive plant communities. Sphagnum moss *(Sphagnum* sp.*)*, leatherleaf *(Chamaedaphne calyculata)* and northern highbush blueberry *(Vaccinium corymbosum)* are characteristic components within the well defined, usually concentric, plant zones of Ohio's acid bogs. Sedges and rushes *(Carex* and *Juncus)*, marsh fern *(Dryopteris thelypteris)*, and shrubby cinquefoil *(Potentilla fruticosa)* are characteristic components of the recognizable yet less regimented plant zones of Ohio's fens. Furthermore, most of these fens exhibit a number of prairie species, relicts of the post-glacial continental droughts, occupying the drier portions of the fen meadow zone.

16. PRAIRIE POETRY. Patricia K. Armstrong, The Morton Arboretum, Lisle, IL

The prairie is an excellent subject for creative writers. Poetry classes at the Morton Arboretum have explored our prairie restoration project from the aspect of the plants and animals which live there, the Indians who loved the prairie and became a part of it, the pioneers who hated the prairie and destroyed it for farms, and modern man who now appreciates what he has lost and tries to restore it. Prairie Poetry is an aesthetic and educational experience in discovering our roots in our prairie heritage.

17. A REVIEW OF HERBICIDE USE IN ESTABLISHING NATIVE PRAIRIE GRASSES. Eugene E. Woehler, Wisconsin Department of Natural Resources, Madison, WI

Annual weed competition is the major factor limiting success in establishing native prairie grasses and forbs on agricultural lands in the upper Midwest. Herbicides have been the primary means of weed control in all major agricultural crops over the past two decades. These chemicals have proven to be effective, economical and environmentally acceptable. Switchgrass, big and little bluestem and Indiangrass tolerate 2½ pounds of atrazine per acre applied as a pre-emergent spray which controls a wide spectrum of annual broad-leaved and grassy weeds. Amine form of 2,4-D at 1 quart per acre controls annual broad-leaved weeds when applied at a growth stage of 1-6 inches. Roundup paraquat and atrazine used separately or in combination show promise as a pre-plant treatment under a no-till seeding of switchgrass on a permanent pasture comprised of perennial cool-season grasses and weedy forbs.

Carefully documented experiments are necessary to provide basic data for label consideration and legal use of herbicides in establishing native prairie species.

18. ESTABLISHING NATIVE, PERENNIAL GRASSES AND FORBS USING HERBICIDES AND MOWING. Thomas B. Bragg & David M. Sutherland, Department of Biology, University of Nebraska, Omaha, NE

Upland and lowland sites were seeded to native, perennial grasses and forbs; then atrazine, 2,4-D, and mowing treatments were applied at one- and two-year intervals. Mowing resulted in the most diverse stand of seeded species in both lowland and upland sites (average cover/grass species = 16% and 15%, respectively, with 4 and 9 forb species noted). In the upland, an equally diverse stand was noted with 2,4-D at 2.2 kg/ha. Seeded forbs were absent from all lowland plots treated with herbicides. Atrazine and 2,4-D, however, can be effective in establishing grass stands where the need for rapid establishment outweighs the desirability of diversity. Lowland native grass cover averaged 20% and 8% higher with atrazine than in mowed and control areas. Switchgrass *(Panicum virgatum)* was strongly favored by high concentrations of atrazine (average cover = 96%) although other species declined. In the upland site, 2,4-D was more effective than atrazine in establishing grasses. Sideoats grama *(Bouteloua curtipendula)* and blue grama *(B. gracilis)* were favored by 2,4-D averaging 22% and 12% cover as compared to 15% and 6% with atrazine; little bluestem *(Andropogon scoparius)* cover was highest with atrazine. In both sites, atrazine was more effective at maintaining low forb cover (55%) than mowing (58%), 2,4-D (82%) or control (82%). Direct effects of atrazine on forb establishment, including carry-over effects, are indicated although canopy cover also appears to be a major factor. Unmowed lowland plots averaged 1109 g/m^2 biomass in contrast to 394 g/m^2 for upland and mowed lowland plots. Seeded forbs were found only in the latter areas. In general, herbicide and mowing treatments had different effects in different environments with the more appropriate treatment varying with respect to reestablishment goals. It is essential, therefore, that preliminary studies be conducted to determine first the need for herbicides and second the lowest effective concentration, remembering that herbicides in any amount may have other effects on an ecosystem.

28. RELATIONSHIP BETWEEN PHYSIOLOGY AND PHENOLOGY IN A C_3 AND C_4 GRASS. W. Eric Limbach, Massillon, OH

Seasonal differences in growth and development among the graminoid components of the North American prairies have long been recognized by range managers and grassland ecologists. The inherent physiological traits of cool-season (C_3 biochemical photosynthetic pathway) and warm-season (C_4 biochemical photosynthetic pathway) grasses have significant adaptive values and are closely related to the grasses' periods of seasonal activity. The C_3 grasses initiate underground stem elongation and leaf formation early in the growing season when soil and air temperatures are low; the C_4 grasses remain dormant early in the spring and begin growth when warmer soil and air temperatures are encountered later in the season. Comparative phenology and physiological characteristics of two grass species, *Elymus canadensis* (C_3) and *Andropogon hallii* (C_4), were studied *in situ* at an extension of mixed prairie in eastern Wyoming (1470 m). The effects of low temperatures on growth initiation and development in the two species were studied at a high elevation, experimental transplant garden (2600 m) near Laramie, Wyoming. *Elymus* has a photosynthetic temperature optimum that falls within the range of 20-25 degrees C, low CO_2 assimilation rates (16 mg dm^{-2}hr^{-1} *in situ* and 11 mg dm^{-2}hr^{-1} in the laboratory) and relatively high transpiration rates (0.5 cm s^{-1} leaf conductance *in situ* and 0.8 cm s^{-1} in the laboratory). In contrast, *Andropogon* shows a higher photosynthetic temperature optimum near 33 degrees C, higher CO_2 assimilation rates (40 mg dm^{-2}hr^{-1} *in situ* and 23 mg dm^{-2}hr^{-1} in the laboratory) and lower transpiration rates (0.4 cm s^{-1} *in situ* and 0.3 cm s^{-1} in the laboratory). These physiological data correlate well with the phenological observations. At the mixed prairie site, *Elymus* initiates both underground and above-ground growth by mid-March (mean minimum temperature -5 degrees C) while *Andropogan* just begins above-ground growth at mid-May (mean minimum temperature 14 degrees C). In the experimental transplant garden *Elymus* shows frost tolerance and produces flowering culms which set viable seed by late August. In this same environment *Andropogon* shows frost sensitivity and a greatly suppressed flower development which is still incomplete at the first killing frost in early September. It is now clear that the C_3 species is not only adapted to initiating growth in the cool spring but is able to complete its reproductive cycle under relatively low temperature regimes. The C_4 species requires warm temperatures to initiate growth and must experience a warm growing season to complete its reproductive cycle. The C_3 and C_4 photosynthetic modes reflect inherent physiological differences be-

30. NATIVE TALL GRASS PRAIRIE SPECIES AT THEIR PHYSIOLOGICAL TOLERANCE LIMITS IN EASTERN WYOMING. A. Tyrone Harrison, School of Life Sciences, University of Nebraska, Lincoln, NE

A relict area for species typical of the tall grass prairie vegetation type has been found in eastern Wyoming 16 km northwest of Wheatland (elev. 1300 m; ppt. 30.5 cm) near the eastern foothills of the Laramie Range of the Central Rocky Mountains. Big bluestem *(Andropogon gerardi),* switchgrass *(Panicum virgatum),* and Indiangrass *(Sorghastrum nutans)* are rare in the vicinity and are found either in a narrow elevational band coincident with the ponderosa pine-short grass prairie ecotone or on moist, subirrigated floodplain meadows. Intensive field collections and *in situ* measurements of photosynthesis and transpiration have been completed for the tall grasses showing high photosynthetic rates (40-50 mg $CO_2dm^{-2}hr^{-1}$) and high optimum temperatures for photosynthesis between 30 and 40 degrees C. These arm season C_4 photosynthetic pathway species exhibit greater water use efficiency than the cool season native grasses. Physiological traits with high photosynthetic productivity are typical of C_4 species and are highly adaptive allowing effective competition in prairie environments which have a normal co-occurrence of high precipitation and high temperatures during the short summer growing season. Big bluestem is found on south-facing slopes of steep ravines in the foothills always growing immediately adjacent to large rocks which apparently act as micro-watersheds substantially increasing useable soil moisture from summer rainfall (11 cm ppt. June-Aug.). Since big bluestem at this site is associated with a large aggregation of other warm-season native prairie species, it appears that this Rocky Mountain foothill site is a relict vegetation of either pre- or post-Pleistocene origin with compensating climatic factors allowing survival, the tall grass prairie species *not* having been introduced from the East along old wagon roads as previously thought.

31. THE FLOWER, POD AND SEED PRODUCTION IN EIGHTEEN SPECIES OF MIDWESTERN MILKWEEDS. Robert F. Betz & Herbert F. Lamp, Department of Biology, Northeastern Illinois University, Chicago, IL

A study between 1963 and 1974 was made of the flower, pod and seed production in eighteen species of milkweeds belonging to the genera *Asclepias* and *Asclepiodora.* The species studied were: *Asclepias amplexicaulis, A. exaltata, A. hirtella, A. incarnata, A. lanuginosa, A. meadii, A. ovalifolia, A. perennis, A. purpurascens, A. quadrifolia, A. stenophila, A. sullivantii, A. tuberosa, A. variegata, A. verticillata, A. viridiflora* and *Asclepiodora viridis.* Most of these species are found in prairies, prairie savannas, marshes, or other open situations.

Of approximately 2800 plants observed, *A. meadii* has the lowest average number of flowers/plant (13.1), whereas *A. incarnata* has the highest number (1051.2). Three of the species studied *(A. amplexicaulis, A. lanuginosa* and *A. meadia)* produce only one terminal umbel, whereas *A. hirtella* has 8.7 lateral umbels and *A. incarnata* an average of 37.3 umbels in a broad corymb.

Of the more than 1750 plants observed while in fruit, it was found that the larger and more common species, such as *A. incarnata* and *A. syriaca,* produce the largest average number of pods/plant (7.0 and 4.5, respectively), whereas the smaller and rarer species, such as *A. lanuginosa,* produce the least (0.001 pods/plant or 1 in a thousandz.

Of almost 1350 pods collected and counted for their seed content, it was found that *A. syriaca* produces pods with the most seeds with an average of 238.9 seeds/pod, whereas *A. ovalifolia* and *A. quadrifolia* produces pods with the least amount of seeds (22.7 and 25.5 seeds/pod, respectively).

It would appear from this study that the rarer and more diminutive species associated with virgin plant communities, such as *A. lanuginosa, A. quadrifolia, A. meadia* and *A. ovalifolia,* are more likely to produce smaller numbers of flowers, pods and seeds than those larger, more robust species, such as *A. incarnata* and *A. syriaca,* which are more tolerant of disturbed communities.

32. HYBRID SWARMS OF THE PRAIRIE *ASCLEPIAS SPECIOSA* WITH THE COMMON *ASCLEPIAS SYRIACA.* J.W. Thomson, Department of Botany, University of Wisconsin, Madison, WI; & W.H. Wagner, Jr., Department of Botany, University of Michigan, Ann Arbor, MI

The common eastern milkweed, *Asclepias syriaca,* ranges westward to North Dakota and Oklahoma. The western border of its range is sympatric with the eastern borders of the range of the prairie species, *Asclepias speciosa,* in an area extending approximately from North Dakota and Minnesota south to Kansas. Hybrids have previously been noted in this area. The authors have discovered colonies in western Minnesota which exhibit not only hybridity but apparent backcrossing with the parents to produce hybrid swarms. The evidence supporting this interpretation will be presented. The production of such hybrid swarms, even though they are mainly in disturbed areas next to prairie relicts could possibly contaminate the gene pools of the parent species.

35. PRAIRIE PLANTS IN NON-PRAIRIE AREAS AND NON-PRAIRIE PLANTS IN PRAIRIE AREAS IN SOUTHWESTERN OHIO. Sture Fredrik Anliot, Biology Department, Wilmington College, Wilmington, OH

In southwestern Ohio there are prairies. Calling these areas prairies might stun a "wheat belt" resident, but nonetheless, in spite of their small size and limited habitats, they contain the species characteristic of, largely, the tall-grass prairie. They are found in "undisturbed" atypical habitats within a mosaic of what are, were, or are becoming deciduous forests. These "openings" are either wet or dry, with reference to the surroundings, but contain many of the same prairie species and different species. Other areas have some prairie plants, but could scarcely or not at all be classified as prairies. These plants and their habitats are discussed, as well as plants with other ecological affinities that share the same environments located in Greene, Clinton, Highland, and Adams Counties.

36. A RIGHT-OF-WAY PRAIRIE NEAR ZIMMERMAN, GREENE COUNTY, OHIO. Ralph E. Ramey, Glen Helen Nature Preserve, Yellow Springs, OH

Studies delineating the extent of Ohio's prairies at the time of settlement show prairies filling a considerable portion of the valleys of the Little Miami River and two of its small tributaries in western Greene County. The only sizable remnant of these once vast prairies is an area near Zimmerman which lies under high voltage power transmission lines and is bounded by a mainline railroad, a railroad spur and a four-lane highway. Though considerably disturbed by the construction of these transportation facilities, its survival is now dependent upon their existence. A good mix of wet prairie plants, including prairie dock, occupies the site, and some species appear to be migrating outward to the highway and railroad rights-of-way. The power company is aware of the scientific value of this site, has agreed not to spray it, and may be agreeable to other management techniques if they are indicated.

41. USE OF NORTH DAKOTA GRASSLANDS BY BREEDING BIRDS. Harold A. Kantrud & Russell L. Kologiski, U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Jamestown, ND

Vegetative composition and breeding bird density were determined for a random sample of 180 40-640 ac. (16-259 ha) tracts of native grassland in North Dakota during 1974. Samples were drawn in proportion to the areas of 21 mapped physiographic landforms in four major biotic regions including the Agassiz Lake Plain, Drift Plain, Missouri Coteau, and Southwestern Slope. Plots were subjectively placed into three categories of heavily, moderately, and lightly grazed. Reciprocal averaging and Bray-Curtiss ordination were used to analyze the data.

The Southwestern Slope, Agassiz Lake Plain, Drift Plain, and Missouri Coteau supported highest densities of 11, 10, 7, and 2 bird species, respectively. Among the physiographic landforms, lake plain supported highest densities of six species, followed by ground moraine-five, glaciated bedrock and aeolian sand-four each, alluvial river deposits and end moraine-three each, unglaciated bedrock and kames-two each, and sheet moraine-one.

Reciprocal averaging ordination of the composite bird and plant samples from the 21 physiographic landforms produced an arrangement reflecting general decrease in moisture regime from east to west in North Dakota. The stand orders of the two data sets were almost identical (Spearman rank correlation 0.96, $P<.0001$) indicating a definite relationship between grassland vegetation types and breeding birds utilizing those types. The reciprocal averaging indicated three major vegetation types corresponding to the eastern tallgrass prairie, a central, mixed grass-tallgrass ecotone, and mixed grass prairie of the western part of the state. There was no corresponding major break in the bird ordination between tallgrass prairie and the ecotone. The Bray-Curtis and reciprocal averaging ordinations resulted in almost identical stand arrangements.

Analysis of the effects of grazing on some of the most common bird species indicated that densities of the horned lark and chestnut-collared longspur were greatest under more intensive grazing, while densities of the savannah sparrow, grasshopper sparrow, and clay-colored sparrow were lowest. Densities of the western meadowlark, brown-headed cowbird, lark bunting, and Baird's sparrow were unrelated to the three levels of grazing intensity.

45. COMMUNITY ECOLOGY OF ARTHROPODS IN PRAIRIE REMNANTS IN ADAMS COUNTY, OHIO. George W. Uetz, Curtis A. Meininger, & Michael J. Bruggeman, Department of Biological Sciences, University of Cincinnati, Cincinnati, OH

A preliminary study of the arthropod fauna of relict prairies in southern Ohio was undertaken to determine the degree of endemicity in prairie areas and to assess the applicability of island biogeography models to prairie remnant situations. Arthropods were sampled by sweep netting in several prairies and an old field in Adams County, Ohio, during the summer of 1977. The prairie sites sampled represent two different remnant situations: a single, 1-ha open prairie adjacent to a .6-ha old field; and a cluster of 5 smaller (.05 -.13 ha) prairies separated by forest vegetation.

Similarity of species composition of the two prairie areas was greater than the similarity of either to the old field. As the growing season progressed, all areas became increasingly similar in composition, but prairies remained distinct from the old field. The old field had greater species richness (236 spp) than either the Lynx Prairie cluster (151 spp) or the Wilderness open prairie (155 spp). However, the prairie areas had higher equitability than the old field, which showed a greater degree of species dominance. Arthropod community structure, expressed in species-abundance relationships, was extremely similar in the prairie areas.

Within the cluster of prairie "islands" at Lynx Prairie, patterns of species richness and composition varied among selected taxa. Herbivorous insects (Homoptera) fit the predictions of island biogeography theory, with numbers of species positively correlated with "island" area. Pollen/nectar feeders (Hymenoptera) and carnivores (Araneae) showed less adherence to predictions of the island model. Plant species richness and habitat diversity increase with remnant size and appear to influence the species diversity of arthropods to a greater extent than the degree of isolation of the remnant.

46. ARTHROPOD ASSEMBLAGES ON PERENNIAL GRASSES IN OHIO AND ALASKA. Sonja Teraguchi, Jeffrey Stenzel, John Sedlacek, & Richard Deininger, Department of Biology, Case Western Reserve University, Cleveland, OH

The arthropod assemblages on selected native perennial grasses in Ohio and Alaska were compared by censusing a series of tussocks over a growing season. *Calamagrostis canadensis* was studied in both Ohio and Alaska and *Andropogon gerardi* was studied at several sites in Ohio.

The study tests one aspect of the hypothesis that the habitat is a templet for community structure, namely, that greater climatic harshness and unpredictability reduces species richness. The tussocks were similar to one another with respect to above-ground biomass but were different with respect to taxonomic identity of the grass providing physical structure and resources or were different with respect to climate.

Peak species richnesses of parasitoids and of both suctorial and non-suctorial herbivores were similar for Ohioan and Alaskan *C. canadensis*. Seasonal patterns showed some differences. Peak population densities of suctorial herbivores were lower for Ohioan *C. canadensis* than for Alaskan *C. canadensis*, while species richnesses and population densities of carnivores were higher.

Peak species richnesses of herbivores on Ohioan *A. gerardi* were similar to those for *C. canadensis* while parasitoid species richnesses were lower except for one site. Population densities of suctorial herbivores on Ohioan *A. gerardi* were similar to those on Ohioan *C. canadensis* while species richnesses and population densities of carnivores were lower.

49. AN ECOLOGICAL STUDY OF CLADONIFORM LICHENS IN GRASSLAND AREAS, CONDUCTED IN RELICT AND SECONDARY PRAIRIE AREAS IN ADAMS COUNTY, OHIO. Ann M. Fovargue, Botany Department, Miami University, Oxford, OH

The role of lichens in permanent grasslands was studied on 120 replicate quadrats located on four small areas at Lynx Prairie and on a secondary hillside prairie at Buzzardroost Rock Preserve. The grasslands were all dominated by *Andropogon gerardi, Andropogon scoparius, Sorghastrum nutans* and *Bouteloua curtipendula* and typical prairie forbs. Cladoniform lichens are now present at these sites and, as well as the prairie species, were noted by E.L. Braun in 1928. Non-destructive sampling procedures were used in the study to determine density, frequency, cover, and presence-absence data for the plants in each quadrat. Above-ground biomass studies were completed for 50 replicates, half with and half without lichens. The presence-absence data using Cole's Index of Interspecific Association and Chi-Square analyses showed a positively significant association between the Cladonia lichens and *Sorghastrum nutans* and a negatively significant association between the lichens and *Aristida* species. Biomass differences between the same species also showed the same trends.

Abiotic factors such as soil nutrient and texture analyses, soil moisture, pH, and soil depth were analyzed for each replicate. Slope gradient, aspect, position of each quadrat on the slope and percent insolation were also quantified. Soil textures of loams and sandy-loams correlated best with lichen presence, but the lichens followed no particular trends in relation to soil moisture, soil depth, or pH. Microtopography did correlate best with lichen presence. *Cladonia* was associated with eastern exposures — northeastern to south-facing slopes. The lichens received the majority of their moisture from the nightly dewfall, and therefore were active photosynthetically in the early morning while the thalli were still moist. The lichen thallus was usually dried out by 10:30 a.m. and remained dormant until evening. It is this strategy that perpetuates lichen flora in shadeless tall grass prairies.

50. THE ECOLOGY OF VESICULAR-ARBUSCULAR MYCORRHIZAE IN A WESTERN PENNSYLVANIA RELIC PRAIRIE. Susan C. Rabatin & D.T. Wicklow, Pymatuning Laboratory of Ecology, University of Pittsburgh, Pittsburgh, PA

Symbiotic fungal relationships involving the roots of plants are extremely common in nature. About 90% of the grasses and forbs commonly found in the prairies, pastures, and fields of North America are infected with phycomycetous fungi of the family Endogonaceae.

This relationship benefits both partners in that mycorrhizal plants show growth increases which can be associated in the main with the relief of phosphorus deficiency symptoms, whereas the fungal partner benefits from host carbon translocates.

Based on the ubiquitous occurrence of this relationship and its important role in plant nutrition, this study was undertaken to assess seasonal variation in percent level of root infection, morphological root infection stages, and spore/sporocarp number. In addition, the relationship between identified species of vesicular-arbuscular mycorrhizal fungi and certain abiotic site parameters was examined. The study was carried out at the Jennings Nature Reserve, "Blazing Star" Prairie (Butler County, Pennsylvania), owned by the Western Pennsylvania Conservancy. This prairie, characterized by a dense stand of *Liatris spicata*, is considered to be a relic prairie remaining from the last glacial period.

Generally, results show that the low pH and phosphorus depletion of the soil at this site relate to a strong mycorrhizal response, root infection ranging from 48-78%. Mycorrhizal root infection increases from the early spring reaching a height in the fall, decreasing slightly over the winter. Arbuscular infection generally heightens in the spring and early summer whereas vesicular infection peaks in the late fall and winter. Spore and sporocarp numbers most probably reflect microsite and endophytic fungal species' differences.

51. NONPOINT POLLUTION AND PRAIRIE LANDSCAPING. Lorrie Otto, Riveredge Nature Center, Newburg, WI

The effects of suburban development on a navigable stream bordering the northern edge of Bayside, Wisconsin, will be shown. Fish Creek becomes a storm sewer and an example of nonpoint source pollution. I wish to suggest that part of the responsibility of land ownership should be that the owner retain and use the rain water which falls upon his property. The advantages of using prairie plants to replace bluegrass lawns are: (1) breaking the force of the rain and allowing the water to percolate slowly into the soil where the action of soil organisms and a deep root system soak up the moisture and dissolved pollutants; (2) filtering sediment from storm water; (3) sifting particulate matter from the air; (4) absorbing heavy metal pollution; (5) preventing toxic run-off of chemicals (as none are used to maintain suburban prairie-like yard); (6) promoting a remarkable reduction in nutrients reaching a stream because there would be no run-off of fertilizer from lawns and no phosphorus leached from autumn leaf dumps; (7) establishment of a network of deep roots mechanically preventing soil erosion; and (8) absorption and chemical detoxification of gases.

56. PRAIRIE AESTHETICS. Richard R. Fayram, Department of Landscape Architecture, University of Wisconsin, Madison, WI

Through the use of watercolor illustrations and ink and pencil sketches, a conceptual framework will be developed that will lead to greater understanding and appreciation of prairie aesthetics. Through this conceptual framework it will be shown how management techniques can be utilized to diversify spatial experiences and enhance aesthetic appreciation of the prairie landscape.

A series of watercolor illustrations will be displayed and presented in a slide presentation to illustrate different facets of prairie aesthetics. Wet, mesic and dry prairies will be illustrated showing general landform, spatial containment and associated communities. The prairie will be analyzed as to plan elements, design elements, construction elements (in a visual sense), and accent features. Plan elements include aesthetic impact of: different scale spaces, types of edges, and landforms. Design elements include: lines, textures, forms, masses and accents. The aesthetic construction of prairies is based on various types of plants and planting compositions including: random individuals, compact aggregations, loose aggregations, clumps, and associations or groups of species forming distinct spatial patterns. The effects of wind, rain, snow, fog, light and shadows will be illustrated in conjunction with seasonal changes (including floristic changes and height relationships) to develop an appreciation of the aesthetic dynamics of the prairie landscape.

The presentation concludes by showing how management techniques can be used to develop more interesting spatial concepts (within the limitations of prairie restoration) including: types of enclosure; edge treatment sequences; scale relationships; natural planting compositions; and path development.

60. AN APPROACH TO AESTHETIC ANALYSIS OF PRAIRIE LANDSCAPES. Darrel Morrison, Department of Landscape Architecture, University of Wisconsin, Madison, WI

While considerable research has been done on the aesthetic analysis of forest stands, particularly by the U.S. Forest Service, very little has been done toward developing techniques for aesthetic assessment of prairie landscapes for the purpose of providing a rational basis for subsequent management, restoration or re-creation of these landscapes by landscape architects and land managers.

In this paper, an approach for such analysis is presented. Among the characteristics which are important in the qualitative assessment of prairie aesthetics and which are recorded and evaluated as a part of this analysis approach are the following:

1. Context and enclosure. Enclosing elements are analyzed in terms of the amount of enclosure (i.e., relative height of enclosure in relation to expanse), the type of enclosure (e.g., topographic, vegetative or structural), and the visual compatibility with the prairie stand. Adjacent land uses are recorded and likewise evaluated in terms of their compatibility.
2. Topographic character of the stand itself and presence or absence of features such as rock outcroppings or open water.
3. Vegetation and visual quality. At three different specified viewing distances, characterizations can be made regarding the prevailing color(s), dominant textural quality, notable distribution patterns, and movement quality of the vegetation. Estimates of apparent ratio of grasses to forbs and an analysis of plant species that are critical to the "visual essence" of the stand can be made.
4. Experimental quality. This category provides opportunity to include non-visual characteristics (e.g., sounds and smells), emotional connotations and other descriptions as part of the aesthetic analysis.

61. AN ASSESSMENT OF SAMPLING TECHNIQUES FOR TALLGRASS PRAIRIES. J.M. Hartman & E.A. Howell, Department of Landscape Architecture, University of Wisconsin, Madison, WI

Management and restoration of prairie communities require a thorough understanding of the species composition, diversity and structure which characterize them. Sampling methods which are used in prairies to obtain this information vary in the time required to complete them, the data available from them, the accuracy of the data, and the statistical usefulness of the data. Researchers must match their questions with the characteristics of the sampling methods available to them. There have been few comparative studies of sampling methods for prairies.

We reviewed current literature to identify a set of common research questions occurring in studies related to prairie restoration and management (e.g., composition associations, classification schemes). We listed the data required to answer these questions in tabular form. We then sampled five tallgrass prairie sites in the University of Wisconsin Arboretum (Madison) with one-meter-square quadrats, basal-contact points, line transects, releves and aerial photographs at a scale of 1:15,000. We collected data such as species composition, frequency, and cover as the sampling methods permitted and recorded time required for sampling and analysis and cost of equipment or computer time. Tables are presented to illustrate the types, accuracy and collection efficiency of the data obtainable from each of the sampling methods. This information provides a basis for comparison of the methods. The result of the comparison is a system to identify appropriate techniques for approaching each category of questions. Researchers can use this system to select sampling methods appropriate to their research goals and available resources, while recognizing the contraints of the methods.

63. LANDSCAPE AND SOIL CLASSIFICATIONS FOR IDENTIFYING PRAIRIE TYPES IN MINNESOTA. Mark Heitlinger, Harlan Finney, & Edmund Bray, The Nature Conservancy, Minneapolis, MN

Two classification systems are presented for identifying different types of native prairie. A map of geomorphic landscapes in Minnesota provides a general distinction, and soils information is utilized for a more detailed differentiation of native grassland types. One application is to approximate the percentage of original prairie diversity that is protected in natural area preserves. Although the data are specific to Minnesota, the techniques can be adapted to other states.

69. THE PRAIRIES OF ERIE COUNTY, OHIO. John A. Blakeman, Perkins Middle School, Sandusky, OH

The prairies of Erie County near Lake Erie in northern Ohio were some of the easternmost prairies of broad expanse in North America at the edge of Transeau's Prairie Peninsula. Herbarium data collected in the late 19th century, other historical data, and surviving prairie remnants indicate that these prairies were of high quality. Comparison with data from prairies in Wisconsin shows that most of the Erie County prairies were wet to mesic with local representations of drier communities on a few ridges and slopes. Except for the xeric communities, Erie County prairies had nearly the same dominant species as those of Wisconsin. Less than one percent of the original 16,000 ha of prairie exists today, and most of it is on the Resthaven Wildlife Area with lesser remnants along railroad rights-of-way. A small prairie has been established to maintain locally endangered ecotypes.

71. THE BLUFF PRAIRIES ALONG BIG DARBY CREEK, OHIO. James E. Stahl, Metropolitan Park District of Columbus and Franklin County, Ohio, Columbus, OH

Along the banks of Big Darby Creek, a tributary of the Scioto River, in Central Ohio are scattered patches of prairie plants. This area represents roughly the eastern limit of Transeau's Prairie Peninsula. Some of the prairie vegetation is merely small clumps of plants widely distributed in protected spots throughout the area in various types of terrain.

The better examples are found on heavily eroded bluffs along Big Darby Creek. Possibly the best remnant is an area of 3 to 4 acres found on a high bluff along the eastern bank of the creek in Battelle Metro Park. Here clumps of prairie grasses, including big and little bluestem and Indiangrass, grow to heights of 6 to 8 feet.

The forbs, however, are the spectacular aspect of this small prairie. They include large patches of purple coneflower (reaching heights of 4 feet), prairie coneflower, and blazing stars. Others are bergamot, columbo, green milkweed, Indian paintbrush, milk vetch, Seneca snakeroot, spiderwort, stiff gentian, and species of aster, goldenrod, and sunflower.

The main threat to this area now is trampling and destruction by fishermen and "well-intentioned" park employees who try various measures of erosion control to preserve the bluff and thus allow species such as sweet clover and thistle to invade.

74. THE PRAIRIE PRESERVATION SOCIETY OF OGLE COUNTY, ILLINOIS. Douglas E. Wade, Lorado Taft Field Campus, Northern Illinois University, Oregon, IL

This is the story of the founding and organization of the Prairie Preservation Society of Ogle County, Illinois in 1975 and its accomplishments up to August 1978. The Society, incorporated as a non-profit organization, has three positive action goals. Its members (220 by Jan. 1978) have purchased and placed under management and use (research and education) an 11½-acre dry mesic (limestone) prairie. Already, some 150 students, teachers, and others have assisted in fencing, posting, woody plant removal, and burning on the Bicentennial Prairie. An education committee is moving ahead on a countywide project aimed at teachers and students in all districts. The Society holds monthly meetings which include informative programs and has sponsored three annual banquets, replete with outstanding speakers on prairie topics. A series of articles is being published in several county newspapers and will be clipped by students and teachers to form a Prairie Primer geared to the county. The prairie has been marked and mapped into a quadrat system to make research and observations identifiable; a soil map and a contour map have been prepared in overlays. Infrared and color aerial photographs will be shot periodically throughout the growing season. The Society also encourages preservation and management of other prairie and marsh remnants in the county, along roads, along railways, in pioneer cemeteries, and on private lands. The project serves as a model.

77. THE SPECIES COMPOSITION OF OLD SETTLER CEMETERY PRAIRIES IN NORTHERN ILLINOIS AND INDIANA. Robert F. Betz & Herbert F. Lamp, Department of Biology, Northeastern Illinois University, Chicago, IL

Out of approximately 850 cemeteries which were checked between 1968 and 1977 for prairie vegetation in 39 counties of northern Illinois and 6 counties in northwestern Indiana, 146 had some prairie species. There were 39 of these cemeteries with prairie or prairie savanna vegetation worthy of further study; 26 were mesic prairies on silt loam soils ("black-soil prairies"), 5 were prairie savannas with bur oak *(Quercus macrocarpa)* on transitional soils, 5 were sand savannas with either black oak *(Quercus velutina)* or black-jack oak *(Quercus marilandica)*, 2 were dry prairies on gravelly or sand loams, and 1 was a sand prairie. The A-horizon in the virgin silt loam prairies was between 12 and 18 inches, 5 to 8 inches in the transitional silt loam prairie savannas and only 2 to 4 inches in the sand savannas.

More than 160 species of prairie and prairie savanna plants were found on these cemetery prairies, representing approximately 40 different families. The Compositae had the most representatives with 48, followed by the Gramineae with 15 and the Leguminosae with 12 species. Some species, such as big bluestem grass *(Andropogon gerardi)*, were found in almost all the cemetery prairies studied, while other species, such as the prairie white-fringed orchid *(Habenaria leucophaea)* and the prairie dandelion *(Agoseris cuspidata)* were present in only one of the 39 cemetery prairies.

Big bluestem grass *(Andropogon gerardi)*, little bluestem grass *(Andropogon scoparius)*, Indiangrass *(Sorghastrum nutans)*, prairie dropseed *(Sporobolus heterolepis)*, and porcupine grass *(Stipa spartea)* in various combinations were the dominant grasses on the mesic silt loam prairies. Side-oats grama *(Bouteloua curtipendula)* was an additional dominant grass on the two dry prairies, while little bluestem was clearly dominant on the six sand prairies and savannas studied.

SIXTH NORTH AMERICAN PRAIRIE CONFERENCE

12-17 August 1978

PROGRAM

14 Aug., Monday

7:30 a.m.-5:00 p.m. Registration & Displays

SESSION I Plenary Symposium

THE PRAIRIE PENINSULA —
IN THE SHADOW OF TRANSEAU

Auditorium
Charles C. King, *Presiding*

8:30 a.m. **Introduction.** Ralph E. Ramey

8:35 **Geographical Setting of Ohio Prairies.** Ralph E. Ramey

8:45 **Geological Setting of Ohio Prairies.** Jane L. Forsyth

9:00 **Reflections on Transeau the Man.** Edward S. Thomas

9:10 **Peninsula or Archipelago?** Paul B. Sears

9:30 **Origin and Development of the Concept of the Prairie Peninsula.** Ronald L. Stuckey

10:15 Break

10:35 **Development of the Ohio Vegetation Survey.** Robert B. Gordon

10:55 **Some Vertebrates of the Prairie Peninsula.** Milton B. Trautman

11:15 **Memories of E. Lucy Braun.** Lucile Durrell

11:25 **The Adams County Prairies: 50 Years after the Studies of E. Lucy Braun.** Allison W. Cusick

11:40 **The Big Barrens of Kentucky as Part of Transeau's Prairie Peninsula.** Jerry M. Baskin

12:30 p.m. LUNCHEON Banquet Rooms A,B,C, & D

2:00 **Panel of Symposium Speakers and Audience Participation**

2:50 End of Symposium

SESSION II-A

PRAIRIES AT THE EDGE OF THE PENINSULA

Room 2-3
Joseph D. Laufersweiler, *Presiding*

3:00 p.m. 1. **A Prairie Grove in Southwest Michigan.** Michael Fleckenstein and Richard Pippen.

3:20 2. **Stark-Case Prairie, a Significant Remnant in Northeastern Ohio.** Robert W. Hawes and Freda Case.

3:35 3. **Buffalo Beats, a Prairie Remnant in Unglaciated Southeastern Ohio, Supports Transeau's Prairie Peninsula Concept.** Warren A. Wistendahl.

3:50 4. **Compass-plant** *(Silphium laciniatum)* **in Ohio: Its Historic and Present-day Distribution.** Allison W. Cusick.

4:00 5. **Prairies of the Kansan Outwash Deposits in Northern Kentucky.** William S. Bryant.

4:15 6. **Characterization of Some Southeastern Barrens.** Hal DeSelm.

4:30 7. **History of a Pioneer Prairie Cemetery in Northern Madison County, Ohio.** Julie M. Overton.

SESSION II-B

RESTORATION & MANAGEMENT

Auditorium
Paul E. Knoop, Jr., *Presiding*

3:00 p.m. 8. **Approaches to the Design of Small Prairie Plantings.** Evelyn A. Howell and Darrel Morrison.

3:20 9. **Prairie Restoration and Management in North Central Missouri.** J. Wayne Vassar and Gerald A. Henke.

3:35 10. **Saving Michigan's Railroad Strip Prairies.** Margaret A. Kohring.

3:50 11. **Restoration and Management of the Armand Bayou Prairie.** Cameron Munroe.

4:00 12. **Restoring Prairies as an Educational Tool.** Robert F. Horlock.

4:15 13. **Sheyenne National Grassland in North Dakota — From Sand to Grass and More.** Dale F. Shanholtzer.

4:35 14. **Living with the Natives.** Jim Lehr.

SESSION III

A TIME TO RELAX AND ENJOY

Auditorium
Robert McCance, Jr., *Presiding*

7:45 p.m. 15. **The Origin and Ecology of Ohio's Bogs and Fens,** a narrated multimedia presentation on six screens complete with the sights and sounds of these interesting habitats. Guy Denny.

8:30 16. **Prairie Poetry,** a presentation of prairie slides accompanied by poetry to evoke an emotional response by the viewer. Patricia K. Armstrong.

15 Aug., Tuesday

SESSION IV-A

MANAGEMENT & APPLIED USES

Auditorium
Richard E. Moseley, Jr., *Presiding*

8:30 a.m. 17. **A Review of Herbicide Use in Establishing Native Prairie Grasses.** Eugene E. Woehler.

8:45 18. **Establishing Native, Perennial Grasses and Forbs Using Herbicides and Mowing.** Thomas B. Bragg and David M. Sutherland.

9:05 a.m. 19. **The Differential Response of Prairie Plant Species to Prescribed Burning in Northwestern Minnesota.** R. H. Pemble, G. L. Van Amburg, and Lyle Mattson.

9:25 20. **The Response of Prairie Arthropod Populations to Prescribed Burning in Northwestern Minnesota.** G. L. Van Amburg, James A. Swaby, and R. H. Pemble.

9:45 21. **Seed Vitality and Seedling Vigor in Selected Prairie Plants.** Lee E. Eddleman and Patricia L. Meinhardt.

10:00 22. **Seed Conditioning and Germination of New Jersey Tea,** *Ceanothus americanus.* Peter Schramm and Ronald G. Johnson.

10:15 BREAK

Robert W. VanKeuren, *Presiding*

10:35 23. **Native Forb Seed Production,** John A. Dickerson, Warren G. Longren, and Edith K. Hadle.

10:55 24. **Germination Tests and Purity Determinations for Native Wisconsin Prairie Seed.** Marlene Halinar.

11:15 25. **Criteria for Introduction of Species to Natural Areas.** Victoria Nuzzo.

11:25 26. **Reestablishment of Native Grasses by the Corps of Engineers on Project Lands in the Southwestern Division Area.** Harold E. Green, Mark S. Sifuentes, and Chester O. Martin.

11:45 27. **Warm-Season Grass Establishment on Mine Spoil in Kentucky.** William Kuenstler, Donald S. Henry, and Samuel A. Sanders.

Noon LUNCH

SESSION IV-B

PHYSIOLOGY, GENETICS, AND EVOLUTION

Room 2-3
T. Richard Fisher, *Presiding*

8:30 a.m. 28. **Relationship Between Physiology and Phenology in a C3 and C4 Grass.** W. Eric Limbach.

8:45 29. **Differentiati[illegible] Habitat Response in Blue Grama** *(Bouteloua [illegible]* WITHDRAWN **and Side-oats Grama** *(Bouteloua curtipen[illegible]* **om the United States and Mexico.** Calvin McMillan.

9:05 30. **Native Tall Grass Prairie Species at Their Physiological Tolerance Limits in Eastern Wyoming.** A Tyrone Harrison.

9:25 31. **The Flower, Pod and Seed Production in Eighteen Species of Mid-Western Milkweeds.** Robert F. Betz and Herbert F. Lamp.

9:45 32. **Hybrid Swarms of the Prairie** *Asclepias speciosa* **with the Common** *Asclepias syriaca.* J. W. Thomson and W. H. Wagner, Jr.

10:00 33. **Flowering Patterns and Production of a Grassland Site in Central Oklahoma.** Roger C. Anderson and Dwight E. Adams.

10:15 BREAK

15 Aug., Tuesday

SESSION IV-C SITE & HABITAT DESCRIPTIONS

Room 2-3
Lynn Edward Elfner, *Presiding*

10:35 34. **Limestone Glades in Southern Illinois.** Donald R. Kurz.
10:55 35. **Prairie Plants in Non-Prairie Areas and Non-Prairie Plants in Prairie Areas in Southwestern Ohio.** Sture F. Anliot.
11:15 36. **A Right-of-Way Prairie near Zimmerman, Greene County, Ohio.** Ralph E. Ramey.
11:25 37. **The Prairie Remnants of Marion, Crawford, and Wyandot Counties in North Central Ohio.** K. Roger Troutman.
11:45 38. **Savannas in Illinois.** Michael H. Madany.
Noon LUNCH

SESSION V-A ECOLOGICAL STUDIES

Auditorium
Kent L. Scott, *Presiding*

1:30 p.m. 39. **Interactions Between the Prairie Garter Snake *(Thamnophis radix)* and the Eastern Garter Snake *(Thamnophis sirtalis)* in Killdeer Plains, Wyandot County, Ohio.** George H. Dalrymple and Norman G. Reichenbach.
1:45 40. **Threatened, Endangered, and Extinct Birds of Illinois Prairies.** Marlin L. Bowles, Kathryn Kerr, Richard H. Thom, and Dale E. Birkenholz.
2:05 41. **Use of North Dakota Grasslands by Breeding Birds.** Harold A. Kantrud and Russell L. Kologiski.
2:20 42. **Significance of Native Prairies to Greater Prairie Chicken Survival in Missouri.** Donald M. Christisen.
2:40 43. **Cover Use by Radioed Attwater's Prairie Chicken in Gulf Coastal Prairie of Texas.** John D. Horkel, Virginia F. Cogar, and Nova J. Silvy.
3:00 44. **The Decline of Hill Prairies Due to Grazing in Illinois.** Randy W. Nyboer.
3:15 BREAK

Charles C. Laing, *Presiding*

3:35 45. **Community Ecology of Arthropods in Prairie Remnants in Adams County, Ohio.** George W. Uetz, Curtis A. Meininger, and Michael J. Bruggeman.
3:55 46. **Arthropod Assemblages on Perennial Grasses in Ohio and Alaska.** Sonja Teraguchi, Jeffrey Stenzel, John Sedlacek, and Richard Deininger.
4:10 47. **The Response of a Central Oklahoma Grassland to Burning.** Dwight E. Adams and Roger C. Anderson.

SESSION V-B ECOLOGICAL STUDIES

Room 2-3
Janice V. Perino, *Presiding*

1:30 48. **Determination of the Presence, Density, and Dominance of Plant Species Showing Allelopathic Associations and Their Relationship to the Abundance of Native Legumes.** Gary Peterson.
1:45 49. **An Ecological Study of Cladoniform Lichens in Grassland Areas, Conducted in Relict and Secondary Prairie Areas in Adams County, Ohio.** Ann M. Fovargue.
2:05 50. **The Ecology of Vesicular-Arbuscular Mycorrhizae in a Western Pennsylvania Relic Prairie.** Susan C. Rabatin and D. T. Wicklow.
2:20 51. **Nonpoint Pollution and Prairie Landscaping.** Lorrie Otto.
2:40 52. **Soil Loss and the Search for a Permanent Agriculture.** Wes Jackson.
3:00 53. **A Model of Prairie Peninsula Vegetation and Ecology Before 1860.** Donald L. Williams.
3:15 BREAK

SESSION V-C POSTER SESSION

3:35-4:45 p.m. 54. **Soils of Prairies in Ohio.** Joseph R. Steiger.
55. **Prairie Heritage Appreciation Program, a Different Preservation Approach.** Roger D. Gustafson.
56. **Prairie Aesthetics.** Richard R. Fayram.

SESSION VI BANQUET & LECTURE

DeVere Burt, *Master of Ceremonies*

6:30 p.m. Rooms A,B,C, & D—Banquet, Dulcimer Fair, Jay Leibovitz and Leo Kretzner
8:00 Auditorium—The Prairie Dog Players, Marion Campus, The Ohio State University, Larry R. Yoder. Prairie Color Slide Contest Awards. James E. Stahl. **The Living Prairie.** Durward L. Allen.

16 Aug., Wednesday

SESSION VII-A SURVEYS, CLASSIFICATIONS, AND EVALUATIONS

Auditorium
Dennis M. Anderson, *Presiding*

8:30 a.m. 57. **The Need for an Ecosystem-wide Tallgrass Prairie Classification System as a Guide for Prairie Preservation.** John W. Humke.
8:50 58. **Finding, Describing, and Evaluating Prairies in Illinois.** John White.
9:30 RECESS
9:35 59. **A Quality Analysis Technique for Wisconsin Grasslands.** Evelyn A. Howell.
9:55 60. **An Approach to Aesthetic Analysis of Prairie Landscapes.** Darrel Morrison.
10:15 BREAK

Joseph P. Croy, *Presiding*

10:35 61. **An Assessment of Sampling Techniques for Tallgrass Prairies.** J. M. Hartman and E. A. Howell.
10:55 62. **A Survey of the Extent of Prairie Preservation in Michigan.** Kim A. Chapman and Robert J. Pleznac.
11:15 63. **Landscape and Soil Classifications for Identifying Prairie Types in Minnesota.** Mark Heitlinger, Harlan Finney, and Edmund Bray.
11:35 64. **An Inventory of Railroad Prairie Remnants in Illinois.** John A. Bacone.
Noon LUNCH

SESSION VII-B SITE & HABITAT DESCRIPTIONS

Room 2-3
Mrs. M. C. (Buggie) Markham, *Presiding*

9:35 65. **Dayton Prairie — A Remnant of Prairie Terra Coupee in Michigan.** Paul W. Thompson.
9:55 66. **The "Fine Structure" of a Prairie Upland — Pothole Border in North Central Iowa.** David C. Glenn-Lewin and Alan Crist.
10:15 BREAK

Jane L. Forsyth, *Presiding*

10:35 67. **A Plant Survey of the Gensburg-Markham Prairie in Illinois.** Phil Hanson.
10:45 68. **The Pre-Settlement Vegetation of the Plain of Glacial Lake Chicago in Cook County, Illinois.** Phil Hanson.
10:55 69. **The Prairies of Erie County, Ohio.** John A. Blakeman.
11:10 70. **The Prairie Remnants along the Stillwater River in Miami County, Ohio.** Scott L. Huston.
11:25 71. **The Bluff Prairies along Big Darby Creek, Ohio. James E. Stahl.**
11:40 72. **The Irwin Prairie and Schwamberger Preserve in Northwestern Ohio.** N. William Easterly.
Noon LUNCH

SESSION VIII-A SURVEYS AND CLASSIFICATION

Auditorium
Sture F. Anliot, *Presiding*

1:30 73. **A Volunteer-supported Effort to Find and Preserve Prairie Remnants in Illinois Cemeteries.** Kathryn Kerr and John White.
1:50 74. **The Prairie Preservation Society of Ogle County, Illinois.** Douglas E. Wade.
2:10 75. **Classification of Natural Communities in Illinois.** John White and Michael H. Madany.

SESSION VIII-B SITE & HABITAT DESCRIPTIONS

Auditorium
Larry R. Yoder, *Presiding*

2:30 76. **Species Composition of Northeastern Illinois Prairie Fens.** Robbin C. Moran.
2:50 77. **The Species Composition of Old Settler Cemetery Prairies in Northern Illinois and Indiana.** Robert F. Betz and Herbert F. Lamp.
3:10 78. **A Unique Natural Area in Dane County, Wisconsin.** Mark A. Martin.
3:25 79. **Distribution of Royal Catchfly** (*Silene regia* Sims), **an Endangered Ohio Prairie Plant.** Charles C. King.
3:35 80. **A Right-of-Way Prairie near Milford Center, Union County, Ohio.** Charles C. King.

MEMORABILIA OF THE CONFERENCE

SPONSORSHIP AND PLANNING

The Conference is hosted by the Ohio Biological Survey, Prairie Survey Project, K. Roger Troutman, Chairperson. Also cooperating is the Ohio Department of Natural Resources, Division of Natural Areas and Preserves, Richard E. Moseley, Jr., Chief. Ralph E. Ramey is Conference Chairperson and may be contacted directly at Glen Helen, 405 Corry Street, Yellow Springs, Ohio 45387 (Phone 513-767-7375). Charles C. King is coordinator of arrangements and communications, and may be contacted at the Ohio Biological Survey office. Ronald L. Stuckey of The Ohio State University Botany Department is the Editor of the Proceedings.

OHIO BIOLOGICAL SURVEY

The Ohio Biological Survey, founded in 1912, is an inter-institutional organization of Ohio colleges, universities, museums, and other organizations. By cooperating with the professional staffs of the membership, the Ohio Biological Survey produces and disseminates scientifi and technical information concerning the flora and fauna with which we share the Ohio environment. Programs and policies are determined by an Advisory Board consisting of representatives of the member institutions. The Ohio Biological Survey is administered through the College of Biological Sciences, The Ohio State University. Inquiries concerning programs and publications should be addressed to the Executive Director, Ohio Biological Survey, 484 West 12th Avenue, Columbus, Ohio 43210. (Phone 614-422-9645)

DIVISION OF NATURAL AREAS AND PRESERVES

The State Nature Preserves System was established when the Ohio Natural Areas Act became law on 31 August 1970. This act authorizes the Ohio Department of Natural Resources to protect and manage for present and future generations a state-wide system of nature preserves which are representative examples of the significant natural features of the state. On 1 September 1976 the Ohio General Assembly created the Division of Natural Areas and Preserves within the Ohio Department of Natural Resources. To date, the system contains 40 natural areas encompassing 8533 acres of woods, bogs, marshes, prairies, glacial kettles, gorges, and other biological and geological features. Inquiries concerning programs and publications should be addressed to the Division of Natural Areas and Preserves, Ohio Department of Natural Resources, Fountain Square, Columbus, Ohio 43224. (Phone 614-466-7803)

PERSPECTIVE

THE SIXTH NORTH AMERICAN PRAIRIE CONFERENCE continues the series of biennial meetings previously known as the Midwest Prairie Conference. The Conference name reflects the expanding interest in native North American grasslands.

The first meeting was held at Knox College, Galesburg, Illinois, in 1968 with 120 enthusiastic prairie devotees from diverse professional and lay backgrounds focusing their attention on the topics of prairie research, conservation, and restoration. Since then, additional meetings have been held in 1970 at the University of Wisconsin, Madison; in 1972 at Kansas State University, Manhattan; in 1974 at the University of North Dakota, Grand Forks; and in 1976 at Iowa State University, Ames. Although the current mailing list numbers approximately 1500, a formal organization has not been necessary for the increasing success of these meetings.

Published proceedings of the previous meetings provide a wealth of information concerning prairies:

Schramm, Peter, Editor. 1970. *Proceedings of a Symposium on Prairie and Prairie Restoration*. Knox College Biological Field Station Special Publication No. 3. 66 pp. $5.50 postpaid. Contact Schramm, Knox College, Galesburg, Illinois 61401 and make check payable to Peter Schramm.

Zimmerman, James H., Editor. 1972. *Proceedings of the Second Midwest Prairie Conference*. Published by the editor. 2114 Van Hise Ave., Madison, Wisconsin 53705. $8.50 postpaid. Make check payable to James H. Zimmerman at above address.

Hulbert, Lloyd C., Editor. 1973. *Third Midwest Prairie Conference Proceedings*. Division of Biology, Kansas State University, Manhattan, Kansas 66506. 91 pp. $6.00 postpaid. Contact Hulbert at above address, and make check payable to Division of Biology.

Wali, Mohan K., Editor. 1975. *Prairie: A Multiple View*. The University of North Dakota Press, Grand Forks, ND 58202. 433 pp. $10.00 + postage. Make check payable to University of North Dakota Press.

Pemble, Richard H., Ronald L. Stuckey, and Lynn E. Elfner. 1975. *Native Grassland Ecosystems East of the Rocky Mountains in North America, a Preliminary Bibliography*. A supplement to Wali (1975) above. ca. 7000 references. 466 pp. $7.00 + postage. Make check payable to University of North Dakota Press at above address.

Glenn-Lewin, David, and Roger Q. Landers, Editors. 1978. *Fifth Midwest Prairie Conference Proceedings*. Department of Botany and Plant Pathology, Iowa State University, Ames, Iowa 50011. 230 pp. $3.50 postpaid. Contact Landers at above address and make checks payable to Fifth Midwest Prairie Conference Proceedings.

INVOCATION FOR THE BANQUET

Elizabeth V. Gesner

Division of Natural Areas and Preserves
Ohio Department of Natural Resources
Fountain Square
Columbus, Ohio 43224

Dear God,

In many ways, you could not find a more different group of people than all of us here. We come from many states with vastly different landscapes, follow different pursuits, and many of us don't even speak the same professional language. Even when we do, we don't necessarily always agree. In spite of this there is one unmistakable bond we all share, our fascination with and reverence for the living prairie. It is this spirit of love and respect for the plants and animals of the prairie landscape that sustains our diverse endeavors, gives them purpose, and brings us here together. We pray here tonight that this spirit continues to grow among us, and also that we may nurture the growth of that same spirit in others, especially those who will come to take up our work in seeking to understand, preserve, and restore this beautiful and fragile portion of our earthly inheritance, the prairie. Amen.

SIXTH NORTH AMERICAN PRAIRIE CONFERENCE

Banquet

Tuesday, 15 August 1978 6:30 p.m.
Fawcett Center for Tomorrow Rooms B, C, & D.

6:30 *Welcome:* DeVere Burt, Master of Ceremonies

Invocation: Betsy Gesner

6:40 *Dinner*

7:30 *Concert:* *"From the Mountains to the Prairies"*
Music on the mountain dulcimer
jay a. leibovitz & Hank Arbaugh

7:50 *Adjournment*

Program

Auditorium

8:00 *Greetings from the College of Biological Sciences*
The Ohio State University: Patrick R. Dugan,
Acting Dean

Comments by the Conference Chairperson:
Ralph E. Ramey

"Little House on the Prairie"
The Prairie Dog Players
The Ohio State University, Marion Campus
Larry R. Yoder, Advisor

Prairie Color Slide Contest Awards Presentation:
James E. Stahl

THE LIVING PRAIRIE *Durward Allen*

LITTLE SOD HOUSE ON THE PRAIRIE
A Comedy Skit in One Act

Larry R. Yoder
Department of Botany
College of Biological Sciences
The Ohio State University — Marion Campus
Marion, Ohio 43302

The set consists of a stump and a large (2 m) cut-out of a clump of big bluestem on stage left, a sod house 2 m high and 3 m long with a doorway and windows painted in, and a plastic sunflower on stage right. Props consist of a seed bag filled with vermiculite, rakes, a hoe, and a hoe outfitted with a hollow handle with removable end. Pa should have matches hidden everywhere on his person including the space under his hat which should be of the western sodbuster type. Ma and the girls should have dresses with full skirts and bonnets. The sheriff should have a 10 gallon hat (oversize), a pair of 6 shooters, chaps, and boots.

Fade in theme music from "Little [Sod] House on the Prairie," fade music, curtain opens, voice over as Pa, Ma, and the girls enter from stage left.

Narrator: Welcome to the Sixth North American Prairie conference and our Buckeye version of . . . *Little Sod House on the Prairie* . . .

Fade music as Pa, Ma, and girls take their positions. Girls have rakes; Ma, the seed; and pa, the hoe. They begin to work soil and scatter seed (use vermiculite). Laura pauses and begins to speak as Ma puts down sack and others lean on their tools.

Laura: Pa, why are we planting these funny seeds, any way? Here we are planting this mixed up junk when everyone else is planting corn or soybeans or writing lucrative NSF grants in molecular biology?

Pa: Don't fret on it Laura, just keep planting. Keep thinking about all that interstate right-of-way across the country with nothing but blue grass on it. I tell you there's a whole land to be conquered, right up to and including the White House lawn!

Ma: Now, Charles, don't take on with her so. After all, the neighbors do talk. You remember last winter? Right in the middle of the killer blizzard they had in Ohio. The electricity went out and you called the power company. You said it was a dire emergency. All would be lost if they didn't come to our rescue. How do you think I felt after they flew in by helicopter, got the power back on, and then discovered three refrigerators all completely filled with stratified seed while we ate dried beans!

Pa: Yes, Carolyn, I know it may have looked a little strange, but you just don't understand.

Ma: And last fall, when everyone was busy getting their crops in, where were we? Out along the railroad collecting prairie seeds. And that's not to mention the times you've run off on those prairie field trips with Troutman and Ramey and left us all alone.

(Pa is staring off into space, half listening.)

Pa: Oh yes, Carolyn, I've been meaning to tell you, I'll be heading off to the prairie conference in Columbus, Ohio, soon.

Ma: Oh no you don't Charles. You're up to something. How dumb do you think we are. That's eastern mesic forest country. There's no prairie in Ohio.

Pa: That's what a lot of folks think, but they'll see different. Really that's where our meeting is this year.

Laura: Tell us what it'll be like, Pa.

Mary: Yes. How will you find your way?

Pa: Well, first off, there's no problem finding my way so long as there are plenty of compass plants. We'll head east across prairie country, and I'll just follow 'd flax *Linum* d' road.

Laura: Where will you eat, Pa? Do they have any Col. Custer's Kansas Fried Prairie Chicken?

Pa: I don't know daughter, but when we take the National Road east through Indianapolis we'll wonder where did Indygo?

(Sheriff enters stage right.)

Sheriff: All right, Charles, where is it!

Pa: Oh, good morning sheriff, how are ya?

Sheriff: Don't good morning me, this is the umpteenth time I've been out here, now where is it.

Pa: Why, right over here, sheriff. See, we just seeded it in. I've got *Andropogon, Spartina,* and *Panicum* and we were lucky enough to find three new *Solidago*'s and a *Silphium*.

Sheriff: No, I don't care about those durn weeds you're always planting. You know what I want, your EPA burning permit!

Pa: Well, I . . . ah . . .

Sheriff: Come on, Charles, unless you've got that permit I'm going to run you in.

Pa: Please, Sheriff, have a heart. I couldn't help it. The grass was so dry I couldn't resist. And you should have seen it when I touched it off . . . Whoosh! . . . Boy did we get a burn! Cleared things out better than I've seen in years.

Sheriff: That may be, but you scared folks over in the subdivision half to death. They thought it was a gol-durn atom bomb. Never seen anything like it—all that fire and smoke. I thought everybody's heard of Smokey the Bear . . . So let's see that permit of yours, Charles.

Pa: I . . . . I don't have one.

Sheriff: That's what I thought. I'm takin' you in.

Pa: But Sheriff, how do those suburbanites think I feel — building their houses right over the prairie — and I have to sit over here listening to all those lawn mowers mowing off every blade of grass in sight. The heck with Smokey the Bear, didn't they ever hear that "Tall is Beautiful."

Sheriff: Come on, stand over here.

(Pa turns and faces audience, down stage slightly left of center, arms extended, still clutching the hoe in one hand. Sheriff frisks him. Turns matches out of his pockets.)

Sheriff: Got any more?

(Pa lifts his hat—it's full of matches.)

Sheriff: Keep going.

(Pa digs some more out of his boots.)

Pa: That's all.

Sheriff: Don't play games with me, Ingals, you're in enough trouble already. I want all of them.

(Pa slowly unscrews the hollow handle of his hoe and empties one final match into the sheriff's hand.)

Pa (weakly): Do you think I'll get out in time for the prairie conference?

Sheriff: Ok, let's go.

(Sheriff takes the sections of hoe handle and motions to stage left. They exit stage left.)

Sheriff: You say that grass really took off, eh . . .

Pa: Oh, did it ever . . .

(Ma and the girls remain on stage watching them go. Ma starts forward slowly as Mary asks . . .)

Mary: Now what are we going to do, Ma?

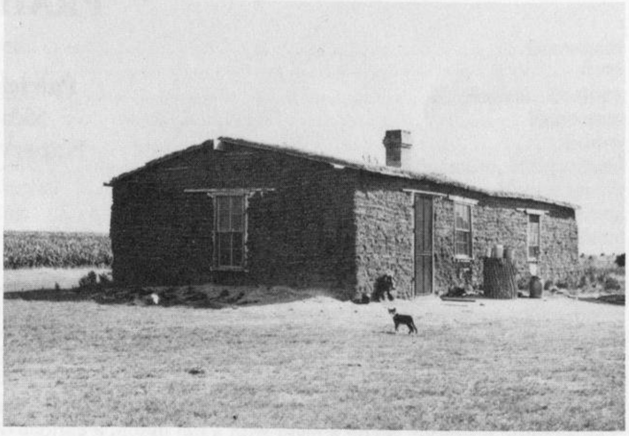
(Ma slowly sinks to the stump center stage, looks out across audience and shakes her head.)

Ma: I don't know girls, I just don't know . . .(pause) I do know one thing though . . .

Laura: What's that, Ma?

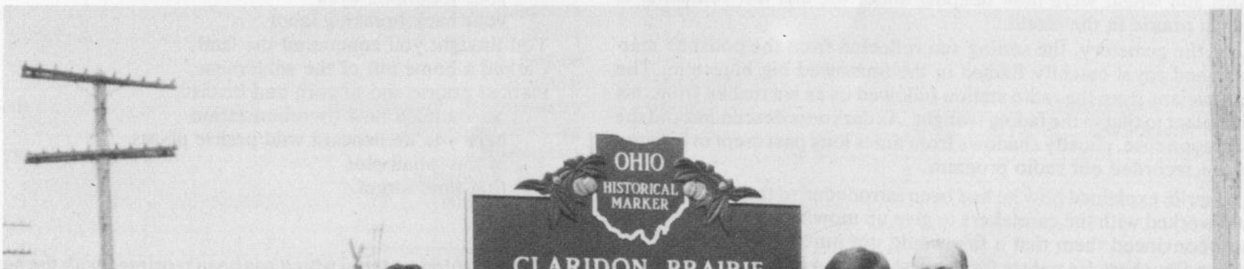
Ma: All our blues stem from the xerothermic!

(Lights fade, curtain closes quickly. Clear props from stage, open curtains for bow.)



Sodhouse

A pioneer's home on the shortgrass prairie, Decatur County, Kansas, September 1902. (Photograph from a glass lantern slide collection of E.N. Transeau and currently in the possession of G.E. Gilbert; also printed in J.H. Schaffner, 1926. Ohio State Univ. Stud. Contrib. Bot. No. 178. p. 37.)



Dedication of Claridon Prairie

Claridon Prairie, also called Caledonia Prairie, is a tallgrass prairie with a high species diversity in Marion County, Ohio. The Marion County Historical Society sponsored the dedication ceremonies. From left to right: Richard Carey who presided at the ceremony, Larry R. Yoder, Congressman Clarence J. Brown, K. Roger Troutman, County Engineer Jack Tozzer, Terry Wilson of Conrail, Carl Lehner who was the marker chairman, Richard E. Moseley of the Ohio Division of Natural Areas and Preserves, and Trella Romine who is the prairie discoverer. As a child in the 1930's, Trella walked the railroad tracks in this area picking "baby's breath" for floral arrangements. After reading nature articles by Edward S. Thomas, she realized that this plant was actually flowering spurge, and she then recognized several other prairie species here. Later Larry R. Yoder confirmed that this site was a prairie remnant.

PRAIRIE POETRY

Patricia Kay Armstrong
535 S. Washington
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While attending the Sixth North American Prairie Conference in Columbus, Ohio, in August of 1978, I presented a "Prairie Poetry" program. Charlie King, Roger Troutman, and Ralph Ramey were especially enthusiastic and wanted me to do a special reading in a prairie for the university radio station. The site of Chuckery Cemetery (now Bigelow Cemetery State Nature Preserve) was picked because it is one of the best prairie remnants in central Ohio and because Charlie was working with the caretakers to have it managed as a prairie preserve. So on a night with a full moon, a carload of us including Charlie, Ralph, Dr. Bob Betz (a specialist on finding and preserving old settler prairie cemeteries in Illinois), and myself drove out to Chuckery Cemetery.

I'll never forget the excitement as Charlie, Bob, and Ralph talked about prairie cemeteries, and the powerful feeling I was getting about being in a cemetery at night under the full moon. I kept thinking how ironic it was that prairie plants seem to hide themselves behind tombstones to survive — found life in the place of the dead — and that the settlers who had destroyed the prairie with their plows to grow corn and wheat were now sleeping under the last few remnants of virgin prairie in the world.

At the cemetery, the setting sun reflected from the polished markers and royal catchfly flamed in the unmowed big bluestem. The technicians from the radio station followed us as we rushed from this rare plant to that in the fading twilight. As darkness descended and the full moon rose, ghostly shadows from times long past crept in to listen as we recorded our radio program.

Charlie explained how he had been introduced to the cemetery and had worked with the caretakers to give up mowing and had even half way convinced them that a fire would not hurt anything. We were seeing Chuckery Cemetery for the first time in a long while that it had not been mown, and the variety of prairie plants that we found were a delightful surprise. Then Bob preached a very enthusiastic sermon on why prairie remnants needed to be saved and how that could be accomplished. It ended up by my reading "Tall Purple Grass," the first poem I had ever written on a prairie theme when I had discovered big bluestem at the edge of a parking lot and was struck by its significance. Just as I came to the line, "Now you watch automobiles and shopping carts pass," a pickup rumbled by on the gravel road. It was a very moving experience!

Tall Purple Grass[1]

Tall purple grass by the parking lot,
How did you get here from the long ago?
What luck spared you from the
  Farmers' plow,
    The choking weeds,
      The bulldozer's blade?
You used to run freely over hillside and plain
From here to Nebraska—a thousand miles or more.
Do you remember all that sky?
How the wind used to sigh
And tell you secrets as it passed by?

Tall purple grass in the morning sun,
How did it feel to be king of the land?
When your flower-splashed swards hid the
  Bison herds,
    Men on horseback,
      And wagon trains?
Now you watch automobiles and shopping carts pass
Huddled alone by the A. and P.
Dreaming of what used to be
No one notices you but me.

Tall purple grass.

The following two poems were written after the intense experience in Chuckery Cemetery:

Death and Life[1]

Is that you, Big Blue Stem, Compass Plant, Gay Feather,
  Lurking in the shelter of this carved stone?
1868 it says he found his final rest
  Beside the endless fields of corn.
Did you skip across the fence
  Seeking immortality amongst the dead
Where plows no more disturb
  The prairie sod?

In a Prairie Cemetery[1]

Little children
Beloved wife
Strong farmer
  here you lie beneath the prairie dock and big blue stem
  that knew your running feet
  your lonesome eyes
  your back-breaking labor.
You thought you conquered the land,
Carved a home out of the wilderness,
Planted prairie sod to corn and beans.
  Surrounded now by urbanization
  here you lie beneath wild prairie plants
  in this small plot
  that time forgot.

[1] Copyrighted material which has been reprinted with the permission of Patricia Kay Armstrong who in 1979 complied and edited a collection of *Prairie Poetry,* The Naperville Sun, Naperville, Illinois, 146 p.

Compass Plant

O.E. Anderson Compass Plant Prairie, Lawrence County, may be the only Ohio station for *Silphium laciniatum*. (Photograph by Charles C. King, 1979.)

ABBREVIATIONS

Abstr.	Abstract
Acad.	Academy
Academ.	Academician
Admin.	Administration
Adv.	Advance, Advancement
Afr.	African
Agric.	Agricultural, Agriculture
Agron.	Agronomy
Ala.	Alabama
Amend.	Amendment
Amer.	America, American
Anal.	Analysis
Anat.	Anatomy
Anim.	Animal
Ann.	Annals
Anniv.	Anniversary
Annot.	Annotation
Announce.	Announcement
Annu.	Annual
Appl.	Applied
Apr.	April
Arch.	Archives
Archaeol.	Archaeology
Ariz.	Arizona
Ark.	Arkansas
Assoc.	Association
Astron.	Astronomy
Atmos.	Atmosphere
Aud.	Auditory
Aug.	August
Bienn.	Biennial
Biochem.	Biochemical, Biochemistry
Biol.	Biological, Biology
Biophys.	Biophysics
Bot.	Botanical, Botany
Brit.	Britain, British
Bull.	Bulletin
Bur.	Bureau
Calif.	California
Can.	Canada, Canadian
Cat.	Catalog
Cent.	Central
Ch.	Chapter
Chem.	Chemical
Circ.	Circular
Climatol.	Climatology
Co.	Company
Coll.	College
Colo.	Colorado
Com.	Commercial
Comm.	Commission
Commun.	Communication
Comp.	Comparative
Conch.	Conchology
Conf.	Conference
Congr.	Congress
Conn.	Connecticut
Conserv.	Conservation
Contrib.	Contribution
Coord.	Coordinating
Corp.	Corporation
Cult.	Cultural, Culturist
D.C.	District of Columbia
Dec.	December
Del.	Delaware
Dept.	Department
Dev.	Development
Dig.	Digest
Dir.	Director
Dis.	Disease
Diss.	Dissertation
Dist.	District
Div.	Division
Doc.	Document
E.	East
Ecol.	Ecological, Ecology
Econ.	Economic
Ed.	Editor
Educ.	Education, Educational
Encycl.	Encyclopedia
Eng.	Engineer, Engineering
Engl.	England
Entomol.	Entomological, Entomology
Environ.	Environmental
Evol.	Evolution
Exam.	Examination
Exch.	Exchange
Exhib.	Exhibit
Exp.	Experiment
Ext.	Extension
Extr.	Extract
Fac.	Faculty
Feb.	February
Fed.	Federation, Federal
Fish.	Fisheries
Fla.	Florida
For.	Forest, Forestry
Foren.	Forensic
Found.	Foundation
Ga.	Georgia
Gard.	Garden
Gaz.	Gazette
Gen.	General
Geochem.	Geochemistry
Geogr.	Geographic, Geography
Geol.	Geological, Geology
Gov.	Government
Grad.	Graduate
Gynecol.	Gynecology
Herb.	Herbarium
Hered.	Heredity
Herp.	Herpetological, Herpetology
Hist.	Historical, History
Hortic.	Horticultural
Hydrobiol.	Hydrobiology
Hydrogr.	Hydrography
Hydrol.	Hydrology
Ichthyol.	Ichthyology
Ill.	Illinois
Illustr.	Illustration
Immigr.	Immigration
Immunol.	Immunology
Imp.	Imperial
Import.	Important
Inc.	Incorporated
Ind.	Industrial
Infect.	Infection
Inform.	Information, Informative
Inorg.	Inorganic
Inst.	Institutional, Institute
Intern.	Internal
Internatl.	International
Invest.	Investigation
Ital.	Italic
J.	Journal
Jan.	January
Jul.	July
Jun.	June
Kans.	Kansas
Ky.	Kentucky
La.	Louisiana
Lab.	Laboratory
Lang.	Language
Leafl.	Leaflet
Lect.	Lecture
Lett.	Letter

Lib.	Library
Limnol.	Limnology
Lit.	Literature
Mag.	Magazine
Malacol.	Malacological
Mammal.	Mammalogy
Manage.	Management
Manu.	Manuscript
Mar.	March
Mass.	Massachusetts
Math.	Mathematical, Mathematics
Md.	Maryland
Mech.	Mechanical
Med.	Medicine, Medical
Mem.	Memoir, Memento, Memorandum
Ment.	Mental
Meteorol.	Meteorological, Meteorology
Method.	Methodology
Mich.	Michigan
Microbiol.	Microbiology
Micros.	Microscopical, Microscopy
Midl.	Midland
Mimeo.	Mimeograph
Min.	Minister
Mineral.	Mineralogy
Minn.	Minnesota
Misc.	Miscellaneous
Miss.	Mississippi
Mo.	Missouri
Mod.	Modern
Mol.	Molecule
Monogr.	Monograph
Mont.	Montana
Morphol.	Morphology
Munic.	Municipal
Mus.	Museum
Mycol.	Mycology
Nat.	Natural, Naturalist, Nature
Natl.	National
N.C.	North Carolina
N.D.	North Dakota
Nebr.	Nebraska
Nev.	Nevada
Newsl.	Newsletter
N.H.	New Hampshire
N.J.	New Jersey
N.M.	New Mexico
No.	Number
Nov.	November
N.S.	New Series
Nucl.	Nuclear
N.Y.	New York
Observ.	Observatory
Occas.	Occasional
Occup.	Occupation
Oceanogr.	Oceanography
Oceanol.	Oceanology
Oct.	October
Offic.	Official
Okla.	Oklahoma
Ont.	Ontario
Opt.	Optical
Oreg.	Oregon
Org.	Organic
Organ.	Organization
Orig.	Original
Ornithol.	Ornithological, Ornithology
O.S.	Old Series
P.	Page
Pa.	Pennsylvania
Paleontol.	Paleontology
Pam.	Pamphlet
Pap.	Paper
Parasitol.	Parasitology
Pat.	Patent
Path.	Pathogen
Pathol.	Pathology
Pediat.	Pediatrics
Petrol.	Petroleum
Pharm.	Pharmacy
Phil.	Philosophy
Phila.	Philadelphia
Photogr.	Photograph
Phys.	Physics, Physical
Physiol.	Physiological, Physiology
Phytol.	Phytology
Pl.	Plate
Poll.	Pollution
Pop.	Popular
Postgrad.	Postgraduate
Prehist.	Prehistoric
Prelim.	Preliminary
Proc.	Proceedings
Prof.	Professional
Progr.	Progress, Progressive
Proj.	Project
Publ.	Publication
Quant.	Quantitative
Quart.	Quarterly
Radiat.	Radiation
Radioact.	Radioactive
Radiobiol.	Radiobiology
Radiol.	Radiology
Rec.	Record
Reclam.	Reclamation
Regist.	Registration
Rep.	Report
Reprod.	Reproduction
Res.	Research
Rev.	Review
Rd.	Road
R.I.	Rhode Island
San.	Sanitary
S.C.	South Carolina
Sci.	Science
S.D.	South Dakota
Sect.	Section
Sed.	Sedimentary
Sep.	September
Ser.	Series
Serv.	Service
Sess.	Session
Soc.	Society
Sociol.	Sociology
Spec.	Special
St.	Street
Sta.	Station
Stat.	Statistics
Stud.	Studies
Sum.	Summary
Sun.	Sunday
Suppl.	Supplement
Supt.	Superintendent
Surg.	Surgery
Surv.	Survey
Symp.	Symposium
Syst.	Systematics
Taxonom	Taxonomy
Tech.	Technical
Technol.	Technological
Tenn.	Tennessee
Tex.	Texas
Theor.	Theoretical
Topo	Topographic, Topography
Toxicol.	Toxicology
Trans.	Transaction
Transl.	Translation
Transp.	Transportation
U.K.	United Kingdom
U.N.	United Nations
Univ.	University
U.S.	United States

U.S.A. .... United States of America
U.S.S.R. .... Union of Soviet Socialist Republics
Va. .... Virginia
Verein. .... Vereiningung
Verh. .... Verhandlungen
Vt. .... Vermont
Vol. .... Volume
Wash. .... Washington
Wildl. .... Wildlife
Wis. .... Wisconsin
W.Va. .... West Virginia
Wyo. .... Wyoming
Zool. .... Zoology

Buggy and Team of Horses on Western Prairie
(Undated photograph from collection of R.A. Popham; also printed in E.N. Transeau, H. C. Sampson, and L.H. Tiffany. 1940. Textbook of Botany, Harper and Brothers Publ., N.Y., N.Y. 812 p., photograph on p. 765 and on p. 767 in rev. ed., 1953.)

***Spartina pectinata* Community on Floodplain, Savanna, Illinois**
(Undated photograph from a glass lantern slide collection of E.N. Transeau and currently in the possession of G.E. Gilbert; also printed in H.C. Sampson, 1921. Bull. Ill. State Lab. Hist. Surv. 13: pl. 50.)

Schaffner's Account of Prairie Fires

Dr. Bernard S. Meyer (In press) has written a manuscript entitled *A History of Botany at The Ohio State University: The First 100 Years* which will be a publication of the Ohio Biological Survey. During his research, he obtained permission from Grace Schaffner Cody, the daughter of John H. Schaffner, to examine the diaries of her father. In 1891, he recorded the following account about prairie fires near and on his family's farm:

> In the early days of Kansas there was nothing which had a more pleasing and awe-inspiring effect on me than the prairie fires with which we were surrounded each spring for about six or seven weeks. Every evening after the golden beams of the western sun had died away, we were surrounded by a complete circle of flaming light, some caused by fires far below the horizon and some by the bright flames of fires only a few miles away. Often the grass was so high that it was impossible to see cattle in it without being on horseback and it can easily be imagined when an awful conflagration this would make if there was the least wind blowing. We always had a day set apart for the great event of burning off the prairie about our farm and great was our delight if the weather was favorable when the time came. I well remember one of these occasions when a friend and I set fire to several miles of prairie. Going to a place where the grass was easily pulled, we would make a large roll and after lighting it we would run for a long distance until it was consumed. Slowly would the line of fire start and keep about even pace until a part of it came to a ravine or low place, when the flames would increase and proceed at a thundering speed, mowing down everything before it not even stopping to burn the tops of the blue stem. Death and destruction were before it, insects and rabbits and birds fled but often too late to escape death; and as we walked over the still warm ashes, we found many snakes and small quadrupeds that had been burned. By the aid of the bright flames we could see hundreds of burned bird's nests, some with the little birds still writhing in the agonies of death. The head fires sweep swiftly, along the ravines and over the thicker patches of grass, leaving in every direction hundreds of little patches behind to burn at leisure. Now was the time to enjoy the scene; in the darkness and gloom of the night the perspective of the view was overcome and patches of fire seemed stacked one above the other like rocks on a hillside. I told my friend that I would like to have a photograph of the scene, but he said that it was impossible to take the picture of a fire and I have wondered ever since whether or not it is true. But now we noticed where two leading 'headfires' were coming together and sat down to watch the collision. The nearer they came the faster they went and one would learn quite a lesson in natural philosophy by watching the phenomenon. When they came together the flames were one hundred feet high and the heat terrible. The light was almost equal to day but in another five minutes all was dark and gloomy and we began to grope our way homeward over the bleak and bare earth.

KEY WORD SUBJECT INDEX

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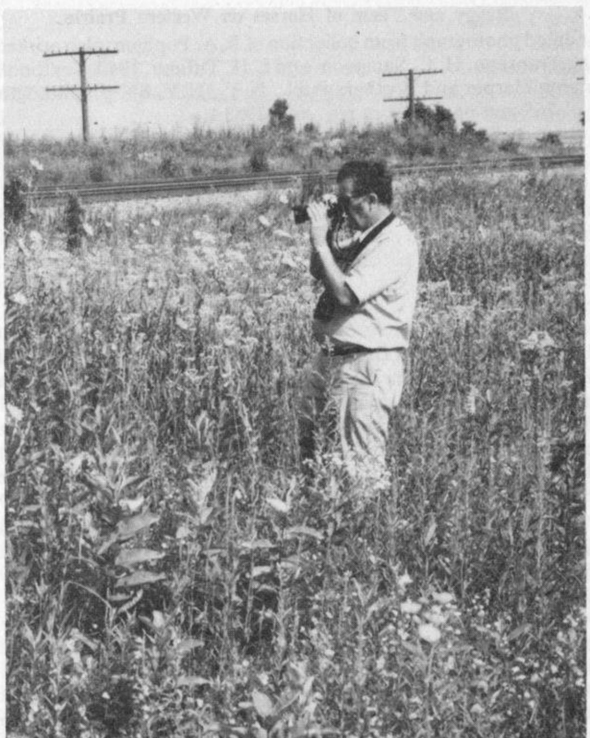
(
Charles C. King, Aug. 1980.)



Ralph E. Ramey in a Prairie

Ralph E. Ramey in a railroad strip prairie near Pittwood, Illinois. (Photograph by K. Roger Troutman, 1974.)

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AUTHOR INDEX

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