Curtis Prairie. 1972

Anderson, Roger C. (Roger Clark)
Madison, Wisconsin: University of Wisconsin-Madison Arboretum, 1972

https://digital.library.wisc.edu/1711.dl/DQL7WGJVRYYY38P

Curtis Prairie

The University of Wisconsin Arboretum

This field book is dedicated to Mrs. Jean Otto who loved the Arboretum and visited it often.

Mrs. Otto had a deep appreciation and understanding for the natural world and readily transmitted it to those who knew her. For her each season brought its own delights; migrating birds, colors of fall, the stark beauty of bare branches against the winter sky, the tender wild flowers poking through soft earth in spring, and lush green of summer—all were part of the rhythm of her life.

We hope that those who use this booklet will gain a deeper feeling and understanding of the natural world thereby making this a suitable memorial for Jean Wilson Otto.

Leach

THE USE OF FIRE AS A MANAGEMENT TOOL ON THE CURTIS PRAIRIE

At the University of Wisconsin Arboretum, Madison, fire has been used as a management tool to maintain our prairies for over twenty years. During the 1930's and 1940's the necessity and importance of fire in maintaining biotic communities was so slighted, indeed downgraded, that to propose fire as a useful tool in the early 1950's required a great deal of insight and clear objective interpretation of carefully regulated experiments. This paper reviews the development of the Curtis Prairie and some of the research efforts that have given us the information needed to understand the role of fire in the tall grass prairie.

The primary management goal of the University of Wisconsin Arboretum is to rehabilitate or artificially establish as many of the native Wisconsin biotic communities as possible. As a result the Madison Arboretum is different from most arboreta in that it is a collection of communities rather than horticultural plantings. The Arboretum's 1,240 acres include over thirty-one different biotic communities; some are natural, whereas others have been restored over the thirty-seven year history of the Arboretum.

Our best success at community restoration has been with the prairie. There are two areas of prairie in the Arboretum: the sixty-acre Curtis Prairie, named for the late Professor of Plant Ecology, John T. Curtis, and the thirty-five-acre Henry Greene Prairie. Of the seven million acres of prairie that once covered Wisconsin, little remains today. Nearly all of the original prairies were located in the southern part of the state, with the greatest concentration occurring in the southwest.

In Wisconsin, as elsewhere in the Midwest, the prairie story relates to climate, plants, man, and fire. Before European settlement, southern Wisconsin was a mosaic of oak savannah and prairie. Both of these communities are dependent upon fire for their maintenance and revert to forest communities without burning, the savannah more quickly so than the prairie. Oak forests in southern Wisconsin are of sprout origin, and with the exception of a few large open-grown trees that existed in the savannah, they had their origin with the cessation of the nearly annual fires. (Muir 1965, Curtis 1959)

Restoration

In 1835, most of the Arboretum area, including the present site of the Curtis Prairie, was oak savannah with fifteen to twenty burr and white oak trees per acre. Prairie grasses and forbs dominated in between the trees with scattered "oak grubs" and a few species of shrubs occurring throughout. The area now occupied by the Curtis Prairie was settled in 1837 and was regularly plowed and planted to field crops until the early 1920's (Curtis 1951). The abandoned fields were then used as a horse pasture from 1927 to 1932. The end result was an area completely devoid of prairie plants and dominated by Kentucky and Canadian bluegrass and it was these conditions that existed when the first efforts at prairie restoration began.

In 1935, little was known about prairie restoration. Under the direction of T. Sperry, CCC work crews brought in sod from local prairie remnants that contained a mixture of prairie species and planted them among the bluegrass, generally with little or no pretreatment being done to the site. This initial program ended in 1940 and no additional plantings were made until 1950. However, the decade of the late forties and early fifties produced the understanding of the role of fire in the prairie and information regarding the ecology and composition of the prairies. These were major factors that contributed to the success we have had at restoration to date.

The first research paper that clearly delineated the role of fire in grassland maintenance as it relates to the Curtis Prairie was published by Curtis and Partch in 1948. Fire, appropriately used, was found to be an effective tool in retarding the growth of bluegrass while enhancing the prairie species. Bluegrass, an introduced cool-season grass, begins growth in April, while dominant prairie species initiate growth in May. Similarly, the native prairie species are dormant by October, whereas the introduced bluegrass and some other European weeds are actively growing. By burning in the spring or fall, the bluegrass is set back while the prairie species are enhanced. An increase in production and flowering of the major grass species and legumes following fire was also reported (Curtis and Partch, 1948; Archbald, 1954; Robocker and Miller, 1955).

The composition of native Wisconsin prairies was intensively examined (Curtis and Greene, 1949; Curtis 1955) and these studies provided the basic information on the nature of the final product. Work on germination of prairie species (Greene and Curtis, 1950) and methods of seeding, pretreatment of the planting site and the use of cover crops provided basic information needed for prairie restoration (Partch, 1950; Greene and Curtis, 1953; Robocker, *et al.,* 1953; Archbald, 1954; Robocker and Miller, 1955; Miller and Curtis, 1956). Unfortunately, the various methods of seeding, site preparation and the use of cover crops that were tried yielded results that were not always reproducible because of variable climate conditions that occurred during the growing season following establishment and frequently detailed records were not kept of all restoration experiments (Cottam, 1972). However, the role of fire as an effective management tool became very clear.

Since 1950, the Curtis Prairie has had a biennial burning schedule with approximately one-third of the area being burned one year and the remaining two-thirds the following year. This program of prescribed burning has been very effective in reducing the frequency of many introduced weeds and greatly enhancing the prairie species.

At five-year intervals, a grid of meter square quadrats that are located fifty feet apart are used to determine the composition of the prairie. The first survey was done in 1946 and at that time the Curtis Prairie was essentially a bluegrass field with a few prairie species growing in it. In the first survey a data sheet was used that contained only ten prairie species as these were the only species that were abundant enough to be included in the study. In subsequent years this data was worthless as a result of the increase in numbers and dominance of other prairie plants. The 1961 survey showed that portions of the Curtis Prairie were similar to native prairie stands in terms of the number of indicator species and in the summed frequencies of the prairie species (Cottam and Wilson, 1966).

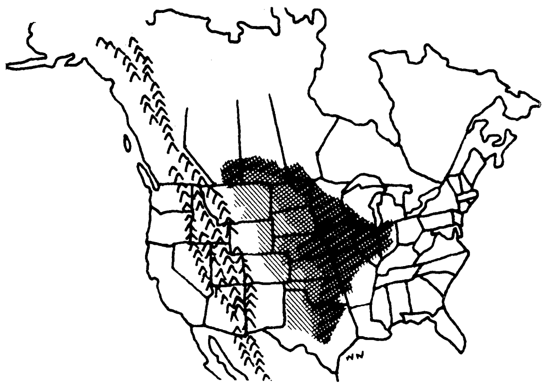
Table I
Frequency of Plant Species in Curtis Prairie, Stand A, 1951 and 1961*

	Frequency	
	1951	1961
Prairie Species		
Achillea millefolium	44	55
Ambrosia artemisiifolia	79	53
Andropogon gerardi	6	44
Andropogon scoparius	-	47
Asclepias verticillata	59	61
Eryngium yuccifolium	1	69
Helianthus grosseseratus	-	5
Lactuca canadensis	48	84
Liatris aspera	2	37
Monarda fistulosa	53	73
Ratibida pinnata	6	32
Rudbeckia hirta	-	3
Silphium terebinthinacium	2	21
Solidago gigantea	-	3
Solidago nemoralis	-	81
Solidago rigida	-	8
Sorghastrum nutans	-	68
Other Species		
Agrostis alba	-	8
Aster pilosus	71	31
Pastinaca sativa	32	11
Poa compressa	79	97
Solidago altissima	32	48
Weeds		
Agropyron repens	29	11
Oxalis stricta	54	44
Poa pratensis	60	13
Trifolium repens	74	43

*Data of Cottam and Wilson, 1966. (In Lussenhop, 1971)

WHERE DOES THE NORTH AMERICAN PRAIRIE OCCUR?

It occupies that part of our continent between the forest and the desert, between rain and drought. It was once continuous from Indiana to the Rockies, in lands where corn and cows have taken its place.



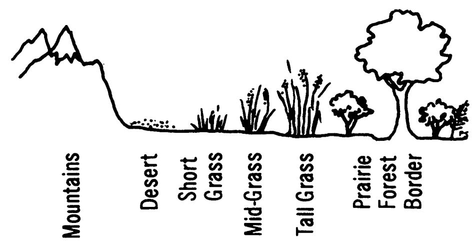


Table I provides the general pattern of changes in frequency that have occurred on the Curtis Prairie since its establishment. These results show that the frequency of the dominant grasses, big and little bluestem (*Andropogon gerardi, A. scoparius*), Indian grass (*Sorghastrum nutans*), and many of the prairie forbs including the goldenrods (*Solidago* spp.), yellow coneflower (*Ratibida pinnata*), and especially the rattlesnake master (*Eryngium yuccifolium*) substantially increased in frequency between 1951 and 1961. In addition, many of the troublesome weedy species such as wild parsnip (*Pastinaca sativa*) and Kentucky bluegrass (*Poa pratensis*) markedly declined.

The Curtis Prairie gently slopes from the west, where the maximum elevation of 925 feet is reached, to the northeast at minimum elevation of 865 feet. Figure 1 shows the soil drainage pattern in the Curtis Prairie. The west end of the prairie is well drained to moderately well drained while the eastern end is poorly drained. The drainage pattern is essentially from the southwest to the northeast.

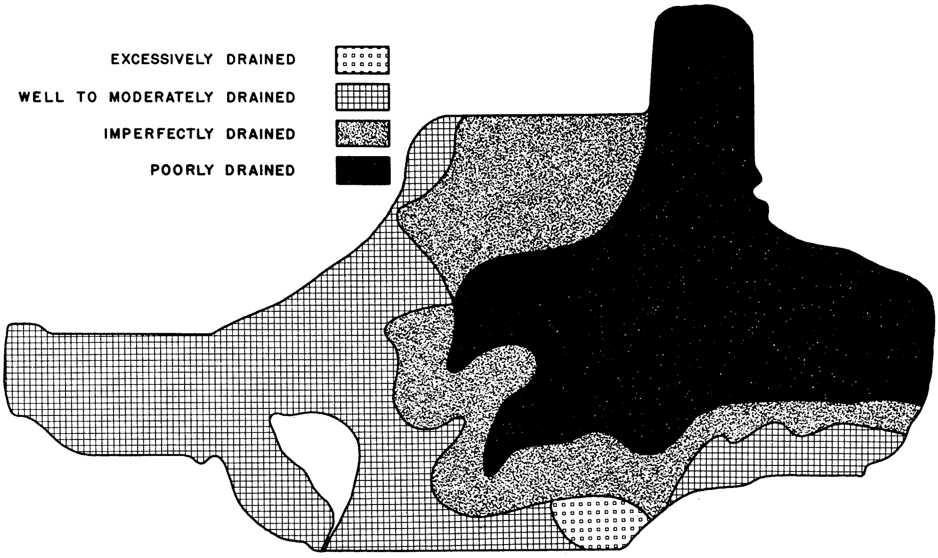


Figure 1. Soil drainage pattern in the Curtis Prairie

The vegetational pattern in the Curtis Prairie in 1966 and 1971 is shown in Figures 2 and 3. These maps were prepared by calculating a Continuum Index Value (Curtis, 1955) for each quadrat in the 1966 and 1971 censuses and then using synographic mapping techniques to delineate community types. Prairies composed of all wet prairie indicators will have a CI value of 100, mesic prairies have value of 300, and all dry prairie indicators in a community would result in a CI of 500.

Based on the drainage and soil moisture pattern, the communities show a reasonable delineation. Comparison of 1966 and 1971 CI maps of the Curtis Prairie show that there is a slight shift to lower CI values. Studies on the Greene Prairie (Anderson and Cottam, 1970) revealed that after the initial establishment the species segregated themselves according to their optimum moisture regime.

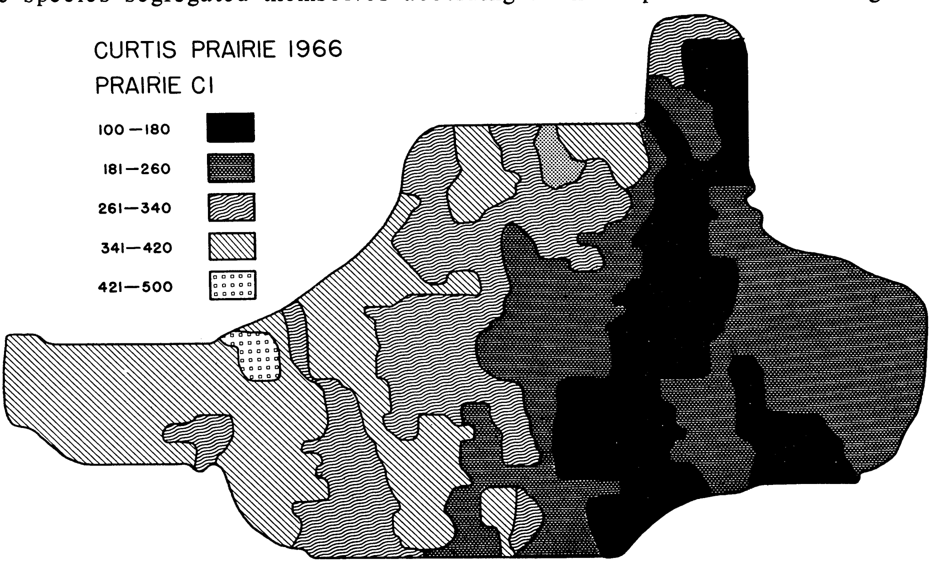


Figure 2. Vegetational pattern in the Curtis Prairie, 1966

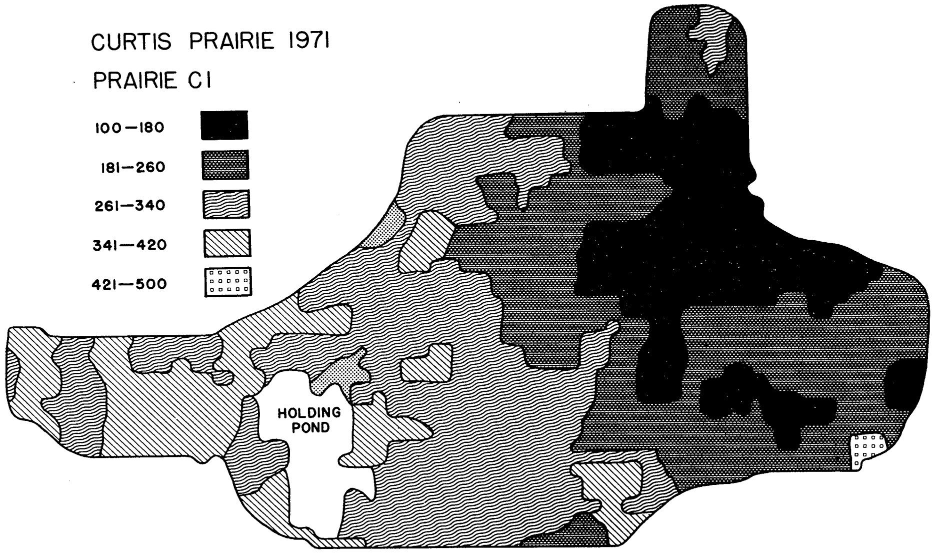


Figure 3. Vegetational pattern in the Curtis Prairie, 1971

Thus changes in composition within any given area might be expected to continue as the species make a more complete adjustment to the environment.

Since the 1940's there have been several studies of the effect of prairie fires on a range of topics that include soils, soil arthropods, and spiders (Hole and Nielsen, 1963; Lussenhop, 1971; Riechert and Reeder, 1971). The soil on which the Curtis Prairie was established had its genesis under forest cover rather than prairie. Studies began by the soil scientist, Francis Hole, in 1956 revealed that during the agricultural era, which lasted about ninety years (1840's to 1930's), the forest soil lost about twenty tons of organic matter per acre. That amounts to about 26 percent of the organic matter contained in an undisturbed forest soil. However, during a nineteen-year period, from 1940 to 1959, the prairie restored twelve tons of organic matter or 60 percent of that lost (Nielsen and Hole, 1963). Based on his work, Professor Hole believes that a prairie soil is slowly forming under the Curtis Prairie. However, it is estimated an A1 horizon in a prairie soil can form in 500 years and a textural B horizon in 4,000 years (Arnold and Riecken, 1964). Because burning enhances the productivity of the tall grass prairies, it also increases organic matter and nitrogen in the soil.

Studies of invertebrate response to fire has shown that burning reduces the diversity and limits the number of soil arthropod individuals. Soil arthropod diversity is related to the quantity of litter and rate of decomposition. Fire reduces the amount of litter and also increases the rate of nutrient turnover; to this extent it limits soil arthropod diversity (Lussenhop 1971).

Organisms that occur below the soil surface are well shielded from the fire because of the soil's insulating properties. During a prairie fire, surface temperatures of up to 200°C were recorded for 70 to 140 seconds. However, at depths of 0.5 and 1.0 cm in the soil, temperatures were unchanged (Riechert and Reeder, 1971).

Immediately following fire, predatory spiders and soil arthropods that are resistant to dessication were found to increase (Lussenhop, 1971; Riechert and Reeder, 1971). However, arthropods which are unable to escape the fire by getting under the soil or other protective objects such as stones, frequently are killed by the fire. For this reason it has been recommended that a portion of small prairies be left unburned each year to permit some of these more fire-sensitive species to survive. This recommendation seems reasonable, as during presettlement times, the large prairie tracts undoubtedly had sizeable areas that were missed by fire and where the fire-susceptible species may have persisted and then reinvaded the burned tracts during the next growing season.

During the past five years, two studies on the Curtis Prairie examined the causative mechanism for increased productivity of the prairie following burning. The first of these studies examined net radiation patterns and soil temperatures at the surface and 25 cms into the soil. Figure 4 shows these measurements for four days that span the major portion of the growing season.

During the spring, daytime temperatures were substantially warmer on the burned prairie than on the unburned. The blackened surface readily absorbed energy while on the unburned prairie the litter layer retarded soil warming and its lighter color reflected back some of the radiant energy. However, at night, the lack of a litter layer on the burned surface allowed it to cool much faster than the surface of the unburned prairie. While these conditions persist to some degree throughout the growing season, they are most pronounced in May and early June before much vegetative cover has developed on the burned site (Brown, 1967).

Total production of above ground biomass was 4,180 lbs. per acre on the unburned site compared with 8,478 on the burned. It was hypothesized that conditions for growth were more favorable on the burned site especially during the spring because the soil warmed up faster, extending the growing season. During May, the shoots on the burned area were exposed to favorable temperatures for photosynthesis during the day and at night the cooler temperatures near the ground reduced nighttime respiration. It was reasoned that the reflective litter surface on the unburned site increased the energy load on the leaves once they emerged above the litter and this resulted in unfavorable leaf temperatures. Leaf temperatures were predicted from net radiation measurements, but no measurements of leaf temperatures were made (Brown, 1967).

This work was continued by Peet (1971). She measured reflectance, air temperatures at 5 cms above the ground, leaf temperatures and net primary productivity of big bluestem using gas exchange methods. Her results also showed that the burned prairie presented more favorable conditions during the spring, but the actual differences in leaf temperatures were not as great as those predicted by the method used by Brown (1967) and that the reflected energy from the litter surface could not account for the differences in leaf temperatures. However, the litter surface did reduce wind movement and this could be an important factor in raising leaf temperatures on the unburned site during the early part of the growing season. As a result, leaf temperatures during midday were nearer the photosynthetic optimum, about 26°C for big bluestem, on the burned than on the unburned site.

Both of these studies pointed to the importance of early spring growth conditions. By May 31, 1971, the burned prairie had 21.8 g/m^2 while the unburned prairie had only 0.6 g/m^2 of above-ground biomass (Peet, 1971). The extended growing season and the more optimal conditions for net photosynthesis in the early spring on the burned site are important factors in the increased productivity of burned prairies in the Midwest.

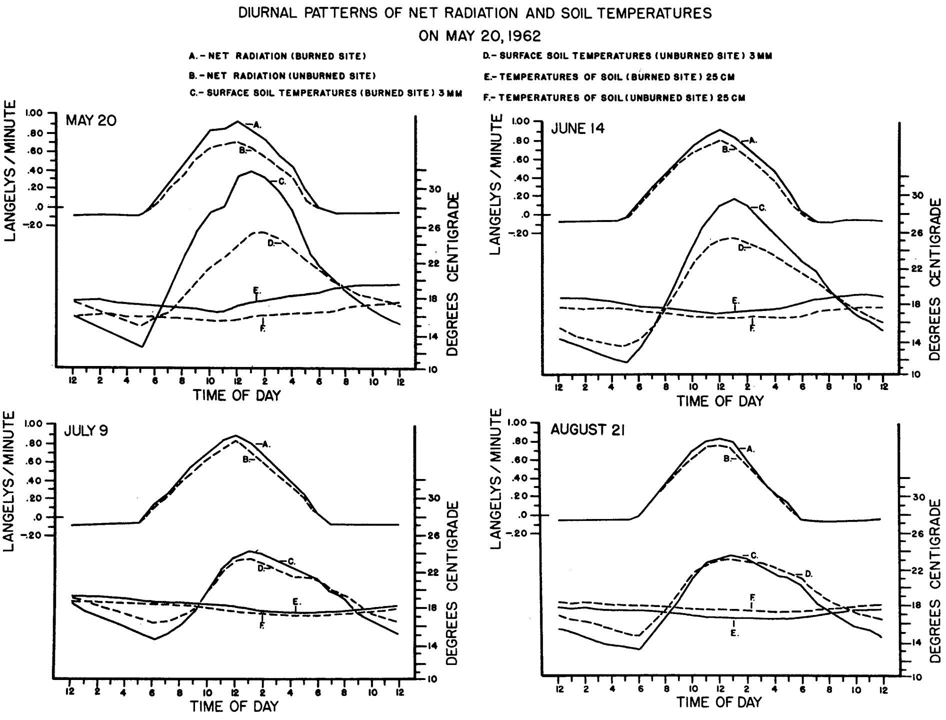


Figure 4. Net radiation and soil temperatures for four days during the growing season on the Curtis Prairie

Since the establishment of the Curtis Prairie in 1935, there have been four Masters and six Doctoral theses, as well as sixteen published papers resulting from studies carried out in the Arboretum's prairies. Many of these scientific works have had a significant impact on recent ecological thinking. However, the Curtis Prairie has played an equally important role in educating the general public in the Madison area about fire ecology and its significance to the prairie community. The Arboretum is essentially surrounded by an urban area of nearly 200,000 people, and the objections raised to our prescribed burning program are presently minimal. For the past eight years, the Arboretum's prairies have served as an outdoor classroom for thousands of school children. This educational program has more than paid for itself in understanding and goodwill. Today, elementary school children are taught the concepts of fire ecology that were rejected fifteen years ago by leading ecologists throughout the country. Nonetheless, recent concern about air pollution has emphasized the need to educate the public about the difference between natural smoke and that which is produced by factories and automobiles.

In 1953, when Walt Disney was filming the "Vanishing Prairie," he sent his crew to photograph the burning of the Curtis Prairie as this was the only place in the world where anything even approaching the spectacle of a primeval tall grass prairie fire could be found. Since that time, there have been other major efforts made at restoration but it is fair to say that more has been learned about prairie ecology through the restoration of the Curtis Prairie than any other.

The future of the Curtis Prairie and the whole of the Arboretum is not secure. Recent expansion of the West Beltline Highway that parallels the southern boundary of the Curtis Prairie has caused serious erosion and siltation problems. About an acre of the prairie was lost when a settling pond was built to capture the sediment from the Beltline during construction (Figure 3). We are also threatened by other urban development and a growing number of visitors who are not sufficiently educated to properly use a natural facility such as the Arboretum. Solutions to the current problems that the Arboretum now faces cannot be solved by more publications in scientific journals; public support and understanding must be expanded.

Our Tour Program and publication of books, such as *A Guide to the Arboretum Prairies* (Riech, 1971), have helped. Many people have learned to love the prairie, to appreciate its diversity, and understand the role of fire in this community. It is this knowledge that gives the Arboretum and the Curtis Prairie a chance for survival in the future.

LITERATURE CITED

Anderson, M. Rebecca and Grant Cottam. 1970. Vegetational change on the Greene Prairie in relation to soil characteristics. Proc. 1st Prairie Symposium. Knox College, Galesburg, Ill.

Archbald, David. 1954. The effect of native legumes on the establishment of prairie grasses. Ph.D. Thesis. Botany, Univ. of Wis., Madison. 98 pp.

Arnold, R. W. and F. F. Riecken. 1964. Grainy gray ped coating in brunizem soils. Ia. Acad. Sci. Proc. 7:350-360.

Brown, Charles T. 1967. Growth and energy relationships on burned and unburned prairie in southern Wisconsin. M.S. Thesis, Botany, Univ. of Wis. 51 pp.

Cottam, Grant. 1972. Personal communications. Botany Dept., Univ. of Wis., Madison.

Cottam, Grant and H. Cameron Wilson. 1966. Community dynamics on an artificial prairie. Ecology 47:88-96.

Curtis, J. T. and H. C. Greene. 1949. A study of relic Wisconsin prairies by the species-presence method. Ecology 30:83-92.

Curtis, J. T. and M. L. Partch. 1950. Some factors affecting flower production in *Andropogon gerardi*. Ecology 31:488-489.

Curtis, J. T. 1955. A prairie continuum in Wisconsin. Ecology 36:558-565.

Greene, H. C. and J. T. Curtis. 1950. Germination studies of Wisconsin prairie plants. Amer. Midland Natur. 43:186-194.

Greene, H. C. and J. T. Curtis. 1953. The reestablishment of prairie in the University of Wisconsin Arboretum. Wild Flower 29:77-88.

Hole, Francis. 1968. Soil genesis under prairie. Proc. 1st Prairie Symposium. Knox College, Galesburg, Ill.

Lussenhop, John F. 1971. Response of a prairie soil arthropod population to burning. Ph.D. Thesis, Zoology, Univ. of Wisconsin, Madison. 100 pp.

Miller, Bonita and J. T. Curtis. 1956. Differential response to clipping of six prairie grasses in Wisconsin. Ecology 37:355-365.

Muir, John. 1965. The story of my boyhood and youth. Univ. of Wis. Press, Madison. 227 pp.

Nielsen, J. C. and Francis D. Hole. 1963. A study of the natural process of incorporation of organic matter into soil in the University of Wisconsin Arboretum. Trans. Wis. Acad. Sci., Arts and Letters. 52:213-227.

Partch, Max. L. 1950. Some factors affecting flower production in *Andropogon gerardi*. Ecology 31:488-489.

Peet, Mary M. 1971. The effect of burning on microclimate and production in Wisconsin tall grass prairie. M.S. Thesis. Botany, Univ. of Wis., Madison. 125 pp.

Reich, Binda. 1970. Guide to the Arboretum Prairies. Friends of the Arboretum, Madison.

Riechert, Susan E. and William G. Reeder. 1971. Effects of fire on spider distribution in southwestern Wisconsin. J. Animal Ecology (in press).

Robocker, W. C., J. T. Curtis, and H. L. Ahlgren. 1953. Some factors affecting emergence and establishment of native grass seedlings in Wisconsin. Ecology 34:194-199.

Robocker, W. C. and Bonita J. Miller. 1955. Effect of clipping, burning, and competition on establishment and survival of some native grasses in Wisconsin. Jour. Range Management 8:117-120.

Roger C. Anderson
1972