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Loss Of Hill Prairie Through Woody Plant Invasion at Pere Marquette State Park, Jersey County, Illinois

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William E. McClain

Edward A. Anderson

Division of Natural Heritage,
Illinois Department of Conservation
524 S. 2nd St.
Springfield, Illinois 62701

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ABSTRACT: A study of hill prairie communities was conducted at Pere Marquette State Park to determine the rate and effects of woody plant invasion. This resulted in a loss of species diversity in the prairie within 5 to 7 years from the onset of tree and shrub invasion. After 15 to 20 years, the prairie had essentially disappeared, probably a result of the increased shade. Rough-leaved dogwood (*Cornus drummondii*) was identified as the principal woody invader, and the non-native bush honeysuckle (*Lonicera maackii*) was abundant in some study plots. Prescribed fire, cutting, and selective use of herbicides are recommended for the control of woody plant invasion.

INTRODUCTION

Many of the hill prairies in Illinois have been in a state of decline for several years as a result of woody plant invasion. Although the existence of this phenomenon is generally accepted, no descriptions of this process are available in the literature. At Pere Marquette State Park in Jersey County, Illinois, studies were undertaken to determine the principal woody invaders and the effects of the woody plants upon the hill prairie community.

Most of the loess and glacial drift hill prairies in Illinois are located on steep, south-, southwest-, or west-facing bluffs or hillsides along the Illinois and Mississippi rivers and their tributaries (Evers 1955). Because of their inaccessible locations and lack of disturbance, several of these are regarded as some of the best prairie remnants within the state.

Some of these hill prairies contain state threatened and endangered plants and others provide habitat for rare prairie butterflies (Sedman and Hess 1985, Sheviak 1981). These prairies represent significant natural communities that probably have been present in the state since the Hypsithermal period, approximately 8300 years ago, when prairie became a dominant landscape in Illinois (King 1981).

Despite the abundance and generally conspicuous locations of hill prairies along river bluffs, relatively few studies of Illinois hill prairies are available in the literature. "Hill Prairies of Illinois," a statewide study of hill prairies, is still the most comprehensive document on this subject (Evers 1955). Since the 1950s,

researchers have documented soil and microclimatic conditions on hill prairies (Kilburn and Warren 1963, Bland and Kilburn 1966, Raft and Kilburn 1969, Reeves et al. 1978). These studies indicate that hill prairies, because of soil types, aspect, and exposure, are more xeric than adjacent forest. Certain plants, such as little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), narrowleaved bluets (*Hedyotis nigricans*), showy goldenrod (*Solidago speciosa*), and purple prairie clover (*Dalea purpurea*), characterize the plant communities of these hill prairies (Evers 1955, Kilburn and Ford 1963, Kilburn and Warren 1963, Bland and Kilburn 1966, Dziadyk 1978, Ebinger 1981).

Despite the xeric conditions that characterize them, hill prairies are readily invaded by woody plants. Branches from trees at the prairie forest border create shade and furnish perching sites for birds, who carry in the seeds of shrubs and trees, initiating the formation of a dense shrub zone between the prairie and forest. Costello (1931), in recognizing the shrub zone in the loess hills of Iowa, concluded that "it was here that the conversion from prairie to forest took place." Studies in Illinois alluded to the invasion of hill prairies by woody plants, but data were not presented (Kilburn and Warren 1963, Ebinger 1981).

In a resurvey of a study by A. G. Vestal (1918) of glacial drift hill prairie openings along the Embarras River in Coles County, researchers found that the total number of prairie openings at this site had been reduced from ten in 1918 to only three in 1978 (Reeves et al. 1978). Photographic measurements of five hill

prairies within Pere Marquette State Park, Jersey County, indicated a loss of 61.9 percent of hill prairie in the 37-year period from 1937 to 1974 (McClain 1983). A similar loss of 65.5 percent (173.2 to 59.9 acres) of the hill prairie at Revis Springs in Mason County was recently confirmed by measuring acreages of hill prairie on 1939 and 1978 black and white aerial photographs.

Although these studies provide evidence of the loss of hill prairie through woody plant invasion, the principal invaders were not identified and the effects of the woody invasion upon the prairie community were not described. The documentation and description of these changes are important for reference with future research and for the acquisition and management of hill prairies.

DESCRIPTION OF STUDY AREA

Pere Marquette State Park is located in Jersey County, Township 6N, Range 13W, Section 9, Brussels Quadrangle, USGS 7.5 minute series. The entire park lies within the Driftless Section of the Middle Mississippi Border Division (Schwegman 1973). This geographic area is characterized by steep topography and numerous outcrops of dolomite, limestone, and shale, particularly within Pere Marquette State Park. The most widespread geologic formation is the Pleistocene loess, which forms a thick mantle 50 to 100 feet thick over the underlying bedrock (Rubey 1952).

The soil of the hill prairies is Hamburg silt, which is essentially unaltered loess. This soil is calcareous throughout and grass-covered rather than forested. The upper horizon of these soils is very friable and grayish-brown to brown in color (Fehrenbacher and Downey 1966).

With the exception of the hill prairies, the landscape within Pere Marquette State Park is forested. An examination of the Government Land Office Survey Records of the 1820s indicates that the area was forested prior to European settlement. From the 1820s until the establish-

ment of Pere Marquette State Park, the forests were used as a source of lumber and fuel.

Owing to its exceptional scenic features and the interests of local citizens, land was purchased in 1932 for the purpose of establishing a state park. The construction of a lodge, trails, and other park buildings was undertaken by the Civilian Conservation Corps (CCC) under the supervision of the National Park Service during the 1930s. Their work, which continued from April 1, 1933, to June 30, 1939, included 96 man days for fighting "weed fires" on and off park property, the construction of 4 miles of firebreaks, 11 miles of fire hazard reduction, and 286 man days of fire suppression training (Illinois State Archives). One firebreak was constructed at the crest of a large hill known locally as McAdams Peak in honor of William McAdams, an amateur archaeologist who studied Indian cultures at this site in the 1860s.

The CCC built three pavilions on McAdams Peak to provide visitors with vistas of the Illinois River Valley. At the time of construction of these pavilions

there was a large hill prairie on the lower slopes of McAdams Peak. This hill prairie, a corn storage building, and the slanted rocks of the Lincoln Fault are visible in a photograph (circa 1936) taken by a CCC member (Figure 1). Most of the trees present in the photograph are eastern red cedar, whose conical forms are easily identifiable. Black and white aerial photography indicates that there were 14.0 acres of hill prairie at this site in 1937. Since that time, woody vegetation has advanced up the hillside, obliterating the view of the Lincoln Fault (Figure 2) and reducing the hill prairie on McAdams Peak to only 2.4 acres (McClain 1983). The corn storage building shown in Figures 1 and 2 was restored by the CCC and is now the visitor's center.

Another photograph taken during the same time period from the top of McAdams Peak shows several barns and farm buildings, which were razed by the CCC in the 1930s. The hillside was relatively free of shrubs and trees, making it easy to see the visitor's center in the lower right side of the photograph. In March of 1989, in a photograph taken at approximately the same site, it was im-

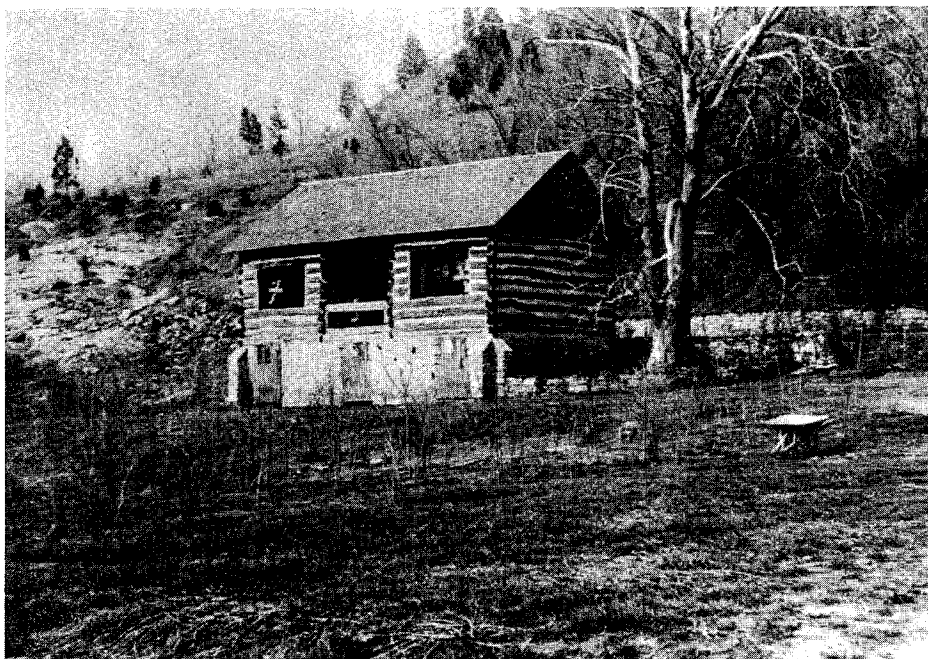


FIGURE 1. The visitor center at Pere Marquette State Park, Jersey County, Illinois, circa 1936. Note the red cedars on the hillside and the rocks of the Lincoln Fault, the bare area on the left.



FIGURE 2. The visitor center at Pere Marquette State Park, Jersey County, Illinois, March 1989. Note the large trees and cedars on the hillside.

possible to see any of the park buildings because of the dense shrub and tree growth present on the hillside.

Prior to the acquisition of the site by the Illinois Department of Conservation (IDOC), a farm was located in the flat bottomland at the base of McAdams Peak. According to a local citizen familiar with the site in the late 1920s and early 1930s, three to four horses were kept at the base of the hill prairie. Photographs taken during this era do not indicate the presence of fences on McAdams Peak and it is assumed that the hill prairies were not intensely grazed.

Field biologists from the Illinois Natural Areas Inventory (INAI) examined the McAdams Peak hill prairie on June 28, 1977. They found 5.0 acres of "grade B," lightly grazed loess hill prairie with woody encroachment and 4.0 acres of "grade C" prairie with moderate to dense woody invasion (White 1978). The "grade B" prairie was used for the hill prairie samples in this study (see Methods).

Other areas were recognized as being transitional between hill prairie and

dense shrub or young forest communities. This transitional zone is characterized by scattered woody plants that do not form a canopy over the prairie vegetation.

The areas of advanced woody invasion are located approximately halfway up the slope of McAdams Peak. This zone is characterized by a dense thicket of shrubs and trees, which form a canopy over the prairie vegetation. This canopy is made more dense by the rank growth of wild grape (*Vitis* sp.), bittersweet (*Celastrus scandens*), raccoon grape (*Ampelopsis cordata*), and Virginia creeper (*Parthenocissus quinquefolia*) throughout the crowns of the shrubs.

Beginning in 1973, personnel from IDOC began a prescribed burning program at Pere Marquette, thus ending 40 years of fire suppression. Burns were conducted on the high quality prairie (INAI "grade B") on McAdams Peak in 1973, 1977, 1982, 1985, and 1988. No fires are known to have occurred on the study sites with transitional and advanced woody invasion since the park was established in 1932.

METHODS

Three vegetation types were selected for sampling: hill prairie, hill prairie with an intermediate or transitional stage of woody succession, and hill prairie with advanced woody succession. Four circular .01-ha quadrats were subjectively established within each vegetation type to sample the woody plants. All woody stems were measured and placed into the size classes listed below. The results were tabulated and multiplied times a conversion factor to establish the number of stems on a per hectare basis.

The seven size classes were:

- I less than breast height (1.5 m)
- II breast height but ≤ 1 cm (0.39 in)
- III > 1 cm but ≤ 3.5 cm (1.4 in) dbh
- IV > 3.5 cm dbh but ≤ 6 cm (2.4 in) dbh
- V > 6 cm but ≤ 9 cm (3.5 in) dbh
- VI > 9 cm (3.5 in) dbh

Nine 1m² quadrats nested within the .01 ha circular quadrats were used to determine the frequency of the herbaceous vegetation. The nomenclature for all plants follows Mohlenbrock (1986).

In order to determine the onset of woody invasion, the ages of roughleaved dogwood were determined by cutting individuals at ground level and counting their growth rings. A Swedish increment corer was used to remove cores from eastern red cedar. Growth rings were counted on these to correlate their ages with a 1936 photograph of the site (Figure 1).

RESULTS

Hill Prairie

The prairie on McAdams Peak is the largest hill prairie remaining in the park. The most abundant plants are sky blue aster (*Aster azureus*), sideoats grama, purple prairie clover, little bluestem, and showy goldenrod. A total of 24 native herbaceous prairie species were present in the study plots of this site (Table 1).

This hill prairie contains plant species—sideoats grama, scurf pea (*Psoralea ten-*

TABLE 1. Frequency of herbaceous plants in hill prairies at Pere Marquette State Park, Jersey County, Illinois.

SPECIES	Hill Prairie % Frequency	Transitional Woody Zone % Frequency	Advanced Woody Zone % Frequency
<i>Amorpha canescens</i>	11	—	—
<i>Aster azureus</i>	100	14	—
<i>Aster ericoides</i>	25	6	—
<i>Antennaria plantaginifolia</i>	6	—	—
<i>Acalypha gracilens</i>	3	—	—
<i>Andropogon gerardii</i>	19	61	—
<i>Asclepias viridiflora</i>	3	—	—
<i>Belamcanda chinensis*</i>	—	—	8
<i>Bouteloua curtipendula</i>	100	11	—
<i>Brickellia eupatorioides</i>	36	22	—
<i>Botrychium virginianum</i>	—	—	3
<i>Carex</i> sp.	—	—	6
<i>Conyza canadensis</i>	—	—	14
<i>Dalea candida</i>	8	—	—
<i>Dalea purpurea</i>	83	—	—
<i>Desmanthus illinoense</i>	3	—	—
<i>Desmodium canadense</i>	17	8	3
<i>Elymus virginicus</i>	—	—	8
<i>Eupatorium rugosum</i>	—	—	8
<i>Euthamia graminifolia</i>	3	—	—
<i>Hedystis nigricans</i>	72	—	—
<i>Lithospermum incisum</i>	3	—	—
<i>Melilotus alba*</i>	—	—	28
<i>Panicum</i> sp.	8	—	—
<i>Poa pratensis*</i>	—	—	39
<i>Psoralea tenuiflora</i>	17	—	—
<i>Pycnanthemum pilosum</i>	6	19	—
<i>Ruellia humilis</i>	3	—	3
<i>Schizachyrium scoparium</i>	100	33	6
<i>Senecio plattensis</i>	28	—	—
<i>Solidago speciosa</i>	97	22	—
<i>Sorghastrum nutans</i>	50	39	—
<i>Verbascum thapsus</i>	—	—	3

* Non-native species

uiflora), white prairie clover (*Dalea candida*), and yellow puccoon (*Lithospermum incisum*)—that are regarded as characteristic hill prairie species (Evers 1955). No woody plants were present in any of the four .01-ha plots.

Transition Zone

In this zone, the number of prairie species

sampled decreased from 25 to 11 and the frequency of the remaining species dropped dramatically, except for Indian grass (*Sorghastrum nutans*), which decreased slightly, and big bluestem (*Andropogon gerardii*), which increased significantly (Table 1).

Age studies of 13 rough-leaved dogwoods, one of the principal invaders, in-

dicated an average age of five to seven years. Eighteen species of woody plants were recorded for this zone (Table 2).

Advanced Zone

In this vegetation zone, only three species of prairie plants were present in the study plots. These plants, little bluestem, wild petunia (*Ruellia humilis*), and Canada tick trefoil (*Desmodium canadense*), had very low frequencies (Table 1).

Alien herbaceous plants such as blackberry lily (*Belamcanda chinensis*), white sweet clover (*Melilotus alba*), and Kentucky bluegrass (*Poa pratensis*) comprised most of the herbaceous flora (Table 1). In addition to the alien herbaceous species, the alien shrubs autumn olive (*Eleagnus umbellata*), bush honeysuckle (*Lonicera maackii*), and Japanese honeysuckle (*Lonicera japonica*) formed a dense understory. Cross sections from the trunks of 17 of the larger roughleaved dogwoods revealed a range in age of 22 to 31 years. These individuals had achieved diameters of 3 to 6 cm and heights in excess of 3 m. In some individuals, a period of very rapid growth of as much as 4 cm in diameter occurred in the first ten years of life.

Increment cores taken from 19 large eastern red cedars located near these study plots revealed a range in age of 38 to 67 years. A total of 37 cedars are visible in the 1936-era photograph of the site (Figure 1).

DISCUSSION

At Pere Marquette State Park, rough-leaved dogwood is the principal shrub invader of hill prairies. Its role as the primary invader is enhanced by the fact that its fleshy fruits are attractive to birds, who disperse the seeds. Once established, this shrub is known to reproduce vigorously by adventitious shoot production. This high reproductive capacity and tolerance of wind, full sun, and dry soils make this plant especially well adapted for its role as initial shrub invader of hill prairies (Weaver 1965).

TABLE 2. Woody vegetation of hill prairies at Pere Marquette State Park, Jersey County, Illinois, expressed as individuals per hectare.

SPECIES	TRANSITIONAL ZONE						ADVANCED ZONE					
	I	II	III	IV	V	VI	I	II	III	IV	V	VI
<i>Acer negundo</i>	—	—	—	—	—	—	—	75	25	—	—	—
<i>Acer saccharum</i>	—	—	—	—	—	—	1000	—	25	25	—	—
<i>Ampelopsis cordata</i>	—	—	—	—	—	—	125	—	—	25	—	—
<i>Campsis radicans</i>	125	25	—	—	—	—	—	—	—	—	—	—
<i>Celastrus scandens</i>	1000	75	—	—	—	—	2000	225	575	—	—	—
<i>Celtis occidentalis</i>	—	—	—	—	—	—	1375	—	—	—	—	—
<i>Cercis canadensis</i>	—	25	—	—	—	—	—	50	—	50	—	25
<i>Cornus drummondii</i>	875	2375	2150	700	—	—	1625	1375	6500	3725	100	—
<i>Cornus florida</i>	250	—	250	—	—	—	—	—	25	—	—	—
<i>Crataegus mollis</i>	—	125	—	—	—	—	—	—	—	—	—	—
<i>Diospyros virginiana</i>	125	—	—	—	—	—	500	125	—	—	—	—
<i>Elaeagnus umbellata*</i>	—	—	—	—	—	—	—	25	—	—	—	—
<i>Fraxinus americana</i>	20,000	575	—	—	—	—	5125	125	125	100	25	—
<i>Juglans nigra</i>	—	50	—	—	—	—	—	50	25	50	—	—
<i>Juniperus virginiana</i>	—	25	—	—	—	—	375	50	—	—	—	—
<i>Lonicera japonica*</i>	—	—	—	—	—	—	375	—	—	—	—	—
<i>Lonicera maackii*</i>	250	—	—	—	—	—	2875	25	—	—	—	—
<i>Morus alba</i>	—	—	—	—	—	—	—	25	25	—	—	—
<i>Parthenocissus quinquefolia</i>	—	—	—	—	—	—	625	—	—	—	—	—
<i>Ptelea trifoliata</i>	—	—	—	—	—	—	—	—	—	50	—	—
<i>Quercus prinoides</i>	150	775	—	—	—	—	4125	—	50	—	—	25
<i>Quercus velutina</i>	125	—	—	—	—	—	125	—	25	—	—	—
<i>Rhus aromatica</i>	250	1425	—	—	—	—	1625	200	—	—	—	—
<i>Rhus glabra</i>	125	500	375	—	—	—	125	200	175	—	—	—
<i>Robinia psuedoacacia*</i>	—	75	—	—	—	—	—	—	—	—	—	—
<i>Sassafras albidum</i>	125	50	—	—	—	—	250	—	—	—	—	—
<i>Smilax hispida</i>	—	—	—	—	—	—	500	—	—	—	—	—
<i>Toxicodendron radicans</i>	—	—	—	—	—	—	375	—	—	—	—	—
<i>Ulmus americana</i>	—	—	—	—	—	—	2375	—	—	—	—	—
<i>Vitis riparia</i>	125	25	—	—	—	—	500	25	—	—	—	—

* Non-native species

Once established, the dogwoods probably alter the species composition of the prairie by producing shade, which creates new microclimates. Birds perch on these plants and carry in the seeds of more dogwoods as well as other woody plants. Seventeen of the 27 woody plant species present in the advanced stage of succession have fleshy fruits or seeds that are attractive to birds (Gill and Healy 1974, Henderson 1987). As the density of the dogwood thicket increases, there is a corresponding decrease in the native flora

(Tables 1 and 2). As the prairie flora decreases, alien or weedy species such as white sweet clover and Kentucky bluegrass proliferate. These two plants may have gained entrance to the hill prairies through the use of the CCC firebreak on McAdams Peak as a bridal path (Evers 1955).

The decline of hill prairies is thought by some individuals to be a relatively recent phenomenon. Indeed, based upon the results of this study and McClain's (1983),

the decline within the last 50 years or less has been catastrophic. The invasion of woody plants and subsequent loss of hill prairie at Pere Marquette State Park is the result of nearly 40 years of fire suppression, beginning with fire control and firebreak construction by the CCC in the 1930s, and ending in 1973 with the introduction of prescribed burning by the Illinois Department of Conservation.

The theory that climate is the primary factor in perpetuating grasslands was

rejected by the eminent geographer Carl O. Sauer (1950). His position is further substantiated by tree ring research covering over 300 years in Illinois (Blasing and Duvick 1984) and actual weather data, both of which show no prolonged change to a wet or dry climate. It is more reasonable to assume that a combination of factors such as fire, climate, edaphic conditions, and aspect have all contributed to the perpetuation of grasslands, and that certain causative factors (most likely fire) are no longer operative.

In the three vegetation zones in this study, the abundance of prairie plants differed significantly. Little bluestem, sky blue aster, sideoats grama, purple prairie clover, and showy goldenrod occurred with high frequencies in the open hill prairie, but were absent in the advanced stage of succession (Table 1). Although little bluestem persisted, its frequency decreased from 100 percent in open hill prairie to only 6 percent in the advanced zone (Table 1).

Other studies of hill prairies have indicated that grazing results in a loss of hill prairie species diversity (Nyboer 1981). The hill prairies on McAdams Peak apparently did experience light grazing prior to 1932. Although grazing may have had a detrimental effect on the hill prairies at Pere Marquette State Park, this is an inadequate explanation for the decline of the entire prairie flora in areas of woody plant invasion on sites known to have supported hill prairie in the 1930s. The decline of the prairie flora must be attributed to the woody plant invasion, which has resulted from nearly 60 years of fire suppression.

In the advanced stage of woody plant succession, it is apparent that more forest trees become established. Sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), black walnut (*Juglans nigra*), yellow chestnut oak (*Quercus prinoides*), and hackberry (*Celtis occidentalis*) are present in large numbers in these plots (Table 2). Individuals of these trees are likely to survive to maturity thus

completing the transition from hill prairie to forest.

During the field work for this study, large numbers of the alien species Japanese and bush honeysuckle were present in the study plots (Table 2). The presence of alien plants in native plant communities is of great concern to natural resource managers because these species compete with or displace native species, alter plant successional patterns, and influence plant community structure (Bratton 1982, Ebinger 1983, Ebinger et al. 1984, Harty 1987). Our study at Pere Marquette State Park indicates that alien woody and herbaceous plants can contribute significantly to the decline of hill prairie communities. At Principia College in Jersey County, Illinois, black locust (*Robinia pseudoacacia*) was abundant in hill prairie areas (Kilburn 1970). In a study of woody invasion of glacial drift hill prairies along the Embarras River in Coles County, Illinois, burning bush (*Euonymus alatus*), a native to eastern Asia, was the predominant invading shrub (Behnke and Ebinger 1989). Alien plants can be expected to persist in hill prairies because many of them have fruits or seeds that are disseminated by birds.

It is apparent from this study as well as McClain's (1983) and Behnke and Ebinger's (1989) that substantial acreage of hill prairie is being lost to woody plant invasion. Cutting is recommended to clear hill prairies of dense growths of shrubs and large trees. The selective use of herbicides should also be considered for those species that sprout vigorously following cutting or fire. Even dead standing trees should be removed because they serve as perches and roosting sites for birds, which carry in seeds of woody plants.

Management activities on hill prairies should include prescribed burning. Annual fires should be conducted for four to five years on those sites that have a serious woody invasion problem. Once the invasion is under control, prescribed burns every two or three years should be sufficient to maintain the prairie.

Consideration also should be given to conducting autumn prescribed burns. Most historical accounts of prairie fires in Illinois indicate that they occurred in autumn (Beckwith 1879). The effects of an autumn prescribed burn on Revis Hill Prairie in Mason County, Illinois, showed a sprouting response by woody vegetation similar to a spring burn, but annual plant species seemed to be favored (Schwegman and McClain 1985). The approach used in this study, now in its sixth year, appears to be successful in controlling woody plant invasion and advancing the prairie at the expense of the forest.

Additional research is needed to assess the effects of increased shade and competition with woody plants on hill prairies throughout the Midwest. Research on the rate of invasion, the presence and influence of alien species, and the effects of various management practices on hill prairies experiencing woody plant invasion are also needed.

However, many hill prairies in Illinois are still unmanaged. This study indicates that the conversion from prairie to young forest or shrub community is complete within 15 to 20 years from the onset of woody plant invasion. Without vigorous management, it is apparent that many of the hill prairies of Illinois will disappear within the next 20 years, resulting in the loss of a very unique and irreplaceable flora and fauna.

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