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## Iowa Prairie: Original Extent and Loss, Preservation and Recovery Attempts

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Iowa's prairie has to be assessed in the context of the pre- and post-agriculturally dominated ecosystem in which it now exists. This requires an understanding of prairies and of society's perspective of prairies. Therefore, the attitudes of people through time have to be considered; (1) those who were involved in the demise of the prairie, (2) those who helped saved the pieces of the prairie and (3) those who may be called upon to recover the prairie ecosystem.

Estimates of the extent of the presettlement prairie ecosystem of Iowa vary. Recent GIS research with General Land Office Surveys allows inclusion of savanna with other estimates of presettlement ecosystems resulting in a more precise delineation of the magnitudes of presettlement ecosystems: prairie 79.5%, forest 11.7%, savanna 6.7% and wetland 1.4%. The conversion of the 28.6 million acres of Iowa prairie to agriculture was rapid and extensive. Most of the Iowa prairie was settled and much of it converted to agriculture in the first 70 years after the arrival of Euro-Americans in 1833. Today less than 0.1% of the presettlement prairie remains.

Prairie preservation was recommended in the Twenty-Five Year Conservation Plan 14 years after it was first suggested by Hayden in 1919. A committee chaired by Shimek proposed a 5000 acre preserve in NW Iowa as a part of a continental plan to conserve the North American prairie. During the 1940s, Hayden emerged as a leader of a major effort of the Iowa Academy of Science to identify and preserve prairies. These preservation efforts culminated in the dedication of Iowa's first prairie preserve in 1947. Hayden's information also was valuable in subsequent preservation of prairies by conservation organizations and governmental agencies.

In the past two decades, interest in locating and protecting prairie remnants has increased. Remaining prairie is best represented in western Iowa's Loess Hills and in the northwestern part of the state. Many prairie remnants have survived because they were used as hay fields. In spite of increased efforts to preserve prairie, remnants are still being degraded or lost to agriculture and urban sprawl.

Within the past decade there has been increased recognition of the importance of ecosystem recovery. Iowa's roadsides are now acknowledged as a valuable natural resource for establishment and restoration of prairie. This recognition has led to the development of a program of integrated roadside vegetation management that utilizes native prairie as a means of controlling weeds, reducing soil erosion, improving aesthetics and reducing costs. The 580,000 acres of primary and secondary roadsides in the state have the potential of becoming a statewide network of prairie corridors. Furthermore, three large-scale prairie recovery projects are in various stages of development (1) Walnut Creek National Wildlife Refuge by the U. S. Fish and Wildlife Service, (2) Waterman Creek Project by the Iowa Department of Natural Resources and (3) the Loess Hills Landscape Conservation Plan by the Nature Conservancy. All prairie recovery projects face numerous challenges, but such attempts are essential if we hope to recover a vanishing ecosystem.

INDEX DESCRIPTORS: prairie, savanna, grassland, presettlement prairie, prairie preservation, prairie restoration, prairie reconstruction, ecosystem recovery, prairie history, original land surveys, prairie demise.

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The Iowa landscape prior to Euro-American settlement consisted of a vast tallgrass prairie interspersed with savannas and wetlands. Woodlands were limited primarily to river and stream valleys in the eastern and southern part of the state. The rich black soil created by the extensive root system of the native prairie provided a valuable resource for agriculture. Within one lifetime, the tallgrass prairie was rapidly converted to cropland. As a consequence, the exact composition of Iowa's original prairies is not known because many plant and animal species were gone before their presence was recorded. Very little native prairie remained when prairie preservation efforts were initiated more than a century after settlement. The prairie preserves and remaining unprotected remnants constitute less than 0.1% of the original Iowa prairie and are scattered across an agricultural landscape. Even those scattered remnants have been, and continue to be, impacted by people.

My paper, "Iowa prairie: an endangered ecosystem," presented at the 1980 symposium "Perspectives on Iowa's Declining Flora and Fauna" described the demise of the Iowa prairie and presented a case for its endangered condition (Smith 1981). Prairie preservation activities

were described and some of the early prairie restoration and reconstruction projects were mentioned. Roosa (1978) provided a comprehensive summary of the history of prairie preservation. The intervening years have witnessed a change in attitudes toward Iowa prairies.

Assessing the "state of Iowa prairie" in such an agriculturally dominated landscape is difficult at best. Knowledge of the prairie itself is important, but placing it in the context of its agricultural surroundings is equally important. In addition, any understanding of such a diminished ecosystem has to consider the attitudes and activities of those who contributed to the demise and those who may be called upon to assist in recovery. Since 1980, prairies have been viewed with a more positive perspective. More people want to know about prairie and are becoming involved in prairie preservation. More than 70 years after the initial proposal, prairie roadsides are becoming a reality. New technologies have enabled researchers to make more precise determinations regarding the extent of the presettlement prairie ecosystem and to locate and assess extant prairie remnants. Recently, society has become more supportive of large-scale ecosystem recovery projects.

### EXTENT OF IOWA'S ECOSYSTEMS PRIOR TO SETTLEMENT<sup>1</sup>

Although Iowa's presettlement ecosystems included a variety of grasslands, woodlands and wetlands most estimates of the original extent of native ecosystems differentiated only between forest and prairie and did not include other ecosystems. The most frequently cited estimate of the extent of presettlement prairie is that it occupied six-sevenths (85%) of the state (Shimek 1911, Hayden 1945). This estimate for prairie corresponds well with Dick-Peddie's (1953) estimate of 15% for the extent of presettlement forest.

Opinions regarding the amount of presettlement forest in Iowa vary. Pammel (1896) estimated "five to six million acres" (14–17%) of forest. Baker (1908) quoted forest coverage estimates for the state ranging from 6–20%, but expressed the opinion that the amount of forest was probably less than 13%. Aikman and Hayden (1838) placed the amount of native forest at 12%. At the 1980 symposium, Thomson and Hertel (1981) indicated that 19% of the state was forested at the time of settlement. They derived this percentage from a map of the "Original Forest Cover" of Iowa prepared by State Forester G. B. MacDonald in 1935. MacDonald had compiled the map from the General Land Office (GLO) surveys of 1832 to 1859 (Thomson and Hertel 1981). Another estimate offered by van der Linden and Farrar (1984) placed the extent of presettlement forest at 18 percent. Later, Thomson (1987) reevaluated the 1832–1858 GLO surveys to check their reliability for determining acreage of forest cover. He reported that measurements obtained from MacDonald's map were accurate, but suggested that the survey notes identified an unknown, but possibly sizable, amount of forest that would not be considered forest in 1987. Obviously, if the higher estimates of presettlement forest are accurate, the original prairie landscape would be less than the commonly cited 85 percent.

These variations in the estimates of original prairie and forest coverage are understandable because the dividing lines between ecosystems are not always sharply delineated. Often a complex mosaic of the two vegetation types occurs at the interfaces of the ecosystems. The tallgrass prairie interfaced with the forest in the eastern and southern part of Iowa forming a complex of groves, scattered timber and prairie openings. It interfaced with wetlands in the north-central and northwest forming a mosaic of prairie potholes, marshes and wet meadows. Differences in estimates of the extent of the presettlement prairie and forest may be due (1) to variations in interpretation of vegetation types at their interface, (2) to the inclusion of wetlands within the prairie ecosystem, (3) to the existence of a little understood ecosystem, savanna, which was not considered in earlier estimates.

According to Packard (1988), tallgrass savanna was one of the major natural communities of the Midwest. However, this ecosystem was not considered in early studies of presettlement vegetation, and it was not until the 1950s that the studies of Wisconsin vegetation by Curtis and his students led to the acceptance of savanna as a substantial component of midwestern grassland (Packard 1988).

Apparently, there were two types of savannas: open savanna and scrub savanna (Nuzzo 1986). Open savanna resembled a park with widely distributed trees, a graminoid and herbaceous ground layer, and virtually no shrub layer (Curtis 1959, Dyksterhuis 1957). Scrub savanna was composed of moderate to dense thickets of woody species within a prairie matrix, with a few stunted open grown trees (Bray 1955, Grimm 1984).

<sup>1</sup> The use of acres instead of hectares in discussing presettlement ecosystems in this paper is due to the fact that all of the literature dealing with pre and post settlement ecosystems is reported in acres. In addition, the logic of the land surveys is based upon linear measurement by chains from which 10 square chains equalled 1 acre.

Terms such as scattered trees, openings, scattering timber, scrub woodland, rough, park, prairie grove and barrens attest to the mixed nature of the prairie-forest border of the Paleozoic Plateau and the Southern Iowa Drift Plain, landforms delineated by Prior (1991). These are all features that are associated with savannas. According to Baker (1908), estimates of forest "included the thickets bordering the streams, and the scrub oak thickets in various parts of the state, which should scarcely be dignified by being called forests." From the present day perspective, Baker was describing savanna.

By virtue of being at the interface of prairie and forest, most of the savanna communities had a transitory existence, moving with the expansion or contraction of the forest or prairie. Fire played an important role in the creation and maintenance of savannas. A hot wind-driven fire could destroy trees and shrubs opening up the woods for development of understory savanna vegetation. The trees that survived were those with a thick protective bark such as bur oaks. Frequent surface fires would prevent the growth of saplings and maintain graminoid and forb vegetation beneath the widely spaced oaks. Scrub savannas like oak and aspen rough were closely aligned with fire intervals; frequent fires would tip the balance in favor of the prairie vegetation and suppress the woody species whereas infrequent fires allowed the woody species to flourish. The frequency and magnitude of fires declined as Iowa was settled, resulting in shifts of savanna vegetation. The existing savannas began succession toward forest, while at the same time, woody species expanded onto the grassland forming new savannas. The movement toward woodlands continued with settlement, however, the newly-formed savannas had little opportunity to develop as Euro-American settlers were rapidly clearing and cultivating more and more land. Most savanna communities were gone, either cleared or undergoing conversion to forest, within 20 to 40 years of settlement (Hubbard 1887, Nuzzo 1986).

Although the presence of presettlement savannas is generally accepted today, estimates of their extent are almost nonexistent. Furthermore, it is unclear whether savanna was included as part of the forest or part of the prairie in earlier estimates of forest or prairie cover. Clearly, the inclusion of savanna would affect estimates of magnitude of Iowa's presettlement prairie ecosystem.

A second variance in estimates of the extent of the tallgrass prairie involves the wetland ecosystem. The Des Moines Lobe of the Wisconsin glacier covered an area of 7.6 million acres and obliterated most of the preglacial stream systems in north central and northwest Iowa, creating a relatively level, poorly drained landscape. This resulted in an immense complex of prairie interspersed with numerous potholes, marshes, wet meadows, meandering rivers and streams, shallow lakes and four large deeper lakes (Bishop 1981). In a wet spring, it is likely that much of the area was a continuous complex of wet prairie, sloughs, sedge meadows and marshes. This area of mixed prairie and wetland of approximately 6 million acres was undoubtedly included within estimates of presettlement prairie (Bennett 1938) as were most of the prairie wetlands throughout the remainder of the state. Determining the extent of the original wetlands themselves is difficult and estimates vary. An inventory of wetlands by the United States Department of Agriculture for 1906 listed 930,000 acres in Iowa although some estimates of presettlement wetland are as high as 2 million acres (Thompson 1992).

Table 1 is a composite of previous estimates of the extent of presettlement ecosystems of Iowa. The variations in estimates of the ecosystems are indicative of the difficulty of precisely determining the extent of the presettlement prairie. Wetlands such as rivers, streams and lakes were easy to delineate, but others such as marshes, swamps and potholes were more difficult to separate from the surrounding vegetation. The concept of savanna was unknown so that ecosystem was not considered. Determining the extent of presettle-

Table 1. Estimates of Magnitude of Pre-settlement Iowa Ecosystems

| PRE-SETTLEMENT ECOSYSTEM | PERCENT OF STATE | ACREAGE (million) |
|--------------------------|------------------|-------------------|
| Prairie*                 | 81–85%           | 28.8–31.3         |
| Forest**                 | 15–20%           | 5.4–6.9           |
| N. Central Wetlands      | 5%               | 1.8               |
| Savanna                  | ????             | ????              |

\*Probably included all of the wetlands and possibly some of the savanna

\*\*Probably included most of the savanna

Composite of estimates from Pammel 1896, Baker 1908, Shimek 1911, Bennett 1938, Aikman and Hayden 1938, Hayden 1945, Dick-Peddie 1953, Bishop 1981, Smith 1981, Thomson and Hertel 1981, van der Linden and Farrar 1984, Thomson 1987, Thompson 1992

ment prairie from this information is tenuous. If all the wetlands and part of the savannas were included within the estimates of prairie, this would reduce the magnitude of the presettlement prairie to less than 30 million acres and possibly less than 26 million acres.

Paul Anderson and his group at Iowa State University (1996) recently completed a Geographic Information System (GIS) project that provides valuable information for an understanding of the size and distribution of the presettlement prairie and other ecosystems including savanna. Anderson's team used copies of GLO surveyors' field notes and township maps to prepare a vegetation data layer for GIS data analysis. The names of the vegetation types were digitized onto the GIS map just as they had been recorded by the deputy surveyors. The GIS team did not interpret or group the vegetation types so that others using the data could aggregate according to their needs. In addition, the research team used the digitized maps to compile the total acreage of each vegetation type listed by the surveyors.

Thomson (1987) indicated that the GLO survey notes were an imperfect data source, and Anderson (1996) suggested caution be exercised in their use due to the variability and accuracy of the data. These concerns should be considered in using the data. Nevertheless, in spite of their inadequacies, the GLO notes provide the best, and in some cases the only, information available for determining the extent of the original ecosystems.

Information from the GIS digitizing study has been useful in resolving the differences in estimates of presettlement prairie and forest. Table 2 illustrates the types of vegetation reported on the GLO Surveys and the acreage of each compiled from the digitized maps. The presettlement vegetation types were grouped into four ecosystem categories: prairie, forest, savanna and wetland. Two of the surveyors' vegetation listings, openings and groves, could have been categorized with prairie and forest respectively, but since they are obviously features of savannas they were placed in that category.

This study provides virtually the only available quantitative information regarding presettlement savanna. Including the savanna category helps resolve some of the earlier variations in estimates of forest and prairie cover for Iowa. Estimates of 85% for the prairie ecosystem and 15% for forest were both too high. No doubt, this is a result of lack of consideration of the savanna and wetland ecosystems.

The 28,593,130 acres of prairie recorded in the GLO survey notes would have occupied nearly 80% of Iowa. Although this is somewhat lower than the 85% coverage usually quoted for the state, it is still

indicative of the presence of a vast prairie landscape at the time of settlement. Since prairie vegetation is a large component of savannas, it is easy to understand the source of the higher percentage.

Apparently, the savanna acreage was included within most estimates of forest vegetation. The sum of 7% for savanna and 12% for forest equals some of the higher estimates of the extent of presettlement forest. Baker's (1908) understanding of the composition and extent of the presettlement forest vegetation appears to have been the most accurate.

The value of 489,096 acres for wetlands, 1.36% of the entire state, was lower than expected. It is possible that surveyors might have designated some wetland vegetation as prairie. However, some marshes were described by the surveyors as "good for haying" or "could support hay," which indicates that they perceived them to be dry enough for haying at least part of the year. This suggests that it is unlikely they included any significant amount of wetlands in the prairie category.

As cautioned, the information provided by the surveyors varies. Some of the variations are apparent upon examination of the maps digitized by Anderson and his group (1996). It appears that different deputy surveyors used different designations for the same vegetation type. Counties such as Allamakee, Davis, Dubuque, Jackson, Lee, Wapello and others show limits of vegetation types following township lines. For example, Deputy Surveyor Strong designated the primary vegetation of two townships as Timber/Scattering/Opening while in the two townships immediately to the south, deputy surveyors Legate and Cox indicated the vegetation was Timber. The vegetation is likely the same, but the deputy surveyors interpreted it differently.

#### DEMISE OF THE IOWA PRAIRIE

Prior to Euro-American settlement, 28.6 million acres of tallgrass prairie dominated the Iowa landscape. On June 1, 1833, settlers started moving onto the land surrendered by the treaty that ended the Black Hawk War. The Black Hawk Purchase, the first area opened for settlement, was a 6 million acre strip along the west bank of the Mississippi River. A series of treaties between 1836 and 1851 removed the remaining Indian titles to land within the state.

Rivers provided ready transportation access into new areas and became import and export routes as settlements were established. Settlers tended to follow the river valleys from the Mississippi River into the interior of the state. The Des Moines, Iowa and Cedar valleys were the most frequently chosen. The tendency to move up the rivers resulted in an expansion of settlement across Iowa from the southeast to northwest (Parker 1940). The interiors of large prairies were the last to be settled due to their distance from navigable streams and their tendency to be wet and impassable a good part of the year (Smith 1992).

Settlers favored sites with a dependable water supply, readily available wood and well-drained, tillable land. Consequently, home sites and farm fields tended to be located at the edge of the forest near the prairie or in the savanna (Jordan 1964). This was verified by Anderson and his staff (1996) as they noted that many of the fields were either surrounded by prairie and close to timber or surrounded by timber and close to prairie.

When the wooded edges and savanna groves were occupied, settlers were forced to move onto the prairie. Escalating population pressure after the Civil War accelerated the occupation of the prairie. The farm-making settlers came to till the land, and they immediately began to do so. The tallgrass prairie was difficult to break with the plow. The extensive intertwined roots of the prairie plants were tough, especially in the moister areas where tall, thick grasses grew. In addition, the tough grass roots were interspersed with resistant

Table 2. Historic vegetation of Iowa from General Land Office surveys 1832–1859\*

| VEGETATION TYPE | SURVEYOR LISTING                  | NUMBER OF ACRES   | PERCENT OF STATE |
|-----------------|-----------------------------------|-------------------|------------------|
| Prairie         | Prairie                           | 28,593,130        |                  |
|                 | <b>Total Prairie</b>              | <b>28,593,130</b> | <b>79.45</b>     |
| Forest          | Timber                            | 4,189,263         |                  |
|                 | Ravine                            | 320               |                  |
|                 | Island                            | 21,070            |                  |
|                 | Windfall                          | 6,803             |                  |
|                 | <b>Total Forest</b>               | <b>4,217,456</b>  | <b>11.72</b>     |
| Savanna         | Barrens                           | 199,519           |                  |
|                 | Timber/Barrens                    | 117,009           |                  |
|                 | Scattering Trees                  | 200,977           |                  |
|                 | Timber/Scattering/Barrens         | 190,060           |                  |
|                 | Timber/Scattering/Openings        | 1,239,270         |                  |
|                 | Part Prairie/Part Timber          | 203,046           |                  |
|                 | Openings                          | 80,648            |                  |
|                 | Grove                             | 141,328           |                  |
|                 | Brush                             | 3,760             |                  |
|                 | Rough                             | 3,058             |                  |
|                 | Thicket (including willow)        | 27,261            |                  |
|                 | <b>Total Savanna</b>              | <b>2,405,936</b>  | <b>6.69</b>      |
| Wetland         | Meadow                            | 184               |                  |
|                 | Slue (Slough)                     | 53,050            |                  |
|                 | Swale or Drain                    | 71                |                  |
|                 | Marsh                             | 367,145           |                  |
|                 | Swamp                             | 18,443            |                  |
|                 | Swamp/Marsh                       | 13,024            |                  |
|                 | Wetland                           | 33,120            |                  |
|                 | Spring or Bog                     | 69                |                  |
|                 | Bayou                             | 3,990             |                  |
|                 | <b>Total Wetland</b>              | <b>489,096</b>    | <b>1.36</b>      |
| Other           | Lake, Pond or River(inc. sandbar) | 197,473           | 0.55             |
|                 | Field (Native and Euro-American)  | 83,214            | 0.23             |
|                 | City or Village                   | 3,446             | 0.01             |
|                 | <b>Total Other</b>                | <b>284,133</b>    | <b>0.79</b>      |
|                 | <b>IOWA TOTAL</b>                 | <b>35,989,751</b> |                  |

\*Data from GIS Research to Digitize Maps of Iowa 1832–1859 Vegetation from General Land Office Township Plat Maps by Paul Anderson, et. al, Landscape Architecture, Iowa State University

roots of prairie plants such as New Jersey tea or intermingled with hazel roots in the savannas (Bogue 1963). Much of the initial prairie breaking was done with massive unwieldy breaking plows pulled by several yokes of oxen and operated by custom crews (Coffin 1902). Technological advancements such as a steel cutting edge on the moldboard and the subsequent development of cast-iron plowshares provided effective breaking plows that could be mass produced (Bogue 1963).

Increased availability and use of these plows accelerated the turning of the prairie sod. The well-drained upland prairies quickly went under the plow or, along with the savannas, were grazed out by livestock. As a result of increasing numbers of settlers and developing agricultural technology, the prairie wilderness quickly disappeared. The frontier lasted less than 10 years in any particular area. Macbride (1902) observed that "... the prairies are plowed almost to the last acre ..."

Next to the breaking plow, overgrazing was a major factor responsible for the decline of the tallgrass prairie (Weaver 1954). The

native grasses such as big bluestem, Indian grass and switchgrass couldn't handle heavy grazing from large numbers of cattle (Oliver [1843] 1966). The introduced cool-season grasses like Kentucky bluegrass tolerated heavy grazing and trampling and spread rapidly, aided by the suppression of late spring fires (Curtis and Partch 1948, Ehrenreich and Aikman 1963). In addition, grazing resulted in major changes in the composition of the native forbs of the prairie. Legumes, composites and other native plants declined while the unpalatable and prostrate species increased (Drew 1947). Smooth brome was introduced from Hungary to provide a cool season grass to extend the grazing season of pastures.

While the better-drained upland prairies were being plowed and the prairie openings grazed, the pioneer farmers looked to the low meadows and temporary wetlands for wild prairie hay. These wet prairie hay meadows were the last frontier of the tallgrass prairie. Agricultural census records for wild hay provide documentation of the demise of this last vestige of the tallgrass prairie in Iowa. This is exemplified by records of the acres of wild hay harvested from

1896 to 1946 (Fig. 1a). As indicated by the 1.55 million acres of wild hay harvested when records were initiated, there were a number of wet prairie meadows remaining in 1896. The 1.55 million acres constitutes approximately 5.5 percent of the original 28 million acres of presettlement prairie. Wet prairie drainage had begun in earnest on a large scale in Iowa a few years earlier, about 1888, as sufficient capital and technology became available (Bogue 1963). With improvements in tiling and associated drainage technology, more and more wet prairies were converted to cropland and the amount of wild hay declined. World War I increased the demand for agricultural products and stimulated more drainage.

By 1920, when much of the wet prairie had been drained for cultivation (Berry 1927), the wild hay harvest for that year indicates that approximately 1.7% of native prairie remained in Iowa. Unbroken tracts of prairie were scattered about the state, especially in the northwestern quarter, but even these were disturbed by pasturing and mowing (Shimek 1925). The last of the wild hay harvest records in 1946 indicate that 85,382 acres of wild hay patches still remained, about 0.3% of the presettlement prairie (Iowa Department of Agriculture 1947). Although no assessment of the native vegetation quality of these wild hay remnants is recorded, it is quite likely they were more disturbed than those of a half century earlier. The number of prairie remnants continued to decline after records for wild hay were discontinued in 1946, but some have persisted on tillable land in Iowa due the cultural tradition of harvesting wild hay.

Without the tradition of harvesting prairie hay, there would be no large prairie remnants remaining in Iowa (Schennum 1986). On the whole, mowing was less destructive to the native grasses than grazing. However, the forb component of the prairie remnants was reduced by early-season mowing and the removal of coarser weeds (Drew 1947). In addition, frequent mowing encouraged invasion of exotic species such as timothy, red clover and sweet clover as the seed of these exotic plants often came in on the haying equipment. A heavy invasion of sweet clover diminished the value of prairie hay and often lead to the breaking of the prairie (Weaver and Fitzpatrick 1934). In addition, the pattern of haying tended to favor other exotics. Traditionally the prairie hayfields were harvested in late summer during the period of peak growth and flowering of the prairie grasses and many forbs, but after the peak for the cool season Eurasian species. Annual repetition of this method of haying often favored other Old World invaders (especially perennials such as smooth brome and bluegrass) over the natives, adding to the shift in the composition of the prairie vegetation. This shift toward exotic vegetation was exacerbated if the hayfields were supplemented by disking in such cool season Eurasian species as timothy, red clover, redtop and smooth brome. In spite of being subjected to treatments that affected their natural diversity, a number of these prairie hayfields retained a very diverse composition of native vegetation. However, due to a lack of quantitative records, we are uncertain as to how closely these remnants resemble the original composition of the prairie.

Today, many Iowans are cognizant of the magnitude of the loss of the tallgrass prairie, but few are aware of how rapidly it vanished. A child born in the back of a covered wagon entering Iowa when it was opened for settlement in 1833 would have been 57 years old when Iowa was considered settled in 1890 by having at least 15

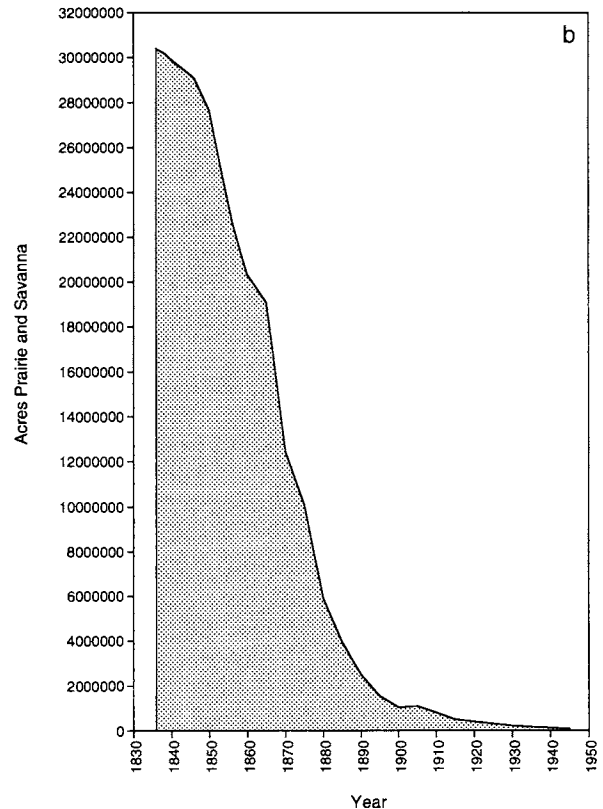
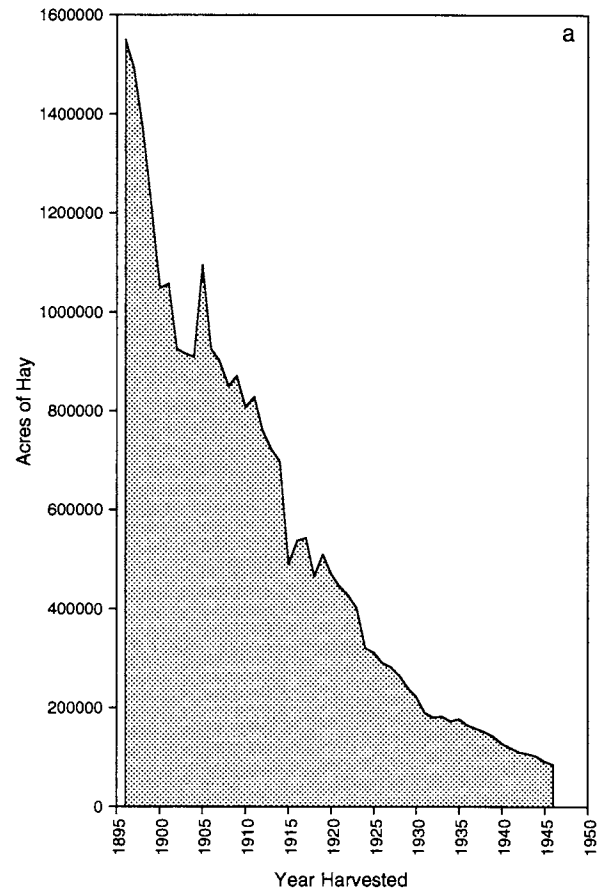


Fig. 1a. Iowa wild hay harvest, 1896–1946 from annual agricultural census of Iowa Department of Agriculture.

Fig. 1b. Conjectured demise of the Iowa prairie and savanna, 1896–1946, derived from population data.

people per square mile in each county (Harter and Stewart 1930). Ten years later, in 1900, Iowa reached the maximum number of farms ever recorded (Bogue 1963). That person would have been 77 years old in 1910 when it was reported that 97% of the state had been developed for agriculture (Iowa Department of Agriculture 1911). Within one lifetime, the vast 28.5 million acre tallgrass prairie as well as more than 2.5 million acres of savanna were converted to agriculture (Fig. 1b). Within this same time period, essentially the same conversion was occurring on the prairies of the adjoining states of Illinois, Minnesota and Missouri as well as the eastern Dakotas and Nebraska. The only native prairie that remained consisted of isolated remnants, prairie hayfields, old settler cemeteries, railroad and road rights-of-way, undrained prairie potholes and "out of the way" places unsuitable for farming. Since that time, even these remnants have declined or been lost. Most of the remaining prairie in Iowa, Illinois, Missouri and Wisconsin consists of widely scattered remnants, relict prairie islands awash in an agricultural sea.

It is amazing that most people were, and still are, unaware or unconcerned that an entire major ecosystem was being lost. To the contrary, old settlers often noted with pride that they had plowed the first furrow and made the wasteland productive. One might wonder how they could have been so unconcerned about the loss of this magnificent prairie ecosystem. However, we must keep in mind that their living conditions dictated a different perspective from that of our present-day society. Those early settlers were dealing with what they perceived as a harsh land, a vast and limitless wilderness that could easily absorb attempts at civilization. They were trying to carve out a place for themselves and their families and had no way of knowing, or even predicting, the ultimate result of their efforts (Smith 1981). Leopold (1953) succinctly sums the situation: "Our grandfathers did not, could not, know the origin of their prairie empire. They killed off the prairie fauna and they drove the flora to a last refuge on railroad embankments and roadsides." However, it seems that once embarked on a particular course, the land-hungry prairie farmers could not, or would not, change direction. The onslaught continued even though a few informed voices such as Shimek (1911a, 1925) observed that the prairie was fast disappearing and being replaced with artificial groves, cultivated crops and introduced weeds. Few ecosystems on the earth's surface have been modified as rapidly and as thoroughly as the tallgrass prairie (Whitney 1994).

Current estimates place the amount of remaining prairie at less than 0.1% of its original coverage. Very likely these estimates are optimistic and include disturbed and degraded relict prairies. Therefore, it can be inferred that the amount of good quality prairie that remains is considerably less than 28,000 acres. It has been suggested that to qualify as prairie, a remnant should have a species composition close to that of presettlement prairie. By that standard, estimates of the amount of remaining prairie would have to be reduced; then less than 0.05% might be a more realistic estimate of remaining prairie.

## PRAIRIE PRESERVATION IN IOWA

### Beginning of Conservation in Iowa

Conservation activities were initiated in Iowa shortly before the turn of the century. Thomas Macbride was one of the early leaders of the conservation movement (Conard 1997). In an 1895 presentation to the Iowa Academy of Science (IAS), he proposed a statewide system of county parks for Iowa designed to protect representative woodland communities (Macbride 1895). The following year the IAS petitioned the Congress of the United States requesting legislation promoting the preservation and rational use of the remaining forests of our country (Swisher 1931). Macbride (1898) continued his push for preservation in his President's Address to the IAS in 1897 with

a call for forest reservations and watershed protection. Macbride was a part of the generation that had played a major role in the plowing of the prairie and the clearing of the woodlands. He apparently had a sense of what was being lost (Conard 1997). Later, he commented on the magnitude of the loss of the natural landscape in his President's Address to the Iowa Park and Forestry Association (Macbride 1902), saying, "little is left for our injury or desecration; the prairies are plowed almost to the last acre; the woodlands have been cleared away entirely or converted into pasturelands . . ."

Spurred by Macbride's activities, Iowa's initial conservation efforts focused on protection of forests, but no measures were taken to preserve or protect prairies. Cawley (1972) suggested that the relative scarcity of forest in the Iowa landscape may have prompted the attention given to woodland preservation. As there was a limited awareness and concern regarding the demise of the prairie, it is not surprising that there were no early attempts to preserve this biological heritage for future generations.

### Early prairie preservation attempts

Prairie preservation was first suggested by Ada Hayden (1919). She noted that the "the goddess of agriculture has banished the prairie," and suggested that small prairie plots in each county, in rights-of-way and other places of little economic value for agriculture, be set aside "to secure to the present and the coming generations a heritage." She indicated that students, auto and rail travelers would all benefit if rights-of-way preserves were located close to schools for study. However, she didn't recommend any specific remnants for preservation.

Hayden's mentor, L. H. Pammel, became involved with prairie preservation as chairman of the State Board of Conservation. The July 1923 issue of the *Bulletin of Iowa State Parks* contains a section entitled "The Prairie." The article describes responses to an editorial about prairie in the *Des Moines Capital* which was reprinted in other Iowa papers and the *Chicago Tribune*. The editorial prompted numerous letters to Pammel as Chairman of the Board of Conservation. The letters described the prairies of the 1860s and requested that some prairie remnants be preserved as parks (Pammel 1923).

Pammel (1926b) expressed the opinion that prairie was the most distinctive part of Iowa and should be preserved for posterity. He noted that cultivation and pasturing had almost entirely obliterated the native prairie flowers except as they occurred on railroad rights-of-way. On the other hand, he added that the loss of prairie would not be regretted because it produced the most fertile agriculture land in the world. Apparently, he viewed the preservation of prairie in railroad rights-of-way as a means of saving a slice of the past without interfering with agricultural productivity. In the 1920s, almost all of the railroad rights-of-way in Iowa contained high quality prairie. Shimek (1925) observed that the "purest remnants of the prairie" are often found within the rights-of-way of the older railroads which were built into the territory before all of the original prairie was broken. Pammel (1926a), acting for the Board of Conservation of Iowa, worked with railroads to preserve remnant prairies occurring in their rights-of-way. He reported that the Wabash Railroad had established 12 or more prairie preserves in the right-of-way between Des Moines and Moulten, most of the preserves were a mile or more in length. The Chicago and Northwestern Railroad indicated a willingness to do the same thing. Apparently, this program of prairie preservation never progressed beyond the initial stage as there are no other records of these railroad preserves and they no longer exist.

Pammel (1926b) proposed that prairie plants be established along roadsides both paved and graveled. "Why not an automobile trip across Iowa made more pleasant by presentation to the traveler of Iowa's native plant life with its mixture of color? Why weeds and

noxious growth lining the highways?" If this proposal could have been developed into a long-term statewide program of roadside prairie preservation and maintenance, it would have created a fantastic network of prairie preserves for future generations. Sixty more years would pass before such a program was initiated.

When Pammel retired in 1926, the *La Cross Tribune and Leader-Press* reported that one remaining project of special appeal to him was the acquisition and preservation of a piece of virgin prairie so that Iowans in years to come might know what the "Iowa prairies" looked like before "the tall corn grew" (Anon 1926). Hayden, a strong proponent of prairie preservation, worked closely with Pammel for a number of years. There is no record of how they may have influenced one another on this subject.

Shimek began his investigations of prairies shortly after the turn of the century and published his first major prairie paper in 1911 (Shimek 1911). Fifteen years later, he reported that relatively little native prairie remained in Iowa (Shimek 1925). In spite of the limited amount that remained, he felt that restoration of prairie tracts for incorporation into the state park system was entirely feasible and could be accomplished at little cost. He suggested that the widely scattered remnants of prairie flora would provide sufficient seed for the restoration of disturbed prairie areas throughout the state. The agricultural census of that year supported his contention as it reported a harvest of approximately 311,365 acres of prairie hay (Iowa Department of Agriculture 1926). These prairie hayfields would have been an ideal resource for implementing Shimek's prairie restoration plan.

A recommendation for prairie preservation next appeared in the Iowa Twenty-Five Year Conservation Plan (Crane and Olcott 1933), which was conceived and fostered under the leadership of Jay "Ding" Darling (Parker 1947). In the section listing and describing Scientific Preserves is the following recommendation:

Along the railroad rights-of-way, and here and there in small patches throughout the state, unbroken virgin prairie sod is still to be found. Some of these will be saved because they lie within protected areas, or simply because the ground cannot be used for farm purposes. But somewhere in Iowa a large enough original tract of prairie vegetation should be secured in order to save, under the control of the state, the characteristic landscape and wild flowers and wild life of the native prairies. Several tracts ranging from forty to three hundred acres have been found by the survey. The Conservation Plan includes a Prairie Preserve which will be one of the remaining original areas, or which may be produced by purchase of semi-waste land and bringing it back to prairie condition in a few years' time.

There is no record of the survey to which they refer, but apparently field survey information was available for several locations. The Conservation Plan refers to restoration as well as preservation, i.e., the preserve could be one of the remaining original areas or it could be low quality waste land capable of being restored. Perhaps Shimek's (1925) observations regarding the return of prairie had convinced them that disturbed prairie could recover in a short period of time.

#### Attempting large-scale prairie preservation

While the Twenty-Five Year Conservation Plan was being formulated, preservation of the tallgrass prairie was being addressed on a larger scale at the international level. The National Research Council and the Ecological Society of America jointly established a Committee on Ecology of Grasslands of North America in response to the drought, dust storms, over-grazing and distressing economic conditions that prevailed in the mid-continent grasslands during the 1930s. The committee's first report in 1933 noted the destruction

of natural areas, particularly grasslands, and initiated steps to develop coordinated research studies and secure the preservation of representative natural grasslands of the North American prairie from Illinois, Iowa, North Dakota, Nebraska, Oklahoma, Texas, Arizona and the Province of Saskatchewan (Shelford 1934, 1935).

Local committees were formed in each state and province to locate and designate a large prairie preserve as well as a small prairie research area near an educational institution. Shimek chaired the Iowa Local Committee which proposed development of a small research site on the east edge of Iowa City near the University of Iowa and a large prairie preserve in Dickinson County. The little-known Shimek Plan for a national prairie preserve encompassed a section of the Little Sioux River Valley and extended to a part of the lakeshore of West Lake Okoboji. The area included a large section of "unbroken" prairie with excellent glacial landform features, two native woodlands, two fens, two streams, lake shoreline and marshes. The plan involved acquisition of tracts of original vegetation and restoration of the intervening areas (Shimek 1934). One present-day preserve, the Freda Haffner Kettlehole, was within the proposed area. Cayler Prairie Preserve was just to the north. The Shimek Plan would have been a marvelous implementation of the prairie preservation portion of the Twenty-Five Year Plan and would likely have garnered the support of Darling and other members of the Iowa State Planning Board. In addition, there was a possibility that Henry Wallace, U. S. Secretary of Agriculture, would have provided national support for the plan (Shimek 1935). If the plan could have been initiated, a coalition involving Wallace, Darling and Shimek would have been a powerful force. Although the reasons are unknown, the plan was never implemented and a grand opportunity for recovery of a large chunk of prairie ecosystem was missed.

#### Iowa's best opportunity for prairie preservation

A decade later Ada Hayden emerged as a leader for preservation of Iowa prairie. Two able co-participants in this preservation effort were Louise Parker, vice-chair of the Iowa Conservation Commission (ICC) from 1941-49 and John Aikman, chair of the IAS Conservation Committee from 1941-47. Upon assuming the chair of the IAS Conservation Committee, Aikman reorganized the committee to more effectively represent the IAS in making a lasting contribution to the conservation program of the state (Aikman 1942). One of the IAS Conservation Committee's early activities was a cooperative study with the Iowa Prairie Subcommittee (chaired by Hayden) of the Committee on the Preservation of Natural Conditions of the Ecological Society of America (Aikman 1943). The IAS Conservation Committee developed reports on conservation areas of special interest to each committee member as a first step toward formulation by the IAS of a complete program of conservation for Iowa. The IAS Conservation Committee report of 1944 describes a cooperative study with the ICC to acquire representative prairie areas in the state. Acquisition of prairies was perceived to be an urgent need because of the demand for additional crop land created by World War II. It was feared that owners of the most desirable virgin prairie remnants would plow them for crop production. Therefore, the IAS Conservation Committee recommended that the IAS give immediate active support and assistance to the prairie procurement program of the ICC (Aikman 1945).

Hayden (1945) prepared a paper on Parks and Preserves entitled "Present Status and Outlook of Conservation in Iowa" for inclusion in the IAS Conservation Committee report of 1944 (Aikman 1945). She reviewed the history of preservation in Iowa and culminated with a recommendation for the preservation of prairie:

We should preserve some examples of our state as the early travelers and traders found it. This magnificent grassland type



of vegetation which once covered 85 per cent of the area of the state and which is responsible for the great wealth derived through agricultural pursuits is now almost extinct and agricultural subsistence is on the decline in the depleted older soils of southern Iowa . . . Large representative areas of a section or more in size would not only serve as a biological but an historic preserve of some of the virgin soil, as well as a practical laboratory for the study of soil which is the most fundamental resource of Iowa.

She felt that some haste in prairie preservation was necessary as time for action was short:

More than ten years have passed since the preservation of prairie was recommended in the Iowa Twenty-Five Year Plan. The time remaining for action is limited. In the past three years small areas never grazed before have been cropped to the bare black earth. Many of the few remaining sods have been turned. Nevertheless a few representative sections and some choice smaller areas are on record from which state preserves can be selected.

The IAS Conservation Committee report for 1945 reaffirmed the urgent need for conservation of Iowa prairie and designated "A Project on the Conservation of Iowa Prairie" as its chief activity for the year. They noted the leadership of Hayden, now a member of the committee, in studying the problem, promoting general interest and cooperating with the ICC in determining the character of the prairie areas to be preserved (Aikman 1946).

The IAS Conservation Committee report for 1945 also included a paper by Hayden (1946), "The Selection of Prairie Areas in Iowa Which Should be Preserved." Hayden had initially prepared the report for the ICC and now presented it to the IAS. Upon recommendation of the IAS Conservation Committee, the IAS initiated the Prairie Project and adopted Hayden's report as a policy guide for the project. Her report laid out the objectives and procedures for selection of prairie areas that should be preserved from the few remaining in the state. Using the categories developed by Shimek (1911), the report recommended what grasslands would be necessary to illustrate the primary biological and soil types of Iowa prairie. Hayden (1946) recommended the following categories of prairie for preservation: (1) those reflecting climate of the northern, central and southern parts of the state, (2) those illustrating soil types derived from major glacial drifts, interglacial loess and peat deposits, and (3) representative topographic types such as broad flat glacial plains, rolling glacial drift surfaces, ridges of the Loess Hills, well-drained alluvial floodplains, hill prairies of NE Iowa and sand prairies. Apparently Hayden directed or conducted most, if not all, of the fieldwork for the Prairie Project (Conard 1997).

The IAS Conservation Committee report of 1946 indicated that progress of the Prairie Project was greater than anticipated and that the state's first prairie preserve had been acquired. Upon recommendation of the Prairie Project Subcommittee, the ICC had purchased the Walton (Lime Springs) Prairie, a 199 acre tract in Howard County (Aikman 1947a). Parker's (1947) speech for the dedication of the preserve was published along with the 1946 IAS Conservation Committee report. Hayden (1947a) included a progress report on the Prairie Project with a supplement describing and illustrating the principal tracts that had been inspected. She presented the results of her survey and an assessment of the most desirable remaining tracts of prairie. These remnants were representative of virgin soils, flora and fauna. By that time, she had inspected, described and photographed 30 prairie sites. She recommended 22 sites in 10 counties totaling approximately 6000 acres as potential prairie preserves. High priority was given to sites (1) meeting specifications of the Twenty-Five Year Plan, (2) with potential as a field research site, (3)

of large size with multiple soil types, (4) of previous published research, and (5) with potential for being integrated to form larger complexes.

The primary component of the IAS Conservation Committee report of 1947 (Aikman 1947b) dealt with the progress of the Iowa Prairie Project. It indicated that a Priorities Committee appointed by the Director of the ICC had met and selected for early purchase four areas of prairie representing distinct agricultural soil types. It also identified organizations and agencies that were supporting the Prairie Project and indicated the need for organized legislative support. The 1947 report of the IAS Conservation Committee contained a paper by Hayden (1947b) describing some of the small relicts of native grassland available for preservation. The sites she noted were strips of grassland along roadsides and railroads, wayside prairie patches, abandoned cemeteries, county parks and preserves and old country school sites.

Kalsow Prairie from Hayden's survey was acquired by the ICC in 1948 as the second prairie preserve. The following year the IAS formed an advisory committee to assist the ICC with management of the prairies (Hayden and Aikman 1949). It appeared that the pressure applied by the Prairie Project of the IAS and other groups had finally motivated the state to develop a prairie preservation program. However, Hayden's death in 1950 deprived the Prairie Project of its driving force and the project languished. The Lime Springs Prairie, the first prairie preserve in Iowa, was expanded and renamed Hayden Prairie in 1950 to commemorate her work, but it would be almost a decade before more prairies were preserved.

In retrospect, Hayden's work was Iowa's best opportunity for prairie ecosystem recovery. With such broad-based support, a massive prairie recovery project could have been launched. Not only was the necessary cooperation in place, but sufficient prairie remained as evidenced by the agricultural census which reported that 92,067 acres of wild hay was harvested in 1945 when Hayden was conducting her survey (Iowa Department of Agriculture 1946). Hayden's survey (1946) identified native prairie remnants of sufficient size to form a matrix interspersed with disturbed prairie tracts that could constitute a significant ecosystem recovery project. Some of the prairies identified in Hayden's survey have since been preserved either through acquisition by the state or by private preservation organizations like TNC and added to the State Preserves System. However, acquisition has been on a prairie-by-prairie basis rather than by assembling a landscape-scale project.

Failure to mount a major effort to acquire the prairies identified by the Hayden survey was essentially the last opportunity to capture a significant portion of Iowa's remaining prairie. Changes occurring immediately after World War II and during the 1950s made it increasingly difficult to retain vestiges of the prairie ecosystem. Technological advances in agriculture accelerated, farms increased in size, cropping systems were simplified, agriculture became big business and prairie remnants vanished.

#### Increasing support for prairie preservation

There was a brief burst of prairie preservation activity when the state purchased two more prairies that had been on Hayden's list, Cayler Prairie in 1958 and Sheeder Prairie in 1961. However, for the most part, prairie preservation languished in the 1950s (Conard 1997).

The primary advocates for prairie preservation during the first half of the century were members of the academic community. In the 1960s, the spectrum of involvement in prairie preservation broadened to include governmental agencies and other private citizens although academicians continued active participation. The Iowa Chapter of TNC was founded in 1963, the same year that Iowa's

Governor Hughes appointed the Governor's Committee of Outdoor Resources. Both groups supported an inventory by Smith and Landers (1964) of privately-owned natural areas in the state that were suitable for preservation. The Governor's Committee recommended the formation of a State Preserves System in its final report edited by Haugen (1964). In 1965, the 61st Iowa General Assembly created a State Preserves Advisory Board and established the position of State Ecologist. This legislation and the resulting State Preserves Advisory Board, members of which were appointed by the governor to recommend significant sites for formal dedication as preserves, were outgrowths of the IAS Conservation Committee (Roosa 1981). During the formative years of the State Preserves Advisory Board, most prairies already owned by the state were formally dedicated as preserves. During this time, Landers and Christiansen prepared management plans for three prairie preserves, Kalsow, Sheeder and Hayden. Because the State Preserves Advisory Board was unable to acquire funds for purchase of prairie preserves, it encouraged other agencies such as county conservation boards to preserve representative prairies in their counties (Cawley 1972).

Prairie preservation developed a firmer base in the mid-1970s as the Iowa Chapter of TNC and the State Preserves Advisory Board completed their first decade. The pace of prairie-related activities in Iowa increased after Dean Roosa was hired as State Ecologist for the State Preserves Board in 1976. Roosa provided an impetus and motivation for several programs that stimulated prairie awareness and preservation: (1) annual natural history forays to systematically survey Iowa counties, (2) personal reconnaissance of natural areas that later served as the basis for a statewide inventory, (3) initiation of the annual Iowa Prairie Heritage Week, and (4) formation of the Iowa Natural History Association.

The Iowa American Revolution Bicentennial Celebration in 1976 prompted a proposal by Herbert Kersten, a Fort Dodge physician, for establishment of a 40,000 acre Tallgrass Prairie Park Complex for Iowa in the corridor between Des Moines to Ames.<sup>2</sup> The proposed Prairie Park was to include up to 2500 acres of reconstructed prairie along with a frontier village and an 1850 railroad. A feasibility study by a consulting firm for the Bicentennial Commission determined that the project was achievable, but quite expensive.

The Iowa Natural Heritage Foundation was founded in 1979 and soon became involved in prairie preservation. They played a vital role in prairie preservation by being able to move rapidly to acquire a prairie tract in imminent danger of being lost.

In 1981, with the encouragement of Dean Roosa and the State Preserves Advisory Board, TNC entered into a two year agreement with the ICC to initiate the Iowa Natural Areas Inventory (INAI) modeled on the TNC Heritage Program. It was anticipated that the INAI would provide more current information regarding location and quality of the remaining prairie remnants.

As a part of the inventory of natural areas in Iowa, the INAI initiated a survey of prairie remnants in selected areas of Iowa (Howe et al. 1984). The survey began in 1983 and continued into 1984. It located and gathered basic ecological data on prairies in the Loess Hills, northeast Iowa hill prairies and large black soil prairies. This comprehensive survey examined and verified the existence of 49 prairie remnants that had been reported to the INAI, but not previously documented. In addition, hundreds of potential prairie sites were identified on infrared (IR) photographs that had been taken in 1978 and 1980. These prairies usually occurred in (1) undrained pothole wetlands, (2) areas cut off from cropland by roads and railroads, (3) cemeteries, (4) prairie hayfields and (5) steep slopes in stream-dissected landscapes. Prairie remnants located on IR photos had to be field verified to assess their quality. By the end of the 1984 field

season, 15 new IR-identified sites had been field verified as high-quality prairies and an additional 20 sites had been corroborated by secondary sources as high-quality remnants (Schennum 1986). Thirty-five prairie hayfields containing high-quality prairie were identified and field inventoried. The INAI prairie inventory confirmed that the prairie remnants in the state are not uniformly distributed among various geographic locations or natural community types.

Compared to their presettlement frequency and acreage, Loess Hills prairies were the best represented of all the remaining prairie types, and the largest remaining tracts of prairie in Iowa lie on this landform. Twenty-one high quality Loess Hills prairie remnants were documented, one 3000 acres and the other 20 ranging in size from 5 to 640 acres and averaging 125 acres. Many of these prairies were being invaded by woody shrubs and threatened by succession to shrubby bur oak woodland due to fire exclusion (Schennum 1986).

An initial inventory of the hill prairies of the Paleozoic Plateau of NE Iowa indicated that remnants of this community were also well represented, though much smaller, averaging under 10 acres (Schennum 1986). However, years of fire exclusion had resulted in extensive invasion by woody plants, especially red cedars (Blewett 1986).

The blacksoil prairies of northern Iowa were once the most extensive prairie type in the state. Approximately 26 million acres of Iowa has been classified as Grade 1 agricultural land (Marbut 1934). This correlates well in amount and distribution with the fertile, blacksoil prairies. Due to their high agricultural productivity, very few blacksoil remnants remain. However, a few high-quality remnants such as Hayden, Cayler, Kalsow, and Steele prairies have survived the plow. A number of the remaining blacksoil prairie remnants were concentrated in the Iowa Lakes area of northwest Iowa (Schennum 1986).

The Iowa Prairie Network was formed in 1990 bringing together people across the state to promote, protect, and enhance prairies. The positive response to this organization and the high level of membership involvement in activities related to prairies confirmed the increased interest in Iowa prairies.

## IOWA PRAIRIE ECOSYSTEM RECOVERY

In the past two decades, awareness of the magnitude of the loss of the tallgrass prairie ecosystem has increased. This awareness has prompted increased interest and activity in protecting prairie remnants. It is unfortunate that an ecosystem has to decline almost to the vanishing point before action is taken. To preserve our vanishing natural heritage, the Iowa Chapter of TNC, certain county conservation boards and the Iowa Department of Natural Resources (DNR) have acquired a number of prairie remnants in the state. The Iowa Natural Heritage Foundation aided in the acquisition of some remnants. The groundwork for this preservation activity was provided by a long line of prairie proponents, including the IAS and the State Preserves Advisory Board. Consequently, many of the remaining significant prairie remnants have been accorded some degree of protection.

More than 100 areas totaling close to 5000 acres are now owned or managed by public agencies or conservation organizations (Table 3). Some of these areas were obtained specifically as prairie preserves, while others incidentally contained prairie along with another primary acquisition feature. The prairie remnants vary considerably in size and quality from an acre to more than 200 acres in size and from low to high quality. Hayden and Steele prairies at 240 and 200 acres respectively are the largest remaining blacksoil prairies in Iowa, both have been dedicated as state preserves.

In the Loess Hills, tracts such as Broken Kettle Grassland, Five Ridge Prairie, portions of Stone State Park, Sioux City Prairie, por-

<sup>2</sup> Unpublished booklet available from author.

Table 3. Prairies managed by public or conservation agencies\*

| UNIT NAME                                | COUNTY            | OWNER/MANAGER               |
|--|-------------------|-----------------------------|
| ● Ames High Prairie                      | Story             | Nature Conservancy          |
| ● Anderson Prairie                       | Emmet             | Iowa DNR                    |
| Atkins Roundhouse                        | Benton            | City of Atkins              |
| Big Sand Mound                           | Louisa/Muscatine  | Monsanto/Mid America Energy |
| Big Sioux Wildlife Area (Nelson Tract)   | Lyon              | Iowa DNR                    |
| Black Hawk Point                         | Allamakee         | Iowa DNR                    |
| Blazing Star Prairie                     | Buchanan          | County                      |
| Bob Hay Conservation Area                | Webster           | County                      |
| Broken Kettle Grassland                  | Plymouth          | Nature Conservancy          |
| Brushy Creek Recreation Area             | Webster           | Iowa DNR                    |
| Bundt Prairie                            | Guthrie           | County                      |
| Cardinal Marsh                           | Winneshiek        | Iowa DNR                    |
| ● Catfish Creek                          | Dubuque           | Iowa DNR                    |
| ● Cayler Prairie                         | Dickinson         | Iowa DNR                    |
| ● Cedar Hills Sand Prairie               | Black Hawk        | Nature Conservancy          |
| Chipera Prairie                          | Winneshiek        | County                      |
| Cinder Path Bike Trail                   | Lucas             | County                      |
| ● Clay Prairie                           | Butler            | Univ. N. Iowa Foundation    |
| Crim Savanna                             | Emmet             | Iowa DNR                    |
| ● Crossman Prairie                       | Howard            | Nature Conservancy          |
| ● Dinesen Prairie                        | Shelby            | County                      |
| Devil's Ridge Wildlife Area              | Osceola           | County                      |
| Dog Creek Park                           | O'Brien           | County                      |
| Doolittle Prairie                        | Story             | Iowa DNR/County             |
| Douglas Township Cemetery                | Ida               | County                      |
| Duke Prairie                             | Clinton           | County                      |
| Effigy Mounds National Monument          | Clayton/Allamakee | U. S. Nat. Park Service     |
| Ely-Bauermeister/Wolter's Prairie        | Osceola           | County                      |
| Falcon Spring                            | Winneshiek        | County                      |
| Fen Valley                               | Clay              | County                      |
| ● Fish Farm Mounds                       | Allamakee         | County                      |
| ● Five Ridge Prairie                     | Plymouth          | County                      |
| ● Freda Haffner Kettlehole               | Dickinson         | Nature Conservancy          |
| Garlock Slough                           | Dickinson         | Iowa DNR                    |
| ● Gitchie Manitou                        | Lyon              | Iowa DNR                    |
| Gleason-Hubel Wildlife Area              | Harrison          | County                      |
| Goewey Prairie                           | Osceola           | County                      |
| Goose Lake Complex                       | Kossuth           | Iowa DNR                    |
| Great Western Trail                      | Warren            | County                      |
| Hawkeye Wildlife Area                    | Johnson           | U.S. Corp Engr/Iowa DNR     |
| Hawthorne Wildlife Area                  | Mahaska           | Iowa DNR                    |
| ● Hayden Prairie                         | Howard            | Iowa DNR                    |
| High Bridge Wildlife Area                | Clay              | Iowa DNR                    |
| Highway 92 Wildlife Area                 | Adair             | Iowa DOT/County             |
| Hitaga Sand Ridge Prairie                | Linn              | County                      |
| ● Hoffman Prairie                        | Cerro Gordo       | Nature Conservancy          |
| Horton Township Cemetery Prairie         | Osceola           | County                      |
| Hubbard Railroad Prairie                 | Hardin            | County                      |
| Jemmerson Slough                         | Dickinson         | Iowa DNR                    |
| ● Kalsow Prairie                         | Pocahontas        | Iowa DNR                    |
| Kettleson-Hogsback Complex               | Dickinson         | Iowa DNR                    |
| ● Kisk-ke-kosk Prairie                   | Jasper            | County                      |
| Lansing Wildlife Area                    | Allamakee         | Iowa DNR                    |
| ● Liska-Stanek Prairie                   | Webster           | County                      |
| Little Sioux Wildlife Area               | Clay              | Iowa DNR                    |
| Little Swan/Christopherson Slough        | Dickinson         | Iowa DNR                    |
| Little-Bit-Of-Prairie                    | Palo Alto         | County                      |
| Loess Hills Wildlife Area (Little Sioux) | Harrison          | Iowa DNR                    |
| Loess Hills Wildlife Area (Mondamin)     | Harrison          | Iowa DNR                    |
| Loess Hills Wildlife Area (Pisgah)       | Harrison          | Iowa DNR                    |

Table 3. Continued

| UNIT NAME                                      | COUNTY            | OWNER/MANAGER        |
|--|-------------------|----------------------|
| Loess Hills Wildlife Area (Preparation Canyon) | Monona            | Iowa DNR             |
| Ludwig Reserve                                 | Winneshiek        | County               |
| ● Manikowski Prairie                           | Clinton           | County               |
| ● Marietta Sand Prairie                        | Marshall          | County               |
| Martin Area                                    | Cherokee          | County               |
| Mines of Spain State Recreation Area           | Dubuque           | Iowa DNR             |
| Morey Prairie                                  | Clay              | Nature Conservancy   |
| Mormon Trail Park                              | Adair             | County               |
| ● Mt. Talbot Preserve                          | Woodbury/Plymouth | Iowa DNR             |
| ● Nestor Stiles Prairie                        | Cherokee          | Iowa DNR/County      |
| O'Brien Prairie                                | Plymouth          | County               |
| Oak Grove State Park/Big Sioux Park            | Sioux             | Iowa DNR/County      |
| Pike Run Wildlife Area                         | Muscatine         | County               |
| Polk City Cemetery                             | Polk              | Lincoln Township     |
| Prairie Gold Wildlife Area                     | Palo Alto         | County               |
| Preparation Canyon State Park                  | Monona            | Iowa DNR             |
| Prescott Prairie                               | Cherokee          | County               |
| Railroad Prairie                               | O'Brien           | County               |
| Red Cedar Wildlife Area                        | Muscatine         | Iowa DNR             |
| Red Fox Wildlife Area                          | Benton            | Iowa DNR             |
| Riverside Bluffs                               | Woodbury          | County               |
| Rock Creek State Park                          | Jasper            | Iowa DNR             |
| Rockford Fossil Site Prairie                   | Floyd             | County               |
| Roeman-Stetricks Wildlife Area                 | Lyon              | County               |
| ● Rolling Thunder Prairie                      | Warren            | County               |
| ● Sheeder Prairie                              | Guthrie           | Iowa DNR             |
| Sioux City Prairie                             | Woodbury          | Nature Conservancy   |
| ● Slinde Mounds                                | Allamakee         | Iowa DNR             |
| Solon Prairie                                  | Johnson           | County               |
| State Line Marsh                               | Kossuth           | Iowa DNR             |
| ● Steele Prairie                               | Cherokee          | Iowa DNR/County      |
| ● Stinson Prairie                              | Kossuth           | County               |
| Stone State Park                               | Woodbury/Plymouth | Iowa DNR             |
| Sweet Marsh Wildlife Area                      | Bremer            | Iowa DNR             |
| ● Sylvan Runkel Prairie                        | Monona            | Iowa DNR             |
| Telford Prairie                                | Palo Alto         | County               |
| Towhead Lake                                   | Calhoun           | Iowa DNR             |
| ● Turin Loess Hills Preserve                   | Monona            | Iowa DNR             |
| Volga River Recreation Area                    | Fayette           | Iowa DNR             |
| Walnut Creek National Wildlife Refuge          | Jasper            | U.S. Fish & Wildlife |
| Washta Access                                  | Ida               | Iowa DNR             |
| Waterman Prairie Complex                       | O'Brien           | Iowa DNR             |
| Waubonsie State Park                           | Fremont           | Iowa DNR             |
| West Oak Forest                                | Mills             | County               |
| Wiese Slough                                   | Muscatine         | Iowa DNR             |
| ● Williams Prairie                             | Johnson           | Nature Conservancy   |
| Wolter's Prairie                               | Butler            | County               |
| Wright Wildlife Area                           | Adair             | County               |

●Dedicated as State Preserve

\*Information compiled by John Pearson, Iowa DNR

tions of Waubonsie State Park and the Loess Hills Wildlife area including the Sylvan Runkel Prairie contain significant amounts of prairie totaling more than 3000 acres. The total area of additional prairie remnants in the Loess Hills probably exceeds several thousand acres. In fact, it has been conjectured that the total area of all prairies in the Loess Hills may be as much as 12,000 acres.

Significant prairie remnants in private ownership in other parts of

the state include Bernau Prairie, Kossuth County; Wearin Prairie, Mills County; Big Sand Mound, Muscatine County; Solitaire Ridge, Winneshiek County; Bergman-Becker Prairie, Dickinson County; Flaherty Prairie, Clarke County and Kirchner Prairie, Clay County. In addition, more than 1000 acres of privately owned prairie remnants are scattered along the upper part of the Little Sioux Valley.

As indicated, the privately owned remnant prairies on prime ag-

riculture land in Iowa have survived because they have been managed as hayfields. Most of the hayfield remnants exist because of long-standing family traditions. For nostalgic or sentimental reasons, they are valued by their owners who intend to retain them as hayfields. However, should these remnant prairies change ownership, there is a significant risk of them being plowed and converted to agriculture.

In addition, native prairie plants have survived in pastures that have been moderately grazed. If grazing is reduced or discontinued, prairie plants reappear, especially on the steeper slopes less impacted by cattle. The greatest risk for these areas is that the management regime of limited grazing will be changed to intense, constant grazing which could eliminate the relict prairie plants.

In general, people seem to be interested in preserving or protecting prairies. As a consequence, more of the few remaining remnants are being saved. However, prairie remnants are still being lost or degraded. This loss and degradation was confirmed by a recent survey conducted by the University of Northern Iowa Roadside Office. Agencies, non-governmental organizations and individuals throughout the state were surveyed regarding remnant prairies in roadsides or associated with roadsides. Information was received about prairies in 94 counties. Survey results indicated that roadside prairie remnants continue to decline. Some remnants have been lost and the majority of those remaining are degraded. Even remnants with a relatively high diversity of native plants have been, or are being, disturbed by adjacent land use. Siltation from erosion of nearby fields and/or careless over-spraying of crops are two of the most frequent disturbances of the roadside remnants (Carole Kern personal communication).

#### Prairie recovery on roadsides

Some of the initial attempts at prairie recovery began on Iowa's roadsides. In the mid-1980s, roadside prairie management programs began to be developed in counties across the state as the importance of roadsides as a part of Iowa's prairie heritage was recognized. Prairie had occurred on roadsides since the first roads were established in the state. The early roads and railroads were constructed in native prairie, and as a consequence, this prairie was preserved within the rights-of-way. In addition, since prairie still existed adjacent to the rights-of-way when new transportation corridors were constructed, prairie plants reestablished in areas that had been disturbed by construction (Shimek 1925). During the 1920s, Shimek (1925) observed that much of the native prairie formerly preserved along the roadsides was disappearing with the widening of primary roads and the enforcement of unwise indiscriminate weed laws along secondary roads. Nevertheless, some roadside prairie remnants survived to the present day and resisted invasion by non-native weeds.

Prairie reconstruction and restoration on roadsides was proposed in the early 1970s as a means of weed control (Christiansen and Lyons 1975). A basic premise of this proposal was that native prairie vegetation is better adapted to the area of its origin than non-native weeds or introduced plants. Prairie plants have a competitive edge over most weeds and this can reduce the need for frequent mowing and the use of broad spectrum herbicides. In the mid-1980s, the concept of the use of native prairie for weed control in roadsides was incorporated into a broader concept of integrated roadside vegetation management (IRVM) that included reduced mowing, spot application of herbicides and the use of fire. Restoration or reconstruction of native prairie is a keystone of the IRVM program.

A number of Iowa counties have adopted all or a portion of an IRVM program and 35 counties have hired roadside managers to direct their programs. In addition, the Iowa Department of Transportation (DOT) has adopted most of the IRVM practices and administers a Living Roadway Trust Fund that supports activities re-

lated to IRVM. There are approximately 580,000 acres of primary and secondary roadsides in Iowa. A statewide system of roadside prairie corridors connecting the remaining tallgrass prairie remnants in Iowa would be a prairie recovery project of awesome magnitude.

#### Large-scale prairie recovery projects

Three large prairie restoration and reconstruction projects were proposed for Iowa in 1990 and 1991. The Walnut Creek National Wildlife Refuge and Prairie Learning Center was established in 1991 through the efforts of U. S. Representative Neal Smith. A primary goal for the 8654-acre refuge is to restore the former prairie and savanna landscape, as nearly as possible, to the condition that existed prior to Euro-American settlement. The project includes reconstruction of 5000–6000 acres of prairie. According to the master plan, both prairie plant and animal species, including a limited number of bison and elk, will be reintroduced into the area.

Two other large projects in Iowa include the 5000-acre Waterman Creek Project by the Iowa DNR near Sutherland in O'Brien County and the Landscape Conservation Program by TNC in the Loess Hills. The Waterman Creek area was selected because it contains a significant number of prairie remnants that could form the core of the ecosystem recovery process. Approximately 20% of the area is comprised of pasture containing native prairie vegetation. Prairie restoration techniques would be appropriate for this portion while the remainder of the project area would require prairie reconstruction. Land within the project boundaries is being acquired on a willing seller basis. However, the project is proceeding at a slow pace due to intense local opposition and a reduction in acquisition monies from the Resource Enhancement and Protection Program (REAP).

The TNC program in the Loess Hills involves examining the best way to preserve and restore prairie within that landform region. The results of the Iowa Natural Areas Inventory (Schennum 1986) indicated that the Loess Hills were an ideal candidate for prairie ecosystem recovery. They contain more area of prairie and larger tracts of prairie than any other region in the state. TNC has examined almost 7000 acres of prairie in the Loess Hills and estimates that there may be as much as 5000–7000 acres of prairie remaining to be surveyed. It has targeted 12 prairie recovery sites in the Loess Hills and is working toward insuring maximum prairie preservation as well as restoration and reconstruction in each of those 12 areas. The TNC program involves land acquisition, cooperation with governmental agencies and working with private land owners to maximize prairie recovery. At present, the largest acquisition site is the Broken Kettle Area with a core of 2195 acres. This TNC program is a part of a larger eco-regional program for ecosystem recovery, the Central Tallgrass Prairie Eco-Region.

The U. S. Fish and Wildlife Service has prepared an Environmental Impact Statement (EIS) for a two-state prairie corridor project known as the Northern Tallgrass Prairie Habitat Preservation Area. The project could include many scattered prairie remnants within a corridor extending from Des Moines northwest through Iowa and western Minnesota to the Canadian border (U. S. Fish and Wildlife 1998).

These large projects are an indication that the perspective of prairie preservation in Iowa has changed from saving the pieces to a more proactive context of ecosystem recovery involving preservation, restoration and reconstruction.

#### Challenges of prairie ecosystem recovery

Prairie ecosystem recovery in Iowa is not going to be easy. Because the original prairie has been obliterated almost to the vanishing point, restoration as described below by Sayen (1989) will not be possible in most of the state:

The goal of restoration must be natural recovery. Remove the destructive forces, attempt to restore in an ecologically appropriate manner as many species, community functions and structures as possible, taking a holistic view of the ecosystem. Proceed in accordance with natural succession. Vigilantly monitor and guard against further human abuses and let nature run her course.

Except for the Loess Hills, there are virtually no locations in the state with sufficient prairie remnants to provide a critical mass for natural recovery. In the blacksoil region, prairie remnants are islands in an agricultural sea, isolated, tiny areas with large perimeters exposed to encroachment by human-originated disturbances. They have to be carefully managed just to maintain their natural integrity.

Obviously, prairie restoration alone is not going to be sufficient. Prairie reconstruction is going to have to be a part of any recovery plan. Some ecologists and conservationists are concerned that even restoration and reconstruction combined may not be enough. In Jackson's (1995) opinion, prairie recovery may be almost impossible because the tallgrass prairie is virtually nonexistent and much of the resiliency required to recover to its native condition has been lost. She goes on to point out that remnants are few and far between, native seed sources are limited, and the ubiquitous presence of aggressive exotic species such as smooth brome make prairie reconstruction difficult and restoration of disturbed remnants a daunting challenge.

Leopold (1949) eloquently summed up the condition: "What a thousand *Silphiums* looked like when they tickled the bellies of the buffalo is a question never again to be answered and perhaps not even asked." Prairie recovery is unquestionably a momentous challenge, but our society either has to meet that challenge or risk losing an integral part of our biological heritage.

As indicated, the Loess Hills with a greater number of prairie remnants, some quite large, have the greatest potential for prairie ecosystem recovery. TNC's Landscape Conservation Program is designed to capitalize on that potential. However, this is an extensive undertaking that will require considerable capital and personnel. Hopefully, the international significance of the region will attract attention and support for this undertaking.

On the Waterman Creek Project area, sufficient native prairie plants remain to provide the inoculum for natural revegetation. Prairie restoration can be done on the hillsides where the remnant prairie occurs. However, extensive prairie reconstruction will be required to recreate prairie in the croplands of the bottomlands and uplands. In addition, the project faces stiff resistance from local residents reluctant to relinquish farmland. They have not yet acknowledged the need for prairie recovery, at least not that close to their home.

The Walnut Creek project is being attempted on land that has been subjected to long-term agricultural usage, a condition typical of most of the Iowa agricultural landscape. The only remaining natural areas are a few tiny prairie remnants and several degraded relict savannas and prairies. For the most part, expensive, labor-intensive reconstruction techniques will have to be used to recreate prairie and savanna. Even the few relict savannas and prairies with greater potential for restoration will require intensive restoration and management practices and the reintroduction of selected native species.

In spite of the difficulties that have to be surmounted, it is gratifying that we have progressed to the point of recognizing the need for prairie ecosystem recovery. The concept of ecosystem recovery is essential as we attempt to protect our relict prairie islands and recover a vanishing ecosystem. Perhaps these small islands can serve as nuclei for clusters of restored and reconstructed prairies to form

larger, more viable areas for prairie recovery, rather than isolated outposts at risk of being inundated by an alien agricultural sea.

In 70 years, we dismantled an Iowa prairie ecosystem that had been 10 to 12 thousand years or more in the making. After the ecosystem was dismantled, the prairie remnants continued to decline, more than 40 years elapsed before a single remnant was preserved. Prairie ecosystem recovery will be slow and progress measured in small increments. In our fast-paced society, the waiting will be difficult. Ultimately the success of prairie ecosystem recovery will depend upon our society's willingness to exercise patience and to adopt a different perspective of time in order to see recovery projects through to completion.

In summary, prairie ecosystem recovery in Iowa is going to be costly, labor intensive and time consuming. That is the price required for recovery of a valuable resource that was allowed to dwindle almost into oblivion.

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#### LITERATURE CITED

- AIKMAN, J. M. and A. HAYDEN. 1938. Iowa trees in winter. Extension Circular 246. Iowa State College. Ames, Iowa.
- AIKMAN, J. M. 1942. 1942 report of the conservation committee of the Iowa Academy of Science. Proceedings Iowa Academy of Science 49:30-31.
- AIKMAN, J. M. 1943. 1943 report of the conservation committee of the Iowa Academy of Science. Proceedings Iowa Academy Science 50:27-28.
- AIKMAN, J. M. 1945. 1944 report of the conservation committee of the Iowa Academy of Science. Proceedings Iowa Academy Science 51:40-41.
- AIKMAN, J. M. 1946. 1945 report of the conservation committee of the Iowa Academy of Science. Proceedings Iowa Academy Science 52:30-31.
- AIKMAN, J. M. 1947a. 1946 report of the conservation committee of the Iowa Academy of Science. Proceedings Iowa Academy Science 53:35-40.
- AIKMAN, J. M. 1947b. 1947 report of the conservation committee of the Iowa Academy of Science. Proceedings Iowa Academy Science 54:26-28.
- ANDERSON, PAUL F. 1996. GIS research to digitize maps of Iowa 1832-1859 vegetation from general land office township plat maps. 41pp. + Appendices. Report prepared for State Preserves Advisory Board and Iowa Department of Natural Resources and printed by the Living Roadway Trust Fund. Available from Living Roadway Trust Fund, Iowa Department of Transportation, Lincolnway, Ames, IA
- ANON. 1926. Dr. L. H. Pammel, formerly of La Crosse, retires from Iowa conservation board. La Crosse Tribune and Leader-Press. Dec. 19.
- BAKER, H. P. 1908. Native and planted timber in Iowa. U. S. Department Agriculture Forest Service Circular 154.
- BENNETT, L. J. 1938. The blue-winged teal: its ecology and management. Collegiate Press, Inc., Ames, IA.
- BERRY, W. J. 1927. The influence of natural environments in north central Iowa. Iowa Journal History and Politics 25:277-298.
- BISHOP, R. A. 1981. Iowa's wetlands. Proceedings Iowa Academy Science 88:11-16.
- BLEWETT, T. 1986. Red cedar's (*Juniperus virginiana*) expanded role in the prairie-forest border region. Pages 122-124. In Proceedings Ninth North American Prairie Conference, 1984. G. K. Clamby and R. H. Pemble, editors. Tri-College University, Moorhead, MN.
- BOGUE, A. G. 1963. From prairie to corn belt. University of Chicago Press, Chicago, IL.
- BRAY, J. R. 1955. The savanna vegetation of Wisconsin and an application of the concepts order and complexity to the field of ecology. Ph.D. thesis. University of Wisconsin. Madison, WI. 174 pp.
- CAWLEY, E. T. 1972. The history of prairie preservation in Iowa. Pages

- 22–24. *In* Proceedings of Second Midwest Prairie Conference, 1970. J. H. Zimmerman, editor. Univ. of Wisconsin, Madison, WI.
- CHRISTIANSEN, P. and D. LYONS. 1975. A Research Report on Roadside Vegetation Management. Report to Iowa Department of Transportation and Linn County. Available from the Iowa DOT Library.
- COFFIN, L. S. 1902. Breaking prairie. *Annals of Iowa*, 3rd Series 5:447–452.
- CONARD, R. 1997. Places of quiet beauty: parks, preserves, and environmentalism. University of Iowa Press, Iowa City.
- CRANE, J., and G. W. OLCOTT. 1933. Report on the Iowa twenty five year conservation plan. Iowa Board of Conservation and Iowa Fish and Game Commission, Des Moines, IA.
- CURTIS, J. T. and M. L. PARTCH. 1948. Effects of fire on the competition between bluegrass and certain prairie plants. *American Midland Naturalist* 39:437–443.
- CURTIS, J. T. 1959. The vegetation of Wisconsin. University of Wisconsin. Madison, Wisconsin.
- DICK-PEDDIE W. A. 1953. Primeval forest types. *Proceedings Iowa Academy Science* 60:112–116.
- DREW, W. B. 1947. Floristic composition of grazed and ungrazed prairie vegetation. *Ecology* 28:26–41.
- DYKSTERHUIS, E. J. 1957. The savannah concept and its use. *Ecology* 38: 435–442.
- EHRENREICH, J. H. and J. M. AIKMAN. 1963. An ecological study of the effect of certain management practices on native prairie in Iowa. *Ecological Monographs* 33:113–130.
- GRIMM, E. C. 1984. Fire and other factors controlling the Big Woods vegetation of Minnesota in the mid-nineteenth century. *Ecological Monographs* 54:291–311.
- HARTER, W. L. and R. E. STEWART. 1930. The population of Iowa; its composition and changes: A brief sociological study of Iowa's human assets. Iowa State College Bulletin No. 275, Ames, IA.
- HAUGEN, A. O., editor. 1964. Report on Iowa's outdoor resources: their conservation and use in outdoor recreation. Des Moines, IA.
- HAYDEN, A. 1919. Conservation of prairie. Iowa Parks: Conservation of Iowa Historic, Scenic, and Scientific Areas. Des Moines, IA.
- HAYDEN, A. 1945. State parks and preserves. *Proceedings Iowa Academy Science* 51:43–48.
- HAYDEN, A. 1946. The selection of prairie areas in Iowa which should be preserved. *Proceedings Iowa Academy Science* 52:127–148.
- HAYDEN, A. 1947a. A progress report on the preservation of prairie. *Proceedings Iowa Academy Science* 53:45–82.
- HAYDEN, A. 1947b. The value of roadside and small tracts of prairie in Iowa as preserves. *Proceedings Iowa Academy Science* 54:28–29.
- HAYDEN, A. AND J. M. AIKMAN. 1949. Considerations involved in the management of prairie preserves. *Proceedings Iowa Academy Science* 56: 133–142.
- HOWE, R. W., M. J. HUSTON, W. P. PUSATERI, R. H. LAUSHMAN and W. E. SCHENNUM. 1984. An inventory of significant natural areas in Iowa: Two year progress report of the Iowa Natural Areas Inventory. Iowa Conservation Commission, Des Moines, IA.
- HUBBARD, B. 1887. Memorial of a half-century. Putnam's Sons, New York, NY.
- IOWA DEPARTMENT OF AGRICULTURE. 1900–1947. Annual Yearbooks of Agriculture. Vols. 1–48.
- IOWA STATE PLANNING BOARD. 1935. Restore the forest cover. A graphic brochure prepared by the Iowa State Planning Board.
- JACKSON, L. L. 1995. Agricultural industrialization and the loss of biodiversity. Pages 66–76. *In* Protection of global diversity: converging strategies. L. Guruswamy and J. McNeely, editors. Duke University Press, Durham, NC.
- JORDON, T. G. 1964. Between the forest and the prairie. *Agricultural History* 38:4.
- LEOPOLD, A. 1949. A Sand County Almanac and Sketches Here and There. Oxford University Press, New York, NY.
- LEOPOLD, A. 1953. Round River. Oxford University Press, New York, NY.
- MACBRIDE, T. H. 1895. Landscapes of Iowa. The Iowa Historical Record. Vol. XI. (Reprinted: Palimpsest 7:283–293. 1926).
- MACBRIDE, T. H. 1898. The President's address. *Proceedings Iowa Academy Science* 5:12–23.
- MACBRIDE, T. H. 1902. President's address. *Proceedings Iowa Park and Forestry Association* 1:1–13.
- MACDONALD, G. B. (Undated). Land Use Report (Forestry). Typed copy available Iowa State University Library. SD 12.18, M14L.
- MARBUT, C. F. 1934. National Resources Board Report, 1934. Government Printing Office, Washington, D. C.
- NUZZO, V. A. 1986. Extent and status of Midwest oak savanna: presettlement and 1985. *Natural Areas Journal* 6:6–36.
- OLIVER, W. 1843. Eight months in Illinois: with information to emigrants. March of America facsimile series no. 81 (1966). University Microfilms, Ann Arbor, MI.
- PACKARD, S. 1988. Rediscovering the tallgrass savanna of Illinois. Pages 62–67. *In* Proceedings of the Tenth North American Prairie Conference 1986. A. Davis and G. Stanford, editors, Native Prairie Association of Texas, Dallas, TX.
- PAMMEL, L. H. 1896. Iowa. *Proceedings of the American Forestry Association* 12:170–173.
- PAMMEL, L. H. 1923. The prairie. *Bulletin Iowa State Parks* 1:13
- PAMMEL, L. H. 1926a. Prairie preserves and railroads. *Bulletin Iowa State Parks* 4:25–26.
- PAMMEL, L. H. 1926b. Our highways and railway right-of-ways for bee pasturage. Report of the Iowa State Horticultural Society 61:305–310.
- PARKER, G. F. 1940. Iowa pioneer foundations. Volume I. State Historical Society of Iowa. Athens Press, Iowa City, IA.
- PARKER, L. 1947. Iowa's first prairie preserve. *Proceedings Iowa Academy Science* 53: 83–84.
- PRIOR, J. C. 1991. Landforms of Iowa. University of Iowa Press, Iowa City, IA.
- ROOSA, D. M. 1978. Prairie preservation in Iowa-history, present status and future plans. Pages 204–206. *In* Proceedings Fifth Midwest Prairie Conference, 1976. D. C. Glenn-Lewin and R. Q. Landers, editors. Iowa State University, Ames, IA.
- ROOSA, D. M. 1981. Iowa natural heritage preservation: history, present status, and future challenges. *Proceedings Iowa Academy Science* 88:43–47.
- SAYEN, J. 1989. Guest Editorial. Notes toward a restoration ethic. *Restoration and Management Notes* 7 (2):57–59.
- SCHENNUM, W. 1986. A comprehensive survey for prairie remnants in Iowa: methods and preliminary results. Pages 163–168. *In* Proceedings of the Ninth North American Prairie Conference, 1984, G. K. Clamby and R. H. Pemble, editors, Tri-College University, Moorhead, MN.
- SHELFORD, V. E. 1934. Report of the committees on the study and preservation of communities. *Ecology* 15:208–209.
- SHELFORD, V. E. 1935. Report of the committees on the study and preservation of communities. *Ecology* 16:274–275.
- SHIMEK, B. 1899. The distribution of forest trees in Iowa. *Proceedings Iowa Academy Science* 7:47–59.
- SHIMEK, B. 1911. The prairies. *Bulletin from the Laboratory of Natural History* 35:Oct. The State University of Iowa, Iowa City, IA.
- SHIMEK, B. 1925. The persistence of the prairie. *University of Iowa Studies Natural History* 11:3–24.
- SHIMEK, B. 1932. The relation between the migrant and native flora of the prairie region. *University of Iowa Studies in Natural History* 14:10–16.
- SHIMEK, B. 1934. The Shimek Plan. A proposal for establishment of a prairie research area near Iowa City and a large prairie preserve along the Little Sioux River west of Lake Okoboji. (Unpublished manuscript consisting of a report prepared by a committee chaired by B. Shimek, University of Iowa. Maps included.). Archives Section, University of Iowa Library.
- SHIMEK, B. 1935. Letter to Shelford regarding the Shimek Plan. Archives Section, University of Iowa Library.
- SMITH, D. D. 1981. Iowa prairie, an endangered ecosystem. *Proceedings Iowa Academy Science* 88:7–10.
- SMITH, D. D. 1992. Tallgrass prairie settlement: prelude to the demise of the tallgrass ecosystem. Pages 195–199. *In* Proceedings of Twelfth North American Prairie Conference, 1990. D. D. Smith and C. A. Jacobs, editors. University of Northern Iowa, Cedar Falls, IA.
- SMITH, S. G. AND R. Q. LANDERS. 1964. Survey of natural areas in Iowa suitable for preservation. Report compiled for Iowa Chapter of The

- Nature Conservancy and Governor's Committee on Conservation of Outdoor Resources.
- SWISHER, J. A. 1931. The Iowa Academy of Science. *Journal History and Politics* 29:343.
- THOMPSON, J. R. 1992. Prairies, forests, & wetlands: The restoration of natural landscape communities in Iowa. University of Iowa Press, Iowa City, IA.
- THOMSON, G. W. and H. G. HERTEL. 1981. The forest resources of Iowa in 1980. *Proceedings Iowa Academy Science* 88:2-6.
- THOMSON, G. W. 1987. Iowa's forest area in 1832: a reevaluation. *Proceedings Iowa Academy Science* 94:116-120.
- U. S. FISH AND WILDLIFE SERVICE. 1998. Northern Tallgrass Prairie Habitat Preservation Area: Final EIS. Office of Regional Director, Ft. Snelling, MN.
- VAN DER LINDEN, P. J. and D. R. FARRAR. 1984. *Forest and Shade Trees of Iowa*. Iowa State University Press, Ames, IA.
- WEAVER, J. E. and T. J. FITZPATRICK. 1934. The prairie. *Ecological Monographs* 4:109-295.
- WEAVER, J. E. 1954. *North American Prairie*. Johnson Publishing Co., Lincoln, NE.
- WHITNEY, G. G. 1994. *From coastal wilderness to fruited plain: a history of environmental change in temperate North America from 1500 to the present*. Cambridge University Press.