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Factors related to the occurrence of certain prairie graminoid species in Black Hawk County, Iowa, roadsides

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FACTORS RELATED TO THE OCCURRENCE OF CERTAIN PRAIRIE GRAMINOID SPECIES IN BLACK HAWK COUNTY, IOWA, ROADSIDES

An Abstract of a Thesis
Submitted
In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

Pauline Mary Drobney
University of Northern Iowa
August 1990

ABSTRACT

The native vegetation of Iowa was primarily tallgrass prairie and currently exists only in small isolated parcels, including some remnants occurring in roadsides. Roadside prairie remnants are important for historical, environmental, aesthetic, scientific, and economic reasons. Information about factors influencing the occurrance of roadside prairie vegetation could be useful to roadside vegetation managers in development of initial vegetation surveys and subsequent to restoration of roadside prairie vegetation.

This study was conducted to determine what factors most affected the percent coverage of prairie graminoids in roadsides; particularly soil moisture availability, drainage, soil disturbance, and availability of a prairie seed sources. Prairie vegetation of the study was confined to graminoid species selected from roadside segments of the Black Hawk County Roadside Vegetation Survey. Cover categories of prairie vegetation were 1) 0%, 2) 5-15%, 3) 16-49%, and 4) 50-100%.

Of the total 494 roadside segments taken, an approximate 4:2:2:1 ratio was noted among cover categories in decreasing order from cover category 1 through 4. In Chi-square tests, prairie vegetation cover was significantly related to road age, soil association, and road type, but was not significantly related to permeability, erodibility, original vegetation, and adjacent land use. Statistical analyses of roadside slope were inconclusive.

The relative amount of prairie vegetation that occurred in roadsides increased with road age. Samples in roadsides along roads

more than 51 years old had the highest percentage of prairie vegetation (37%) in cover category 4, and most samples (67%) in roadsides less than 21 years old contained no prairie vegetation.

Soils well suited for agricultural use generally had a higher proportion of prairie vegetation than soils poorly suited to agricultural use. Among soil associations poorly adapted to agriculture, Sparta-Olin-Dickinson, had a relatively higher number of samples in cover category 4, and also was adjacent to relatively large remnants of non-roadside prairie.

Prairie vegetation occurs in greater frequency and in higher cover values adjacent to gravel roads than adjacent to paved roads.

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This Study by: Pauline Mary Drobney

Entitled: Factors Related to the Occurrence of Certain Prairie Graminoid Species in Black Hawk County, Iowa, Roadsides

has been approved as meeting the thesis requirement for the

Degree of Master of Arts

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CHAPTER 1

INTRODUCTION

Prairie vegetation once covered much of the landscape of midwestern United States, including Iowa, but few examples of that original flora remain. The remaining fragments of the original tall grass prairie ecosystem are irreplaceable storehouses for biological diversity, and are therefore valuable for scientific research, for understanding of the environment that formed the basis of Iowa's agricultural economy, and for historical, environmental, and aesthetic reasons. In addition, these prairie remnants are the last vestiges of an ecosystem, and, as such, we have a moral obligation to preserve them.

In recent years, interest in preservation and restoration of prairie remnants has increased. The establishment of prairie vegetation in roadsides has become a focus of interest as it effectively controls weeds and eliminates the need for intensive mowing and herbicide use. With proper management, prairie vegetation effectively stabilizes soil in erosion prone areas. In addition, prairie roadsides are aesthetically pleasing and provide a strip of native vegetation across a human modified landscape, linking natural areas to one another. Programs have been developed on a state level to assist governmental units in Iowa to develop integrated roadside vegetation management programs which include restoring prairie vegetation in roadsides.

This study was conducted to determine if certain physical characteristics of roadsides are associated with the survival of prairie vegetation in roadsides. An initial phase of integrated roadside vegetation management is to inventory the existing vegetation. The identification of characteristics influencing the presence of prairie vegetation in roadsides can provide managers with basic information for development of the vegetation inventory process. This basic information can be used to locate prairie remnants in lieu of a complete roadside vegetation inventory. In addition, this information can be useful in understanding the vegetation management needs of areas being restored to prairie communities.

Statement of Problem

The purpose of this study was to determine if factors known to affect plant communities and their stage of succession, including soil moisture availability, drainage, soil disturbance, topography, the type of vegetation under which soils are formed, and availability of a prairie seed source are related to visual estimates of the percent coverage of prairie graminoids in roadsides. The study was designed so that it would have maximum practical applicability for County Roadside Managers and others interested in locating and restoring roadside prairie remnants. The intent was to determine if readily available information about the physical characteristics of roadsides could predict locations of prairie remnants. This technique would be beneficial to counties unable to conduct comprehensive on-site roadside vegetation surveys.

Specific study objectives were to:

1) Determine the frequency of selected prairie graminoids along

segments of six roads in Black Hawk County that represent a variety of physical factors that affect plant communities.

2) Compare the frequency of prairie vegetation found on selected roadsides with characteristics hypothesized to affect the occurrence of prairie vegetation, including:

- age and surface type of road,
- soil association, permeability, slope, and erodibility,
- adjacent land use,
- the type of vegetation under which soils were formed.

Literature Review

Information about the physical and biological characteristics that affect the plant communities in prairies, and about the impact of Euro-American settlement on the prairie is useful in forming a perspective about the condition and management needs of current prairie remnants. A discussion of this information follows.

Original Prairie Landscape

What is now known as Iowa, was occupied by tall grass prairie, with grasses sometimes tall enough that " . . . a man riding horseback amid these tall grasses in the low places could knot them over his head and ride forth from under the knot." (Flickinger 1904, p. 225). Trees occurred sparsely in the prairies, in areas known as savannas or were relegated to wooded stream or river valleys. The vast and dynamic nature of the prairies of Iowa with their seasonally changing flora was described by Shimek (1911, p. 170): "But the real rich beauty of the prairie was developed only after mid-summer when myriads of flowers of most varied hues were everywhere massed into one great painting, limited only by the frame of the horizon, uniform in splendid beauty, but endlessly varied in delicate detail."

The prairies are abundant with flowers. Curtis (1971) notes that there are more species of plants in the daisy family (Asteraceae) than in any other plant family in prairies and that as such, prairies might appropriately be referred to as "daisylands". However, monocots such as grasses and sedges consistently dominate the vegetation in prairies and closely related communities such as sedge meadows, and marshes (Steiger 1930, Weaver 1954, Brotherson 1969, Curtis 1971, Crist and Glenn-Lewin 1978, Eyster-Smith 1984). Because of the overwhelming preponderance of members of the grass family (Poaceae) in most prairies (Steiger 1930, Anderson 1954, Weaver 1954, Curtis 1971, Eyster-Smith 1984), prairies are often referred to as grasslands. In wet, poorly aerated regions, however, members of the sedge family (Cyperaceae) can replace grasses in dominance (Steiger 1930, Weaver 1954, Brotherson 1969, Curtis 1971).

Demise of the Prairie

The prairie ecosystem that dominated the presettlement landscape of Iowa provided the economic resource that led to its demise. The continual cycle of deterioration and regeneration of roots of tall grass prairie plants generated a deep organically rich soil, ideally suited for agriculture. The following observation by Flickinger, (1904 p. 67) indicates that Iowa settlers recognized the agricultural value of the prairie soil, but not necessarily the value of the prairie.

> "Going to the 'raw prairie' with a breaking plow and team, and turning the first furrow, probably one mile in length, without a rock, grub, tree or stump to hinder the plow, they very soon saw the great difference between making a farm on eastern wooded lands and the fertile prairies of Iowa. Infinite wisdom caused seven-

eights of her surface to be prairie, that Iowa might the more easily and speedily turned into a paradise."

The rapid conversion of mesic prairies to agricultural land that occurred when Euro-Americans settled in Iowa was accompanied by fire suppression. Fire, a regular occurrence in the prairie ecosystem, had been an important factor in maintaining the essentially treeless character of prairies, the unique open-grown trees and herbaceous understory of savannas, and the open character of woodlands of the prairie region (Shimek 1911, Curtis 1971, Pyne 1986, Wilhelm and Ladd 1988). Although lightning fires occurred on prairies in presettlement times, there is evidence that most of the fires occurring on the prairies were anthropogenic (Higgins 1986). An early account of Black Hawk County includes a reference to annual fires ignited by Indians (Hartman 1915) and is local testimony to the anthropogenic nature of many prairie fires.

Fire suppression was actively encouraged by Euro-American settlers whose agrarian livelihood and lifestyle was threatened by prairie fires (Flickinger 1904). Subdivision of prairies for agricultural purposes was accelerated by the invention of the moldboard plow, and resulted in passive fire prevention by creating firebreaks on the prairie landscape (Smith 1981). Increased use of land for agriculture was accompanied by increased numbers of roads and by development of urban areas, resulting in further fragmentation of prairies and, more effective fire suppression on existing prairie. The effects of the removal of fire from the natural landscape in Black Hawk County is noted by Parker (1856), who observed the vigorous growth of thousands of acres of young trees, formerly checked by fire. In addition to destruction of prairie due to fire suppression, as agricultural systems developed roads were improved, and prairie vegetation that had re-established into roadsides was destroyed. Existing prairie seed sources adjacent to roadsides became increasingly rare, preventing natural recolonization of prairie vegetation. In addition, European settlers used non-native species such as smooth brome (Bromus inermis) for soil stabilization and for pasture (Swink and Wilhelm 1979), increasing destruction to native vegetation, and competition by non-native species.

Distribution of Prairie Vegetation

Prairie species assort into specific communities because of relationships between their biological and environmental requirements. In a sense, roadside prairie remnants are a microcosm of these relationships and an understanding of these relationships is essential for restoration and management of roadside remnants. Major factors affecting the distribution of plant species include soil characteristics, availability of moisture, topography, exposure to sun and wind, and frequency of fire (Shimek 1911, Steiger 1930, Weaver 1954, Brotherson 1969, Curtis 1971, Crist and Glenn-Lewin 1978, Eyster-Smith 1984, Pyne 1986). Different species occur in disturbed areas or in areas close to disturbance (Steiger 1930, Weaver and Fitzpatrick 1932, Costello 1944, Curtis 1971, Platt and Weis 1977).

Plants respond to the environment because of specific photosynthetic pathways and reproductive strategies (Rabinowitz and Rapp 1980, Tieszen et al. 1980, Kemp 1980, Ode 1980, Barnes et al. 1983) as well as structural and functional adaptations that relate primarily to moisture conditions. In addition, some animals are associated with specific types of vegetation in roadsides (Klatt and Getz 1978) and can affect seed dispersal of prairie plants, influencing plant community structure (Curtis 1971, Platt and Weis 1977). The distribution of plant species in prairies is therefore governed by a complex intermingling of factors, including many physical factors. Thus, as Curtis (1971 p. 268) states,

> " . . . prairies form a vegetational continuum, with a continually changing species composition based on the unique responses of the individual members to changes in the environment. There are no groups of species which are sharply delimited from other groups, such as would be present if the prairies consisted of a series of discrete and recognizable communities each with its own environmental optima."

The amount of moisture available to the roots is a major physical factor affecting the distribution of prairie plants (Steiger 1930, Costello 1944, Curtis 1971, Bacone and Harty 1981). Water content of soil was the most important factor affecting the structure of prairie vegetation in Steiger's (1930) studies in Nebraska, and in Crist and Glenn-Lewin's (1978) studies of Stinson prairie in Iowa. A strong relationship exists between soil moisture, and topography and soil type (Crist and Glenn-Lewin 1978).

Topography also strongly influences the distribution of prairie vegetation (Steiger 1930, Weaver 1954, Lindsey 1961, Curtis 1971, Crist and Glenn-Lewin 1978, Ode 1980, Whitney 1982). Slight variations in relief often produce marked differences in vegetational composition that are strongly related to available soil moisture and drainage (Curtis 1971, Whitney 1982). Water input into soil is dependent on topography because narrow ridges and convex slopes disperse water runoff, and hollows, terraces and floodplains, concentrate runoff water (Fouts and Highland 1978, Whitney 1982).

Vegetation exerts a major influence on the properties of soils (Hausenbuiller 1972). The continual cycle of root decay and regeneration that occurs in grassland vegetation results in the accumulation of decaying material, causing grasslands typically to have deep rich organic layers of soil. Conversely, tree roots are relatively long-lived and do not contribute as much organic matter to the soils as grasses. Soils formed under forests, therefore, are lighter in color with a thin layer of organic material resulting from leaf litter (Hausenbuiller 1972).

Soil characteristics influence the distribution and successional stage of vegetation in natural areas (Aikman 1930, Steiger 1930, Tolstead 1941, Costello 1944, Weaver 1954, Lindsey 1961, Lindsey et al. 1965, Curtis 1971, Crist and Glenn-Lewin 1978, Bacone and Harty 1981, Steiger 1981, Whitney 1982). The proportion of sand, silt, and clay in soil determines its texture (Fouts and Highland 1978), and texture affects water holding capacity, permeability, vegetation type, and human use of an area. Permeability is the ability of the soil to transmit air and water (Fouts and Highland 1978) and this influences the water holding capacity of soil.

Local physical disturbance to the soil such as that caused by prairie rodents is a natural part of the prairie ecosystem, allowing it to be a dynamic system of gradually shifting plant populations (Curtis 1971, Platt and Weis 1977). Massive and repeated disturbance to any plant community, however, tends to revert that community to an early stage of succession and retain it there (Curtis 1971).

Survival of Prairie Remnants in Iowa

Less than 0.1% of Iowa's original 28 million acres of natural grasslands currently remains, and this occurs as small scattered remnants (Howe et al. 1984, Smith 1989). Of the known remaining tall grass prairies in Iowa, only 14 are larger than 40 acres, the largest being Hayden Prairie State Preserve at 240 acres (Howe et al. 1984).

The reasons for survival of prairie remnants in Iowa range from conscious preservation of natural resources to neglect of economically useless parcels of land. Hayden Prairie in Howard County, and Kalsow Prairie in Pocahontas County, were intentionally preserved despite the economic value of the land for agricultural purposes. Natural areas that were too steep, rocky, wet, or sandy to be accessible or economically useful were often inadvertently preserved. Such areas include the hill prairies of the limestone outcrops in northeast Iowa, as well as sand prairies and fens. Seventy eight percent of the natural areas found by Duritsa (1983) in Black Hawk County were associated with soil types that were not conducive to agricultural use or urbanization. Additional prairie remnants have survived because prairie vegetation did not interfere with land use, as in pioneer cemeteries, railroad rights-of-way, and roadsides.

Pioneer cemetery prairie remnants. Often, pioneer cemeteries in the prairie region were established in unplowed prairie sod. Maintenance of cemetery vegetation by mowing or burning reduced competition from woody species, thus preserving a portion of the local prairie flora (Hayden 1947, Betz 1972, Betz and Lamp 1981, Overton 1981, Pleznac 1983). Several prairie cemeteries exist in Iowa; among the best known is Rochester Cemetery, in Cedar County. In addition, former cemetery expansion areas such as the Joseph B. Clay Prairie in Butler County have been established as prairie preserves. Prairie cemeteries, though small, can serve as repositories for rare prairie species such as kittentails (Besseya bullii), a species whose existence is threatened in Iowa. The only known site for this plant in Black Hawk County is a prairie cemetery (Duritsa 1983).

Railroad prairie remnants. The age of railroads began in the 1850's (Flickinger 1904), when prairie vegetation was still plentiful in Iowa. The unbroken prairie that often existed adjacent to the disturbed soil resulting from railroad construction, provided a source of seed for natural revegetation of railroad rights-of-way. The prairie that re-established along these rights-of-way persisted after the adjacent prairie was plowed (Shimek 1925), and resembled the original prairie in quality even after 60 years had passed (Shimek 1931). Railroad management objectives often include removal of woody vegetation by mowing, cutting and burning, and these activities favor prairie vegetation. In addition, accidental fires initiated by "hot boxes" on rail cars contributed to the maintenance of prairie vegetation. Recently, management practices such as herbicide use and repeated dredging has decimated many of these prairie remnants.

In agricultural regions, railroad rights-of-way contain a significant portion of remaining prairies (Hayden 1947, Kohring 1981, Ramey 1981, Borowske and Heitlinger 1980, White 1986). These remnants are important because railroad rights-of-way: 1) represent cross sections of soil types and moisture gradients providing a broad representation of the natural landscape; 2) contain a diversity of prairie species; 3) buffer adjacent high quality remnants from negative influences that occur when natural areas are bordered by non-native vegetation; and 4) contain native seed sources (White 1986).

Roadside prairie remnants. Roadside prairie remnants have a history of origin and maintenance similar to railroad rights-of-way (Shimek 1925). These remnants are similarly valuable resources, although in most cases roads were built later than railroads (Thompson 1989) and therefore had fewer adjacent prairie seed sources available. Remnants of native communities currently exist along roadsides in Black Hawk County, Iowa (Duritsa 1983). Roadside prairie remnants can exist as small, isolated patches along roads, or can extend for long distances when roads run parallel to railroad rights-of-way. Other roadside remnants are in effect, a part of an adjacent natural area that can extend several acres beyond the roadside as a relatively large diverse system such as Cedar Hills Sand Prairie on Butler Road in northwest Black Hawk County.

Roadside Prairie Preservation and Restoration

A pioneer effort in establishment and maintenance of native vegetation in roadsides began in Dane County, Wisconsin, in 1975 (Nuzzo 1975). Several organizations cooperatively developed a project called the Prairie Heritage Trail, a 10 mile hiking, biking and auto tour.

Since then, agencies in several states including Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, and Wisconsin, have reduced mowing frequency and pesticide usage on established roadsides, and have increased the number of plantings of native vegetation in disturbed or new roadsides (Cull 1978, Thompson 1978, Gouveia 1983, Cole 1987, Ehley 1990, Kabat 1987, Monroney 1987, Otto 1987, Costello 1987, Ivanovitch 1987, Ritzer 1987, Varland 1987, Wallace 1987). This shift in roadside vegetation management policy has occurred for economic, environmental, historical, research, educational, and aesthetic reasons.

In the early 1980's, 'The Black Hawk County Roadside Vegetation Management Committee' was formed to develop alternatives to traditional herbicide usage and/or mow management techniques in Black Hawk County roadsides. This committee's goals were to enhance wildlife habitat, decrease the roadside management costs, decrease environmental pollution due to pesticide usage, control noxious weeds, and increase the aesthetics of roadsides while maintaining current safety standards. These goals would be accomplished by preserving and extending existing remnants of native vegetation in roadsides (Haywood 1984).

The objectives of the Black Hawk Roadside Vegetation Committee were very similar to those of the Dane County Prairie Heritage Trail in Wisconsin. The Dane County project, therefore, was used as a guide in procedural development of the Roadside Vegetation Management Plan of Black Hawk County. The purpose of the Black Hawk County plan was to provide: "1) efficient and economical control of noxious weeds; 2) aesthetically pleasing roadside vegetation that is longlasting and requires low maintenance; and 3) food and cover for wildlife" (Haywood 1984).

An initial phase of this project was an inventory of general vegetation types present in Black Hawk County roadsides, with emphasis on the location of prairie vegetation. This inventory was conducted primarily from August through October, 1984 and a portion of the data was used as the basis for this study.

CHAPTER 2

METHODS

Road Sites

Portions of six roads and their corresponding roadsides in Black Hawk County were selected for study as representative of road types, road ages, soil associations, soil permeability, topography, erosion potentials, adjacent land uses, and original vegetation found in the county. This included 17.3 miles along Bennington Road, 1 mile along Lester Road, 1 mile along Bruggeman Road, and 18.7 miles along Cedar Wapsie Road in the northern tier of townships; and 5 miles along Eagle Road, and 6.4 miles along Tama Road in the southern tier of townships. Figures 1-6, locate the roads relative to features of geology, drainage, and natural areas (Duritsa 1983). Figure 7 shows the location of townships in Black Hawk County (Duritsa 1983).

The roadsides were further subdivided into one tenth mile segments and samples of these segments were arbitrarily limited to the south side of the roads to reduce the data set to a manageable size. A total of 494 data samples were collected. Samples were identified by township, road name, and by the number of the section located directly south of the road on the Iowa Department of Transportation map of Black Hawk County (1985). Tenths of miles were numbered from 1 through 10, from west to east for each section.

Road and Roadside Characteristics

Data collected for each sample included native grass and sedge coverage (selected species), road age, road surface type, soil associations, soil slopes, soil permeabilities, adjacent land use, soil

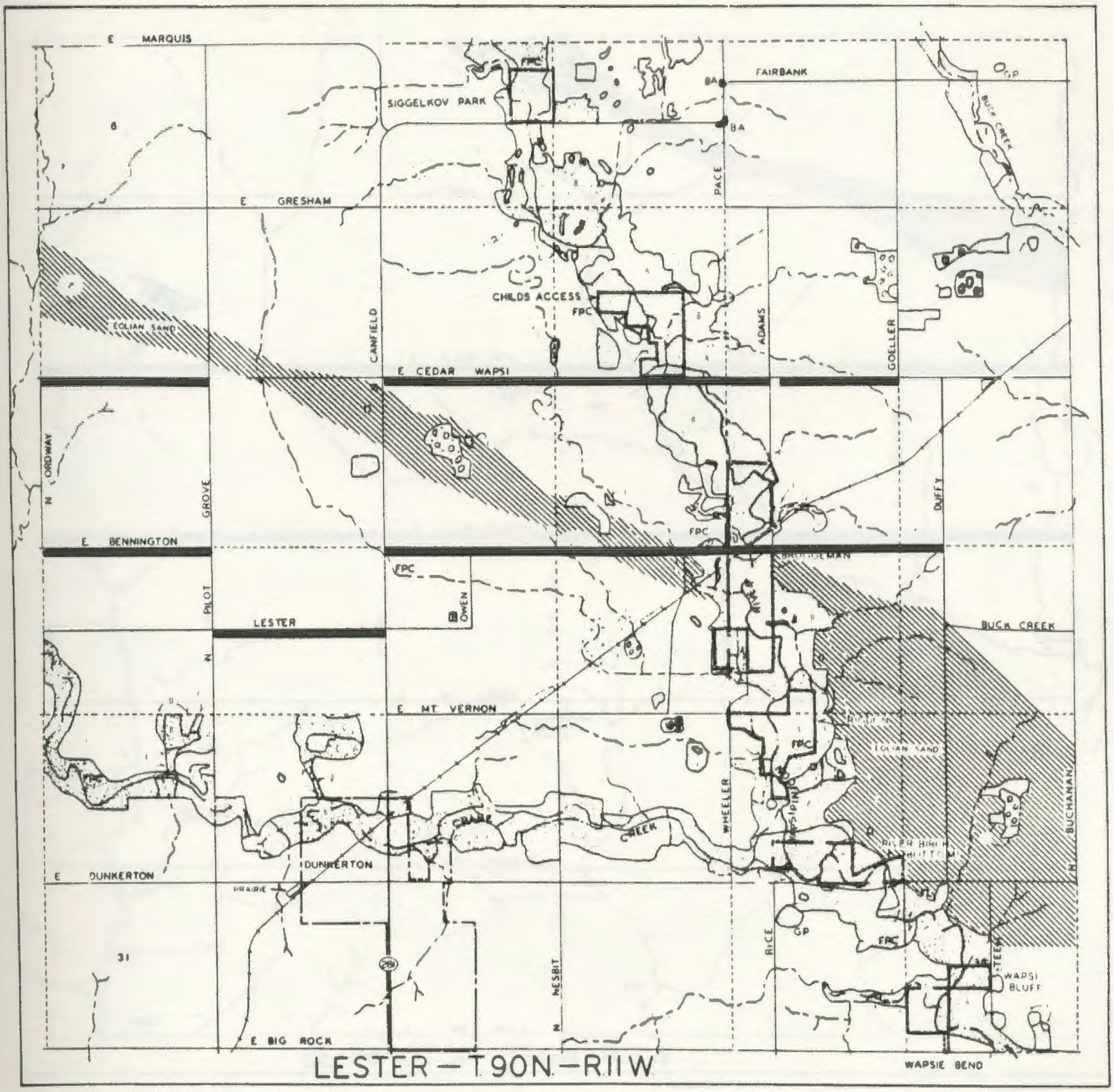

Figure 1. Location of roads studied in Township 44, (Lester Township) T-90N R11W. Map is from Duritsa's (1983) natural areas summary maps.

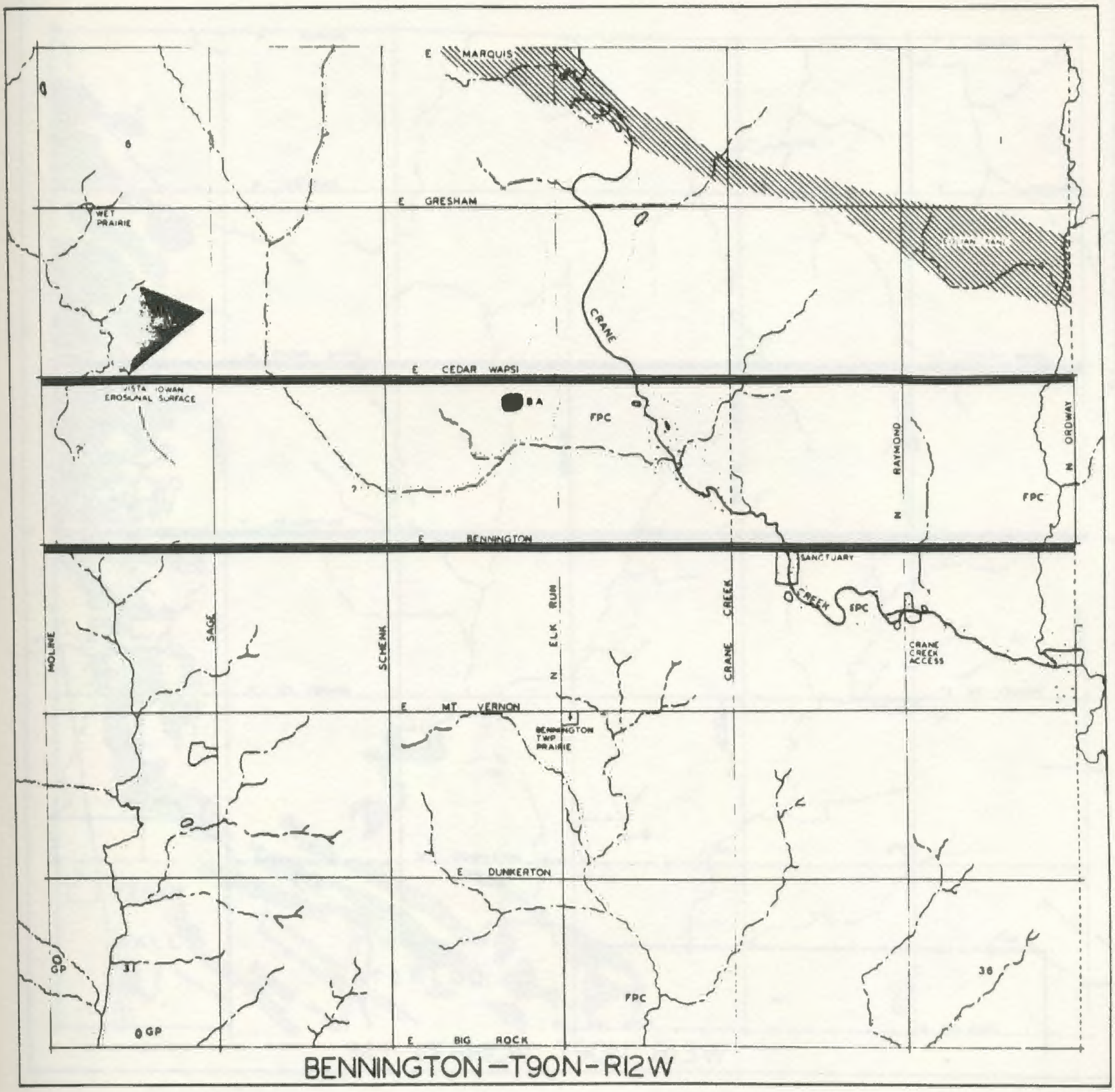

Figure 2. Location of roads studied in Township 43, (Bennington Township) T-90N R12W. Map is from Duritsa's (1983) natural areas summary maps.

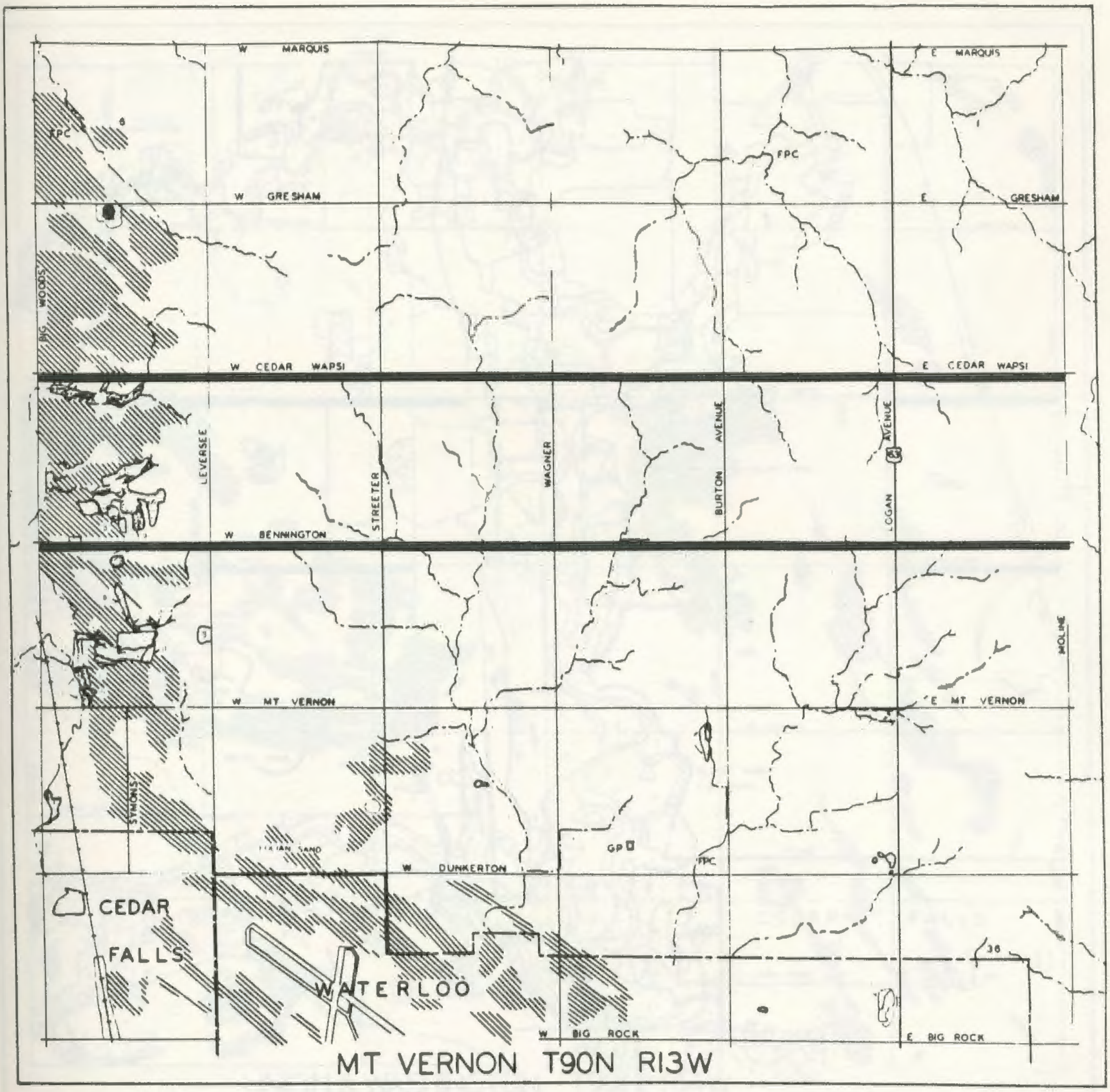

Figure 3. Location of roads studied in Township 42, (Mount Vernon Township) T-90N R13W. Map is from Duritsa's (1983) natural areas summary maps.

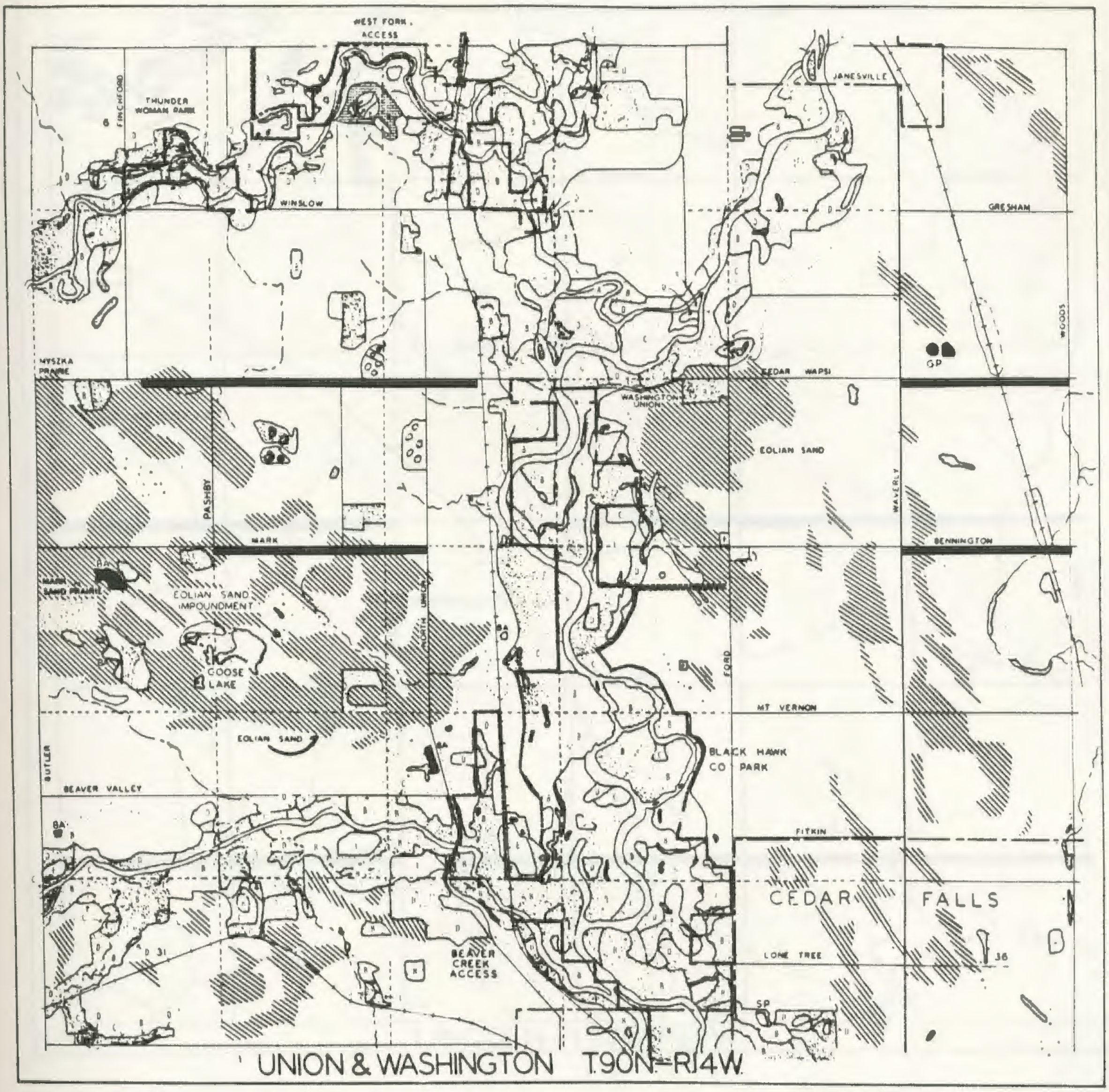

Figure 4. Location of roads studied in Township 41, (Union and Washington Township) T-90N R14W. Map is from Duritsa's (1983) natural areas summary maps.

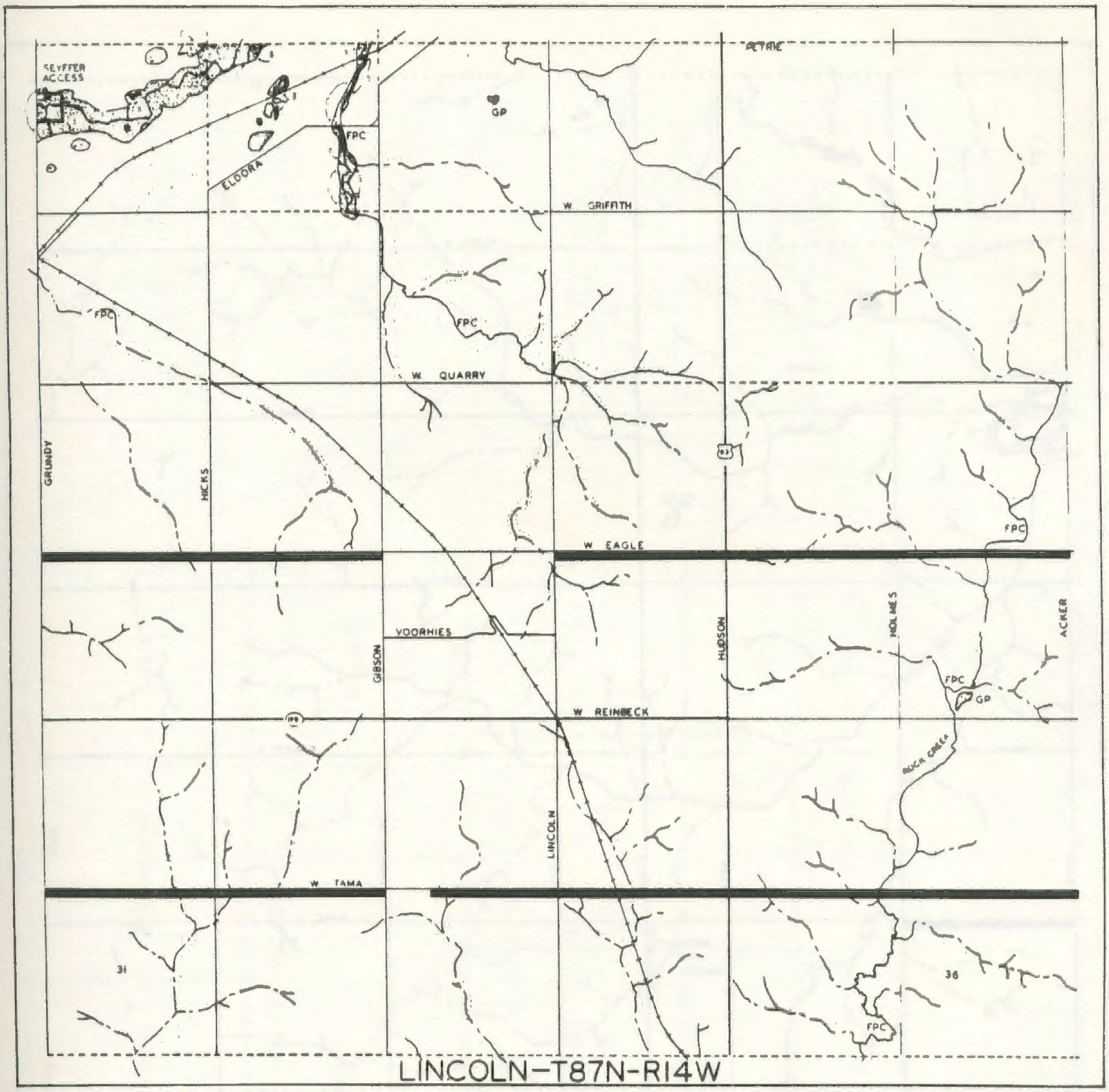

Figure 5. Location of roads studied in Township 11, (Lincoln Township) T-87N R14W. Map is from Duritsa's (1983) natural areas summary maps.

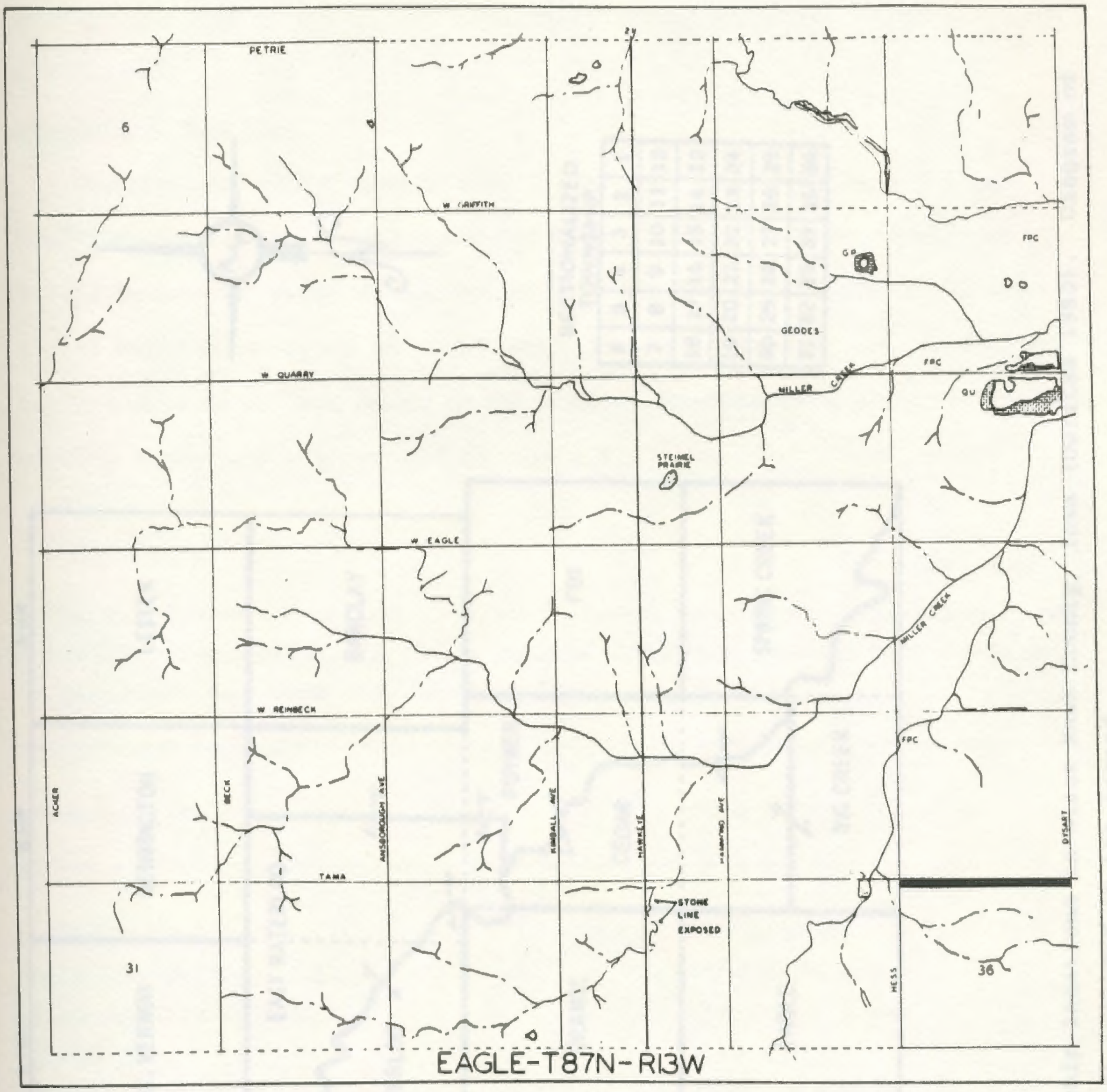

Figure 6. Location of roads studied in Township 12, (Eagle Township) T-87N R13W. Map is from Duritsa's (1983) natural areas summary maps.

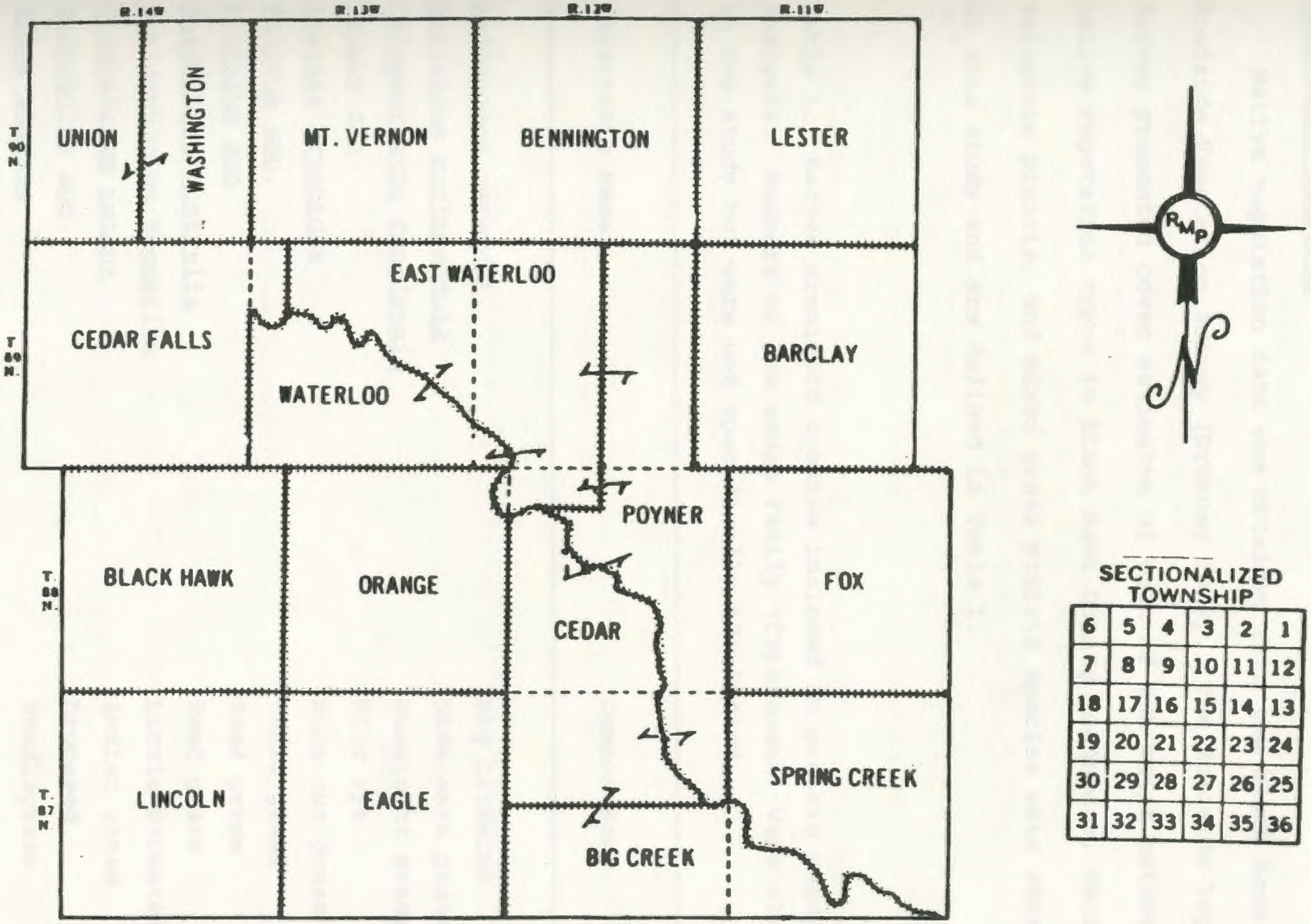

Figure 7. Map of township locations in Black Hawk County, Iowa (Duritsa 1983). Diagram of sectionalized township is included in the legend.

erodibility due to water, and original vegetation under which the soil was formed.

Vegetation Sampling

Native vegetation data was obtained from the Black Hawk County Roadside Vegetation Survey (Drobney 1989). The Roadside Vegetation Survey presented cover estimates of each of the major native and non-native vegetation types in Black Hawk County roadsides. Native wetland, tallgrass prairie, and mixed grass prairie species were selected for use in this study and are defined in Table 1.

Table 1. Native graminoid species included in prairie vegetation cover analysis. Members of the sedge family (Cyperaceae) were also included in the study but were not specifically identified.

Scientific Name	Common Name
Andropogon gerardii	Big bluestem
Bouteloua curtipendula	Side oats grama
Calamagrostis canadensis	Bluejoint grass
Elymus spp.	Wild rye
Leersia oryzoides	Rice cut-grass
Panicum spp.	Panic grass
Paspalum spp.	Bead grass
Phragmites australis	Reed grass
Schizachyrium scoparium	Little bluestem
Sorghastrum nutans	Indian grass
Sporobolus spp.	Dropseed
Stipa spartea	Needlegrass
Thypha spp.	Cattail

Data selected for this study included members of the family Poaceae, Cyperaceae, and Typhaceae with the exception of prairie cord grass (Spartina pectinata), Reed canary grass (Phalaris arundinacea), and Kentucky bluegrass (Poa pratensis). These species were excluded because 1) Prairie cord grass is quite common in roadsides (Drobney 1989) and can occur nearly as a monoculture; 2) Reed canary grass of Eurasian origin was widely introduced in the Midwest and often occurs nearly as a monoculture (Swink and Wilhelm 1979); 3) Kentucky bluegrass, although native to the northern portions of North America, was widely introduced to the Midwest from Europe (Swink and Wilhelm 1979). Exclusion of these species permitted greater sensitivity in data analysis relative to somewhat less aggressive prairie species.

The Black Hawk County Roadside Vegetation Survey was based on the assumption that the roadside samples contained 100% graminoid cover. This cover was estimated in 25% increments, and prairie vegetation that occurred in less than 25% cover was noted. For this study, these notations were arbitrarily assigned a value of 5% cover, and the percentage cover values of the selected graminoid species were totaled and recorded for each 0.1 mile segment. The cover categories for this study were: 1) 0%, 2) 5-15%, 3) 16-49%, and 4) 50-100%. Frequency of occurrence of cover categories were then recorded for divisions within each physical factor category.

Road Age

The ages of the roads were obtained from the office of the Black Hawk County Engineer (Edgar 1987, Donahue 1988). Road age was defined as the number of years since it was last graded for major improvement, and therefore varies from one portion of a road to another. Road age was classified in decades before 1989 in the following categories of years: from 0 to 10 years, 11 to 20 years, 21 to 30 years, 31 to 40 years, 41 to 50 years, 51 to 60 years, and greater than 60 years.

Road Type

Both paved and gravel roads were analysed to determine if there is a relationship between road surface types and the frequency of occurrence of prairie vegetation in adjacent roadsides. All roads on the north edge of a section number consist of one mile unless otherwise stated. The type, location and mileage of the study roads is shown in Table 2. Gravel road surfacing existed on 29.9 miles. In the northern part of the county, this included Bennington Road with 16.3 miles, Bruggeman Road with 3 miles, Lester Road with 1.3 miles, and Cedar Wapsie Road with 2.9 miles. In the southern part of the county, this included Eagle Road with 2 miles, and Tama Road with 4.4 miles.

A total of 20.8 miles of the roads were paved. In the northern part of the county, this consisted of Cedar Wapsie Road with 15.8 miles. In the southern part of the county, this included Eagle Road with 3 miles and Tama Road with 2 miles.

Soils

The soil association information for each 0.1 mile sample was obtained from Fouts and Highland (1978). Various parameters of the soil associations are provided in Table 3. The seven soil associations that occur in Black Hawk County will be abbreviated in the remainder of the text as follows: Tama-Muscatine-Garwin association (T-M-G), the Dinsdale-Klinger-Maxfield association (D-M-K), the Kenyon-Clyde-Floyd association (K-C-F), the Readlyn-Tripoli association (R-T), the Sparta-Olin-Dickinson association (S-O-D), the Loamy alluvial land, channeled-Saude-Flagler association (La-S-F), and the Marshan-Sawmill-Bremer association (M-S-B). Sometimes more than one soil association occurred

Table 2. Types, location, and mileage of study roads. Roads are identified by road name, township number, and number of the section south of the road.

Road Name	Township	Sections	Miles
		Paved Roads	
Cedar Wapsi	41	13, 17	2.0
		16	0.5
		18	0.3
	42	13-18	6.0
	43	13-18	6.0
	44	18	1.0
Eagle	11	22-24	3.0
Tama	11	35-36	2.0
		Gravel Roads	
Bennington	41	20, 24	2.0
		21	0.3
	42	19-24	6.0
	43	19-24	6.0
	44	19	1.0
Bruggeman	44	21-23	3.0
Lester	44	20	1.0
Cedar Wapsi	44	15, 16	2.0
		14	0.9
Eagle	11	19, 20	2.0
Tama	11	31, 32, 34	3.0
		33	0.4
	12	36	1.0

Table 3. Black Hawk County soil series parameters used in statistical analyses and arranged by soil series code (Fouts and Highland, Soil Survey of Black Hawk County, Iowa. United States Dept. of Agriculture, Soil Conservation Service, 1978). Slope code was devised for this study.

SOIL SERIES	SOIL SERIES CODE	SOIL ASSOCIATION*	ORIGINAL VEGETATION**	K VALUE	PERMEABILITY IN./HR.***	SLOPE CODE	% SLOPE
WIOTA	7	/	/	/	/	1	0-2
COLO-ELY	11	1	2	.32	1	2	2-5
SPARTA	41	5	4	.17	3	1	0-2
	41	5	4	.17	3	2	2-5
	41	5	4	.17	3	3	5-9
	41	5	4	.17	3	4	9-18
BREMER	43	/	/	/	/	/	/
ZOOK	54	/	/	/	/	/	/
CHELSEA	63	5	1	.17	3	2	2-5
	63	5	1	.17	3	3	5-9
	63	5	1	.17	3	4	9-18
KENYON	83	3	4	.28	2	2	2-5
	83	3	4	.28	2	3	5-9
	83	3	4	.28	2	4	9-14
CLYDE	84	3	2	--	2	1	0-3
NEVIN	88	/	/	/	/	/	/
LAMONT	110	5	1	.24	2	2	2-7
GARWIN	118	1	2	--	1	1	0-2
MUSCATINE	119	1	4	.28	2	1	0-2
	119	1	4	.28	2	2	2-5
TAMA	120	1	4	.32	2	2	2-5
COLO	133	1	2	--	1	1	0-2
COLAND	135	7	2	--	1	1	0-2

Table 3. Continued.

SOIL SERIES	SOIL SERIES CODE	SOIL ASSOCIATION*	ORIGINAL VEGETATION**	K VALUE	PERMEABILITY IN./HR. ***	SLOPE CODE	% SLOPE
MARSHAN	151	7	2	--	2	1	0-2
	152	7	2	--	2	1	0-2
LOAMY-ESC	154	/	/	/	/	/	/
FINCHFORD	159	6	4	.17	3	1	0-2
	159	6	4	.17	3	3	2-9
BREMER VAR.	166	/	/	/	/	/	/
BASSETT	171	3	3	.28	2	2	2-5
	171	3	3	.28	2	3	5-9
	171	3	3	.28	2	4	5-18
DICKINSON	175	5	4	.20	2	1	0-2
	175	5	4	.20	2	2	2-
SAUDE	177	6	4	.28	2	1	0-2
	177	6	4	.28	2	2	2-5
WAUKEE	178	6	4	.24	2	1	0-2
	178	6	4	.24	2	2	2-5
KLINGER	184	2	4	.32	2	1	1-3
FLOYD	198	3	4	.24	2	2	1-4
ROCKTON	213	/	/	/	/	/	/
PALMS	221	/	/	/	/	/	/
LAWLER	225	6	4	.28	2	1	0-2
	226	/	/	/	/	/	/
FLAGLER	284	6	4	.20	2	1	0-2
	284	6	4	.20	2	2	2-5
DELLS	290	/	/	/	/	/	/
LOAMY-ALLLUVIAL	315	6	1	--	--	1	--
MARSH	354	/	/	/	/	/	/

Table 3. Continued.

SOIL SERIES	SOIL SERIES CODE	SOIL ASSOCIATION*	ORIGINAL VEGETATION**	K VALUE	PERMEABILITY IN./HR.***	SLOPE CODE	% SLOPE
DINSDALE	377	2	4	.32	2	2	2-5
	377	2	4	.32	2	3	5-9
MAXFIELD	382	2	2	--	1	1	0-2
CLYDE-FLOYD	391	3	2	--	2	2	1-4
TRIPOLI	398	4	2	--	2	1	0-2
READLYN	399	4	4	.24	2	1	1-3
OLIN	408	5	4	.20	2	2	2-5
	408	5	4	.20	2	3	5-9
SOGN	412	/	/	/	/	/	/
AREDALE	426	5	4	.28	2	2	2-5
	426	5	4	.28	2	3	5-9
ORAN	471	6	3	.28	2	1	1-3
SPILLVILLE	485	6	4	.28	2	1	0-2
SPILLVILLE PART	585	6	4	.28	2	1	0-2
KOSZTA	688	?	3	--	2	1	0-2
HAYFIELD	725	5	3	--	2	1	0-2
HAYFIELD	726	5	3	--	2	1	0-2
FRANKLIN	761	/	/	/	/	/	/
WAUBEEK	771	6	3	.32	2	2	2-5
LILAH	776	6	3	.20	3	3	2-9
WAPSI	777	6	3	.28	2	1	1-3
DONNAN	782	2	1	.28	2	2	2-5
PROTIVIN	798	/	/	/	/	/	/
BERTRAM	809	/	/	/	/	/	/
SAWMILL	933	7	2	--	2	1	0-2

* The soil association code numbers correspond to soil association names as follows: 1 = Tama-Muscatine-Garwin, 2 = Dinsdale-Klinger-Maxfield, 3 = Kenyon-Clyde-Floyd, 4 = Readlyn-Tripoli, 5 = Sparta-Olin-Dickinson, 6 = Loamy alluvial land, channeled-Saude-Flagler, 7 = Marshan-Sawmill-Bremer.

** Original vegetation code numbers are interpeted as follows: 1 = Forest, 2 = Wetland, 3 = Savanna, 4 = Prairie.

*** Permeability values were converted to a scale of 1 through 3 as follows: 1 = 0.20 to 0.60 in/hr, 2 = 0.20-6.00 in/hr, 3 = > 6.00 in/hr

/ Soil associations not occurring in either encounters one or two, and therefore not considered in the Chi-Square analysis.

per one tenth mile sample. The second occurrence is referred to as encounter 2.

Topography

Topography affects drainage, soil moisture holding capacity, land use, erosion, and, consequently, the type of plant community present in an area.

The topographic parameter of slope (see Table 3) was obtained for each soil type as listed in the Soil Survey of Black Hawk County (Fouts and Highland 1978). The slope ranges were coded from 1 through 5 as indicated in Table 3, although not all soil series have 5 soil slope categories. In addition, slope does not consider topographic changes due to human manipulation. Soil type and slope information was recorded for each 0.1 mile and was obtained from detailed maps of soils at a scale of 4" per mile taken from the Black Hawk County Soil Survey (Fouts and Highland 1978).

Soil Moisture

The amount of moisture available to the roots of plants is dependent on many factors including the soil texture, depth of the soil, composition of the subsoil, topography, drainage patterns, and amount of rainfall. Soil permeability was the parameter used to indicate moisture availability (see Table 3). Permeability was defined by Fouts and Highland (1978) as "the quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil." This study considered only the permeability of the surface layer of each soil series. This decision was based on the assumption that the surface layer would be the most important characteristic affecting the establishment of vegetation. The soil permeability values were estimated from tests of the rate of vertical movement of water through water saturated soil, and are based on relationships among soil characteristics such as structure, porosity, and texture. These values were converted to a scale of 1 through 3 as follows: 1 = 0.20-0.60 in/hr, 2 = 0.20-6.00 in/hr, 3 = > 6 in/hr.

Adjacent Land Use

Three categories of adjacent land use included: residential areas, agricultural areas, and potential native seed sources. Adjacent land use was determined by driving on the roads of the study site and recording land use per 0.1 of a mile. Residential use included rural home or farm sites. The agricultural land category specifically designated crop production, and the native seed source category refers to land possessing a large component of native prairie, wetland or woodland vegetation, but does not necessarily meet a strict criteria of land defined as natural. This category included pastures, cemeteries, railroad rights-of-way, areas managed for wildlife, abandoned areas, and greenbelts along rivers, streams, and intermittent streams.

Disturbance

Frequency and severity of disturbance affects the kind of plant community along roadsides. Disturbances to roadsides are commonly caused by road reconstruction and resurfacing, dredging, drainage tile installation, trash disposal, erosion, pesticide application and pesticide drift from agricultural fields, burning, and mowing (see Chapter 1). Because no formal records of any of these activities and events are consistently kept, the disturbance factor was inferred from information about adjacent land use and erodibility (K) values. Soil erosion causes a major disturbance to roadsides, shifting vegetation to an earlier successional stage and resulting in siltation of the ditches that can require dredging to improve drainage.

Factors affecting erosion include land use, type of vegetation present, slope, soil texture, and rainstorm characteristics (Wischmeier and Smith 1978). Soil erodibility factor K, is commonly used by soil scientists to indicate soil erosion potential from water, and results from an equation that considers all of the above influences on soil erosion (Fouts and Highland 1978, Wischmeier and Smith 1978). K-values are calculated using particle size, percent organic matter, the soil-structure code used in soil classification, and the profile-permeability class for soils containing less than 70% silt and very fine sand. K-values exist for all of the major soil types in Black Hawk County (Fouts and Highland 1978), and were used as a partial indicator of potential soil disturbance in county roadsides. These values range from 0.10 to 0.64 and are listed for each soil series in Table 3. A higher number indicates greater erosive potential.

Original Vegetation by Soil Type

The original vegetation for each soil type was obtained from Fouts and Highland (1978) so that the vegetation that the soil was formed under could be compared with the occurrence of prairie vegetation in roadsides. The four broad categories of original vegetation included: prairie, savanna, wetland, and woodland. The soils in Black Hawk County, and their associated native vegetation are arranged by division in Table 4.

Statistical Analysis

The characteristics of roadsides chosen as parameters in this study were statistically compared to estimated cover values of prairie vegetation from the Black Hawk County Roadside Vegetation Survey using Chi-Square analyses. Because 0.1 mile of roadside often has more than one land use, soil type, slope designation, original vegetation

Table 4. Original vegetation under which soils of Black Hawk County, Iowa were formed (Fouts and Highland, Soil Survey of Black Hawk County, Iowa. United States Dept. of Agriculture, Soil Conservation Service 1978).

GENERAL VEGETATION CATEGORY	ORIGINAL VEGETATION	SOIL SERIES
Prairie	Prairie grasses	Aredale * Bertram Dickinson * Dinsdale * Floyd * Kenyon * Muscatine * Nevin Olin * Saudee * Sparta * Spillville * Tama * Waukee * Wiota Clyde-Floyd complex
	Mixed prairie grasses	Flagler * Klinger * Lawler * Protivin Readlyn * Rockton Sogn
	Drought-tolerant vegetation	Finchford *
	Tall prairie grasses	Bremer
Savanna	Mixed prairie grasses and trees	Bassett * Dells Hayfield * Oran * Wapsi *

Table 4. Continued.

GENERAL VEGETATION CATEGORY	ORIGINAL VEGETATION	SOIL SERIES
	Trees and prairie grasses	Franklin Koszta* Lilah * Waubeek *
WETLAND	Water-tolerant prairie grasses and sedges	Colo * Colo-Ely complex * Sawmill * Zook
	Prairie grasses and sedges	Bremer variant Clyde * Garwin * Maxfield *
	Mixed prairie grasses and water tolerant plants	Tripoli *
	Prairie grasses, sedges and other water-tolerant plants	Coland * Marshan * Palms muck
	Cattails, rushes, sedges and other water-tolerant plants	Marsh
Woodland	Trees	Chelsea * Donnon * Lamont *
	Mixed grasses, brush and generally low quality timber	Loamy alluvial *

The original vegetation of loamy escarpments are undetermined, did not occur in the study site, and were therefore excluded from this table.
* Indicates soil series located in this study area.

designation, erodibility value or permeability value, and because Chi-Square analysis does not permit analysis of consecutive cases within a category simultaneously, more than one Chi-Square analysis was often performed per parameter. For example, 0.1 mile of land adjacent to a roadside could have 3 different land uses. Chi-Square analysis requires that these cases be examined individually, and therefore, in this case, three Chi-Square analyses would be necessary. To simplify the language describing multiple Chi-Square analyses, for each parameter studied, the first datum recorded in 0.1 mi. when collecting data from west to east will be referred to as "encounter 1", and the second datum recorded in the same 0.1 mi. will be referred to as "encounter 2". Because the method of sampling was general, the results are imprecise and the level of probability for statistical significance was set at 0.1. Chi-Square analysis, used to test the significance of each parameter with cover categories, was conducted only on encounters 1 and 2.

CHAPTER 3

RESULTS

Within the roadsides sampled in this study, all vegetation cover categories were represented, although most samples contained no prairie vegetation. Of the 494 samples taken, there were 220 samples in cover category 1 (0%), 111 samples in cover category 2 (5-15%), 102 samples in cover category 3 (16-49%), and 61 samples in cover category 4 (50-100%). This is an approximate 4:2:2:1 ratio in decreasing order from cover category 1 through 4. In other words, cover category 1 with no prairie cover occurred 4 times more often than category 4 with 50-100% prairie cover. Cover categories 2 and 3 occurred twice as often as cover category 4.

Road age, road type, soil association, slope, permeability, adjacent land use, erodibility, and original vegetation are characteristics of roadsides that could be associated with amount of prairie vegetation in roadsides. To test their association, each cover category and factor was statistically analyzed. Missing data resulted in less than 494 samples in some of the data analysed. This occurred because some data was not available, or because in some cases, encounter 2 (a second data set for any given parameter that occurred within a tenth mile sample) did not exist. Only road age, road type, and soil association provided significant relationships. Slope was significantly related to cover categories in encounter 2, but not in encounter 1. No significance was found in the relationships between cover and permeability, erodibility, original vegetation, or adjacent land use.

Factors Significantly Related to Selected Prairie Cover

Road Age

Road age was significantly related (p = 0.0005) to the percent cover of prairie vegetation. The samples used for this Chi-square analysis are listed in Table 5, and a histogram showing the percentage of samples in each cover category relative to the total in individual

Table 5. Relationship of prairie vegetation cover category samples to road age.

Road Age, Years Before Present**	Percentage Categories of Prairie Vegetation Cover*				Total
	1	2	3	4	
0-10	2	1	1	0	4
11-21	20	8	1	0	29
21-30	73	37	26	15	151
31-40	88	40	47	25	200
41-50	18	11	15	7	51
>50	5	5	9	11	30
Total	206	102	99	58	465

* 1 = 0% cover; 2 = 5-15% cover; 3 = 16-49% cover; 4 = 50-100% cover.

** Recorded in the Black Hawk County Engineer's Office (Donahue 1988, Edgar 1987).

road age categories is shown in Figure 8. In roadsides adjacent to roads that were 20 years old or younger, 67% of the samples had no prairie vegetation, and prairie vegetation that did occur was in cover categories 2 or 3. A total of 75.4% of the samples occurred in roadsides adjacent to roads that were between 21 and 40 years old. Of the total samples in roadsides adjacent to roads that were 21-30 years old, 51.6% contained prairie vegetation, and of the samples adjacent to roads that were 31-40 years old 56% contained prairie vegetation. In these age categories, 24% and 20% occurred respectively in vegetation cover category 2, and 17% and 23% occurred respectively in cover category 3. Roadsides adjacent to roads older than 41 years old had fewer samples in cover category 1 than younger roads. Samples in roadsides along roads more than 50 years old had the highest percentage of prairie vegetation (37%) in cover category 4.

Road Type

A significant relationship existed between road type and vegetative cover category (p = 0.0935). The samples used for Chi-square analysis are listed in Table 6, and a histogram showing the percentage of samples in each cover category relative to the total in individual road surface type categories is shown in Figure 9. Samples along both paved and gravel roads frequently exhibited no prairie vegetation; cover category 1 comprised 44.5% of the total samples. Cover category 4 occurred the least (12.3%) along all types of roads. Relatively, categories 1 and 2 occurred more frequently along paved roads, whereas category 3 and 4 occurred more frequently along gravel roads.

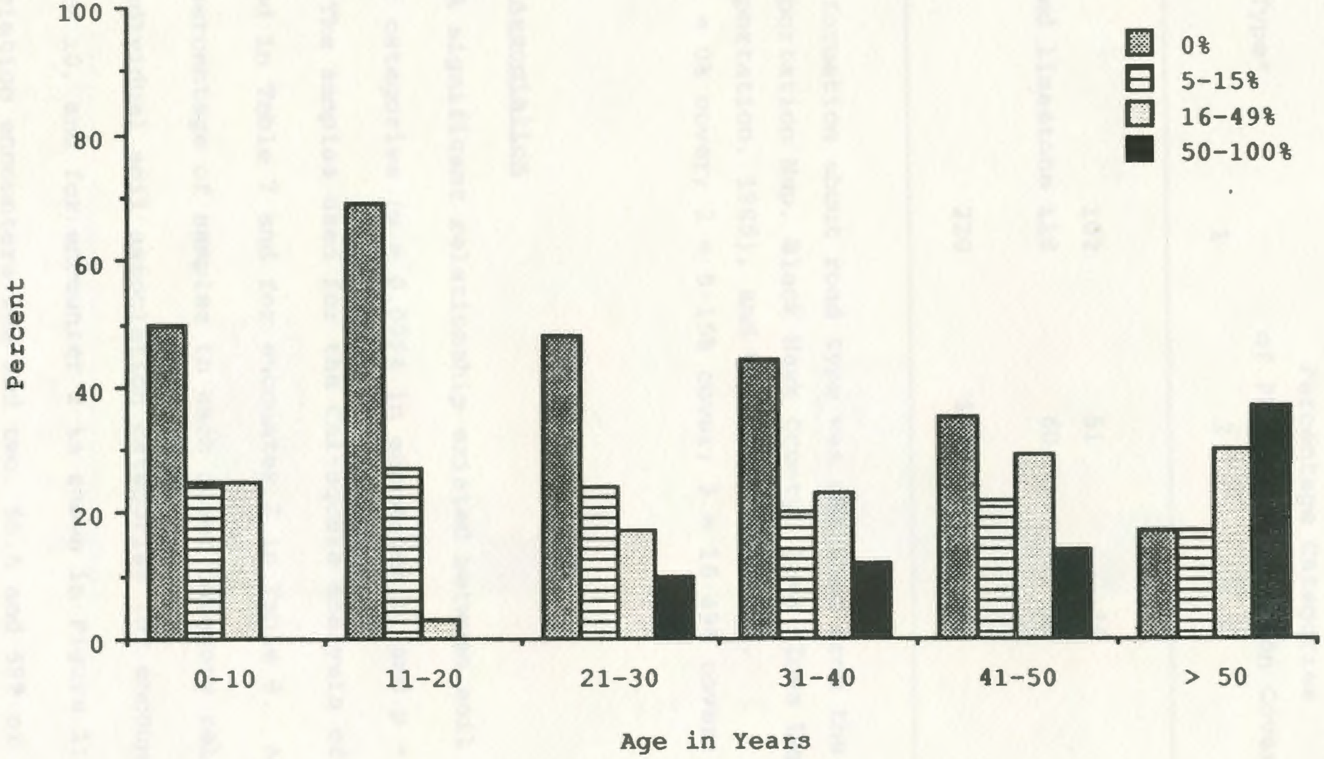

Figure 8. Relative frequency of vegetation cover samples per road age category. Road age information was recorded in the Black Hawk County Engineer's Office (Donahue 1988, Edgar 1987).

Table 6. Relationship of prairie vegetation cover category samples to road type.

Road Type*	Percentage Categories of Prairie Vegetation Cover** 1	2	3	4	Total
Paved	102	51	36	20	209
Crushed limestone	118	60	66	41	285
Total	220	111	102	61	494

* Information about road type was obtained from the General Highway and Transportation Map, Black Hawk County, Iowa (Iowa Department of Transportation, 1985), and was field verified.

** 1 = 0% cover; 2 = 5-15% cover; 3 = 16-49% cover; 4 = 50-100% cover.

Soil Association

A significant relationship existed between soil association and cover categories ($p = 0.0294$ in encounter 1, and $p = 0.0433$ in encounter 2). The samples used for the Chi-square analysis of encounter 1 are listed in Table 7 and for encounter 2 in Table 8. A histogram showing the percentage of samples in each cover category relative to the total in individual soil association categories for encounter 1 is shown in Figure 10, and for encounter 2 is shown in Figure 11. In soil association encounters one and two, 55.5 and 59% of all data respectively, contained prairie vegetation. When numbers of samples from encounters 1 and 2 were combined (see Figure 12), R-T soil

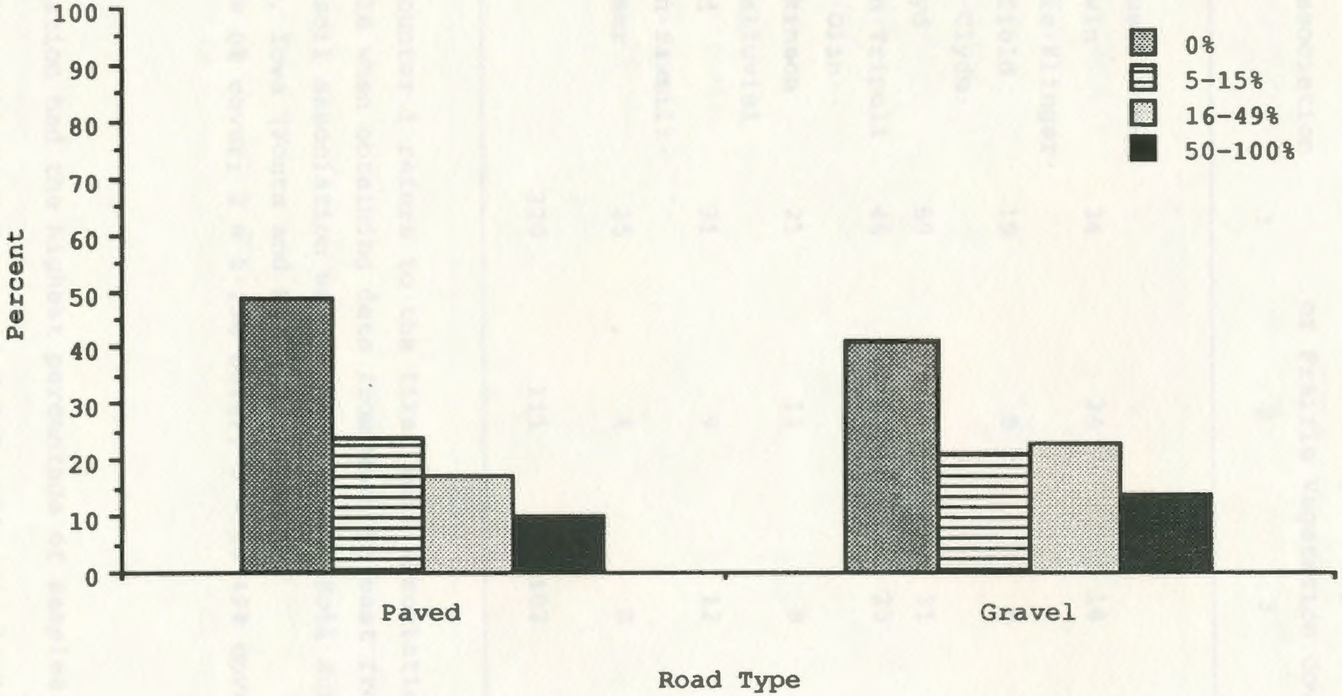

Figure 9. Relative frequency of vegetation cover samples per road surface type category. Information about road type was obtained from the General Highway and Transportation Map, Black Hawk County, Iowa (Iowa Department of Transportation, 1985), and was field verified.

Table 7. Relationship of prairie vegetation cover category samples to soil association, encounter 1*.

Soil Association	Percentage Categories of Prairie Vegetation Cover**				Total
	1	2	3	4	
Tama-Muscatine-Garwin	34	24	14	8	80
Dinsdale-Klinger-Maxfield	15	8	6	3	32
Kenyon-Clyde-Floyd	50	35	31	16	132
Readlyn-Tripoli	44	20	23	25	112
Sparta-Olin-Dickinson	21	11	8	5	45
Loamy alluvial land	31	9	12	2	54
Marshan-Sawmill-Bremer	25	4	8	2	39
Total	220	111	102	61	494

* Encounter 1 refers to the first soil association data collected per 0.1 mile when obtaining data from west to east from a map. Information about soil association was taken from the Soil Survey of Black Hawk County, Iowa (Fouts and Highland 1978).

** 1 = 0% cover; 2 = 5-15% cover; 3 = 16-49% cover; 4 = 50-100% cover.

association had the highest percentage of samples in category 4 (28%). The K-C-F, T-M-G, D-K-M, and S-O-D soil associations all had 12% or 13% of total samples occurring in cover category 4. The soil associations

Table 8. Relationship of prairie vegetation cover category samples to soil association, encounter 2*.

Soil Association	Percentage Categories of Prairie Vegetation Cover**				Total
	1	2	3	4	
Tama-Muscatine-Garwin	12	16	9	7	44
Dinsdale-Klinger-Maxfield	8	4	2	3	17
Kenyon-Clyde-Floyd	23	15	23	11	72
Readlyn-Tripoli	20	19	14	9	62
Sparta-Olin-Dickinson	23	7	5	6	41
Loamy alluvial land	18	4	6	1	29
Marshan-Sawmill-Bremer	13	3	5	1	22
Total	117	68	64	38	287

* Encounter 2 refers to the second soil association data collected per 0.1 mile when obtaining data from west to east from a map. Information about soil associations was taken from the Soil Survey of Black Hawk County, Iowa (Fouts and Highland 1978).

** 1 = 0% cover; 2 = 5-15% cover; 3 = 16-49% cover; 4 = 50-100% cover.

with the lowest proportion of samples in category 4 were the La-S-F soil associations, with 4% and 5% respectively of the total samples in cover

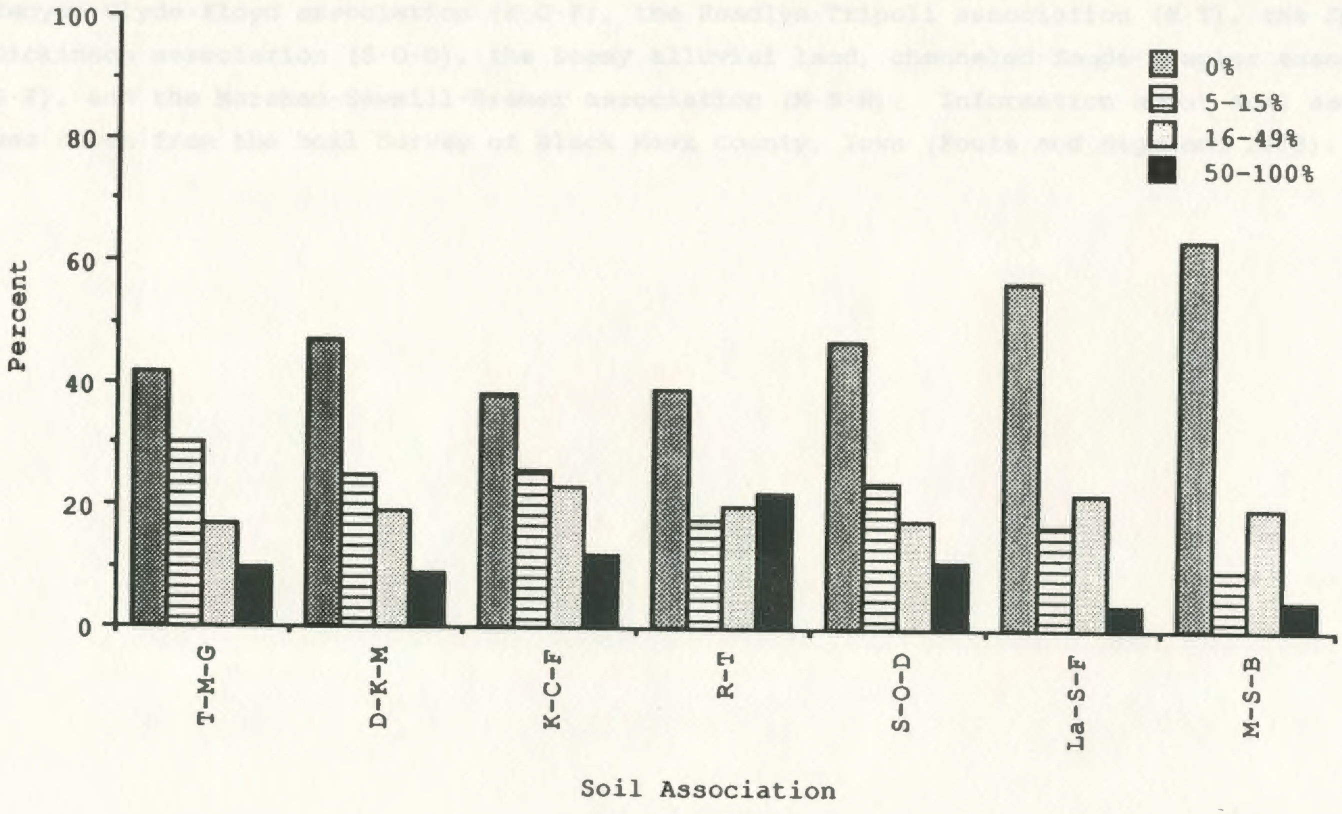

Figure 10. Relative frequency of vegetation cover samples per soil association category for encounter 1. Encounter 1 refers to the first soil association data collected per 0.1 mile. The seven soil associations that occur in Black Hawk County are abbreviated as follows: Tama-

Muscatine-Garwin association (T-M-G), the Dinsdale-Klinger-Maxfield association (D-M-K), the Kenyon-Clyde-Floyd association (K-C-F), the Readlyn-Tripoli association (R-T), the Sparta-Olin-Dickinson association (S-O-D), the Loamy alluvial land, channeled-Saude-Flagler association (La-S-F), and the Marshan-Sawmill-Bremer association (M-S-B). Information about soil association was taken from the Soil Survey of Black Hawk County, Iowa (Fouts and Highland 1978).

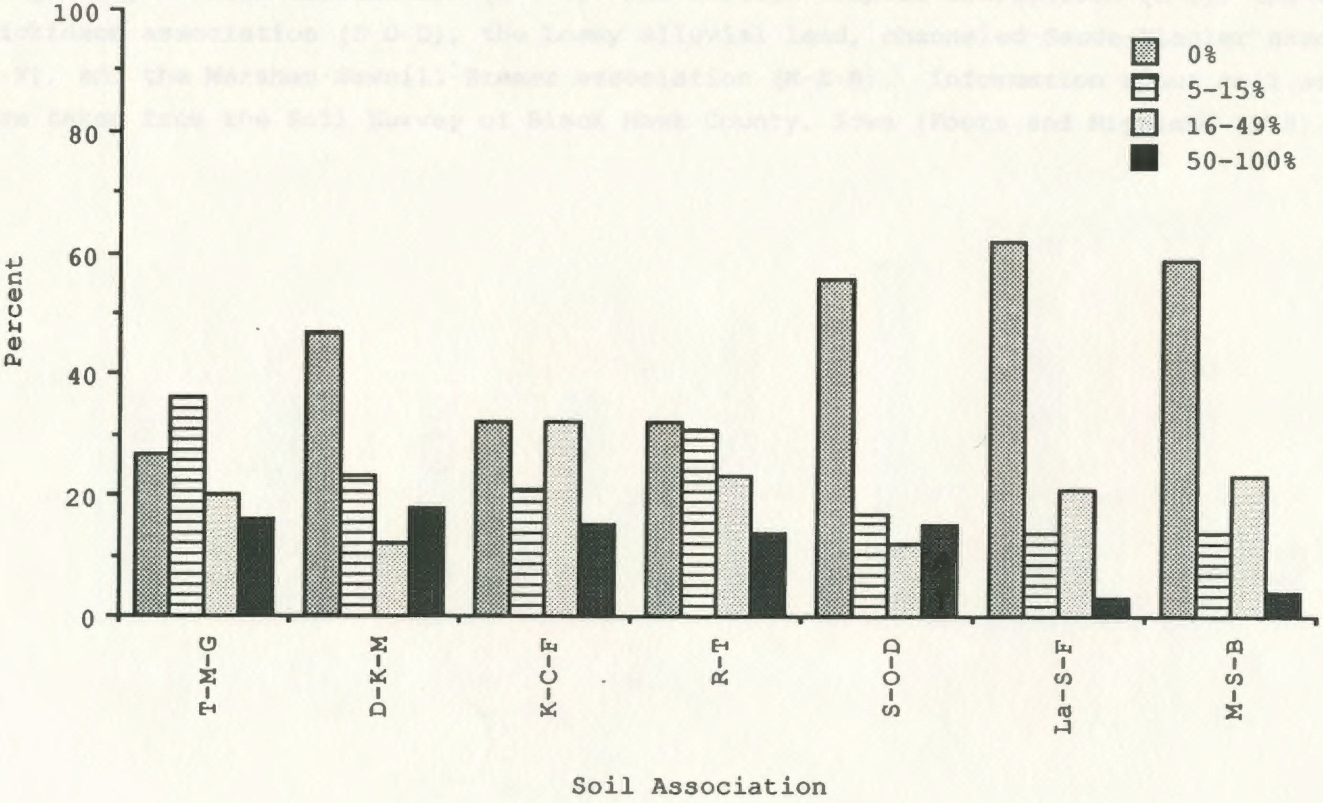

Figure 11. Relative frequency of vegetation cover samples per soil association category for encounter 2. Encounter 2 refers to the second soil association data collected per 0.1 mile. The seven soil associations that occur in Black Hawk County are abbreviated as follows: Tama-

Muscatine-Garwin association (T-M-G), the Dinsdale-Klinger-Maxfield association (D-M-K), the Kenyon-Clyde-Floyd association (K-C-F), the Readlyn-Tripoli association (R-T), the Sparta-Olin-Dickinson association (S-O-D), the Loamy alluvial land, channeled-Saude-Flagler association (La-S-F), and the Marshan-Sawmill-Bremer association (M-S-B). Information about soil association was taken from the Soil Survey of Black Hawk County, Iowa (Fouts and Highland 1978).

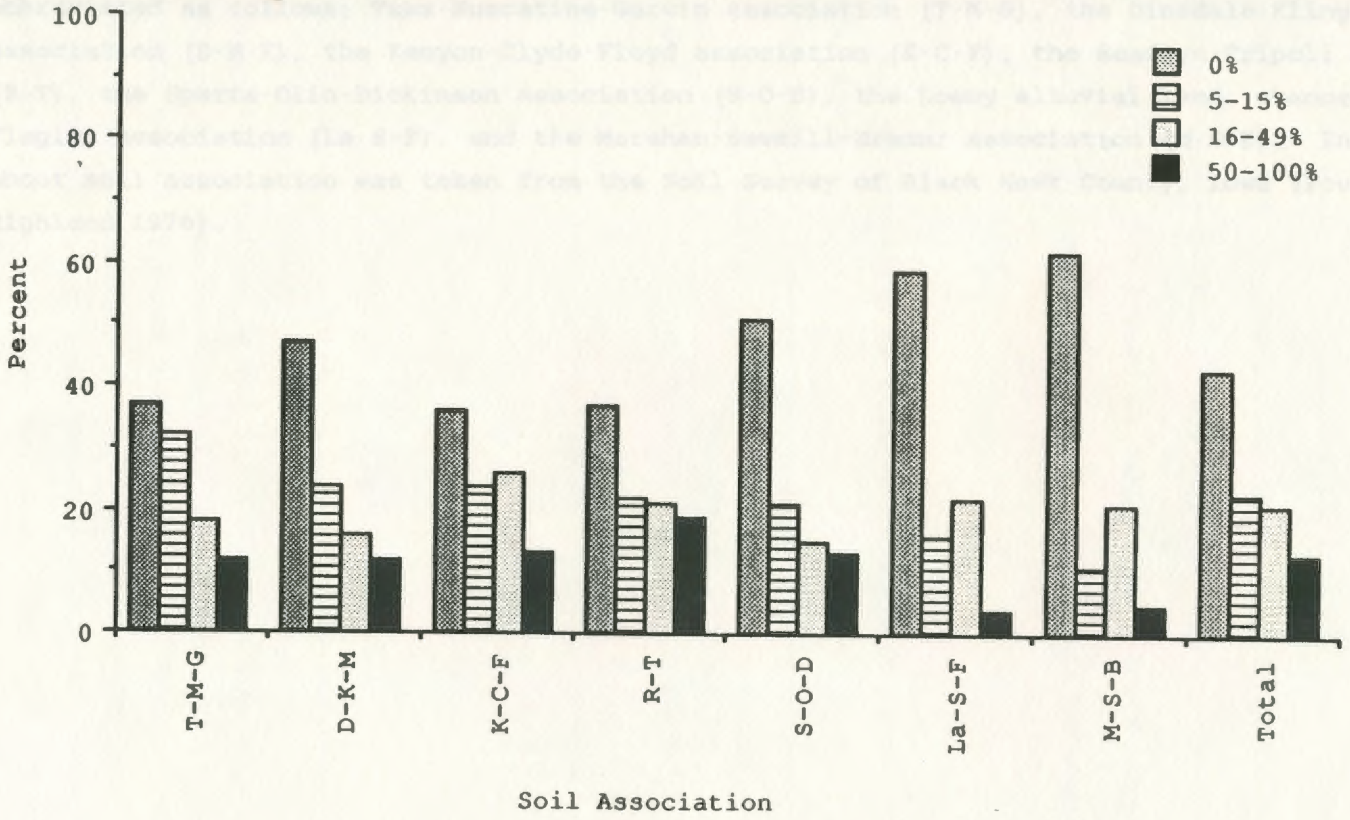

Figure 12. Relative frequency of vegetation cover samples per soil association category for the combined data from encounters 1 and 2. Encounter 1 refers to the first soil association data collected per 0.1 mile, and encounter 2 refers to the second soil association data

collected per 0.1 mile. The seven soil associations that occur in Black Hawk County are abbreviated as follows: Tama-Muscatine-Garwin association (T-M-G), the Dinsdale-Klinger-Maxfield association (D-M-K), the Kenyon-Clyde-Floyd association (K-C-F), the Readlyn-Tripoli association (R-T), the Sparta-Olin-Dickinson association (S-O-D), the Loamy alluvial land, channeled-Saude-Flagler association (La-S-F), and the Marshan-Sawmill-Bremer association (M-S-B). Information about soil association was taken from the Soil Survey of Black Hawk County, Iowa (Fouts and Highland 1978).

category 4. Of the 7 soil associations, the M-S-B soil association had the highest percentage of samples occurring in cover category 1.

Slope

Slope was not significantly related to cover categories in encounter 1, but was significantly related to cover categories in encounter 2 (p = 0.0640). The samples used in the Chi-square analysis for encounter 1 are listed in Table 9, and for encounter 2 are listed in Table 10. A histogram showing the percentage of samples in each cover

Table 9. Relationship of prairie vegetation cover category samples to slope, encounter 1*.

Slope**	Percentage Categories of Prairie Vegetation Cover***				Total
	1	2	3	4	
A	128	65	60	32	285
B-F	92	46	42	29	209
Total	220	111	102	61	494

* Encounter 1 refers to the first slope sample made per 0.1 mile when obtaining data from west to east from a map. Slope is associated with the soil series of Black Hawk County, Iowa (Fouts and Highland 1978).

** Slope categories are those of Fouts and Highland (1978) and are relative to individual soil series. Slope "A" indicates the lowest slope class per soil series and usually is of 0-2 % slope. Slopes "B-F" indicate slopes greater than slope "A" and do not exceed 18 % slope.

*** 1 = 0% cover; 2 = 5-15% cover; 3 = 16-49% cover; 4 = 50-100% cover.

Table 10. Relationship of prairie vegetation cover category samples to slope, encounter 2*.

Slope**	Percentage Categories of Prairie Vegetation Cover*** 1	2	3	4	Total
A	68	39	31	13	151
B-F	48	29	33	24	134
Total	116	68	64	37	285

* Encounter 2 refers to the second slope sample made per 0.1 mile when obtaining data from west to east from a map. Slope is associated with the soil series of Black Hawk County, Iowa (Fouts and Highland 1978).

** Slope categories are those of Fouts and Highland (1978) and are relative to individual soil series. Slope "A" indicates the lowest slope class per soil series and usually is of 0-2 % slope. Slopes "B-F" indicate slopes greater than slope "A" and do not exceed 18 % slope.

*** 1 = 0% cover; 2 = 5-15% cover; 3 = 16-49% cover; 4 = 50-100% cover.

category relative to the total in individual slope categories for encounter 1 is shown in Figure 13, and for encounter 2 is shown in Figure 14. In slope encounters 1 and 2, all slope categories had a higher frequency of samples (45%) in cover category 1, fewer samples (20-26%) in cover categories 2 and 3, and fewest samples (9-18%) in cover category 4. In encounter 2, 65% of the samples in the steeper slope category contained prairie vegetation, but in the nearly level slope category, 55% of the samples contained prairie vegetation. The 50-100% cover category contained 9% of the total samples in the nearly

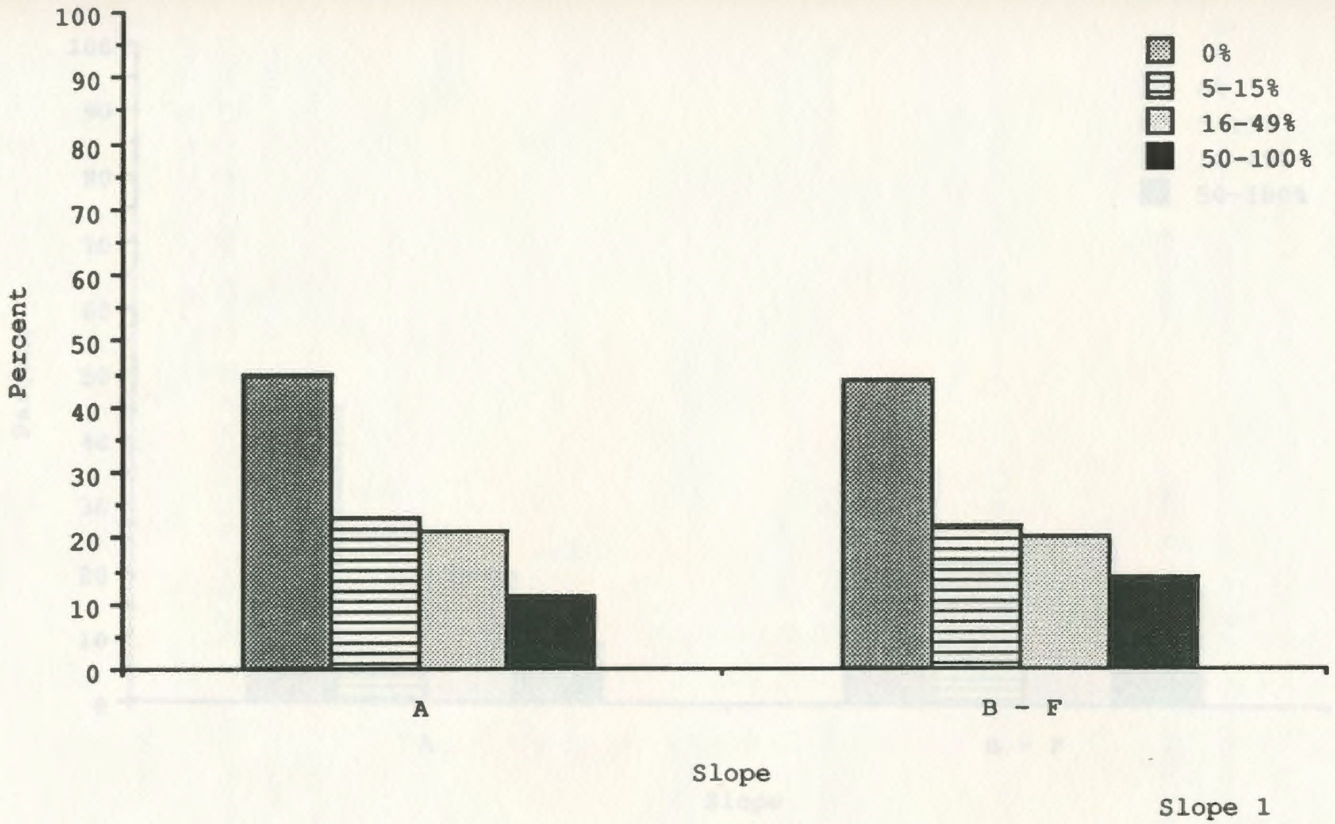

Figure 13. Relative frequency of vegetation cover samples per slope category for encounter 1. Encounter 1 refers to the first slope data collected per 0.1 mile. Slope categories are those of Fouts and Highland (1978) and are relative to individual soil series. Slope "A" indicates the lowest slope class per soil series and usually is of 0-2% slope. Slopes "B - F" indicate slopes greater than slope "A" and do not exceed 18% slope.

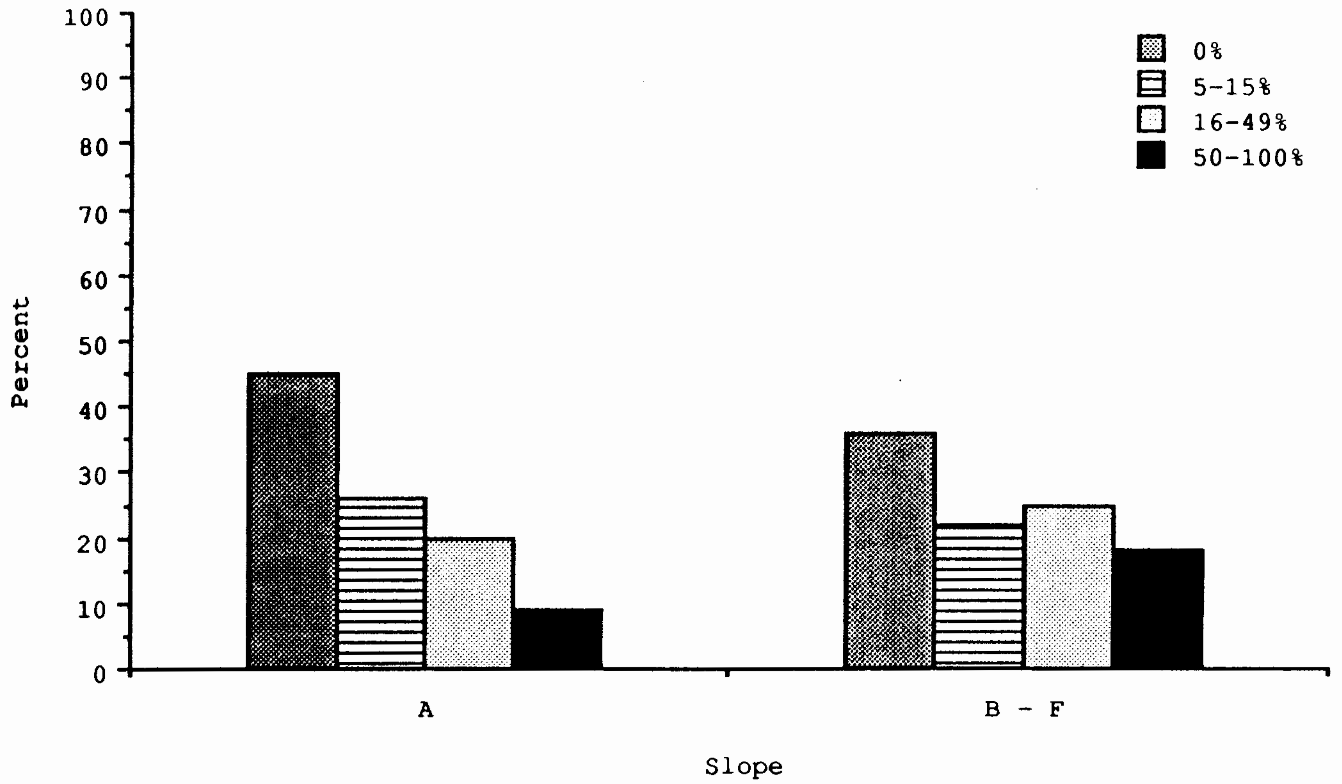

Figure 14. Relative frequency of vegetation cover samples per slope category for encounter 2. Encounter 2 refers to the second slope data collected per 0.1 mile. Slope categories are those of Fouts and Highland (1978) and are relative to individual soil series. Slope "A" indicates the lowest slope class per soil series and usually is of 0-2% slope. Slopes "B - F" indicate slopes greater than slope "A" and do not exceed 18% slope.

level slope category in contrast to 18% of the total samples in the same cover category in the steeper slope category.

Factors not Significantly Relationed to Selected Prairie Cover

Soil Permeability

The samples used in the Chi-square analysis of the relationship between soil permeability and cover for encounter 1 are listed in Table 11, and for encounter 2 in Table 12. Most samples containing prairie

Table 11. Relationship of prairie vegetation cover category samples to permeability, encounter 1*.

Permeability inches/hour	Percentage Categories of Prairie Vegetation Cover**				Total
	1	2	3	4	
0.2-0.6	20	11	6	2	39
0.2-6.0	175	89	88	55	407
>6.0	19	7	5	3	34
Total	214	107	99	60	480

* Encounter 1 refers to the first permeability sample made per 0.1 mile when obtaining data from west to east from a map. Permeability values are associated with the soil series of Black Hawk County, Iowa (Fouts and Highland 1978).

** 1 = 0% cover; 2 = 5-15% cover; 3 = 16-49% cover; 4 = 50-100% cover.

Table 12. Relationship of prairie vegetation cover category samples to permeability, encounter 2*.

Permeability inches/hour	Percentage Categories of Prairie Vegetation Cover** 1	2	3	4	Total
0.2-0.6	10	6	7	2	25
0.2-6.0	87	55	53	35	230
>6.0	18	4	4	1	27
Total	115	65	64	38	282

* Encounter 2 refers to the second permeability sample made per 0.1 mile when obtaining data from west to east from a map. Permeability values are associated with the soil series of Black Hawk County, Iowa (Fouts and Highland 1978).

** 1 = 0% cover; 2 = 5-15% cover; 3 = 16-49% cover; 4 = 50-100% cover.

vegetation were present in the medium permeability category (84.8% in encounter one and 81.6% in encounter two). No significance, however, was found between soil permeabilty and cover (p = 0.4980 for encounter 1, and p = 0.1105 for encounter 2).

Adjacent Land Use

No significance was found in the relationship between adjacent land use and prairie vegetation cover (p = 0.6759 in encounter 1, and p = 0.5304 in encounter 2). The samples of encounter 1 are listed in Table 13, and of encounter 2 in Table 14. A total of 44.6% of the samples in encounter 1 and 46.3% of the samples in encounter 2 occurred in cover category 1. A total of 43.2% and 42.5% of all samples in encounters 1

Table 13. Relationship of prairie vegetation cover category samples to adjacent land use, encounter 1*.

Adjacent Land Use	Percentage Categories of Prairie Vegetation Cover** 1	2	3	4	Total
Residential	27	10	7	4	48
Agricultural	178	91	85	51	405
Miscellaneous	15	10	10	5	40
Total	220	111	102	60	493

* Encounter 1 refers to the first adjacent land use sample made per 0.1 mile when traveling from west to east.
** 1 = 0% cover; 2 = 5-15% cover; 3 = 16-49% cover; 4 = 50-100% cover.

and 2 respectively occurred in cover categories 2 and 3. The lowest percentage of total samples in both encounters 1 and 2 occurred in cover category 4, with 12.2% and 0% of the total samples, respectively, containing 50-100% prairie vegetation.

Erodibility

Erodibility was not significantly related to cover categories. The samples for encounter 1 are listed in Table 15, and for encounter 2 in Table 16. Data for frequency indicated that in encounters 1 and 2 respectively, 48% and 39% of all samples occurred in cover category 1. In encounters 1 and 2 respectively, 20% and 23.5% of all erodibility samples occupied cover categories 2 and 3, and 12% and 14% of the

Table 14. Relationship of prairie vegetation cover category samples to adjacent land use, encounter 2*.

Adjacent Land Use	Percentage Categories of Prairie Vegetation Cover**				Total
	1	2	3	4	
Residential	18	4	6	2	30
Agricultural	21	8	9	5	43
Miscellaneous	11	9	10	5	35
Total	50	21	25	12	108

* Encounter 2 refers to the second adjacent land use sample made per 0.1 mile when traveling from west to east.

** 1 = 0% cover; 2 = 5-15% cover; 3 = 16-49% cover; 4 = 50-100% cover.

erodibility samples occurred in the maximum cover category, or cover category 4.

Original Vegetation

The most frequently occurring original vegetation type in the study area was prairie vegetation, comprising 52.4% and 56.3% of the total samples in encounters one and two respectively. The second most abundant original vegetation type was wetland, followed by savanna and then woodland. No significance was found in the relationship between original vegetation and cover categories (p = 0.7565 in encounter 1, and p = 0.924 in encounter 2). Among the four original vegetation categories, the relative frequencies of samples were similar for each

Table 15. Relationship of prairie vegetation cover category samples to erodibility, encounter 1*.

Erodibility (Factor K)	Percentage Categories of Prairie Vegetation Cover**				Total
	1	2	3	4	
0.17-0.20	28	12	10	5	55
0.22-0.26	39	13	20	12	84
0.27-0.32	74	35	29	18	156
Total	141	60	59	35	295

* Encounter 1 refers to the first erodibility sample made per 0.1 mile when obtaining data from west to east from a map. K values are associated with the soil series of Black Hawk County, Iowa (Fouts and Highland 1978).

** 1 = 0% cover; 2 = 5-15% cover; 3 = 16-49% cover; 4 = 50-100% cover.

cover category. The observed number of samples used in the Chi-square analysis in encounter 1 is listed in Table 17, and for encounter 2 is listed in Table 18. The percentage of samples per original vegetation category ranged from 39-50% in cover category 1, from 0-26% in cover categories 2 and 3, and from 5-17% in cover category 4.

Table 16. Relationship of prairie vegetation cover category samples to erodibility, encounter 2*.

Erodibility (Factor K)	Percentage Categories of Prairie Vegetation Cover** 1	2	3	4	Total
0.17-0.20	28	10	7	7	52
0.22-0.26	15	13	15	5	48
0.27-0.32	29	20	21	13	82
Total	72	43	42	25	182

* Encounter 2 refers to the second erodibility sample made per 0.1 mile when obtaining data from west to east from a map. K values are associated with the soil series of Black Hawk County, Iowa (Fouts and Highland 1978).

** 1 = 0% cover; 2 = 5-15% cover; 3 = 16-49% cover; 4 = 50-100% cover.

Table 17. Relationship of prairie vegetation cover category samples to origin of soils through vegetation, encounter 1*.

Original Vegetation	Percentage Categories of Prairie Vegetation Cover**				Total
	1	2	3	4	
Woodland	9	4	5	1	19
Wetland	75	50	38	26	189
Savanna	13	4	6	4	27
Prairie	123	53	53	30	259
Total	220	111	102	61	494

* Encounter 1 refers to the initial original vegetation sample made per 0.1 mile when obtaining data from west to east from a map. Original vegetation data was summarized from information derived from the Soil Survey of Black Hawk County, Iowa (Fouts and Highland 1978).

** 1 = 0% cover; 2 = 5-15% cover; 3 = 16-49% cover; 4 = 50-100% cover.

Table 18. Relationship of prairie vegetation cover category samples to origin of soils through vegetation, encounter 2*.

Original Vegetation	Percentage Categories of Prairie Vegetation Cover** 1	2	3	4	Total
Woodland	4	1	0	1	6
Wetland	40	24	26	13	103
Savanna	8	3	3	2	16
Prairie	64	40	35	22	161
Total	116	68	64	38	286

* Encounter 2 refers to the second original vegetation data sample made per 0.1 mile when obtaining data from west to east from a map. Original vegetation data was summarized from information derived from the Soil Survey of Black Hawk County, Iowa (Fouts and Highland 1978).

** 1 = 0% cover; 2 = 5-15% cover; 3 = 16-49% cover; 4 = 50-100% cover.

CHAPTER 4

DISCUSSION

Persistence / Pioneers

Roadside prairie remnants are an essential aspect of an integrated roadside vegetation management program. This program emphasizes the use of prairie vegetation in roadsides to stabilize soil, to reduce noxious weed populations thereby reducing the need for pesticides, to increase wildlife habitat, to preserve Iowa's natural heritage, and potentially to reduce the long range costs of roadside maintenance. As of May, 1990, 19 counties in Iowa have hired roadside vegetation managers to implement such programs, and several other counties are interested in doing so (Ehley 1990). A primary step to implement an integrated roadside management program is to locate prairie remnants. A roadside manager can enlarge and enhance these remnants as examples of prairie restoration, and as prairie seed sources for additional prairie reconstruction. Several factors are known to affect the distribution and persistence of prairie vegetation, and the process of locating roadside prairie remnants should take these factors into consideration. Among the major factors affecting distribution of prairie vegetation are soil characteristics (Aikman 1930, Steiger 1930, Tolstead 1941, Costello 1944, Weaver 1954, Lindsey 1961, Lindsey et al. 1965, Curtis 1971, Crist and Glenn-Lewin 1978, Bacone and Harty 1981, Steiger 1981, Whitney 1982), topography (Steiger 1930, Weaver 1954, Lindsey 1961, Curtis 1971, Crist and Glen-Lewin 1978, Ode 1980, Whitney 1982), soil moisture (Steiger 1930, Costello 1944, Curtis 1971, Crist and Glen-Lewin 1978, Bacone and Harty 1981) disturbance (Curtis 1971), adjacent land use, and original vegetation that formed the soil (Steiger 1981, Reznicek 1983). In addition, certain plant interactions (Betz 1984) and animal plant interactions (Klatt and Getz 1978) have been noted in prairie communities.

The survival of roadside prairie remnants is related to such things as disturbance during road construction, the persistence of species, roadside management techniques, and the affects of adjacent land use. As early as 1925, Shimek noted the decrease in prairie vegetation due to management techniques used in roadsides. Often roadside vegetation is negatively impacted by repeated mowing, dredging, and herbicide application. Prior to 1987 in Black Hawk County, frequent mowing to a height of approximately three to four inches (Clark 1989) and intensive herbicide application (Haywood 1989) were common practices. These practices, in addition to the affects of pesticide drift and erosion typically associated with agricultural use of adjacent land, are severely stressful or lethal to native plant populations (Costello 1944, Curtis 1971, Fouts and Highland 1978).

To expedite the work of the roadside manager, the aquisition of practical information to implement a roadside program is important. Information that relates prairie vegetation to physical factors in roadsides could help roadside managers identify and restore existing prairie remnants. This information should be readily available in existing sources. Factors important to the existance of prairie vegetation could include soil permeability (an indicator of soil moisture and drainage), slope (an indicator of drainage and to some degree, moisture), and erodibility of adjacent land (K-value can be used as an indicator of potential disturbance due to erosion and subsequent dredging) which can be secured from a county soil survey (see Chapters 1 and 2). Age and type of road surface information is available from the county engineer, adjacent land use information can be obtained from the United States Department of Agriculture Soil Conservation Service, and original vegetation can be determined from original land surveyor's maps or from county soil surveys.

In this study, factors that were expected to be significantly related to the presence of prairie vegetation in roadsides were older roads, soil associations that are nutrient poor or have drainage extremes, gravel road surfacing, steeper slopes, extremes of soil permeability, higher soil erosion potentials, adjacent land that contains prairie seed sources, and soils that originally supported prairie vegetation.

Characteristics of roadsides or of the data could affect the relationship that factors analysed in this study have to cover of prairie vegetation. Although these characteristics could apply to several of the factors analysed in this study, for simplification, they are usually detailed in only one portion of the discussion.

An example of a characteristic of the data that could affect the apparent significance of the relationship between physical factors in roadsides and prairie vegetation cover is the deletion of prairie cord grass cover data. Prairie cord grass is an important species in wet prairies, and the absence of data for this species probably affected the number of samples of prairie vegetation in the various cover categories.

If included, it would be expected that fewer samples would occur in cover category 1 and that the number of samples in all other cover categories would increase, especially in categories 3 and 4. Prairie cord grass was excluded from all categories so that the data would show changes in the somewhat less aggressive prairie species considered in this study.

[illegible]

It is also possible that results are influenced by ecological conditions that exist in roadsides but do not exist in high quality prairie remnants. Some prairie species or species associations could require specific mycorrhizal associations (Betz 1986), a critical preserve size or configuration (Diamond 1975). Perhaps, an association with specific prairie species during early prairie establishment (Betz 1986) is necessary to produce a stable native plant community. Possibly, this association is currently abscent. Perhaps the interaction of native and non-native species within the confines of narrow linear roadsides produces negative influences on the succession of roadsides to prairie vegetation.

Repeated disturbances due to roadside management techniques, flooding, or by adjacent land management could create a pattern of expansion of native vegetation during times of limited disturbances, followed by degradation or destruction of native populations associated with more intensive or more constant disturbance.

No ?

A factor or combination of factors influencing vegetation in some roadsides could preclude the existence of prairie in some areas. An example could be a roadside adjacent to a densely shaded woodland in a river valley that has been historically wooded. In addition, it is possible that certain aggressive, non-native species could successfully compete with prairie species for resources in a human altered landscape. These factors could permanently prevent the complete re-establishment of prairie communities in some portions of roadsides unless the landscape was drastically altered.

Perhaps the most important factor affecting the amount of prairie in roadsides is the availability of an adjacent source of prairie seeds. Because of the linear area of roadsides and because they are subject to numerous disturbances, including total destruction of existing vegetation, a source of seeds for recolonization of prairie is of paramount importance. Few such seed sources exist along roadsides, potentially causing a gradual deterioration of roadside prairie remnants through time, as they are for one reason or another, degraded or destroyed.

Factors Significantly Related to Selected Prairie Cover

The four factors that were significantly related to the occurrence of prairie vegetation in this study included road age, road type, soil association, and slope. Although these and many other of the factors analysed in this study interact, relative to the dispersal and density of roadside prairie vegetation, the factors are considered separately in the following discussion to clarify the individual contribution of each factor to the presence of roadside prairie vegetation.

Although no prior research is known to have been done to determine if roadsides along older roads or roads with gravel surfaces are more likely to support prairie vegetation than roadsides along younger or paved roads, it is reasonable to assume these hypotheses. Older roads were more likely to have been constructed when adjacent prairie remnants were more abundant. In addition, earlier road beds were constructed of earth and maintained by more primitive and less intensive methods of grading (Thompson 1989). Later construction and maintenance techniques were improved, and included better road drainage, gravel or paved surfacing, and such activities as dust suppression by application of crude oil (Thompson 1989). These later techniques would have more intensively disturbed the adjacent roadsides, and probably would have resulted in greater disturbance to roadside prairie vegetation.

Road Age

Road age was significantly related to the frequency of samples of prairie vegetation. The values in Figure 8 appear to indicate, as expected, that frequency of occurrence and density of prairie vegetation increase as a function of road age. The data for road age can lead to some interesting and reasonable conjectures. In all road age categories, the largest changes in relative frequency of samples containing prairie vegetation occurred in cover categories 1 and 4, with category 1 decreasing over time, and category 4 increasing over time. It appears that within the first two decades after a road is constructed, prairie vegetation occurs infrequently or is absent in roadsides, and the prairie vegetation that does exist is sparse (usually less than 16% of the total vegetation cover). Prairie vegetation gradually increases through time, and after 50 years, probably more than 84% of roadside area will contain prairie vegetation. Of those areas with prairie vegetation, approximately 44% will have densities of the native plants in the 50-100% cover categories.

It was expected that within the first decade after road construction, roadsides would contain less prairie vegetation than roadsides adjacent to roads more than 10 years old. Contrary to this expectation, the data indicates that the 0-10 year old road category contains 19% fewer samples in cover category 1 than the 11-20 year old road category. However, only four samples occurred in the 0-10 year old age road category, and the scanty data in this age category could have influenced the observed results. The two samples that occurred in the cover category 1, represented 50% of the total samples in road age category 0-10 years old. One sample occurred in category 2 and one in category 3, each representing 25% of the total samples per the 0-10 years old road age category. If more roads in the study had been of age 0-10 years old, the percentage of the total samples in cover category 1 would probably be greater than 69% (the percentage of the total occurrences of samples in roadsides adjacent to roads 11-20 years old). The percentage of the total samples that occurred in cover category 1 per road age category decreased consistently with increases in road age. In other words, the younger the roads, the greater the number of samples with no prairie vegetation.

In cover categories 2 and 3, the changes in relative frequencies of samples with increases in road age, were relatively subtle. The difference between the highest and the lowest percentage of total samples among all road age categories was 10% in cover category 2, and was 27% in cover category 3. In contrast, the difference between the highest and lowest percentage of total samples per road age category was 52% in cover category 1, and 37% in cover category 4. This phenomenon of change among cover categories over time probably occurs because after a catastrophic disturbance to vegetation there is a lag time until plant communities recover and stabilize.

The construction of a road is the genesis of a roadside, and if a prairie seed source is available, opportunity exists for re-establishment of prairie vegetation. Although the data is somewhat scanty, it is possible to construct a model for prairie re-establishment succession in roadsides. In the first two decades after road construction, prairie vegetation is apparently sparse. Estimates of cover of prairie vegetation as conducted in this study, however, could underestimate the actual percent cover or the frequency of prairie vegetation in roadsides. Plants are usually not apparent unless they produce flowers, seeds, or exhibit vegetative growth patterns characteristic of the species. It can take several years after seed germination until the species of prairie plants of interest are visible in a roadside. Visibility of the plants is dependent on environmental conditions such as the amount and timing of precipitation received, soil characteristics, management practices used in roadsides and on adjacent land, the kinds of species competing for resources in the roadside, and the distance to a prairie seed source. It is possible, therefore, for plants to be present, but not observed in roadsides.

In the third decade after road construction, the number of samples without prairie vegetation is nearly equal to the number of samples with prairie vegetation. This could represent a turning point in the kinds and relative amounts of species found in roadsides. This change is perhaps subsequently manifested in the fourth decade after road construction. During the third decade, prairie vegetation that was established in the first two decades has apparently begun to mature and produce seed, resulting in re-establishment of additional prairie vegetation in the roadsides. The amount of roadside that is occupied by 25-40% prairie vegetation cover sharply increases, and some of the samples are dominated by prairie vegetation. Meanwhile the number of samples in roadsides that have 5-15% cover of prairie vegetation has begun to decrease. In the fourth decade, prairie vegetation increases in frequency and in density. As the number of samples in cover categories 1 and 2 decrease, the number of samples in cover categories 3 and 4 increase.

In the fifth decade, many of the niches previously occupied by non-prairie species (and monocultures of prairie cord grass) could now be occupied by prairie vegetation (other than prairie cord grass). The most pronounced changes in vegetation in roadsides from the fourth decade to the fifth decade after road construction occur in cover categories 1 and 3. Cover category 3 undergoes a 6% increase, and at the same time, a 9% decrease occurs in the proportion of roadside without prairie vegetation. Possibly this represents another wave of maturation of prairie vegetation similar to the third decade after road construction. This change in the amount of prairie vegetation could also be the result of successional changes through time, reflecting increased diversity of prairie species. However, unless a nearby prairie seed source is available, this is unlikely.

Most of the change from the fifth to the sixth decade after road construction occurs is in the relative number of samples in cover categories 1 and 4, with the relative changes in cover categories 2 and

3 remaining relatively stable. In this decade, cover category 1 decreased by 18%, with a reciprocal increase in category 4 of 23%. Cover category 2 had a 5% decrease in number of cases in the sixth decade, and cover category 3 had a 1% increase of samples since the fifth decade. These numbers could indicate that in the sixth decade, the prairie community continues to mature, and reaches a second turning point in the composition of roadside vegetation. During this period, prairie vegetation occurs in most of the samples in roadsides, and samples with no prairie vegetation have decreased considerably. The relative amount of vegetation in cover categories 1 and 2 are equal, but the relative amount of vegetation increases from cover categories 2 through 4. Relatively more samples occurred in the 50-100% category than in any other cover category; this step pattern of data is nearly inverse to the data pattern that occurred in the third decade. This indicates that older roadsides were becoming more densely occupied by prairie vegetation. The inverse relationship between the third and sixth decades is not a perfect fit, however. More samples occur in cover category 1 in the third decade than occur in cover category 4 in the sixth decade. In successional studies in prairie regions, it has been found that an initial stage of early successional annuals is followed by a stage with combinations of native and non-native perennials before the community succeeds to a flora dominated by prairie vegetation (Shimek 1925, Curtis 1971). A detailed analysis of prairie species might indicate that a transition from a community of more aggressive native perennials to a more diverse native community is occurring. Such a phenomenon was observed in studies of a 440 acre

prairie restoration at the Fermi National Accelerator Laboratory in Batavia, Illinois (Betz 1986). In Betz's study, certain plant species were found to re-establish more successfully in initial plantings. Other species that did not occur during the early successional non-native species stage in the first few years, established successfully after initial plantings of more aggressive prairie species had become established. In the present study, the difference in relative amounts of samples in cover categories 1 and 4 between the third and sixth decade after road construction could be due to competition from non-native perennial species that formerly occupied a similar niche in their native habitats. The observed imbalance between decade 3 and decade 6 could also occur because management techniques necessary to encourage prairie succession are absent, or because management techniques being used are negatively affecting succession to prairie. The combined effects of the absence of fire management, and the practice of frequent mowing, herbicide application in roadside management, and the narrow linear shape of the roadside, complicated by negative impacts from adjacent agricultural land use, could inhibit succession to prairie vegetation.

The deletion of prairie cord grass probably affected the number of samples of prairie vegetation in the various cover categories. If included, fewer samples probably would occur in cover category 1 and the number of samples in all other cover categories would increase, especially categories 3 and 4. The presence of prairie cord grass in the data would change the 0-10 year old road age category less because all roadsides would presumably be devoid of vegetation at the time of construction, and fewer samples containing prairie vegetation would exist in the first decade.

If the pattern observed in the relative amount of cover is continued beyond 60 years, all of the roadsides that are approximately 80 years old would be expected to contain a 50-100% cover of prairie vegetation. This prediction does not consider the possibility that prairie species could have mycorrhizal requirements (Betz 1986), a critical preserve size or configuration (Diamond 1975), or an essential association with other prairie species (Betz 1986) that is currently absent in roadsides. Because relatively few areas with a high species diversity currently exist adjacent to roadsides, apparently recolonization by these possibly essential species is not occurring. It is also possible that prairie succession progresses more slowly when a limited complement of the seeds of prairie species is available for recolonization of roadsides. In addition, the narrow linear shape of roadsides make them susceptible to numerous edge effects (influences from adjacent areas) that could produce additional negative influences on the succession of roadsides to prairie vegetation.

It is possible that before prairie vegetation in roadsides reached 100% cover, a plateau would be reached that would result either in an equilibrium state or a state of flux between native and non-native vegetation. The constant impacts of disturbances discussed in the preceding paragraphs could produce areas of expansion by non-native species that would later contract when disturbance decreased. A pattern of expansion and contraction could repeat itself in various regions and to varying degrees depending on the degree of disturbance. A state of tension also could be reached between native and non-native species, and between early and late successional species of plants.

Areas of prairie vegetation continue to be converted to agricultural or other uses. Based on recent history, it is predicted that if a study similar to this one was conducted 50 years from now, fewer roadsides would contain prairie vegetation, and roadsides containing prairie vegetation would exhibit lower cover categories. This decrease in roadside prairie vegetation would occur because future reconstruction of roads would destroy existing prairie seed sources in roadsides. This destruction would be especially critical because fewer prairie seed sources would exist adjacent to roadsides than in the past. Without a seed source following destruction of prairie vegetation, prairie cannot re-establish. Future lack of prairie seed sources could, however, be counteracted by artificially introducing prairie seed into roadsides. The use of native local ecotype seed could help restore currently existing native prairie remnants while simultaneously retaining the integrity of the local gene pool.

Road Type

A significant relationship was found between road type and the frequency of occurrence of samples in cover categories of prairie vegetation. The paved road category was expected to have fewer samples containing prairie vegetation than gravel roads because greater use of paved roads causes these roads to receive a higher management priority by county personnel, resulting in more intense management (Clarke 1989). Because a manicured appearance has been considered desirable in roadsides in the past, and because paved roads are more heavily used, an emphasis on planting non-natives has occurred more frequently along paved roads than along gravel roads. In addition, paved roads are usually more recently constructed, and therefore have a more limited availability of prairie seeds adjacent to roadsides than existed for older roads.

The magnitude of the numbers in Table 6 and in Figure 9 indicates that roadsides adjacent to gravel roads do contain more prairie vegetation than roadsides adjacent to paved roadsides. In addition, 37% of the samples occurring adjacent to gravel roads in this study contained prairie vegetation with cover greater than 25%, in contrast to 27% of the samples that occurred in roadsides adjacent to paved roads in cover quantities greater than 25%. Some factor or factors associated with paved roads apparently have a negative affect on the survival of prairie vegetation. As mentioned in the discussion relating road age to cover, frequent mowing and herbicide application used in management of roadside vegetation negatively affects populations of prairie plants. Vegetation in roadsides adjacent to gravel roads is less often impacted due to less intense management, and therefore, the survival of prairie vegetation along these roads is more probable. In addition, portions of roadsides adjacent to gravel roads are periodically burned by adjacent landowners, primarily to "control the weeds" (Ehley, 1990). This practice is important in the restoration and maintenance of prairie vegetation, because it increases the vigor of prairie vegetation, and inhibits the growth of non-native vegetation and woody species. Burning roadside vegetation is less frequent in roadsides adjacent to paved roads because the greater usage of paved roads increases the perception of greater liability due to poor visibility on roads caused by smoke (Smith, 1990).

Soils

A significant relationship exists between soil associations and the frequency of samples occurring in cover categories of prairie vegetation. To some extent, the concentration of prairie species in soils of drainage extremes appears to occur in Black Hawk County.

Roadside plant communities contain a large compliment of non-native species and have been greatly modified by human action. Therefore, they fit the definition of a weed community as described by Curtis (1971). Prairie species are known to establish more readily on nutrient deficient soils with drainage extremes such as is found in soils stripped of the A horizon; presumably soil conditions are too hostile for successful establishment and competition by non-native species is lesser (Smith 1989). In weed communities of Wisconsin, the relative content of exotic species decreased as moisture and nutrient availability decclined. An increase in moisture and nutrients corresponded to an increase in annuals and biennials, and a decrease in perennials (Curtis 1971). Exotic species are most likely to occur in mesic soil conditions that most closely resemble the moisture conditions of their native Eurasian habitat, rather than in very dry or wet soils (Curtis 1971). In addition, early successional species are more tolerant of moisture extremes than later successional species (Costello 1944, Tolstead 1941, Curtis 1971). The sites of the original tallgrass prairie communities typically are rich in organic materials, are mesic, and have been nearly completely converted to agricultural land in Black

Hawk County (Fouts and Highland 1978). Because agriculture negatively affects adjacent prairie vegetation, it was expected that roadsides within these soil associations would be more heavily occupied by non-native species. In addition, large portions of the existing prairie remnants occur in excessively well drained soils with low fertility. These remnants would provide a current seed source for adjacent roadsides. A higher frequency and density of prairie vegetation was therefore expected to be found in nutrient poor soils and soils with drainage extremes in areas where disturbance was limited. Less prairie was expected to be found in soils that were ideal for agriculture.

The S-O-D soil association has a large proportion of sand and can be droughty or waterlogged depending on the location. The removal of vegetation results in severe erosion and drifting of sand, causing this soil association to be unsuitable for agriculture. In this study, the S-O-D soil association had a relatively high amount of samples with 50-100% prairie vegetation. When data from both encounters 1 and 2 are combined, the percentage of samples in cover category 4 in the S-O-D soil association is exceeded only by the the percentage of samples in this cover category in the R-T soil association. This supports the hypothesis that prairie vegetation is better adapted to excessively well drained, dry soils than non-native vegetation.

The suitability of prairie vegetation to the S-O-D soil association is further demonstrated by the fact that sizable prairie remnants occur in this soil association in areas other than roadsides. Major locations of this soil association in the study site occur in Washington Union Township, and in Mount Vernon Township, and both townships are associated with prairie remnants of importance in the state (Duritsa 1983). Washington Union Township contains the largest acreage of prairie in the county, including the 35 acre Cedar Hills Sand Prairie (Duritsa 1983). Most of the prairie vegetation in the township occurs on the S-O-D soil association. Probably this occurs because of S-O-D's limited use for agriculture and the ability of prairie vegetation to successfully stabilize soil. In these areas, a source of prairie seeds has existed since presettlement times, and continues to exist allowing recolonization in adjacent disturbed areas including roadsides, to occur more quickly than in other soil associations. This could explain the relatively high proportion of samples in cover category 4.

A large portion of the data, however, contradicts the hypothesis that prairie vegetation occurs in roadsides more often in areas of drainage extremes, in nutrient poor soils, in areas of limited disturbance, and in areas less desirable for agriculture. When soil association data from encounters one and two were combined, more than 50% of the samples in each of four soil associations contained prairie vegetation. These four soil associations are D-K-M, T-M-G, R-T, and K-C-F. The percentage of samples containing prairie vegetation in each of these soil associations respectively is 53%, 63%, 63%, and 64%. In contrast, the percentage of samples in the M-S-B soil association, the La-S-F soil association, and the S-O-D soil association are, respectively, 38%, 41%, and 49%. Differences occur in parent material of soil, soil texture, location (see Table 19), and to some extent, in land use, between the group of four soil associations that contained prairie vegetation in more than 50% of the samples, and the group of

Table 19. Summary of the characteristics of the major soil associations of Black Hawk County as derived by Duritsa (1983) from Fouts and Highland (1978).

	Soil Association/ Landscape Division	Topography	Drainage	Soil Characteristics	Location on Landscape	Location in County	Native Vegetation
1.	Tama-Garwin-Muscatine/Loess covered uplands	nearly level to gently sloping	well drained	silty soils in loess	uplands	southwest	prairie grasses and sedges
2.	Dinsdale-Klinger-Maxfield/loess covered uplands	nearly level to moderately sloping	well drained to poorly drained	silty soils in loess and glacial till	uplands	southwest, west central and northeast	prairie grasses and sedges
3.	Kenyon-Clyde-Floyd/sloping and dissected lands	nearly level to strongly sloping	moderately well drained to poorly drained	loamy soil in loamy material and glacial till	uplands	throughout	prairie grasses, sedges and upland forests
4.	Readlyn-Tripoli/ Glacial till uplands	nearly level to very gently sloping	somewhat poorly drained to poorly drained plants	loamy soils in loamy material and glacial till	uplands	north and east of Cedar River, west of Cedar Falls	mixed prairie grasses and water tolerant
5.	Sparta-Olin-Dickinson/Eolian deposits	nearly level to moderately sloping	excessively drained to well drained	sandy and loamy soils formed in eolian sands and glacial till	uplands and terraces	east side of stream valleys, south side of West Fork River	prairie grasses, forests and marshes
6.	Loamy, alluvial land channeled-Saude-Flagler/ alluvial plains	nearly level to gently sloping	excessively drained to poorly drained	loamy soils in loamy, alluvial sediments	bottom lands and terraces	major stream valleys: Cedar, Wapsipinicon	floodplain and terrace forest, brush and grasses
7.	Marshan-Sawmill-Bremer/Upland drainage ways	nearly level	poorly drained	silty and loamy soils in alluvial sediments	bottom lands and terraces of intermediate stream valleys	intermediate stream valleys: Black Hawk, Miller and Crane Creeks	prairie grasses, sedges, water tolerant plants

soil associations that contained prairie vegetation in less than 50% of the samples in this study. The parent material of the four soil associations with more than 50% of the total samples containing prairie vegetation, was either loess, loess and glacial till, or loam and glacial till. The soil texture generally varied from silty clay loam to loam to clay loam, and the soils are located in uplands. All four of these soil associations contain thick surface layers of soil rich in organic materials, and are extensively utilized for agriculture.

The three soil associations with prairie vegetation in less than 50% of their samples are primarily of eolian or alluvial origin, and contain sand in the surface layer, and/or in the subsoil layer. Soil texture varies from coarse sand and gravel to fine silt, and drainage varies from excessively well drained to very poorly drained. Many of these areas occur on bottomlands and stream terraces, or contain marshy areas or seeps. Most of the original woodland in Black Hawk County occurred in these soil associations, except for some parcels of upland woodland that occurred locally in the R-T soil association. Although a large portion of all soil associations in Black Hawk County are used agriculturally, the S-O-D, M-S-B, and La-S-F soil associations comprise the majority of the greenbelt area along rivers, and are more often used for wildlife habitat because of agricultural limitations (Fouts and Highland 1978, Duritsa 1983).

A general statement could be made, based on the above discussion, that prairie vegetation tended to occur most frequently in areas more suited to agriculture, and less prairie vegetation occurred in areas with more natural areas. This contradicts the hypothesis that the greatest concentration of prairie vegetation would be found in areas with nutrient poor soils, of drainage extremes, of lesser agricultural value, and/or with limited disturbance. This contradiction could be due to ecological conditions in the M-S-B, La-S-F, and S-O-D soil associations, and/or to the nature of the samples in this study. In permanently wet areas, and in areas along rivers or streams where these soils exist, flooding occurs regularly and to differing degrees of severity. Complex prairie communities can take several years to establish, and in alluvial soils, years of extensive and long lasting floods could destroy prairie vegetation when it is still in the establishment phase. Small amounts of prairie vegetation could survive in isolated areas less prone to flooding.

Roadsides are designed to provide some drainage to roads and the effects of flooding can be increased, especially in areas that occur near rivers and streams. Some prairie vegetation could, however, survive on higher, drier areas of the roadsides. This could explain the lower numbers of samples in the 50-100% cover category in the M-S-B and the La-S-F soil associations. Relatively high numbers of samples in the 16-49% cover category could be due to cycles of repeated prairie establishment, followed by flooding. The populations of prairie species expand, only to decrease during repeated periods of flooding. This cycle could result in a lower total number of samples containing prairie vegetation.

Even though there is a relatively high number of samples with 50-100% cover in the S-O-D soil association, this association has a somewhat lesser total number of samples containing prairie vegetation.

The high number of samples with a greater density of prairie vegetation is explained earlier in this chapter, but the lower overall number of samples containing prairie vegetation could be due in part to periodic flooding.

Some kinds of prairie vegetation are well adapted to wet, poorly drained soils that are subject to periodic flooding. Prominent among these species is prairie cord grass, which was deleted from the data in this study. S-O-D, M-B-S, and La-S-F soil associations originally supported vegetation consisting of floodplain woodland, marsh, seeps, or wetland. Prairie cord grass often exists as a significant species of the herbaceous vegetation in these types of habitat. The deletion of this species from the data could partially or wholly explain the relatively large numbers of samples in cover category 1 and a correspondingly low number of samples containing prairie vegetation in these soil associations. The arbitrary deletion of prairie cord grass, resulted in arbitrary deletion of samples that occurred in swales or wetlands.

A large portion of the data samples indicated that prairie vegetation occurred on sites of original occupation by tallgrass prairie vegetation. More than 50% of the samples in the T-M-G, D-K-M, K-C-F, and R-T soil associations contained prairie vegetation, and these soils were originally populated with tallgrass prairie. Prairie remnants could have existed on the land adjacent to these roadsides at the time of road construction, and this seed source would have facilitated re-establishment of prairie vegetation in roadsides. The fact that prairie still exists in roadsides adjacent to agricultural land with no remaining adjacent prairie seed source is a testimony to the persistence of these prairie species. Associations of very wet or very dry soils did not originally support as much tallgrass prairie vegetation, and therefore could not supply as extensive a source of prairie seed as was supplied by areas dominated by tallgrass prairie. Prairie vegetation would be less likely to occur in roadsides adjacent to soils not originally occupied by prairie. In addition to the presence of a prairie seed source, the dispersal distance of prairie propagules affects colonization by prairie species. The propagules of many prairie species travel only short distances because of their mass or their poor adaptation to wind dissemination, (Rice et al. 1960, Platt and Weis 1977) and therefore re-establishment of prairie populations in roadsides from seed sources existing in adjacent land would be restricted to local occurrences. Prairie populations existing in roadsides, limited by the size and shape of the roadside, would recolonize roadsides longitudinally very slowly, and would be interrupted by intersecting roads. For these reasons, an adjacent seed source would have been necessary for re-establishment of prairie vegetation in early roadsides. This would explain the relatively high amounts of prairie vegetation in T-M-G, D-K-M, K-C-F, R-T, and S-O-D soil associations.

Slope

The relationship between slope and cover lacked significance in encounter 1, but was significant in encounter 2. From the data in this study, it cannot be concluded that the second slope class identified in a tenth mile of roadside when collecting data from west to east will be more likely to have a significant relationship to percent prairie vegetation cover than the first slope class identified. These results could be due to variance of data.

In addition, abrupt topographic changes occur locally in roadsides due to the design of roadsides as V- or U-shaped ditches. Prairie vegetation, well adapted to moisture extremes caused by abrupt topographic changes, are distributed in roadsides along local topographic and moisture gradients. The data collection technique for slope only reflected gross topographic changes in the landscape indicated by soil differences. As a result, the abrupt topographic changes that occur in roadsides cause this soil slope data to be inadequate.

The relationship between slope and percent cover of prairie vegetation in slope encounter 2, however, was significant. Nine percent more prairie vegetation occurred in areas with greater slope, supporting the hypothesis that prairie vegetation will occur in these areas. The most striking difference in relative amount of prairie vegetation between level and sloping topography, was in cover category 4. Eighteen percent of the samples in slope category 2 (sloping), contained prairie vegetation in the 50-100% cover range. This indicates that the most dense prairie vegetation probably occurs in areas that are more steeply sloping. This could occur because relatively steep slopes draining to lowlands often result in xeric conditions on the steep banks (Steiger 1930), and permanent standing water in lowlands (Lindsey et al. 1965). Steep slopes therefore could create conditions of greater soil moisture extremes in roadsides. Large hills on adjacent land that slope down to a roadside could create a large watershed draining into the roadside, resulting in more moist or wet soil conditions. Conversely, raised roadbeds with no backslope and an adjacent valley would result in drainage away from roadsides, potentially creating drier soil conditions. In each of these cases, localized populations of prairie species that are well adapted to moisture extremes could occur.

Factors Not Significantly Related to Selected Prairie Cover

Contrary to expectations, water holding capacity of the soil, adjacent land use, erodibility of adjacent land, and original vegetation, were not significantly related to cover of prairie graminoids.

Soil Permeability

Drainage and topography are two factors known to be important to the distribution of prairie vegetation (Steiger 1930, Weaver 1954, Lindsey 1961, Curtis 1971, Crist and Glen-Lewin 1978, Ode 1980, Whitney 1982). As previously discussed, prairie vegetation was expected to occur more often in areas with drainage extremes. Permeability of soil in each soil series was used as the parameter to indicate relationships between soil water holding capacity and drainage, and cover categories. Because drainage is affected by slope of the soil, both permeability and slope were analysed to determine possible relationships to cover categories.

The relationship between permeability and cover was not significant. Permeability rates were grouped into slow, moderate, and rapid categories. The results of previous research suggest a strong relationship between moisture conditions and the presence of prairie vegetation. The lack of significance in this study could have been due to the inherent difficulties in constructing discrete categories from overlapping permeability divisions as listed in Fouts and Highland (1978), or due to the lack of permeability extremes in the study area.

Adjacent Land Use

The survival of roadside prairie remnants is affected by adjacent land use. Agricultural areas are typically erosion prone, contain a non-native seed bank, and thus tend to cause a shift in roadside vegetation to an earlier successional state (Costello 1944; Curtis 1971, Fouts and Highland 1978). Roadsides subject to rapid siltation are dredged more frequently, causing additional and catastrophic disturbance to existing vegetation. Conversely, permanent vegetation in land adjacent to roadsides prevents soil erosion (Hausenbuiller 1977) thereby stabilizing roadside vegetation. Permanent or semi-permanent vegetation often exists in pastures, residential or industrial areas, cemeteries, woodlots, parks, recreational areas, and natural areas. If these areas contain prairie vegetation, they are also a seed source for reestablishment of prairie vegetation in roadsides.

Prairie vegetation in roadsides commonly exists adjacent to prairie remnants except where these roadsides have been recently and severely disturbed by activities that remove most or all vegetation (Smith 1989). Even in recently dredged roadsides, prairie vegetation quickly re-establishes if an adjacent prairie remnant exists (Shimek 1925). However, there was no statistically significant relationship between roadside prairie and native seed sources. This is probably due in part to the overwhelming preponderance of agricultural land (70% of all samples) occurring in the data set that could have skewed the results. Lack of significance between roadside prairie and adjacent native seed sources was probably also due in part because a miscellaneous category representing areas that could contain native seed sources was used instead of a category known specifically to represent adjacent native seed sources. Selection of several segments of roadsides known to exist adjacent to a prairie seed source would have more effectively tested the hypothesis that prairie vegetation in roadsides is significantly related to an adjacent native seed source.

In addition, agricultural practices impact the quality of many potential seed sources such as those along streams that intersect agricultural fields. Negative impacts in these cases include siltation, pesticide drift and runoff, and provision of a non-native seed bank. Areas that do contain native vegetation often have a very low species diversity. If sampling had been biased to collect data from equal numbers of areas adjacent to residential, agricultural, and good quality prairie seed source areas, perhaps more prairies in roadsides would have occurred next to native seed sources.

Erodibility

Most of the soils in Black Hawk County have been impacted by agricultural erosion and therefore erodibility was used as an indication of disturbance in roadsides (Fouts and Highland 1978). Agricultural siltation into roadsides often causes a need for dredging roadsides to facilitate drainage, and dredging destroys existing vegetation. Unless a nearby seed source exists, or the exposed soil contains a seed bank of prairie seeds, or viable prairie rootstock, prairie is unlikely to re-establish adjacent to agricultural land. A relationship between erodibility factor K and the frequency of samples occurring within cover categories was not statistically demonstrated in this study. However, the combined data from erodibility encounters one and two indicated that 50% of the samples occurred in soils within the highest range of erodibility, and that 51% of the prairie vegetation found in the study area occurred within this same erodibility range. This suggests that either the prairie vegetation is less sensitive to disturbance than predicted, that the soil is being effectively stabilized, or that the areas of highly erodible soil were originally the sites of prairie vegetation in the county. Because agriculturally activated soil erosion is a serious problem in Black Hawk County (Campbell 1987), and because erosion is severely destructive to prairie and other types of vegetation (Boothe 1941, Costello 1944, Hasenbuiller 1977, Curtis 1971), the third possibility probably contributes to this phenomenon.

Original Vegetation

The original vegetation as listed relative to soil associations in the Soil Survey of Black Hawk County (Fouts and Highland 1978) was not significantly related to the cover categories of prairie vegetation. This contradicts the previous interpretation that prairie vegetation primarily exists in roadsides within the regions that were formerly prairie. Precise interpretation of information about original vegetation, however is difficult (White 1981, Smith 1989), especially relative to terminology referring to wooded areas. In contrast to treeless prairies, a savanna with a few trees could have been described by early surveyors as either wooded or as prairie. For example, early Clayton County surveyors mapped an area as prairie, even though trees were noted suggesting that the vegetation could have been a savanna community (Smith 1989). Also, soil scientists are cautious in specific interpretation of original vegetation data, noting that an area occupied alternately by woodland and prairie would be recorded as having "mixed trees and prairie grasses" that could also be interpreted as savanna (Smith 1989).

In contrast to the results of this study, other studies have noted positive relationships between the original vegetation under which the soil was formed and current vegetation. In a study of currently existing prairie along areas formerly used as Indian trails in Ontario, Canada, areas inhabited by rich prairie vegetation corresponded with a deep layer of undifferentiated, calcareous soil rich in humus. This soil was typically formed under prairie vegetation, and was much different than the soil formed under mixed forest (Reznicek 1983). In studies of several counties in Wisconsin, some species of prairie plants in roadsides existed only within the confines of former prairies, and other species remained concentrated near former prairie areas as recorded in surveyors' records (Curtis, 1971). Curtis (1971) notes that this phenomenon could occur because the plants were a part of the original prairie, savanna, or open woodland flora, and could partially be an indication of species conservatism. That is, certain species were prairie obligates and colonized new territory at slower rates, and thereby are or were confined to original prairie sites. It is also possible that these species could simply have encountered hostile roadside soil conditions (Curtis 1971). A similar phenomenon could be occurring in the present study area, with prairie vegetation occurring within the range of the original seed source. Although this is possible, it is not likely because most of the soils in the study area were organically rich, moderately well drained soils. Even eroded remnants of these soils are probably not excessively hostile to prairie plant populations. If prairie vegetation is limited by environmental conditions, these conditions are more likely to be caused by the effects of roadside management practices or by management of adjacent land. Examples of such adverse conditions include pesticide application to roadsides, runoff and drift of agricultural pesticides into roadsides, siltation from agricultural land, and frequent mowing of roadsides.

CHAPTER 5

SUMMARY

In Iowa, the presettlement vegetation was predominately tallgrass prairie. Currently, prairie vegetation is confined to small isolated parcels, some of which occur in roadsides. Roadside prairie remnants are important for historical, environmental, aesthetic, scientific, and economic reasons, and are beginning to be restored or reconstructed in several counties in Iowa. Information about factors influencing the occurrence of prairie vegetation could help roadside vegetation managers develop initial vegetation inventory techniques and subsequent prairie restoration procedures.

This study was conducted to determine if factors known to affect plant communities and their stage of succession, including soil moisture availability, drainage, soil disturbance, and availability of a prairie seed source are related to visual estimates of the percent coverage of prairie graminoids in roadsides. Prairie vegetation studied was limited to selected graminoid species including native grass species and members of the family Cyperaceae, but excluding prairie cord grass (Spartina pectinata), Reed canary grass, (Phalaris arundinacea), and Kentucky bluegrass (Poa pratensis). Elimination of these species allowed more precise evaluation of the populations of less aggressive prairie species. Cover categories of prairie vegetation in this study were 1) 0%, 2) 5-15%, 3) 16-49%, and 4) 50-100%.

Of the total 494 samples, an approximate 4:2:2:1 ratio was noted among cover categories. The number of samples represented in cover category 1 (0% prairie vegetation) was approximately 4 times greater than the number of samples represented by cover category 4 (50-100% prairie vegetation). Both cover categories 2 and 3 with 5-15% and 16-49% cover respectively, were observed approximately twice as often as cover category 4 with 50-100% cover. In Chi-square tests, cover was statistically related to road age, road type, soil association, and slope. No significance was found in the relationships between cover and permeability, erodibility, original vegetation, or adjacent land use.

The factors analysed interact with each other and with other characteristics of the roadsides that were not analysed in this study. In addition, aspects of the study site and of data selection affected the results of this study. Among these aspects are exclusion of prairie cord grass, an important species in wet prairies, repeated disturbances due to roadside management techniques, flooding, type of adjacent land management, and physical conditions such as dense shade. In addition, ecological conditions of prairie species such as potential mycorrhizal requirements (Betz 1986), critical preserve size or configuration (Diamond 1975), or an association with specific prairie species during early prairie establishment (Betz 1986) that is currently absent in roadsides but necessary to produce a stable native plant community could influence the degree to which factors affect roadside prairie vegetation. Perhaps the most important factor affecting the occurrence of prairie vegetation in roadsides is the presence of adjacent prairie seed sources, few of which currently exist.

The relative amount of prairie vegetation occurring in roadsides increases with road age. Samples in roadsides along roads more than 51 years old had the highest percentage of prairie vegetation (37%) in cover category 4, whereas most samples (67%) in roadsides less than 21 years old contained no prairie vegetation. Factors contributing to this trend include increasingly complete destruction of adjacent prairie seed sources in more recent years, as well as development of road construction and maintenance techniques that are more catastrophically destructive to roadsides than techniques used in former years.

Prairie vegetation occurred in greater densities in roadsides adjacent to gravel roads (59% of samples along gravel roads contained prairie vegetation) than in roadsides adjacent to paved roads (51% of the samples along paved roads contained prairie vegetation). This could occur because paved roads are more intensely used and are therefore given a higher maintenance priority by county officials. As a result, paved roads are mowed and treated with herbicide more frequently, practices which negatively impact roadside prairie vegetation. In addition, paved roads tend to be newer roads, resulting in more recent disturbance to roadsides, and an earlier successional stage of vegetation. Even though the study did not show a relationship to proximity of seed sources, the reduction in adjacent prairie remnants over the years could be a contributing factor.

When soil association data from encounters one and two (the first and second soil type encountered in a tenth mile) were combined, more than 50% of the samples in each of four soil associations contained prairie vegetation. These four soil associations were D-K-M, T-M-G, R-

T, and K-C-F, all of which are organically rich soils well suited for agriculture. The remaining 3 soil associations, the S-O-D, the M-S-B, and the La-S-F soil associations, all contain agricultural limitations because of existing drainage extremes, lower organic content or higher erosion potential. Therefore, prairie vegetation occurs more often in roadsides on rich organic soils ideally suited to agriculture, than on nutrient poor soils with drainage extremes. This suggests a relationship between the sites of original occupation of tallgrass prairies and current roadside prairies.

Although the Chi-square analysis of the first slope class encountered was significantly related to prairie vegetation cover, analysis of the second slope class encountered was not. These results could be due to variance of data.

The relationship between permeability and cover was not significant. The lack of significance in moisture analysis in this study could have been due to the inherent difficulties in constructing discrete categories from overlapping permeability divisions as listed in Fouts and Highland (1978), or due to the lack of permeability extremes in the study area.

The lack of a statistically significant relationship between adjacent land use and cover could be due to an overwhelming preponderance of agricultural land use (70% of all samples) in this study. Had the study included a higher proportion of natural areas, the statistical relationship between adjacent land use and cover might have been significant.

Original vegetation was not significantly related to cover, possibly because of difficulties in interpretation of information about original vegetation. Ambiguities in interpretation of original vegetation are especially apparent relative to woodland and savanna communities.

Erodibility (K-value) was not significantly related to cover. The areas currently most subject to erosion are those areas without permanent vegetation, most of which are agricultural areas. Although agricultural erosion is detrimental to prairie plant populations, the areas most suitable to agriculture are also the areas most heavily occupied by tallgrass prairie in presettlement times. The selection of data for mesic and dry prairie species, and the exclusion of prairie cord grass, a species of wet areas, from the data could have resulted in a lack of significance in this category.

In conclusion, the results of this study indicate that prairie vegetation in roadsides is most likely to be found adjacent to older roads, adjacent to roads with gravel surfacing, and in organically rich, well drained soils that are well suited to agriculture. This study did not support the hypotheses that prairie would occur in roadsides with extremes of soil permeability, with higher soil erosion potentials, next to steeply sloping landscapes, adjacent seed sources, or in soils originally formed by prairie vegetation. It is possible that a different method of sampling could have resulted in additional factors being significantly related to prairie vegetation cover.

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