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16. Abstract

This is an interim report on the Prairie Restoration Project. This report documents the results of a literature search and the way in which conclusions drawn from that search will be used to design the individual studies.

The goal of the Prairie Restoration Project is to evaluate selected roadside vegetation management techniques that will encourage healthier, more stable grass communities. Five study sites in Texas will be established. These sites are located near Amarillo, Dallas, Abilene, Austin, and Harlingen, and have been selected for their differences in climate, soils, and native vegetation.

A literature search identified key characteristics of mature prairie grass systems. The three major components of grass communities identified that can be influenced by routine maintenance operations are plant disturbance, litter accumulation, and reproduction. Based on the findings, differing maintenance regimes will be designed and evaluated in which these factors are manipulated. The differences between these regimes will be timing of mowing activities in relation to vegetation community dynamics, the frequency of those activities, and the specific techniques and equipment employed in the maintenance operations.

The directions for the structure and general goals of the research are presented, and the status of project sites is outlined. Plan sheets of completed projects are included.

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PRAIRIE RESTORATION: AN EVALUATION OF TECHNIQUES FOR MANAGEMENT OF NATIVE GRASS COMMUNITIES IN HIGHWAY ROADSIDES IN TEXAS

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Research Report 944-1
Research Study Number 7-944
Research Study Title: Construction Landscape Program

Sponsored by the
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TEXAS TRANSPORTATION INSTITUTE
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IMPLEMENTATION STATEMENT

This study determines the best methods to effectively use the natural, successional processes of grass communities to better serve safety, maintenance efficiency, and structural integrity needs of the roadway. This research makes possible the development of guidelines that will aid vegetation managers in selecting the appropriate management techniques when designing roadside maintenance contracts. In addition, these studies will increase the public's awareness and support of TxDOT's efforts related to developing management practices that place increased emphasis on issues of conservation and environmental quality.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or polices of the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation. James R. Schutt and Michael A. Teal prepared this report.

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SUMMARY

This is an interim report on the Prairie Restoration Project. This report documents the results of a literature search and the conclusions that were drawn from that work. The directions for the structure and general goals of the research are presented, and the status of project sites is outlined.

Current roadside vegetation management practices are, in most cases, not compatible with the establishment and maintenance of dense, stable, native grass communities. The fundamental hypothesis of this research is that roadside grasses (specifically native species) are continuously in the process of developing to a relatively steady-state condition similar to that of a mature, prairie grass community.

LITERATURE SEARCH

Most of the research related to grass management has originated in range science studies whose goals are centered on forage value. Research from other areas of science, particularly ecology, give ample evidence that an approach which incorporates management techniques that derive from the natural systems processes of species interactions, succession, competition, and reproduction is possible.

A number of states have management programs that include restoration of native grasses in the roadside. This movement seems to mirror the growing trend of increased environmental awareness in the general public. However, a significant number of roadside vegetation managers acknowledged that research results are not published in a usable form.

There are several issues or conditions that can be identified as key factors in the maintenance of stable prairie communities. By relating these factors to their condition in the roadside and how maintenance affects them, we can begin to formulate some specific management goals. These are disturbance, litter accumulation, and reproduction or

regeneration. Each of these can be influenced by routine maintenance techniques.

Disturbances to grass communities change the physical character of the vegetation or the environment and allow the most aggressive species to colonize the disturbed area. In the case of the roadside, these species are often annual weeds.

Natural litter accumulation (dead plant leaves and stems) helps improve growing conditions for grass. However, excess litter, such as caused by mowing, inhibits the spread of grasses, and prevents prairie understory plants from developing. Reproduction and regeneration are also affected by the factors of disturbance and litter.

Species diversity is usually considered an indicator of stable, climax grass communities. It has been suggested that diversity contributes to grass community resistance to weedy invasion. Studies have also indicated that a number of bird species and numerous rodents will use the roadsides as habitat, and nesting bird populations can be increased in the roadside without an increase in bird mortality.

RESEARCH FOCUS

The Prairie Restoration Program will monitor the effects of various management techniques on grass communities in specific conditions. Investigations conducted will consider mowing frequency, height, timing, equipment, seeding and sodding methods in bare and established sites, herbiciding, and methods to control litter accumulation.

STUDY METHODOLOGY

Each project site is to be located in a different geographic region. The goals and scope of each experiment shall be established on a site-by-site basis.

INTRODUCTION

Roadside grasses have long been recognized as vital in the role of protecting the roadway structure by preventing erosion. The assumption was that if grass was present and alive, then this protection was being accomplished. Unfortunately, the management practices employed in these environments were really an extension of lawn care techniques. This means that many of the maintenance and management practices encourage the proliferation of weedy species and frequently prevent the establishment of the dense cover that provides effective erosion protection.

Current management practices are in most cases, not compatible with the establishment and maintenance of dense, stable, native grass communities. Instead, most practices are primarily structured for:

- mowing determined by grass height only
- traditional contracting practices
- established administrative procedures and capabilities
- type of equipment used
- character and ability of the contractor
- personal bias and experience of maintenance personnel
- public acceptance of roadside aesthetics

The fundamental hypothesis of this program is that roadside grasses (specifically native species) are continuously in the process of developing to a relatively steady-state condition similar to that of a mature, prairie grass community. This steady-state condition (or near-steady-state condition), when obtained, will:

- prevent erosion
- act as a filter of chemical pollutants associated with the roadway

- reduce the need for chemical and mechanical vegetation control measures in the roadside
- be economical to manage
- provide seasonal cover for wildlife
- visually enhance the roadway in terms of color and form

LITERATURE SEARCH

Most of the research related to grass management has originated in range science studies. Much of this type of research relies heavily on the tools of grazing, fertilization, burning, etc. In addition, these studies are always conducted in areas whose conditions and goals are very different from those of the highway roadside. Range improvement goals are centered on forage value. This emphasizes high production usually at a low species diversity since it is easier to manage for one species than for two or more. Low productivity at high diversity is the more desired goal in the roadside.

Today, however, there is a growing body of data that has come form the ecology side of vegetation science and is being applied to present problems of vegetation resource management (Luken, 1990). This approach centers on management techniques that derive from the natural systems processes of species interactions, succession, competition, and reproduction. Roadside vegetation managers are moving towards applying these processes to present-day management problems.

Today even range management is changing its approach in light of changing information and values and is beginning to consider ecological values as well as forage production values (Smith, L., 1979). A recent survey of Midwestern state departments of transportation (Harrington, 1991) shows that at least 14 states have management programs that include restoration of native grasses in the roadside. Minnesota (Harper, 1988) and Iowa (Smith, D., 1994; Landers & Kowalski, 1968) have programs which stress native prairie communities. This is reflective of the growing trend of increased environmental awareness in the general public, as evidenced by the increased use of wildflowers and other native plants in home and commercial landscapes.

The task of applying this science to roadside management is not without difficulty. Of those that participated in the above mentioned survey, only 16% acknowledged that research

results are published in a form usable by right-of-way managers. This problem is compounded by the fact that all management suggestions for grass communities must be site specific (Luken, 1990).

What is the ideal roadside grass community? Ideally, this community would be dense in order to prevent erosion. The grasses would not be too tall, would heal themselves quickly after disturbance, would not be noxious or invasive to crops or structures, and would be attractive. On top of all this we would want them to stay this way all year long. Obviously, we can not accomplish all these. There are, however, several issues or conditions that can be identified as key factors in the maintenance of stable prairie communities. By relating these factors to their condition in the roadside and how maintenance affects them, we can begin to formulate some specific management goals. This approach will have the effect of beginning from where we are in terms of current practices rather than scrapping established techniques for some radically new procedures.

We have identified three major factors that are most prominent in roadsides and are easily influenced by routine maintenance operations that are also critical factors in the development of mature prairie systems. These are *disturbance*, *litter accumulation*, and *reproduction or regeneration*. Diversity is a common characteristic of most prairie communities and is in large part determined by the mix of these three factors.

DISTURBANCE

Disturbance is a factor that promotes diversity (Neiring, 1987). Mowing and herbiciding are disturbances. They change the physical character of the vegetation or the environment and allow the most aggressive species to colonize the disturbed area. In the case of the roadside, these species are often annual weeds.

The difference in promoting diversity and encouraging weeds hinges on when the disturbance occurs and its nature or severity. Mowing should only occur in the late part of the

year (Landers & Kowalski, 1968). Early season mowing coupled with the removal of the regenerated crop in mid-season reduces the vigor of grasses the following spring. Delaying harvesting until late fall increases grass vigor the following spring. The same is true for forbs and legumes (Conard, 1953). The frequency of the disturbance is also a factor in maintaining diversity (Huston, 1979). Herbiciding should only be used to control specific species (Landers & Kowalski, 1968) to avoid affecting desirable plants as much as possible.

It has been suggested that the complete elimination of mowing might be the most effective way to reestablish a diverse prairie community. However, studies have shown that the least disturbed tracts develop into stands of only one or two dominant plants (Drury & Nesbit, 1973; Weaver & Rowland, 1952; Zimmerman & Kucera, 1977).

LITTER ACCUMULATION

Litter accumulation (old, dead plant leaves and stems) occurs naturally in prairie communities. Accumulated litter helps reduce soil temperature, conserve soil moisture, and increases water infiltration. This encourages increased root growth and thicker rhizomes. Excess litter retards germination, inhibits the spread of individual plants, and prevents prairie understory plants from developing (Weaver & Rowland, 1952).

In natural functioning systems, litter accumulates evenly and is removed by fire on a fairly regular basis. On the roadside, litter is comprised mostly of clippings that pile up in thick, linear mats. This results in some areas having an excess amount of litter and other areas with none at all. In the bare areas, high soil temperatures will inhibit germination and invading annuals will out-compete desirable grasses. In excess litter areas, grasses are shaded out altogether and growth is greatly retarded in the spring (Weaver & Rowland, 1952).

Time and temperature are the main variables affecting the rates of litter decay. Colder, drier sites show the slowest decay rates (Schnauss & Kucera, 1977), and humid regions have greater litter producing potential (Zimmerman & Kucera, 1977). It may take from three to

four years for the decomposition of litter to return the material to the soil (Hopkins, 1955).

REPRODUCTION AND REGENERATION

The ability of a grass community to maintain itself is dependent on how successfully it can generate new growth and send out new seeds that have a chance of germinating. As indicated above, each of these is affected by the factors of disturbance and litter.

OTHER ISSUES

DIVERSITY

Species diversity has traditionally been considered an indicator of stable, climax grass communities. This issue has long been and still is in debate (Pickett, 1976; Drury & Nesbit, 1973; Neiring, 1987). Diversity and species competition is a very complex issue, and the effects of diversity are hard to quantify (Huston, 1979). It has been suggested, however, that diversity contributes to stability and that this condition helps communities maintain themselves and resist weedy invasion (Smith, D., 1994).

HABITAT IN THE ROADSIDE

Studies have indicated that it may not be possible to determine the overall effects of highways on wildlife in general. However, several bird species and numerous rodents will use the roadsides as habitat (Michael et al., 1976). In a study of wildlife usage of the roadside in Indiana, it was determined that nesting bird populations can be increased in the roadside without an increase in bird mortality (Roach & Kirkpatrick, 1985).

RESEARCH FOCUS

As indicated above, enough is known about natural systems to understand the major forces at work within them. What is less known is how to successfully encourage these forces in roadside environments. Vegetation managers need to be able to predict the effects of any management practice on the roadside. It is easy to predict the effects of mowing on grass height - the grass gets shorter by mowing. However, it is more difficult to predict the effects of mowing regimes on grass community composition in three years.

The Prairie Restoration Program will focus on monitoring the effects of various management techniques on grass communities. The major goal will be to establish guidelines that will help predict the cumulative effects of these techniques over extended periods of time. Investigations conducted should include mowing frequency, height, timing, equipment, seeding methods in bare and established sites, and methods to control litter accumulation.

STUDY METHODOLOGY

Each project site will be located in a different geographic region in Texas. (See Appendix B.) Because of this, it is anticipated that each district will have a somewhat different set of problems and, hence, a unique set of goals.

District vegetation managers and landscape architects assisted in selecting the study sites. Candidate project site shall be evaluated according to the following criteria:

- site shall contain conditions typical of the area,
- exceptionally difficult or scenic sites should be avoided,
- recommended length shall be approximately 4 to 8 km (3 to 5 miles),
- site should not be fronting residences or businesses,
- sites with a diversity of native grasses are favored.

The goals and scope of each experiment shall be established on a site-by-site basis by identifying specific management problems in each district and then selecting a site that offers the best conditions to evaluate various management techniques.

Experiments - The experiments will involve collecting data on the comparative effects of different mowing regimes, seeding species or techniques, herbicide application, or litter control on the condition of grass communities on the roadside. These conditions may include grass community composition, density, diversity, or aesthetic value.

Design - The experiments shall be assigned to selected sections of the roadside. The selected schedules and procedures shall be replicated within the sections and assigned by random selection. Plots for data collections shall be located in each section and shall take into consideration both slope and orientation, and soils. Data collection shall be line transect, quadrats, and photo-documentation depending on the specific type of data required.

CURRENT PROJECT STATUS

Table 1. Prairie Restoration Project Status

District	Site Selected	Base Maps Completed	Plans Completed	Letting Date Set
4 - Amarillo*	Yes	Yes	Yes	Jan. 1995
18 - Dallas*	Yes	Yes	No	Spring 1995
8 - Abilene	Yes	No	-	-
14 - Austin	Yes	No	-	-
21 - Harlingen	No	-	-	-

* Detailed information on this project is provided in Appendix A.

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APPENDIX A
PRAIRIE RESTORATION PROJECTS

DISTRICT 4 - AMARILLO
CARSON COUNTY

PROJECT GOAL

This project will focus on the following issues:

1. Effect of various mowing regimes on community composition. This site has a diverse community of grasses existing on the site. Some areas have moderate to severe weed infestation. This study will evaluate the changes in vegetation populations under different mowing schedules and hay baling.

2. Seeding methods and plant species seeded in bare soil conditions.
Areas in the district's roadsides are frequently disturbed due to maintenance operations and are seldom reseeded. Annual weeds, particularly Kochia (*kochia scoparia),* quickly colonize these sites and require additional mowing. This study will evaluate multiple seed mixes, specifically their performance in relation to weed infestation and speed of development.

3. Development of roadside color consistent with warm-season grasses.
Annual color is not prominent in the roadsides of the district compared with other districts in the state. This is due primarily to the shorter growing season of the region. This study will evaluate different forms of seasonal color that would be similar in management requirements to warm-season native grasses of the roadside. These would include herbaceous forbs and legumes.

STUDY DESIGN

(See attached plan, pg. 31)

Site Location

The project site is located in Carson County on U.S. Highway 60. It begins at the Potter/Carson County line and extends to FM 2373. Length of the site is approximately 8 km (5 miles). The roadway parallels railroad right-of-way on its north side for the entire distance of the site. All study plots shall be located along the south side of the roadway.

The area is well established in vegetation. A 61m (200') long point-transect at only one location found buffalograss (the most common plant at 21% of sample), blue gramma, silver bluestem, sideoats gramma, annual lovegrass, sand dropseed, showy clorus, windmill grass, threeawn, dogweed, and clover.

The site lies in the Pullman Series soils group; 0 to 1 percent, silty clay loam. A soil profile shall be performed.

Mowing Studies

Three mowing regimes shall be studied. (See attached schedules.) The length of each study area will be approximately 0.6 km (1 mile). The site shall be divided into four sections for mowing evaluations, three of which will be performed under this contract.

Revegetation Studies

Plots of approximately 0.2ha (1/2 acre) will be established by blading an area clean of existing cover. Seed species shall be drill-seeded and mulched according to standard TxDOT specifications. Plots of spot-sod with seeding and solid sod shall also be established at selected crossovers of medians to study the establishment of short-grass cover in those areas.

Seasonal Color Studies

Colorful perennial plant species shall be included in the grass seeding mixes in the revegetation plots. An area shall also be established in the median to evaluate annual varieties.

Data collection procedures shall be:

- permanently marked line transects in each plot from edge of pavement to r.o.w. to monitor plant density and composition.
- permanent quadrats in each plot to monitor changes in composition in pre-determined areas.

LENGTH OF STUDY

The study shall consist of two phases. Phase I shall consist of the initial construction/maintenance contract (i.e. seeding, scarifying, mowing, spraying, etc.) that may be required. The length of the contract shall be a minimum of one year.

Phase II shall consist of data collection during the length of the study. TTI shall be responsible for data collection and evaluation with the advise and assistance from district personnel. The study shall be for a term of five years.

OUTSIDE AGENCY PARTICIPATION

Because of the interest this project has generated in the area, an advisory committee has been established to advise the project and to get a broader exposure to ideas. This committee includes:

- Representatives of the U.S. Soil Conservation Society,
- Researchers from West Texas A&M University,
- Texas Department of Transportation from the district office and from the Environmental Affairs Division,
- Curtis & Curtis Seed Company of Clovis, New Mexico.

SELECTED PLANT SPECIES

Plant diversity is desired within each site; therefore, a variety of grass and forb species was selected. The focus has been on native warm season perennial grasses because they tend to develop very deep root systems, provide long term erosion control, and often grow on poor soils. All species had to meet certain criteria. Criteria for the forb species varied slightly from the grasses.

Criteria for grasses:

- Has to be adapted to the site, preferably a native.
- Mature height between 0.5 to 1m (1 1/2' and 3 1/2'), to provide some uniformity to the site and reduce any safety hazards due to overgrowth.
- Regional seed source location and seed availability.
- Importance to wildlife habitat.
- Compatibility with other plant species.
- Rate of establishment and/or invasiveness.

Criteria for forbs:

- Adaptable to site.
- Mature height less than 1m (3 1/2'), so as to be compatible with the grasses.
- Invasiveness; will it snuff out the grasses, or invade crop lands?
- Perennial
- Seed availability and cost.
- Aesthetic quality.

Indiangrass exceeds the height listed as criteria for selection, but its mature height would be obtained only under ideal circumstances. Indiangrass was selected because of its upright growing habit, and its dramatic, plumelike seedheads.

Table 2. Selected Grasses for Carson County

COMMON NAME	SCIENTIFIC NAME	N	P	SIZE		B/S
				English	Metric	
Blue grama	*Bouteloua gracilis*	♦	♦	1'- 2'	0.3m - 0.6m	B/S
Buffalograss	*Buchloe dactyloides*	♦	♦	4"- 1'	10.2m - 0.6m	S
Sideoats grama	*Bouteloua curtipendula*	♦	♦	1'- 3 1/2'	0.3m - 1.0m	B
Green Sprangletop	*Leptopchloa dubia*	♦	♦	1'- 3'	0.3m - 0.9m	B
Vine mesquite	*Panicum obtusum*	♦	♦	1'- 2 1/2'	0.3m - 0.8m	S
Indiangrass	*Sorghastrum nutans*	♦	♦	3'- 8'	0.9m - 2.4m	B
Sand dropseed	*Sporobolus asper*	♦	♦	1'- 3 1/2'	0.3m - 1.0	B
Western wheatgrass	*Agropyron smithii*	♦	♦	1'- 3 1/2'	1.0m	S

N=Native, P=Perennial; S=Sod-forming, B=Bunchgrass

Table 3. Selected Forbs for Carson County

COMMON NAME	SCIENTIFIC NAME	N	P	SIZE		COLOR
				English	Metric	
Purple coneflower	*Echinacea purpurea*	♦	♦	2'- 3'	0.6m - 0.9m	Purple
Partridge pea	*Cassia fasciculata*	♦		2'- 4'	0.6m - 1.2m	Yellow
Engelmammdaisy	*Englemannia pinnatifida*	♦	♦	1'- 3'	0.3m - 0.9m	Yellow
Illinois bundleflower	*Desmanthus illinoensis*		♦	2'- 4'	0.6m - 1.2m	White
Tansy aster	*Machaeranthera tanacetifolia*	♦		8"- 15"	2.4cm - 38cm	Lavender
Missouri primrose	*Oenothera missouriensis*	♦	♦	6"- 14"	15cm - 35cm	Yellow
Red gaillardia	*Gaillardia aristata*	♦		1'- 2'	0.3 m - 0.6m	Red
Paperflower	*Psilostrophe tagetina*	♦	♦	1'- 2'	0.3m - 0.6m	Yellow

N=Native, P=Perennial

DISTRICT 18 - DALLAS
COLLIN COUNTY

(Plan preparation is not completed for this site. The plan provided contains preliminary site section. Plot location has not yet been established.)

PROJECT GOAL
This project will focus on the following issues:

1. Control of Johnsongrass in roadsides.
   Johnsongrass infests much of the Collin County roadsides. Conventional control methods involve annual spraying of affected areas with herbicides. Unfortunately, this spraying has an adverse effect on the existing grasses, the net effect being an inability of the grasses to effectively compete with or retard the reemergence of the Johnsongrass and other weeds. This study will evaluate the changes in vegetation populations under different mowing/spraying schedules.

2. Seeding methods in existing vegetation.
   In those roadsides where the vegetative cover is sparse (due to spraying or other disturbances) or is of undesirable species, overseeding is necessary to speed revegetation. Drill seeding and broadcast seeding are the seeding methods available. Each method shall be evaluated in this study.

3. Development of roadside color consistent with warm-season grasses.
   The district is reducing or eliminating mowing on many of the rural roads in Collin County. This may have an effect on the traditional annual-flowering plants in the roadside. Taller grass stands in the spring may inhibit seeding and germination of these annuals.

   Reduced mowing also presents the potential for exploring different forms of seasonal color that would be similar in management requirements to warm-season native grasses of the roadside. These would include herbaceous forbs and legumes.

STUDY DESIGN
(See attached plan, pg 32)

Site Location
The site for this study is a 5.91 kilometer (3.67 mile) section of State Highway 78 at the

community of Blue Ridge in Collin County. It extends from the intersection of SH78 and Spur 137 north to the intersection of SH78 and CR158. Both sides of the roadway shall be used.

Mowing Studies

These studies will be performed on the areas between the edge of pavement and the right-of-way. (See attached plan.) The grades in these areas are varied, ranging from little or no slope to 3:1 or a little greater in some places. Because these changes in grade occur so quickly along the roadway, study areas will be established by random assignment regardless of gradient. The variables of slope and orientation will be dealt with by comparison of like areas between study plots.

The study will evaluate four mowing/spraying schedules. These shall be:

- mowing with the use of herbicides
  - (1) summer - fall mowing
  - (2) spring - summer mowing
- mowing without the use of herbicides
  - (3) summer - fall mowing
  - (4) spring - summer mowing

Each schedule shall have three replications for a total of twelve plots. The length of the site was divided into six sections of 976m (3200 feet) each. Utilizing each side of the roadway yields the twelve plots required. The mowing schedules (1 thru 4), were randomly assigned to each plot (labeled A thru L).

Data collection procedures shall be:

- permanently marked line transects in each plot from edge of pavement to r.o.w. to monitor plant density and composition.
- permanent quadrats in each plot to monitor changes in composition in pre-determined areas.

The numbers, location, and assignment method for the transects and quadrats will be determined later.

Seeding Studies

Drill seeding and broadcast seeding plots will be randomly distributed in the mowing study areas. The number and size of the seeded areas shall be determined later. Plant type and species shall include both grass and forbs. Data collection shall be from permanently established quadrats of recorded initial composition and density.

Site preparation may include the removal of ground-litter in those areas to be broadcast seeded. This might be accomplished by machine raking. Reduction of top-growth by flail-mowing coupled with raking may also be included.

Wildflower Studies

This phase of the project will be part of the seeding studies. The primary emphasis on this phase will be species selection. Species shall be evaluated for their visual quality, durability, and response to the different mowing schedules. Data collection shall consist primarily of photo-documentation and plant counts.

LENGTH OF STUDY

The study shall consist of two phases. Phase I shall consist of the initial construction/maintenance contract, (i.e., seeding, scarifying, mowing, spraying, etc.) that may be required. The length of the contract shall be two years.

Documentation of existing site conditions will be conducted once the study design is finalized, but prior to any site disturbance. Subsequent data collection shall occur on an annual basis at the same time each year.

Phase II shall consist of data collection during the length of the study. TTI shall be responsible for data collection and evaluation with advise and assistance from district personnel. The study shall be for a term of five years.

SELECTED PLANT SPECIES

Plant diversity is desired within each site; therefore, a variety of grass and forb species was selected. The focus has been on native warm season perennial grasses because they tend to develop very deep root systems, provide long term erosion control, and often grow on poor soils. All species had to meet certain criteria. Criteria for the forb species varied slightly from the grasses.

Criteria for grasses:

- Has to be adapted to the site, preferably a native.
- Mature height between 0.5m and 1m (1 1/2' and 3 1/2'), to provide some uniformity to the site and reduce any safety hazards due to overgrowth.
- Regional seed source location and seed availability.
- Importance to wildlife habitat.
- Compatibility with other plant species.
- Rate of establishment and/or invasiveness.

Criteria for forbs:

- Adaptable to site.
- Mature height less than 1m (3 1/2'), so as to be compatible with the grasses.
- Invasiveness; will it snuff out the grasses, or invade crop lands?
- Perennial
- Seed availability and cost.
- Aesthetic quality.

Indiangrass and Maximilian Sunflower exceed the height listed as criteria for selection, but the mature heights listed would be obtained only under ideal conditins. Indiangrass was selected because of its upright growing habit, and its dramatic, plumelike seedheads. Maxmilian Sunflower was selected for its height and showy flowers and also its adaptability and forage value for wildlife.

Table 4. Selected Grasses for Collin County

COMMON NAME	SCIENTIFIC NAME	N	P	SIZE		B/S
				English	Metric	
Bermudagrass	*Cynodon dactylon*		♦	4" - 12"	10cm - 30cm	S
Blue grama	*Bouteloua gracilis*	♦	♦	1'- 2'	0.3m - 0.6m	B/S
Buffalograss	*Buchloe dactyloides*	♦	♦	4"- 1'	10.2m - 0.3m	S
Green Sprangletop	*Leptopchloa dubia*	♦	♦	1'- 3'	0.3m - 0.9m	B
Indiangrass	*Sorghastrum nutans*	♦	♦	3'- 8'	0.9m - 2.4m	B
Little Bluestem	*Andropogon scoparius*	♦	♦	2' - 4'	0.6m - 1.2m	B

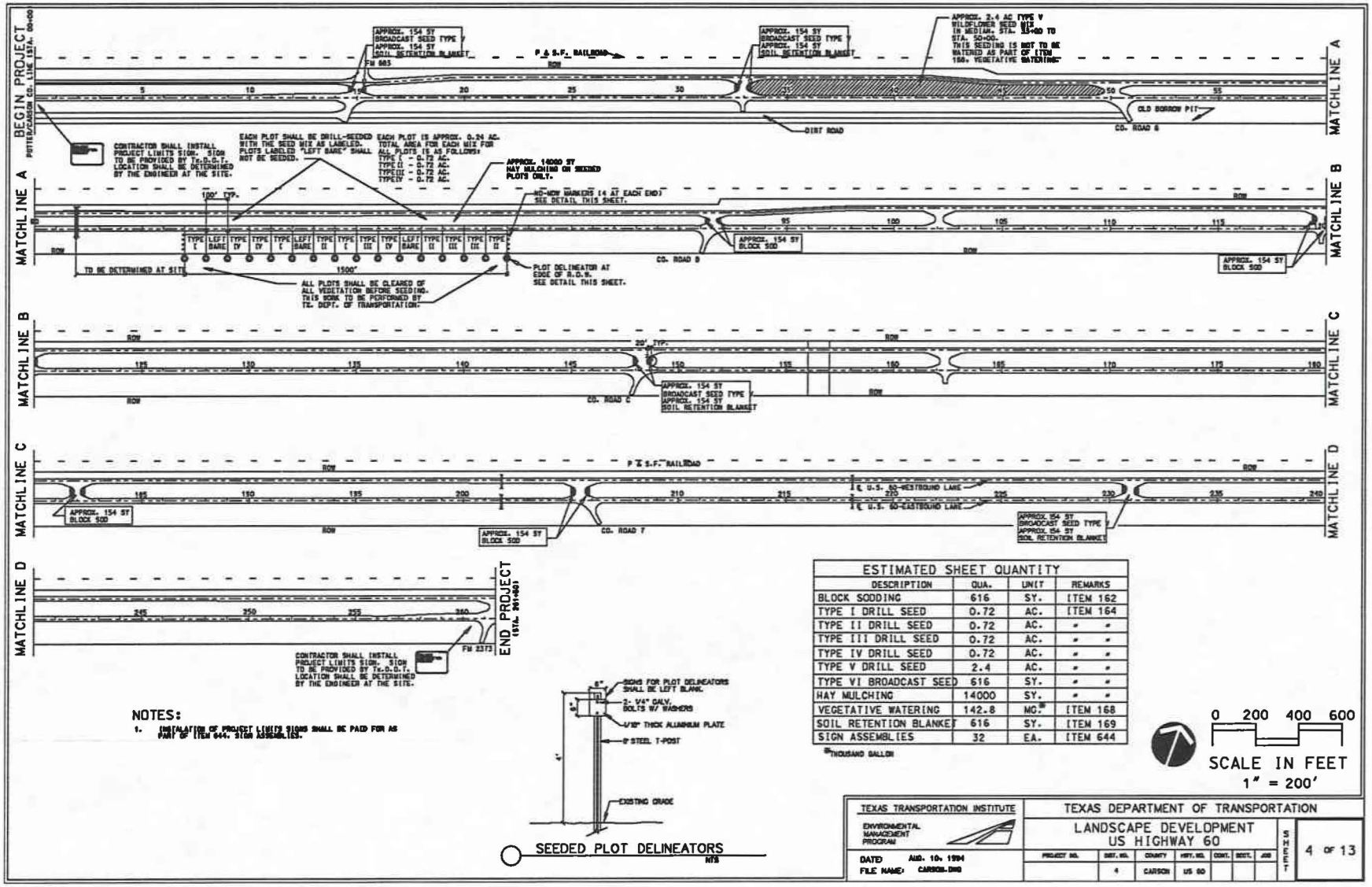
N = Native, P= Perennial; S = Sod-forming, B = Bunch grass

Table 5. Selected Forbs for Collin County

COMMON NAME	SCIENTIFIC NAME	N	P	SIZE		COLOR
				English	Metric	
Purple coneflower	*Echinacea purpurea*	♦	♦	2'- 3'	0.6m - 0.9m	Purple
Maxmimilian Sunflower	*Helianthus maximiliani*	♦	♦	2'- 8'	0.6m - 2.4m	Yellow
Yarrow	*Achillea millefolium*		♦	2'- 3'	0.6m - 0.9m	Yellow/Wht
Mexican Hat	*Ratibida columnaris*	♦	♦	2'- 3'	0.6m - 0.9m	Red/Org.
Purple Prairie Clover	*Petalostemum purpureum*	♦	♦	1'- 2'	0.3m - 0.6m	Deep purple

N = Native, P= Perennial

APPENDIX B
SITE PRELIMINARY PLOTS



ESTIMATED SHEET QUANTITY			
DESCRIPTION	QUA.	UNIT	REMARKS
BLOCK SODDING	616	SY.	ITEM 162
TYPE I DRILL SEED	0.72	AC.	ITEM 164
TYPE II DRILL SEED	0.72	AC.	" "
TYPE III DRILL SEED	0.72	AC.	" "
TYPE IV DRILL SEED	0.72	AC.	" "
TYPE V DRILL SEED	2.4	AC.	" "
TYPE VI BROADCAST SEED	616	SY.	" "
HAY MULCHING	14000	SY.	" "
VEGETATIVE WATERING	142.8	MG.*	ITEM 168
SOIL RETENTION BLANKET	616	SY.	ITEM 169
SIGN ASSEMBLIES	32	EA.	ITEM 644

*THOUSAND GALLON

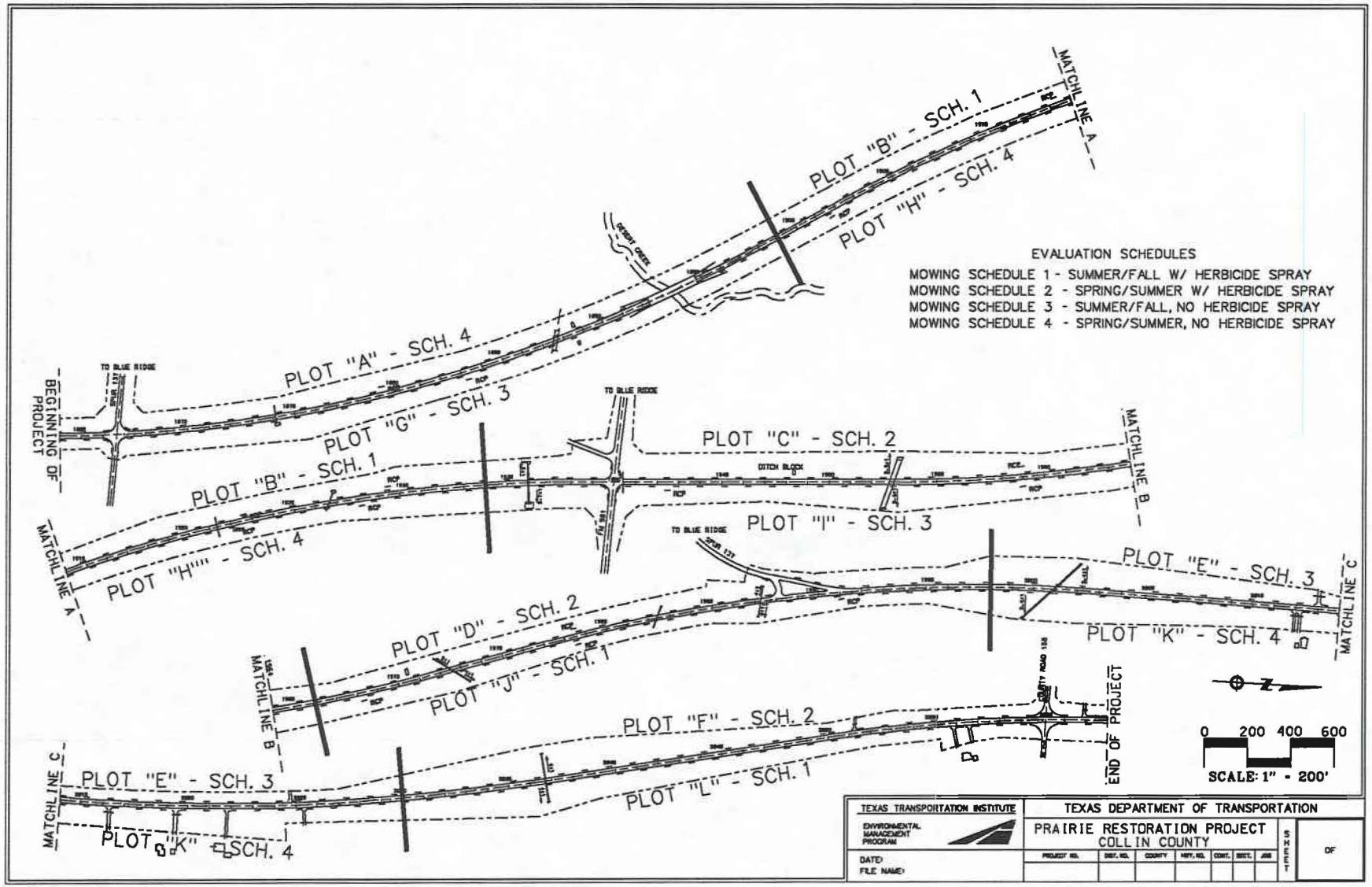
TEXAS TRANSPORTATION INSTITUTE
ENVIRONMENTAL MANAGEMENT PROGRAM
DATE: AUG. 10, 1994
FILE NAME: CARSON.DWG

TEXAS DEPARTMENT OF TRANSPORTATION
LANDSCAPE DEVELOPMENT
US HIGHWAY 60

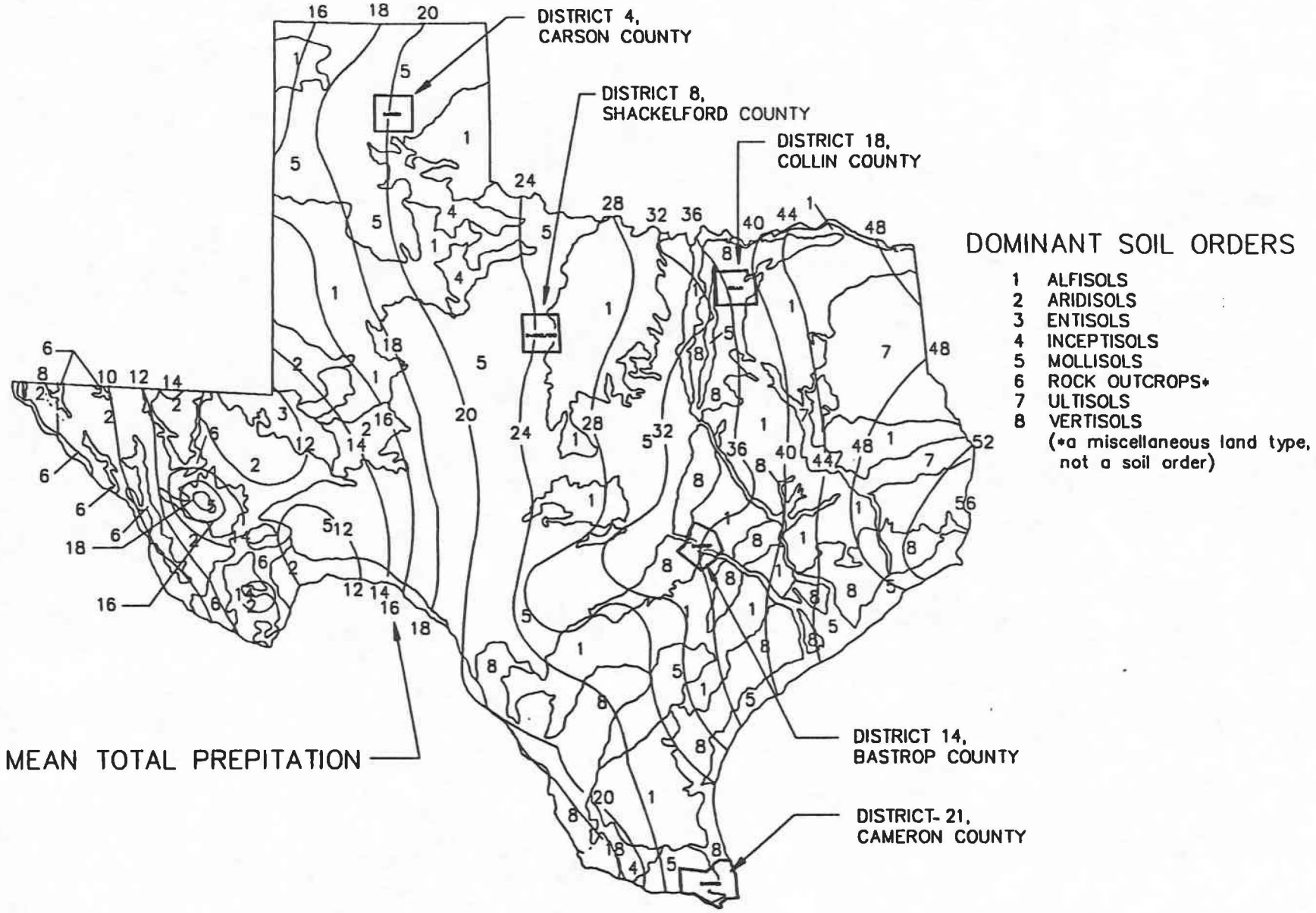
PROJECT NO.	DIST. NO.	COUNTY	HWY. NO.	CONT.	SECT.	JOB
	4	CARSON	US 60			

SHEET 4 OF 13

CARSON COUNTY SITE
PLOT DIVISIONS FOR MOWING STUDIES



COLLIN COUNTY
PRELIMINARY PLOT DIVISIONS FOR
MOWING STUDIES



PROJECT SITES WITH SOILS AND PRECIPITATION