INTEGRATED ROADSIDE VEGETATION MANAGEMENT

TECHNICAL MANUAL

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INTRODUCTION

This project is designed to fill the need for a comprehensive technical information document for vegetation management in roadsides. It is for use during planning, budgeting, and program development. It facilitates decision making by providing Roadside Managers with information on alternatives, procedures, implementation reqirements, costs and future maintenance needs. This manual addresses important considerations when planning a vegetation management program for a specific site. It is an aide for Roadside Managers in assessing vegetation management goals. And it will serve as an operations manual with information presented in a manner managers can quickly reference as needed. Sections include species selection, establishment, erosion control and vegetation maintenance. The manual in its current form is by no means the finished product. It is in a loose leaf form in anticipation of continual growth as new material is produced and acquired. Hopefully the user will feel free to offer suggestions for changes that will shape this document into its most useful form.

THE IRVM APPROACH TO COUNTY ROADSIDE MANAGEMENT IN IOWA

By Alan M. Ehley, U.S.D.A. Soil Conservation Service

INTRODUCTION

Roadsides exist for a variety of reasons, but their primary function is to handle the concentrated flow of surface water from adjacent land and the road surface. Because of steep-sloping land and poor soil conditions within many roadsides, weed invasion and soil erosion are constant problems across Iowa. In 1985, a Roadside Vegetation Management Committee was established in Black Hawk County, Iowa, to address these problems. The committee concluded that the cause of weed invasion and persistence may not be marginal edaphic conditions, but rather the improper establishment and maintenance of Eurasian grasses and legumes. They proposed the establishment of native prairie vegetation in roadsides, and the **integration** of various vegetation management techniques to maintain the plant community. Hence the name, Integrated Roadside Vegetation Management, or IRVM.

IRVM was started in Black Hawk County in 1985 as a new concept used on county rural roadsides. IRVM integrates native vegetation with appropriate management techniques to produce a roadside that is resistant to weed invasion and soil erosion, yet requires little or no maintenance. Following Black Hawk County's lead, many counties across Iowa have adopted IRVM techniques and hired County Roadside Managers to direct the their roadside programs. Managers also work with rural landowners willing to use IRVM techniques on roadsides adjacent to their farmland. Today, this approach to roadside management is being implemented by state transportation departments across the upper Midwest and is attracting interest throughout the nation.

PROGRAM DESCRIPTION

The primary objective of IRVM is to establish and maintain a safe, stable, low maintenance roadside that is attractive and healthy for all life. Whenever and wherever possible, native prairie grasses and wildflowers are used to fulfill this objective. Since 1985, thirty-nine counties across Iowa have implemented an integrated approach to prevent weeds and control soil erosion in their roadsides. The Iowa Department of Transportation and transportation departments in Wisconsin, Minnesota, Nebraska, and Missouri are using similar programs in managing roadsides on their state and federal highways.

Instead of the traditional practice of seeding new or regraded rural roadsides with non-native smooth brome (Bromus inermis Leysser), Kentucky 31 tall fescue (Festuca arundinacea Schreber), or Kentucky bluegrass (Poa pratensis Linnaeus), IRVM counties are using a mixture of five to seven native prairie grasses and an equal number of native prairie forbs. Native Iowa prairie vegetation has been shown to prevent the invasion of perennial and annual weeds while reducing woody species encroachment (Landers 1970). A diverse community of prairie grasses and forbs will also reduce surface runoff within the roadside, thus, reducing the chance for damaging soil movement and resultant gullies or siltation.

Counties utilizing an integrated approach to roadside management hire a professional roadside manager or biologist to oversee roadside activities. Commonly called County Roadside Managers, these employees are responsible for all facets of their county's integrated roadside program. In addition to seeding and maintaining rural roadsides with prairie grasses and forbs, they develop and implement annual and long range roadside management plans.

Roadside managers use various vegetation

management techniques to maintain a vigorous stand on both prairie and non-prairie rural roadsides to prevent weed invasion and control soil movement. A roadside burn every three to five years will increase native plant diversity, recycle nutrients, and retard the growth of any non-native competing vegetation. The roadside burn season typically begins in late April and lasts until mid- or late June. To maintain traffic safety, special burn equipment and crews are used, and extra precautions are taken. Established perennial weeds are eradicated with one or more spot applications of a selected herbicide. After weeds are eliminated, the site is reseeded with a mixture of native prairie seed. Periodic mowing of road shoulders and dangerous intersections may be necessary to maintain traffic safety and allow adequate vehicular sight distance. As part of the roadside planning process, all management techniques are carefully used and later evaluated by County Roadside Managers.

In addition to weed prevention and soil erosion control, the use of native prairie vegetation also provides excellent wildlife habitat along Iowa's 228,000 hectares of rural roadside. Rural roadsides with well-developed prairie will create corridors allowing native wildlife to move from one natural area to another. Also, Iowa travelers will experience the diverse vegetation, beauty, and scenic grandeur that greeted early settlers as they entered Iowa more than a century ago.

One aspect of Iowa's County Roadside Program that separates it from other state roadside programs is the emphasis on working with the local landowners. In Iowa, most of the land in county roadsides is owned by the adjacent landowner, but responsibility for roadside maintenance remains with the County Engineer or County Roadside Manager's office. County Roadside Managers spend considerable time talking to and working with rural landowners. In some cases, the landowners may already be involved with managing their own roadsides. It is not unusual to witness landowners spraying weeds or mowing grass in the roadside adjacent to their cropland, and 3-5% of the rural landowners in Iowa burn their roadsides in the early spring. However, many landowners do not use proper management techniques for roadside vegetation. Often, the grass is mowed too short and too frequently; herbicides are sprayed in the roadside as if it were a field of corn or soybeans; or roadsides are burned at the wrong time, with little or no fire safety equipment. In these situations, the County Roadside Manager contacts the rural landowner, explains the integrated approach to roadside management, and guides the landowner through the proper timing and use of roadside management techniques.

In other cases, a rural landowner may have a fairly good stand of native vegetation already existing in the county roadside. The County Roadside Manager will conduct a follow-up visit with the landowner to explain the integrated roadside program and possibly volunteer to manage the roadside. Regardless of the situation, County Roadside Managers are striving to work with landowners in their county.

FUTURE PROSPECTS

As counties use an IRVM program on their roadsides, they realize that traditional high maintenance and high costs are not necessary. Once established, Iowa's native prairie vegetation has proven to be effective in weed prevention and soil erosion control. County Roadside Managers, using appropriate management techniques, can maintain roadside vegetation while providing wildlife with excellent habitat and travellers a colorful and scenic drive.

As IRVM gains in popularity across Iowa, County Roadside Managers are finding new challenges and asking more questions. For instance, solutions need to be found for temporary soil erosion control that occurs while the native vegetation becomes established; the best formulas for prairie seed mixes and seeding rates need to

be determined for specific roadside sites; the use of widely available cultivars of warm season forage grasses needs to be compared to limited, locally grown native prairie seed; and many more. Those who support IRVM and promote the use of prairie species in roadsides can provide valuable assistance as questions and challenges surface and new research needs to be done.

The forecast for the future of IRVM is favorable. Daily, an increasing number of county, state, and federal roadsides are being protected and managed with IRVM techniques. More County Roadside Managers are being hired. They, in turn, involve more landowners, interested individuals, and agencies in Integrated Roadside Vegetation Management.

LITERATURE CITED

Landers, R. Q. 1970. The use of prairie grasses and forbs in Iowa roadside and park landscapes. Proceedings of the Second North American Prairie Conference, University of Wisconsin, Madison, Wisconsin.

ROADSIDE VEGETATION MANAGEMENT DEMANDS AN INTEGRATED APPROACH

Bill Haywood
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Weed Commissioner, Black Hawk County
September, 1987

Herbicides have been the only tool utilized in roadside management for the past 30 years. It was believed that their use would eradicate undesirable plant species from perennial stands of roadside vegetation. To the contrary, the sole use of herbicides to control unwanted vegetation has been a failure. The herbicides may even be contributing to an increase in populations of noxious plants by removing beneficial, competitive broadleaf plants from the roadside vegetative community.

Herbicides are plant poisons. They are formulated to kill vegetation. Even though certain formulations are selected broadleaf killers, they still have a negative effect on desired vegetation such as the grasses. This, however, is not why herbicides are failing as a control for noxious weed species. The primary reason is that managers have ignored a set of principles related to managing stands of natural, perennial vegetation. The re-institution of those principles into the management plan will make herbicides a valuable, but cautiously, used tool stored in an integrated tool chest.

There are 3 principles which govern the management of natural, perennial vegetation:

1) Nature does not allow bare soils to exist.

2) Bare soils are revegetated by successions of plant groups until a "most fit" community of plants develops on the site.

3) Disturbance of the vegetative cover reverses the succession of revegetation back to the bare soil starting point.

PRINCIPLE 1 - BARE SOILS

Bare soils are defined as any area of the soil surface that is not vegetated. Nature provides a vast supply of plant species to initiate revegetation at the very first opportunity. On bare soils, in full sunlight and without the presence of competition annual weeds literally explode in growth. Annual weeds are typified by being very unspecific about soil characteristics. Their competitive advantage is to be prolific seed producers. Their sole mechanism for perpetuation is to produce seed for other bare soil sites within their seed dispersal zones. This offsets an annual weeds disadvantage of not developing a large, perennial root system. It also makes weeds very weak competitors for moisture and nutrients.

PRINCIPLE 2 - SUCCESSION

There is a continuous introduction of seed to all roadsides regardless if the site is bare soil, populated with annual weeds or established with a perennial, grass/broadleaf community. Unless the surface of a previously bare soil site is stirred or disturbed each year, annual weeds are replaced by biennial and perennial plants. Successful colonizing plants develop in the shade of the annuals the first year. The following year they utilize their biennial or perennial root system to outcompete the annual weeds. This replacement represents the first stage of succession. The new plants that successfully occupy the space are better adapted to utilize the moisture and nutrients provided by the soils of the site. Succession continues as some of the previously successful species are replaced by others that are even more favoured by the site. An additional

parameter affecting succession develops as each group of successful colonizers are not only more suitable to the site, but also more suitable to grow with each other. Eventually, a "most fit" community of plants develops on the original bare soil site.

The "most fit" community will have enough different species comprising it that all available spaces above and below ground will be occupied. The community will also have species present during all possible growing days throughout the year. Because they are so site specific, these late successional, most fit species generally will not be prolific, rapid germinating seed producers. They will spread only to the limits of the soil they are most fit for. The bulk of their energy is directed towards maintaining a vigorous, perennial root system.

To summarize, succession initiates on bare soils with annual weeds. With each following year succession proceeds until a most fit community of plants develops that cannot be replaced by any others.

A monoculture is defined as planting all of one area with a single species of plant. Because succession is natural and results in a plant community, nature will not tolerate a monoculture. With a monoculture there are too many blank spaces in the growing season, too many blank spaces above and below ground. The continuous introduction of seed to the site guarantees that other plant species will colonize the blank spaces.

Most roadsides have traditionally been planted with smooth brome grass as a monoculture. Brome roadsides are continuously invaded by broadleaf and grass plants. To make matters worse, brome is not a late successional, most fit grass on heavy soils. Therefore, the door has been open for many alien, noxious plants to succeed and develop populations in the brome stands.

PRINCIPLE 3 - DISTURBANCES

Disturbance of a parcel of vegetation reverses succession. Disturbances occur in all sizes and conditions. A badger hole produces a small bare ground situation. Annual weeds will be abundant the first season, but rapidly replaced by the adjacent plant community. Excavating silt from a road ditch is a very large disturbance. Many years of succession will be required to re-establish a late successional, most fit community if the site is not seeded artificially.

The introduction of silt into a roadside by wind or water erosion is a disturbance. Although very extensive, these silt disturbances are not long term because the existing perennial vegetation is not killed. It simply results in an extensive crop of annual weeds growing above the perennial vegetation. If the silt deposit is halted, the site will revert back to dominance by the perennial vegetation in a few years.

Broadleaf herbicides are disturbances in themselves. Irregardless of whether they kill the target species, they will stress the grass components of the community and damage perennial, broadleaf components. This leaves the entire community in a weakened condition and allows seed of less fit species to establish and occupy spaces in the community. When Canada thistle is the target species, one treatment of a broadleaf herbicide does not kill the extensive root system. The thistle will respond by producing more sucker plants from its roots. If the community was stressed by the herbicide treatment, the thistle may even end up with a competitive advantage.

THE INTEGRATED PROGRAM

With the above stated 3 principles in mind, a roadside manager can develop an integrated approach to roadside vegetation management.

The first action should be to inventory all roadsides to determine the dominant grass communities in each increment. All subsequent action will be toward promoting a late successional, most fit community of plants in each increment.

All expansive strips of regraded roadsides should be seeded with grass and broadleaf plant seed that are deemed to be late successional, most fit on those soils. This will markedly reduce the number of years it takes for that type of community to develop.

Roadsides established with a brome monoculture will be the most difficult to manage. If warm season prairie grasses have initiated succession onto the sites, timely burning will accelerate succession. It will also help eliminate cool season, noxious plant species. Herbicides may be necessary to eradicate certain persistent noxious plants such as Canada thistle. Bear in mind that one treatment will have little effect on thistle plant populations, but may stress the roadside plant community. Evaluate other noxious plant species before attempting to eradicate with herbicides. Are they promoted by disturbances? Based on the plant community they are in, will their plant population be expected to increase or decrease? What herbicides are they susceptible to? When are they most susceptible? Do the negative effects of the herbicide outweigh any benefits gained? What alternatives are there?

All the above stated management decisions are made for each increment of roadside. Given time, the effects of those decisions will slowly result in elimination or reduction and control of noxious, perennial plant species while increasing roadside most fit plant communities.

A dramatic decrease in annual weeds can be made through a publicity campaign. Farmers should be encouraged to properly manage their field borders next to the upper backslope of the ditch. As often as possible a tilled strip a foot or two wide of perennial grasses should separate the field margin from the upper backslope. Under no conditions whatsoever should a herbicide that kills perennial grasses be applied to the buffer strip or upper backslope. Erosion should be channeled into the ditch at specifically designated points to localize annual weed growth. Brush should not be burned or piled in ditches. Trees should not be sprayed for eradication, but rather cut and the stumps treated.

In summary, by following the 3 principles of nature related to managing perennial vegetation the existing vegetative cover is elevated to a level of primary importance. Burning, mowing and herbicides are all tools that are disturbances. They are integrated into a management plan designed to maintain, invigorate or alter the existing cover. The disturbance they create is controlled. The success of the program no longer pivots on killing noxious plant species, but rather on encouraging the late successional, most fit plant community to prohibit the establishment of undesired plant species.

Roadside Vegetation Management

Roger Q. Landers, Ph.D.
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Texas A & M Research and Extension Center
20 Semptember 1972

People see the roadside from very different eyes. To some the roadside is an extension of their lawn, thus it is kept in the neat trim of closely mowed bluegrass.

To others the roadside is an extension of their fields, and it is closely mowed to emphasize the care and attention that has gone into the growth of the crop.

Or the roadside may be viewed as an extension of the road itself providing clearer views for the driver, often without regard for the health of the plants that grow there, looking upon them more as a nuisance than as a valuable cover.

Or the roadside may appear in sharp contrast to the intensive cultivation and the bare road surface as a bit of nature, with trees growing in from the adjacent forest, prairie grasses from the old railroad right-of-way which preserved remnants of the original expanse of Iowa prairie grasses such as the hairy grama and 2 1/2' little bluestem or the prairie rose, or specially selected species to quickly cover slopes and roadcuts and fill, here hairy vetch and rye, sudan grass, smooth brome, the tall vegetation providing a haven for pheasants.

It would be nice to have all these possibilities, to please everybody, not on every section of road, but atleast within the range of normal driving. All these possibilities have a valid purpose--what are the problems of management with each one?

A neatly trimmed lawn appearance this past year would have required weekly mowings during the growing season. Few of us can afford that. We do well to mow twice or so on most of the roadsides to keep the view clear of tall grasses and weeds. Because Iowa has such a good climate for the growth of plants, the short lawn grasses cannot hold their own against the natural occurence of taller species. Mowing works against the climate to produce a short grass vegetation that is naturally found far to the west where the climate supports the short grasses best. Close mowing of tall plants in Iowa can be detrimental because a scabbed-off slope will show next season an abundance of weeds.

The natural species for Iowa are tall prairie grasses and flowers or trees. We can manage the roadside with minimum effort if these conditions are understood. Weeds thrive in openings created by disturbances, plowing, close mowing, excessive spraying, ruts from heavy equipment, animal digging, overgrazing, etc. Because the prairie species and the selections of standard roadside species are perennial, they come back each spring from the old root system, and most of the time unless distrurbances occur can control the growth of weeds which must start up each year from seeds.

Once a vigorous natural roadside is established it needs no mowing, spraying or replanting except for spot attention where disturbances have allowed the entrance of weeds. The real problem comes in convincing people that what they are seeing is desirable, saving them maintenance costs, reducing the spread of weeds, providing more area for wildlife without cost to the landowners, and providing a variety of interesting shapes and colors of plants along the roadside.

Because of the many different views of the roadside it seems unrealistic to depend on one

general treatment -- blanket spraying -- to manage it. There should be areas mowed, spot spraying where specific weeds have gotten out of control and areas left completely untouched except for safety mowings.

It is our proposal to reduce county blanket spraying of roadsides, to promote spot spraying only those noxious weeds required by law, to educate people on the recognition of valuable, harmless and harmful roadside species, and to set up areas as a demonstration of the newer techniques of roadside management.

1. Following ditch work, areas should be seeded to proven mixtures of species and protected from erosion.
2. Roadsides have variable soil conditions and one plant species cannot possibly cover all conditions.
3. Roadsides already in plant cover should be managed according to a classification procedure whereby most areas are left unmowed and unsprayed, disturbances are kept to a minimum and spot treatments of problem species are cared for on the spot rather than with a blanket spraying.

CHAPTER TWO

STARTING A COUNTY IRVM PROGRAM

POSITION DESCRIPTIONS FOR:
- ROADSIDE MANAGER
- ROADSIDE TECHNICIAN
- ROADSIDE SUMMER HELP

A SAMPLE COUNTY IRVM PLAN

CONDUCTING AN INVENTORY OF ROADSIDE VEGETATION

How Do We Get An Integrated Roadside Vegetation Management Program Started?

by Al Ehley
State Roadside Specialist

Using a Question - Answer format, I will attempt to answer that age-old question troubling counties and their citizens:

HOW DO WE GET AN IRVM PROGRAM STARTED?

Begin as simply and cheaply as possible. Get together a group of like-minded people concerned about roadside vegetation and how it's being managed. Select a recorder to write down comments and any other pertinent information. Now the fun part, hold a gripe session and expose all the flaws of the present system. Tear it apart. After you've listed all the problems with current roadside management practices, put together a list of solutions to balance out the list of problems. When listing solutions, don't be bound by current situations (ie budgets, manpower, expertise, etc.), explore the limits. This may be difficult, but try to prioritize the list of solutions; put together a plan of action. That will be about it for the first meeting. Collect a buck or two from everyone who would like to receive a copy of this information for review and preparation for the next meeting.

To your second meeting, invite several key decision-makers (County Supervisors, CCB Members, SWCD Commissioners, etc.) and other county officials (County Engineer, Weed Commissioner, CCB Director, SCS District Conservationist, etc.). Hopefully some of these people attended the first meeting. Regardless, open the meeting with a review of the minutes and briefly discuss the past meeting. Prepare a new document that will cover the following:

1. Present a list of grievances on current roadside management practices.
2. Suggest a list of alternatives that will satisfy roadside management needs without jeopardizing road safety or the road structure.
3. Write up a proposal to the County Supervisors having them appoint an IRVM Committee. The "IRVM Checklist" has a list of suggested members for an IRVM Committee. Include suggested duties and responsibilities from the handout "What should an IRVM Committee do?".
4. When the County Supervisors appoint an IRVM Committee, you'll be ready to get started on a new approach to better, safer, more scenic, and (in the long term) cheaper county roadside vegetation management. Remember, this committee is NOT appointed just to get a program started, this committee should exist, fulfilling its duties, as long as there is roadside management. (Hopefully for many, many years.)

OK WE HAVE THE COMMITTEE, NOW WHAT?

Write a plan so you will be eligible for Living Roadway Trust Fund (LRTF) money through the Iowa Department of Transportation. There are several counties with excellent plans to guide you in writing your plan.

WHEN DO WE DO A ROADSIDE INVENTORY?

With a plan in place, you'll be eligible for LRTF money to do a roadside inventory. The best time to complete an inventory is late summer to early fall. Review our handout on conducting a roadside inventory for more information.

DOES THE IRVM COMMITTEE HIRE A COUNTY ROADSIDE MANAGER?

No, the IRVM office supervisor should. The County Supervisors may establish a County Roadside Manager (CRM) position within either the County Engineer's office, County Conservation Board system, or somewhere in the county personnel structure where supervision and responsibility are consistent with roadside vegetation management. Most active IRVM counties have the CRM with the CCB system, but several counties have excellent programs with the CRM in the County Engineer's office. The office supervisor will probably hire the CRM, BUT the County Supervisors or office supervisor should allow the IRVM Committee sufficient input in the hiring process.

WHO SHOULD SUPERVISE THE COUNTY ROADSIDE MANAGER?

Probably the CCB Director or the County Engineer. Either one seems to work quite well. Regardless of the supervisor, there should be good communication between all involved departments and groups. The CRM, Co. Eng., CCB Dir., Co. Supervisors, Weed Commissioner, and others should meet weekly or biweekly on roadside projects and other issues, especially during the spring and early summer. Good communication is essential to a successful program.

One thing to keep in mind, a good roadside program needs an effective public relations campaign. This would include newsletters, news articles, media coverage, landowner training clinics, working with school groups, printing brochures, etc. Traditionally, CCB Directors, Naturalists, and other conservation personnel have developed and used these public education techniques. A county may be able to tap into an existing public education network with the roadside program in the CCB Office. (This is just a suggestion.)

HOW MUCH MONEY SHOULD BE ALLOCATED TO IRVM?

Most programs are between $50,000 to $125,000, depending on the level of activity assigned to the roadside program. Some programs are close to $200,000 annually, but IRVM in those counties include tree removal, shrub control, mowing, weed commissioner, and roadside soil erosion control. A good starting point would be $50,000 annually with one full-time CRM and part-time help during the busiest times.

Equipment budgets vary according to what equipment is already available. Generally, about $25,000 is needed for equipment where no other equipment is available. Remember, LRTF's can be used for equipment purchases.

HOW MUCH MONEY SHOULD A COUNTY ROADSIDE MANAGER MAKE?

Most counties look at the CRM position as an entry level job. Beginning wages tend to be between 16 to 20 thousand per year and benefits.

WHAT SHOULD BE THE MINIMUM REQUIREMENTS OF A COUNTY ROADSIDE MANAGER?

A 4 year degree in Conservation or Natural Resources OR equivalent education and experience. Personally, I bank hard on the combination of education and experience over the 4 year degree. Some of the best CRM's in Iowa do not have a degree, but possess the skills and initiative to be excellent roadside managers. Knowledge, skills and ability should include:

1. Organized and able to develop and follow a plan.
2. Work independently, but able to work with others.
3. A leader.
4. Able to talk with and motivate local farmers with IRVM.
5. Familiar with farm equipment and their use, including:
   - tractors
   - drills
   - sprayers
   - chemicals
   - tillage equipment
   - mowers
6. Good writing and public speaking skills.
7. Familiar with, or at least interested in, native prairie grasses and wildflowers.
8. Dedication and the desire to complete the job.

What should an IRVM Committee do?

The duties and responsibilities of an IRVM Committee will vary from county to county. This is logical because each county will have its own desires, priorities, and resources to work with. What may be suitable and important for one county may not be the same for another county, even neighbors!

Below is a list of general duties and responsibilities that most IRVM Committees will be involved with. Items on this list may be appropriate for your county, and there may be items omitted on this list that may be needed for your county. Please use this list as a general guide.

Duties may include, but should not be limited to:

1. Develop a policy statement or statements to guide the county. This statement should address:
    a. the use of native prairie seed vs. cultivars
    b. develop seed plot vs. purchase seed
    c. extent of herbicide use
        -portion of county to spray (whole, half, none)
        -equipment (truck tank, back pack, etc)
        -weed selection to prioritize effort and control
        -encouraging landowner assistance
    d. burning as a management technique
        -burning to control shrub invasion
        -burning with landowners
        -conducting annual burn clinics
        -sharing burn equipment with fire departments
        -burn training for roadside managers
        -burn liability for managers and landowners
    e. shrub control
        -equipment used including herbicides
        -prioritizing areas needing control
        -involving landowners
        -reducing or eliminating seed source

2. Assist in writing a County Roadside Plan, sign it, and forward it on to the Iowa Department of Transportation for eligibility of Living Roadway Trust Fund money.
    a. include roadside budget and review annually

3. Annually review the County Roadside Plan for program evaluation and effectiveness.

4. Provide feedback on IRVM program to County Supervisors and IRVM County Roadside Manager.

5. Participate in hiring a County Roadside Manager.

6. Meet quarterly as a committee and meet annually with County Supervisors and County Engineer for budget review.

7. Assist in the decision as to where to house and who will supervise the County Roadside Manager.

A CHECK LIST FOR DEVELOPING A COUNTY ROADSIDE VEGETATION MANAGEMENT PROGRAM

Step 1 Have the County Board of Supervisors appoint a committee to examine safe alternative weed control methods for use in roadsides. This committee should be composed of the following individuals:

- One member from the County Board of Supervisors
- One member from the County Conservation Board
- One District Commissioner from the SWCD
- County Engineer
- County Weed Commissioner
- County Conservation Board Director
- SCS District Conservationist
- Representatives from local conservation organizations

Step 2 Committee should meet regularly and develop a Long Range Plan for roadside activity. This plan would include a basic roadside objective and operations/activities such as: Preserve a safe roadway while using native prairie vegetation to stablize roadsides and prevent noxious weeds.

- Reduce herbicide usage
- Control roadside disturbances
- Work with landowners in developing local roadside plans
- Educate the public on the roadside program

Step 3 Assign a person to oversee roadside activity as outlined in the Roadside Long Range Plan. This individual may be one of the following:

- The Weed Commissioner
- Employee of the County Engineer's Office
- Employee of the County Conservation Board
- Newly hired Roadside Biologist or Roadside Manager

Step 4 Conduct an inventory of all county roadsides to determine:

- Patches of noxious weeds
- Disturbed sites
- Current extent of native vegetation
- Site specific roadside information for landowner use

Step 5 Launch a public relations campaign to promote the County Roadside Vegetation Management Program.

Step 6 Identify those landowners in the county who are willing to work with the program on their own roadsides.

POSITION DESCRIPTIONS

ROADSIDE MANAGER

TECHNICIAN/ASSISTANT

SUMMER HELP

ROADSIDE VEGETATION MANAGER/WEED COMMISSIONER

DEFINITION

Work within the Secondary Road Department, in a management position, under the direction of the County Engineer to manage roadside within Johnson County.

DUTIES

The Roadside Manager will work with the County Engineer and the Maintenance Superintendent to supervise, schedule and administer the Johnson County Roadside Vegetation Plan which includes: brush control, control of noxious weeds, mowing, seeding of construction and maintenance projects, planting and maintaining prairie grasses, investigate and take appropriate actions on brush complaints and various other services as needed. The Roadside Manager will be responsible for; establishing and maintaining records of chemicals used and their amounts, areas treated, brush priority areas, etc.; supervise the mixing of chemicals; perform routine maintenance on various equipment used; prepare and submit reports concerning chemical use, etc.; inform and educate the public concerning roadside management techniques and policies. In addition, the Roadside Manager will serve on a Roadside Vegetation Committee with other County departments and members of the public sector.

ENTRY REQUIREMENTS

Knowledge of the principles and practices of noxious weed control and safe use of roadside chemicals; knowledge of Secondary Road practices and procedures; knowledge of IDOT signing and safety procedures knowledge of prairie grass establishment and maintenance; ability to identify species of plants, flowers, noxious weeds and woodlands; ability to establish and maintain effective working relationships with the public; ability to perform routine maintenance on vehicles and spraying equipment; ability to maintain records and prepare reports. Preform related work as required.

MINIMUM EDUCATION, TRAINING AND EXPERIENCE

Graduation from high school (additional education in the areas of Botany, Horticulture, Natural Resources or any related areas are perferred but not required) and some experience in weed control activities, personnel management, public relations, etc. or any combination of training and experience which provides the required knowledges, skills and abilities.

REQUIRED SPECIAL QUALIFICATIONS

Must be licensed as a commercial applicator or ability to become licensed. Have or able to obtain valid Iowa Chauffeurs License or Commercial Drivers License as required.

Applications accepted until 4:00 P.M. on April 2, 1990.

ROADSIDE VEGETATION MANAGER/WEED COMMISSIONER

The Johnson County Secondary Road Department is seeking an individual to fill a new management position under the direction of the Johnson County Engineer. The successful candidate will help to establish, supervise, schedule and administer the Johnson County Roadside Vegetation Plan.

Applicant should have knowledge of principles & practices of noxious weed control & safe use of roadside chemicals, Secondary Road practices and procedures, prairie grass establishement and maintenance, ability to identify species of plants, flowers, noxious weeds, and ability to deal with the public.

Applicants must have high school education and additional education in the areas of Biology, Botany, Horticulture, Natural Resources or any related areas are preferred but not required. Must be licensed as a commercial applicator or ability to become licensed. Must have or be able to obtain valid Iowa Chauffeurs license or Commercial Driver license as required. Resumes will be accepted at the office of the Johnson County Engineer, P.O. Box 126, Iowa City, Iowa 52244 until 4:00 P.M. on April 2, 1990. Women and minorities are encouraged to apply. Johnson County is an E.O.E.

Fri, Apr 5, 1991

Interested in Praire Ecology?

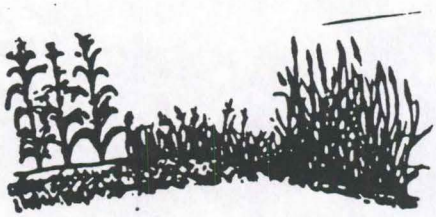
Roadside Vegetation Management Technician - Aquire experience in the rapidly-growing field of integrated roadside vegetation management (IRVM). The IRVM program stresses the use of native prairie vegetation in roadsides. Assist native grass and wildflower seeding, weed/brush control and native seed harvest operations. Farming and/or mechanical background suggested. Plant identification skill desireable. Term of employment - May 15 to August 15 (flexible) 1991. Pay $4.75-7.00/hr. depending upon experience and education. Applications available in the Hardin Co. Engineer's Office, P. O Box 464, Eldora, IA 50627. (515) 858-3461. Ask for Doug Sheeley.

EMPLOYMENT OPPORTUNITY--SUMMER 1991

Fayette County's Integrated Roadside Vegetation Management Program is looking to hire several seasonal summer workers for the 1991 season. Successful applicants will be working with a leading roadside management system, doing all aspects of a totally integrated program.

Special emphasis will be on thistle treatment with backpack spray equipment. Must be a certified public pesticide applicator or be able to pass the test. Study materials available at our office.

Approximate starting date is May 13, and continues throughout the summer. Wage is $4.75 per hour, with compensatory for any extra hours worked. Burn management, prairie seeding, and other general conservation activities part of regular operations.



For more information or application form, contact Wildwood Nature Center at 425-3613, or 422-5146.

Jon Steege, Roadside Vegetation Mgr

SAMPLE COUNTY IRVM PLAN

INTEGRATED ROADSIDE VEGETATION MANAGEMENT PLAN

History:

Warren County has utilized several different methods of roadside management on the 958 miles of secondary roads. When you multiply the number of miles times two and then convert the number of miles into acres of land managed, there is approximately 4,644 acres or 7.26 square miles of roadside to be managed.

- 958 miles of secondary roads
- 958 miles x 2 roadsides = 1916 miles of ditch
- 1916 miles of ditch x 5280 ft/mile x 20 ft wide ditch ÷ 453,560 sq.ft/acre = 4,644.85 acres of roadside
- 640 acres/square mile
- 4644.85 ÷ 640 acres = 7.26 square miles of roadside

Management of that amount of area is no small task and involves much planning. In the past Warren County has used spraying as the major means of noxious weed and brush control in roadside right-of-ways. The county also had no established policy for reseeding after construction or regrading, and the ground was left bare to be seeded by nature or the landowner. Prior to 1981 Warren County used a blanket spraying program. Seeing a need for a better method of control the county adopted a new program. In 1981 the new program adopted the policy of only spraying where landowners adjacent to the right-of-way requested and in areas where large weed problems existed. The spraying was done largely on a contract basis. In October of 1988, three part-time weed commissioner positions were converted to a single full-time position.

The new weed commissioner and the secondary road department then took on all of the spraying duties, eliminating contract spraying. In addition to spraying, the county secondary roads department also mechanically cuts, treats and chips brush in the winter months, and has done so for several years. For the most part this type of management has kept the noxious weed and brush problem at about the same level every year with no noticeable headway. Therefore, Warren County has decided to adopt an Integrated Roadside Vegetation Management plan. The first step taken was the Warren County Board of Supervisors appointed a committee on IRVM. An inventory was also begun to determine the status of the county's roadsides. The following is Warren County's integrated Roadside Vegetation Management plan.

Integrated Roadside Vegetation Management Committee Members:

Bill McClymond, Chair, Warren County Board of Supervisors
Ruth Hardin, Member, Warren County Board of Supervisors
Bob Sandy, County Engineer
Stan Wickett, Weed Commissioner
Dana Kellogg, Ranger/Biologist, Warren County Conservation Board
Dale Faulkner, Soil Conservation Service District Conservationist
Richard Davitt, Commissioner, Soil and Water Conservation District
William Overland, Audubon Society
Chuck Kakac, Pheasants Forever, and Department of Natural Resources Wildlife Biologist.

Available Resources:

1) Equipment

a) Fire
- •300 gallon pumper with trailer
- •300 gallon water supply tank
- •2 Indian backpack pumps
- •flappers and Fire Racks
- •drip torch

b) General
- •2 - 3/4 ton pickup trucks
- •45 hp front wheel assist tractor
- •crawler tractor
- •trailer

c) Seeding
- •hydro seeder
- •native grass drill (in process of purchasing)
- •roller (in process of purchasing)
- •off-set disc
- •tandem disc 8'
- •cultipaker 10'
- •A.C. 66 all crop harvester
- •seed drying racks

d) Spray
- •400 gallon trailer-mounted tank with wand applicator
- •2 - solo backpack sprayers
- •safety equipment

e) Brush
- •2 chippers
- •chainsaws
- •truck
- •safety equipment

2) **Experience and Expertise:**

- Members of IRVM committee
- Also: Dr. Bill Gilbert, College Biology Professor
  Dorothy Barringer, Native Prairie Expert
  David Youngblut, Operations Supervisor, WCCB
  John Pearson, Botanist, Iowa Department of Natural Resources

3) **Funds Available**

•annual herbicide funds		$ 12,000.00
•roadside reseeding funds		10,000.00
•brush control, mowing, labor		43,000.00
•spraying funds		30,000.00
•general appropriations (for purchase of native grass drill)		10,000.00
•donation from Pheasants Forever (to be used for seed)		750.00
	total	**$105,750.00**

The Warren County IRVM committee has determined these goals and objectives to be important and to begin to strive to achieve them.

OVERALL GOALS AND OBJECTIVES OF THE PROGRAM:

- Provide the public a safe travel environment
- Comply with Iowa Noxious Weed law
- Improve public relations and educate public and landowners on Roadside Management
- Apply current botanical, chemical, and mechanical knowledge and technology for the development, maintenance, and beautification of Warren County's roadsides
- Reduce amount of chemicals used in controlling unwanted vegetation on our roadsides
- Reduce long term costs for roadside management
- Provide efficient and economical control of noxious weeds by utilizing warm and cool season grasses
- Enhance wildlife habitat through use of native grasses and wise management
- Improve ground water quality
- Reduce erosion
- Beautify ditches while controlling brush and weeds through re-introduction and rejuvenation of native grasses, wildflowers, and cool season grasses
- Control brush where it causes a problem with safety

<u>Annual Goals and Plans:</u>

- Spot spray noxious weeds and small brush
- Removing trees and brush mechanically; treating stubble; and chipping in areas where it causes visibility and snow problems
- Use mechanical means of controlling weeds and brush

•Burn areas on rotational basis that have existing prairie to rejuvenate them and attempt to improve and promote them
•Harvest seed
•Seed all new construction projects, regrades, and ditch cleaning with native and cool season grasses
•Evaluate different methods of seeding
•Evaluate chemicals and applications
•Use inventory to identify problem areas
•Continue public education on IRVM
•When seeding is done contact adjacent landowners by letter and personal contact to inform them on purpose and objectives of IRVM
•Submit articles and news releases to publicize and promote IRVM
•Evaluate the program on a yearly basis and determine best methods. Make any changes to benefit the program

First Year Goals:

•Seed demonstration site with native grass on large regrade site between road and railroad right-of-way - approximately 15 acres
•Seed all regrades and ditch cleaning
•Experiment with Buffalo grass and Blue grama near intersections and areas where short grass is preferred
•Give programs on IRVM and increase public awareness
•No till seed after burning 3 acres of roadside
•Purchase native grass drill
•Finalize inventory already begun
•Sign several demonstration sites
•Complete annual goals previously listed
•Plant and sign county gateway demonstration site using mixed grasses and wildflowers - approximately 1 acre

Five Year Long Range Goals:

•Improve public relations and continue public education on IRVM
•Beautify roadsides
•Improve wildlife habitat
•Evaluate progress of program and make necessary changes
•Reduce chemical use
•Develop demonstration projects
    Seeding native grasses on regrades
    Interseeding
    Mowing with seeding establishment
    Mowing for brush control
    Burning for brush control
    Wildlife impact studies
•Develop native grass nursery to provide seed source
•Work with adjacent landowners and SCS in developing soil conservation plans that aid in roadside management (grass head lands, filter strips, erosion control)
•Enter inventory on computer program so it can be updated easily
•Conduct burn and seeding clinics
•Develop brochure on IRVM for landowners
•Develop demonstration route and interpretive brochure to show positive effects of roadside management
•Revise annual plans as more information and better techniques become available

•Complete several gateway plantings in highly visible areas
•Encourage landowners to plant native grass adjacent to right-of-way
•Continue with annual plans

Long Range Goals: 10 year

•Continue with public awareness and education
•Evaluate IRVM program and check progress being made
•Update roadside inventory
•Reduce amount of ditch cleaning needed
•Reduce maintenance budget
•Have a good percentage of county roadsides well established with native grasses and forbes
•Improve the beauty and wise management of our roadsides
•Establish several demonstration areas throughout the county
•Involve groups in collection of seed and funding of projects
•Conduct more demonstration projects
•Continue to upgrade and conduct annual plans

Warren County hopes to better our environment and promote the wise use of our natural resources through the implementation of this plan.

Approved: 3-5-90
(Date)

Committee Signatures:

ROADSIDE INVENTORY PROCESS

Barb McKinstry helped develop the current inventory package distributed by the UNI Roadside Office. It makes use of the eight digit link-node accident location number. Barb has done inventories for a couple counties. The following are a few recommendations based on her experience.

Survey every quarter mile.

Begin in late August as this is when the native grasses are most visible and can be seen from the car. This is the best time to locate the best prairie areas. Once they are located and recorded on the survey, a Roadside Manager can return in the future to increase the species list.

Take pictures of good roadsides during the survey to provide the county with promo slides for their program.

Also note the location of problem areas for brush, weeds and erosion.

Gather all the important information without recording too much. An overly extensive inventory costs too much and is unwieldy when it comes time for the Roadside Manager to use it.

Allow six to eight weeks to complete the inventory.

Work with a driver who knows prairie.

Inventory one side of the road at a time.

Obtain good legible maps of the county with link-node numbers clear and distinct.

Introduction

As counties implement an integrated approach to roadside management, a county roadside cover-type survey is one of the first steps necessary in program development and function.

Enclosed is a roadside cover-type survey form that is simple to use yet provides the basic information needed in analyzing current rural roadside conditions and planning for future roadside projects and activities. This form is NOT designed to be a detailed, once-in-a-lifetime survey. A follow up vegetative inventory or site investigation will be needed on <u>all</u> roadside segments identified as "extensive" by this survey. Please review and understand the enclosed guidelines before proceeding with your roadside survey.

GUIDELINES

This form is designed for one mile or less of roadside cover-type evaluation. One form will be needed for each side of the road. Each form contains four columns to record roadside cover-type information and other data in quarter-mile segments. For safety considerations and recording efficiency, a two person team is necessary. One individual will drive and note mileage, and the other will be a passenger to freely view roadside vegetation and conditions and record pertinent data. A tall vehicle, such as a four-wheel drive pick-up, provides better viewing than a low riding sedan.

The recorder is responsible for evaluating roadside vegetation and correctly identifying and recording native prairie grasses, native prairie forbs, perennial weeds, and annual weeds. The majority of rural roadsides will contain non-native Eurasian grasses. The recorder must be able to identify non-native eurasian grasses and differentiate them from native prairie grasses. Therefore the recorder must recognize the following plants:

<u>Eurasian Grasses</u>	<u>Annual Weeds</u>	<u>Native Grasses</u>
brome	ragweed	switchgrass
fescue	foxtail	big bluestem
bluegrass	lambsquarter	little bluestem
redtop	wild parsnip	indiangrass
timothy		side oats grama
orchard		Canada wildrye
		needlegrass
<u>Perennial Weeds</u>	<u>Native forbs</u>	prairie cord grass
all thistles	black-eyed susan	rattlesnake master
leafy spurge	coneflower	prairie clover
teasel	blazing star	partidge pea
wild carrot	compass plant	goldenrod
purple loosestrife	prairie phlox	asters

VEGETATION COVER CODES are defined as follows:

Code 1 0-15% slight - native plants or weeds are scattered and few (less than 15% of total roadside segment)

Code 2 15-50% moderate - several native or weed plants or bunches of plants (15-50% of total roadside segment)

Code 3 50-100% extensive - many bunches or dominance of native plants or weeds (more than 50% of total roadside segment)

SPECIAL NOTE: Code 3 should be used only in extreme cases and should alert the roadside manager that is area needs immediate attention. Either the quarter mile segment is loaded with prairie plants (good) or the quarter mile segment is covered with perennial or annual weeds that need eradication. Code 3 means "HIGH PRIORITY"! Mark over the "X" in the box in the upper right hand corner when a Code 3 is used.

Trees/Shrubs includes all problem trees and shrubs in the roadside.

COVER CODES are defined as follows:

Code 1 slight - scattered small trees or shrubs on backside of roadside. No trees or shrubs on road shoulder or ditch bottom.

Code 2 moderate - several larger trees or numerous shrubs on backside of roadside. No trees or shrubs on road shoulder or ditch bottom.

Code 3 extensive - trees or shrubs on road shoulder or ditch bottom. Trees or shrubs that obstruct driver visibility of oncoming traffic. Also trees or shrubs that block signs or within 300 feet of an intersection, farm entrance, or field drive.

SPECIAL NOTE: Code 3 should be used only in extreme cases and should alert the roadside manager that this area has a serious infestation of trees/shrubs that jeopardizes traffic safety and needs immediate attention. Mark over the "X" in the box in the upper right hand corner when a Code 3 is used.

Bare spots are areas of the roadside that are void of vegetative cover due to ditch cleaning or some other reason.

COVER CODES are defined as follows:

Code 1 slight - none or one small bare area or less

Code 2 moderate - one or two bare areas (less than 100 feet total)

Code 3 extensive - one or more large bare areas (more than 100 feet total)

SPECIAL NOTE: Code 3 should be used only in extreme cases and should alert the roadside manager that this area needs immediate reseeding. Mark the "X" in the box in the upper right hand corner when a Code 3 is used.

Erosion includes both soil erosion occurring within the roadside (ie. gullies, soil slumping) and soil erosion occurring in the adjacent field with soil deposition in the roadside.

COVER CODES are defined as follows:

Code 1 slight - none

Code 2 moderate - one or two gullies or small areas of soil deposition (less than 100 feet total)

Code 3 extensive - several gullies or areas of soil deposition (greater than 100 feet total)

SPECIAL NOTE: Code 3 should be used only in extreme cases and should alert the roadside manager that this area needs immediate attention. Mark the "X" in the box in the upper right hand corner when a Code 3 is used.

Encroachment is where farmers cross over the roadside boundary and crop the land closer to the road. Be careful, without a fence it may be difficult to determine where the field ends and the roadside begins.

COVER CODES are defined as follows:

Code 1 slight - none or not sure

Code 2 moderate - positive farmer is cropping the roadside

Code 3 extensive - farmer is cropping the roadside near ditch bottom or closer to road surface

SPECIAL NOTE: Code 3 should be used only in extreme cases and should alert the roadside manager that this area needs immediate attention and the landowner causing the disturbance should be contacted. Mark over the "X" in the box in the upper right hand corner when a Code 3 is used.

Spray/Burn occurs when vegetation is destroyed by a landowner. Typically herbicide spray drift or a chemical spill will kill existing vegetation along the field - roadside boundary. Also concentrated burning of debris, refuse, and/or wood will heat the soil, damage plant roots, and kill the existing vegetation.

COVER CODES are defined as follows:

Code 1 slight - no noticeable burn spots or light herbicide kill

Code 2 moderate - one small burn spot or herbicide kill area (less than 100 feet total)

Code 3 extensive - one large or several small burn spots or herbicide kill areas (greater than 100 feet total)

SPECIAL NOTE: Code 3 should be used only in extreme cases and should alert the roadside manager that this area has experienced a serious chemical spill or large concentrated burn. Mark over the "X" in the box in the upper right hand corner when a Code 3 is used.

OTHER may be used to identify some other characteristic of the roadside, disturbance, or feature specific to the county doing the roadside vegetation survey.

COMMENTS: can be used to identify particular plants or conditions not specified in the code. It may also be used to record the exact location number (link-node number) for a priority item. The comments space can also be used to explain the Code 3 marking, such as "the roadside and adjacent land appear to be a native prairie approximately 5 acres in size".

COMPLETING THE INVENTORY FORM:

This form is designed to be used with the Iowa Department of Transportation Link-Node Accident Location System. Please review and become familiar with the system as described in the handout. The county intersection location map should be used throughout the inventory and kept with other pertinent roadside inventory information.

The two digit county code and township code numbers should be recorded on the top of the inventory form. The county code number is located on the bottom right hand corner of the intersection location map. The township number is circled and within the boundaries of the township on the intersection location map. Record the surveyor and driver's names, and the date the inventory is completed. Write down the road name if possible. Circle which side of the road the inventory is being done on.

Now it's time to record the final four digits of the beginning link-node location number. Note your intersection on the intersection location map and the number assigned to that position. Record the four digit number above "beginning link-node number". Complete your one mile survey. After the one mile segment is complete, note your intersection on the intersection location map and the number assigned to that position. Record the four digit number above "ending link-node number". (If your survey is less than one mile, record whatever link-node number is appropriate. **Remember, each link-node number represents 1/16th of a mile.**)

* **SPECIAL NOTE:** the beginning link-node number will be larger than the ending link-node number when you are traveling south and west.
* **SPECIAL NOTE:** keep in mind that you will inventory from the passenger side of the car, when inventorying the:
  - east roadside you will always be traveling north
  - west roadside you will always be traveling south
  - south roadside you will always be traveling east
  - north roadside you will always be traveling west

ALL CODE 3's (FORMS WITH THE "X" BOX MARKED OVER) SHOULD BE TRANSFERRED TO A LARGE COUNTY WALL MAP USING THE FOLLOWING COLOR CODES. (large wall maps can be obtained from the Iowa Department of Transportation)

Suggested color codes:

green - native grasses

yellow - annual weeds

red - perennial weeds

blue - trees/shrubs

black - bare areas

brown - erosion

gray - encroachment

orange - spray/burn

ROADSIDE COVER-TYPE SURVEY FORM

north
west — east
south

(circle roadside in relation to road)

____ ____ county number

____ ____ twp number

surveyor/driver _____

road name _____

date _____

COVER CODES: [1] 0-15% slight [2] 15-50% moderate [3] 50-100% extensive [*] forbs

____ ____ ____ ____ beginning link-node number

____ ____ ____ ____ ending link-node number

	0	.25	.50	.75	1.0 MILE
Native Vegetation					
Perennial Weeds					
Annual Weeds					
Trees/Shrubs					
Bare Spots					
Erosion					
Encroachment					
Spray/Burn					
Other					

COMMENTS:

USE OF THE EIGHT DIGIT LINK-NODE ACCIDENT LOCATION NUMBER

The eight digit link-node location number is used by all transportation departments in Iowa. The use of this system by roadside inventory personnel and roadside managers would further match site specific roadside information and activities with an established, well known, and successful transportation location system. Listed below are a few reasons for using the link-node location system with a county roadside inventory.

1. The link-node system is laid out in 1/16th mile increments. Locations can be identified to within 165 feet of the node number.

2. State and county maps are available to county engineers and others with road numbers already assigned.

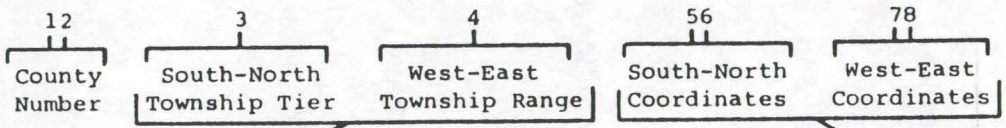
3. Maps are updated every six months to reflect new road construction or road closing.

4. The link-node location system will provide on-going communication with all road use information being planned on both the state and county level.

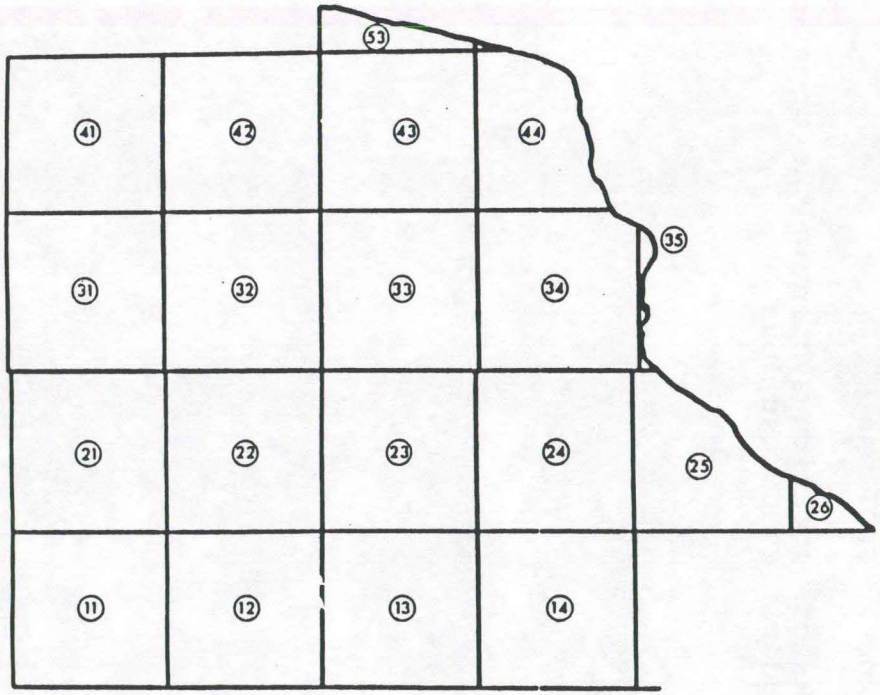
5. The link-node system is in the process of being adapted to personal computer (PC) use.

6. The link-node location system is the standard for the state, counties, and cities across Iowa.

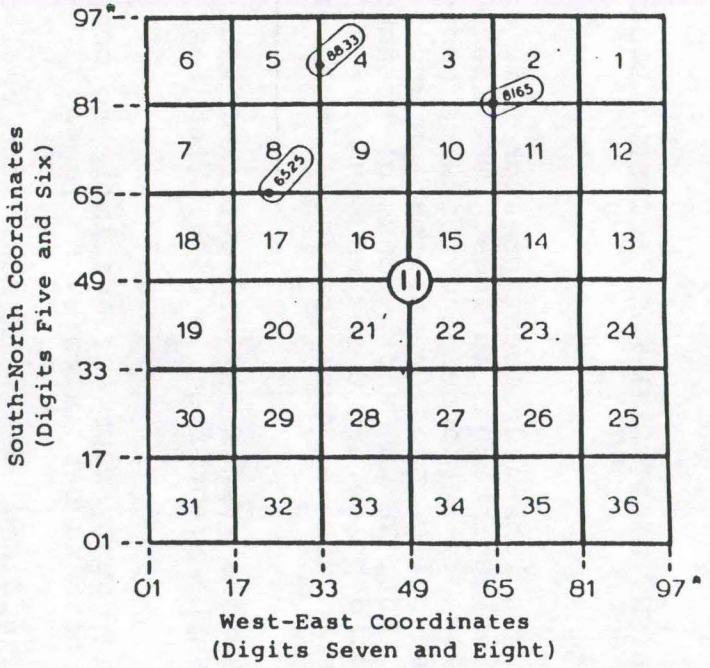
COMPOSITION OF EIGHT-DIGIT NODE NUMBER



EXAMPLE OF CONGRESSIONAL TOWNSHIP NUMBERING (Digits Three and Four)



COORDINATE SYSTEM NUMBERING ON SECTION LINES WITHIN A CONGRESSIONAL TOWNSHIP (Digits Five thru Eight)



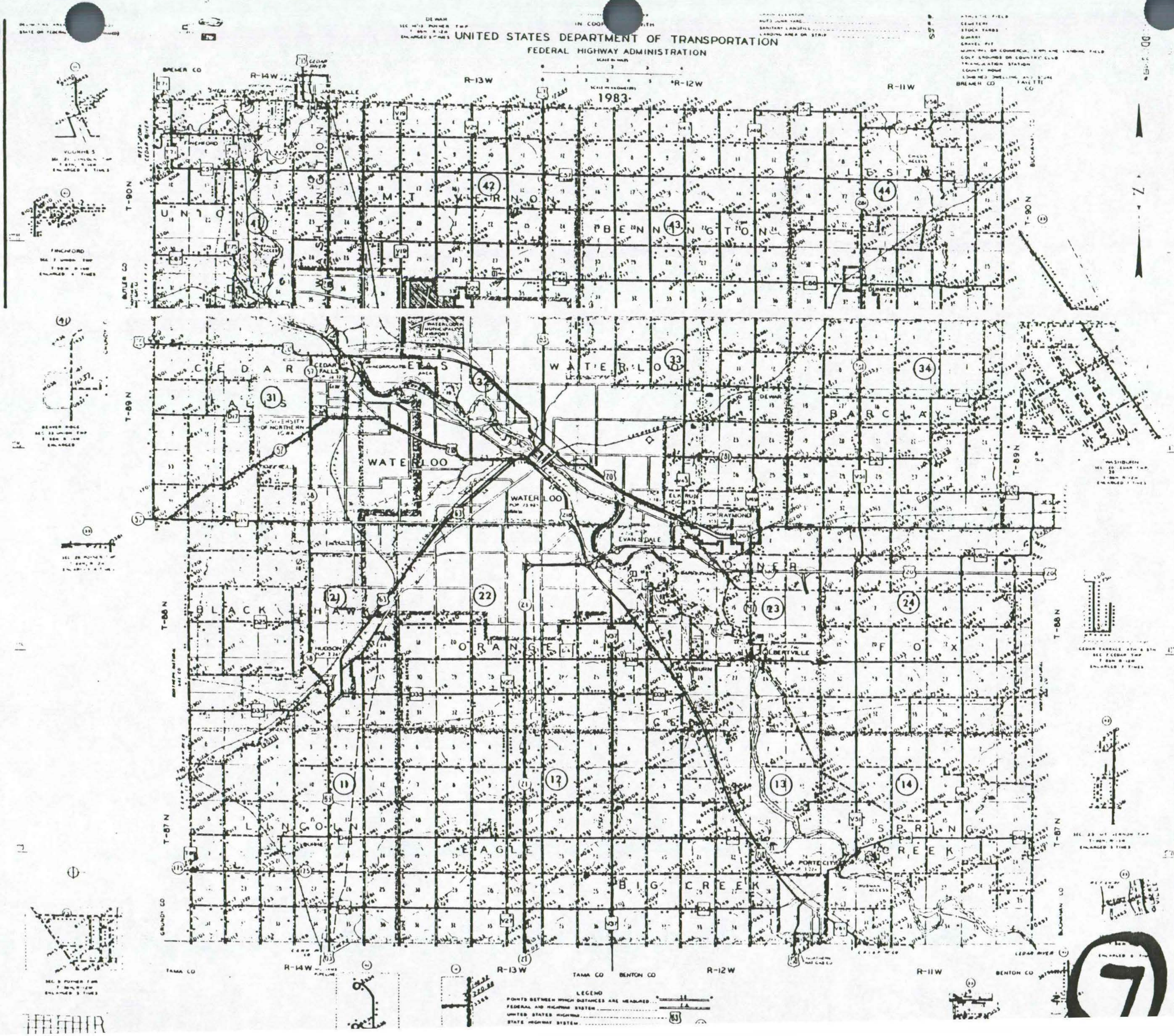
* If Township Line is on County Line

ROADWAY ELEMENTS TO WHICH NODE NUMBERS ARE ASSIGNED

1. All Intersections (Except Alleys)
2. Ramp Terminals
3. Railroad Crossings
4. Grade Separation Structures
5. Major Bridges
6. Road Ends
7. 90 Degree Turns (When Each Leg is at Least ¼ Mile Long)
8. County Lines

DESCRIPTION OF THE IOWA LINK-NODE ACCIDENT LOCATIONAL SYSTEM

IOWA DEPARTMENT OF TRANSPORTATION


UNITED STATES DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
1983
BREMER CO
FAYETTE CO
BUCHANAN CO
BUTLER CO
GRUNDY CO
TAMA CO
BENTON CO
R-14W
R-13W
R-12W
R-11W
T-90N
T-89N
T-88N
T-87N
UNION
MT VERNON
WASHINGTON
PENNINGTON
LESTER
CEDAR FALLS
WATERLOO
BARCLAY
BLACK HAWK
ORANGE
EAST WATERLOO
POYNER
FOX
LINCOLN
EAGLE
CEDAR
BIG CREEK
SPRING CREEK
CEDAR FALLS
UNIVERSITY OF NORTHERN IOWA
WATERLOO
EVANSDALE
ELK RUN HEIGHTS
RAYMOND
HUDSON
GILBERTVILLE
LA PORTE CITY
DUNKERTON
JANESVILLE
DEWAR
WASHBURN
FINCHFORD
CEDAR RIVER
LEGEND
7

CHAPTER THREE

MANAGEMENT PLAN OUTLINE

SAMPLE PLANS:

EDUCATION/AWARENESS

WEED CONTROL

CHEMICAL APPLICATION

SEEDING

BURNING

DITCH CLEANOUTS

MANAGEMENT PLAN OUTLINE
Des Moines County Roadside Vegetation
1992-93 Fiscal Year

MANAGEMENT

A management plan will be established using various techniques to assure aggressive stands of native vegetation.

a) Burning/acres & miles
b) Seed harvest/acres & species
c) Landowner assistance/burning & seeding
d) Inter-agency cooperation

EDUCATION AND PUBLIC AWARENESS

To gain public approval of the integrated approach to roadside management a variety of informational and educational materials need to be developed to reach the rural community.

a) Slide programs
b) News articles
c) Display booths
d) Brochures
e) Radio spots

WOODY BRUSH REMOVAL

Special emphasis will be given to controlling unwanted brush where public safety is a problem. Small brush will be controlled using spot-treatment techniques designed not to disturb beneficial plant communities. Establishing prairie plant communities will help reduce the invasion of woody plant material.

a) Locate problem areas/acres
b) Remove and treat cut stumps/miles and acres
c) Chip and shred material

NOXIOUS WEED CONTROL

Canada thistle and teasel are major concerns in this part of Iowa. Spot chemical application will help control unwanted plants. One application during active growing season and a follow-up prior to winter dormancy will control most noxious weeds.

a) Identify problem areas
b) Spot spray noxious weeds/miles and acres
c) Record chemical use

ROADSIDE INVENTORY

A roadside inventory system is being set-up and implemented for Des Moines County. The location of prairie remnants will be documented and registered on our inventory sheets. High priority will be given to all remnant locations during the 1992 burn season.

a) Locate primary prairie species
b) Map Spring burning sites
c) Prioritize unwanted brush areas
d) Identify encroachment areas and soil erosion

SEEDING OUTLINE

By promoting and using native prairie grass and forbs in our roadsides we can establish a quality vegetative cover that is resistant to weeds.

a) Promote native grass vegetation
b) Identify disturbed areas
c) Work with County Engineer and Secondary Roads personnel keeping abreast of new construction projects.
d) Using no-till drill/seeding into existing cool season grasses with warm season grasses.
e) Records will be kept on <u>new</u> construction programs where native grasses and forbs have been planted to determine success rates.
f) Methods, Research, Trends - Records will be kept to develop trends for establishing native grasses consisting of:
    1) No-till
    2) Conventional
    3) Hydro-seed
    4) Hand seeding
g) Develop seeding guide handbook - matrix of adaptable seeds and sites.

BURNING OUTLINE

Native prairie plants have lived with fire a long time. They store their food and growing buds underground, ready to go back to work once the fire passes. Plant growth is enhanced by recycling of nutrients, quicker warming of black soils, and removal of dead material by fire. Fires also maintain a healthy prairie by keeping unwanted woody vegetation at bay.

a) Identify prairie remnant locations.
b) Contact local fire department before and after the burn.
c) Use backpack sprayers to control burn.
d) Encourage landowner involvement.
e) A drip torch, fire rakes, swatters, and fire brooms will be used.

DITCH CLEANING/LANDOWNER ASSESSMENT

Soil deposits in roadside ditches have stressed the desirable plant communities along many miles of county roadside. Secondary Roads personnel spend a quantity of time each year cleaning out ditches where soil has collected from adjoining farm fields.

a) Identify problem areas.
b) Work with landowners to control problem.
c) Seed ditch elements with appropriate seed type.

EDUCATION/AWARENESS PLAN

You are fortunate in that your job gives you access to information and activities of interest to just about everyone in the county. You've got it. They want it. So share it as much as possible. Help the public feel good about something going on in their county. Become an effective vehicle for distribution of information. This will go a long way towards assuring the success of your program.

Put together a fairly well polished general program that you can provide on short notice. Make use of videos, slides, transparencies and other visual aids. A minimal amount of tailoring will be necessary for most audiences. Let it be known you are happy to provide this service.

Submit articles and news releases to publications about IRVM program. Newspapers favor press releases based on an upcoming event or something out of the ordinary. Use seasonal roadside activities and environmental aspects of the program. Share discoveries you make in your roadsides.

Develop programs to educate landowners on the benefits and cooperative opportunities of IRVM program.

Work with landowners to reduce siltation and sedimentation in county ditches.

Plant a demonstration seeding in a highly visable area.

Involve summer interns in innovative demonstrations.

Use Conservation Capsule programs periodically to publicize IRVM program features.

Do other educational programs and demonstrations as needed.

Prepare an education package for use in classrooms both indoor and outdoor. Design activities that require or provide for student participation. Include materials that can be passed around the room, handled, looked at up close or taken home to parents.

Stay in contact with relevant agencies- SCS, Extension, SWCS Attend their meetings and explain IRVM objectives.

Work with conservation organizations- Pheasants Forever, Sierra Club, Audubon Society, Ducks Unlimited, etc.

Inform County Engineer and Supervisors of program progress.

Borrow the display from the UNI office for fairs and other booth events such as meetings attended by farmers.

Always be adding names to your mailing list.
Write a newsletter or write articles for the County Conservation Board Newsletter.

Send names of important people in your county to CRAO to receive Roader's Digest.

Continually emphasize to all employees in the program that each one of them is a spokesman for IRVM and that they should always watch for opportunities to represent the program positively and to elaborate on its contributions to the county. Program everyone's mind with a few pat responses so they are ready to run out their mouth at a moment's notice. Such as:

"We release far less chemical into the environment and do not harm existing prairie plants."

"Native grasses fix and store far more carbon dioxide than trees do. This more than compensates for the carbon dioxide released during a roadside burn."

"The money once spent on broadcast spraying herbicides now goes towards managing roadsides as a valuable resouce."

"IRVM seeks to prevent costly maintenance by working with landowners to keep topsoil out of ditches."

"IRVM recognizes roadsides as a sanctuary for native prairie plants."

"The county roadside manager performs many functions necessary to roadside maintenance. These are jobs that must be done whether the county has a roadside program or not. By using IRVM principles they are getting the work done more cheaply and in an environmentally sound manner."

"Roadsides provide valuable wildlife habitat in a state that has lost more of its natural landscape than any other state."

"IRVM uses native prairie species to reseed bare areas. These are the plants best suited to survive in our climate and prevent invasion by weeds and control soil erosion."

Assemble a support committee who can advise you on public opinion and help shape the direction of your program and act as goodwill ambassadors for the program. Possible members are: a County Supervisor, a member of the County Conservation Board, a District Commissioner from the SWCD, County Engineer, County Conservation Board Director, SCS District Conservationist, representatives from local conservation organizations, local educators.

WEED CONTROL PLAN
Des Moines County, Iowa

Primary noxious weeds will be controlled on a "complaint only" basis on private land. The only exception will be teasel (Dipsacus) a biennial. An official notice will be published informing Des Moines County landowners that this plant will be controlled. If nothing is done to control the plant after fifteen (15) days of the official notice, a letter will be sent to each landowner that has this weed on their property. If, after ten (10) days of the receipt of the letter, no attempt has been made to control this weed, the Weed Commissioner will control weeds. The landowner will be assessed a fee, based on the Commissioner's control costs, which will be added onto the property tax of the landowner. This is in accordance with Iowa Code, Chapter 317.

Various control practices will be used to control noxious weeds. Timely mowing and burning will kill annual weeds, prevent biennial weeds from going to seed, and reduce food reserves of perennials. Using warm season grasses will control and suppress unwanted plants.

After receiving a complaint of noxious weeds on private land, the Weed commissioner will visit the land and make an assessment of the problem. A written management plan from the Weed Commissioner will be given to the owner or tenant of the land with the noxious weeds. If the management plan isn't implemented with fifteen (15) days after receipt, the Weed Commissioner will control weeds and the cost will be assessed against the real estate on which the noxious weeds are destroyed.

FAILURE TO COMPLY WITH CHAPTER 317.16 OF THE IOWA CODE

A $10.00 fine each day, up to 10 days, will be in effect for tenants or landowners who fail to control weeds. Landowners who fail to comply after repeated attempts to inform them of their responsibility will follow a course of action that will involve the County Auditor, County Board of Supervisors, and the County Attorney.

PRIMARY NOXIOUS WEEDS INCLUDE:

Buckthorn (Rhamnus)
Bull Thistle (Cirsium lanceolatum)
Canada Thistle (Cirsium arvense)
Field Bindweed (Convolvulus arvensis)
Hoary Cress (Cardaria draba)
Horse Nettle (Solanum carolinense)
Leafy Spurge (Euphorbia esula)
Musk Thistle (Carduus nutans)
Perennial Sow Thistle (Sonchus arvensis)
Quack Grass (Agropyron repens)
Russian Knapweed (Centaurea repens)
Tall Thistle (Cirsium altissimum)

SECONDARY NOXIOUS WEEDS INCLUDE:

Buckhorn Plantain (Plantage lanceolata)
Cocklebur (Xanthium commune)
Curly Dock (Rumex crispus)
Multiflora Rose (Rosa multiflora)
Poison Hemlock (Conium maculatum)
Puncture Vine (Tribulus terrestris)
Purple Loosestrife (Lythrum salicaria)
Shattercane (Sorghum bicolor)
Red Sorrel (Rumex acetosella)
Smooth dock (Rumex altissimus)
Teasel (Dipsacus)
Velvet Leaf (Abutilon theophrasti)
Wild Carrot (Daucus carota)
Wild Mustard (Brassica arvensis)
Wild Sunflower (Helianthus annual)

Approved Signatures:

_____
Don Dahl, Weed Commissioner

_____
James N. George, Des Moines County Engineer

_____

_____
Jeff S. Bergman, Director
Des Moines County Conservation Board

_____
Des Moines County Board of Supervisors

CHEMICAL APPLICATION PLAN

Objective: To manage undesirable vegetation at an acceptable level. Complete control may not be achieved without irreversible environmental damage.

Section 317.11 of the Iowa weed law, Weeds on Roads, states: Spraying for control of noxious weeds shall be limited to those circumstances when it is not practical to mow or otherwise control the noxious weeds.

When faced with undesirable vegetation, a combination of more than one vegetation management method, such as mowing, spraying or burning, may be appropriate.

IRVM controls weeds by:
1.) maintaining a healthy stand of vegetation to keep weeds out.
2.) reseeding bare areas with native grasses and wildflowers, the plants best adapted to Iowa's climate and therefore most able to outcompete weeds.
3.) burning
4.) spot-spraying
5.) mowing

IRVM counties use herbicides responsibly by spot-spraying target species only. Compared to broadcast spraying this reduces the stress to desirable plants in the roadside and greatly reduces the amount of money spent on herbicides and the amount of chemicals entering the environment.

I. Survey roadsides

II. Map locations of problem weed areas

III. Prioritize these areas along with complaint areas.

IV. Evaluate new chemicals and applications. Become familiar with a number of herbicides and formulations.

V. Purchase and or maintain necessary spray equipment
   Truck unit
   Back pack
   Hand held

VI. Select herbicides based on objectives, application timing, and conditions

VII. Train spray crew- Make sure they have proper certification and are familiar with weed law. Know your equipment output. Spray water into a bucket and time how long it takes to spray a gallon. Then you know how much chemical you have applied after spraying an area for five minutes. Practice spraying water on pavement to learn how fast you must walk to apply the right amount of chemical/acre.

VIII. Monitor growth of weeds in order to spray at the most opportune time- Spring, when the stem is up so plants can be distinguished from surrounding vegetation but prior to swelling of the bud.

IX. Spray thistles in late May early June and again in the fall. Can also use fall as the first treatment time since Roadside Managers tend to be very busy in the spring. Then do a follow-up spray in the spring to get thistles not killed in fall.

X. Return to sprayed locations to evaluate effectiveness of weed control program

XI. Return or store excess chemicals

SEEDING PLAN
ROADSIDE VEGETATION MANAGEMENT
Des Moines County, Burlington, IA
February, 1992

Goal:

By using native prairie grass and wildflower species we will be able to out compete weeds, reduce chemical use, reduce soil erosion, and increase our wildlife habitat.

Objective:

All new regraded roadsides, cleaned out, or disturbed areas will be reseeded with warm season native forbs and grasses. Working with adjacent landowners and supporting agencies will be on-going.

Components:

Seed bed preparation is one of the most important activities for successful seedings. The ground should be firm but not packed. Seed depth should remain constant at 1/4 inch to 1/2 inch.

Methods of Application:

1. No Till Drill - Will be used to seed into existing vegetation.
2. Conventional Drill - The Truax conventional seed drill will be used on sites that are receptive to this practice.
3. Hydro-Seeding - This seeding practive will be used for wet site application as well as steep embankments.
4. Hand Seeding - To control small bare site areas.
5. Endgate or Broadcast Seeding -

Seeding dates for warm season prairie grasses vary:

1) Frost Seeding - March (spring freezing & thawing will mix seed with the soil).
2) Spring Seeding - April 1 thru July 1 (ideal time for planting).
3) Fall Seeding - will be accomplished by first reducing the weed competition, either by chemical means or repeated cultivation prior to permanent seeding. A major advantage of fall planting is a high percentage of forb seed germination. Fall planting will be achieved in our area in late October, November and early December.

Erosion Control:

1. Cover crops will be used on all seeding projects.
2. Mulching with prairie hay or wheat straw will be used on new seeding projects.
3. Netting will be used to control soil erosion on sites with a 2 to 1 slope or greater.

Strategy:

Native grass and forb seeding will remain consistent throughout the county depending on soil types. A minimum of five grass species, plus forbs for diversity and aesthetics will be planted.

Seed Origin:

All seed furnished shall be purchased locally or within state. Local eco-types are preferred over uncommon varieties.

All native grass seed shall be purchased by pounds Pure Live Seed (PLS). PLS = Bulk lbs. x % PLS. PLS = % Germination x % Purity. All forb seed shall be purchased by bulk ounces or pounds.

Seed Vendors:

Prairie Grass Unlimited Inc.
4100 Y-Camp Road
Burlington, IA 52601
(319)753-0350

Heyne Seed Co.
Rt. 1, Box 78
Walnut, IA 51577
(712)784-3454

Nature's Way
R.R. 1, Box 62
Woodburn, IA 50275
(515)343-6246

ION Exchange
R.R. 1, Box 48C
Harpers Ferry, IA 52146
(319)535-7231

Allendan Seed Co.
Rt. 2, Box 31
Winterset, IA 50273
(515)462-1241

Iowa Prairie Seed Co.
110 Middle Road
Muscatine, IA 52761
(319)264-0562

Plant Species	Rate PLS/LB/Acre	Recommended Use
Little Bluestem	3	Clay Soils
Big Bluestem (Wet Mesic)	5	
Switchgrass (Wet Mesic)	1.5	
Indian Grass	4.5	
Big Bluestem	6	Dry Mesic Soils
Canada Wild Rye	2	
Indian Grass	4.5	
Sideoats Grama	1.5	
Oats	20	Dry Sandy Soils
Little Bluestem	3	
Big Bluestem	8	
Sand Dropseed	3	
Sideoats Grama	4	
Switchgrass	2	
Big Bluestem	5	Wet Mesic Soils
Switchgrass	1.5	
Cord Grass	2	
Dark Green Bulrush	1.5	

PRESCRIBED BURN PLAN

1.) From roadside survey locate roadsides with native prairie species, weeds, and brush problems.
2.) Select from this list roadsides to be targeted in the first year. The average program tries to burn 10 to 15 miles of roadsides in a burn season. For your first year a realistic goal might be five miles of roadsides. If the weather conditions are favorable, you might get more done. But set down specific, measurable goals such as five miles in 1992.
3.) For each burn site note your objective: Encourage existing natives, inhibit weeds and woody species, remove litter buildup, Knock back brome.
4.) Highlight the areas to be burned on a county road map.
5.) Draw a triangle by each site to indicate proper wind direction for burning that site.
6.) Have crew and equipment ready to go when ground dries out in spring.
7.) See burn chapter for details on conducting a burn.

The prime burning dates for favoring warm season grasses may be something like 4/21-5/15. This is a very short time. By restricting your burning to these dates you risk having your burn plans for the year washed out by a couple weeks of rain. If your roadsides are dry enough to burn in March, and you are ready to go then do it. We want to burn as much as possible. And we do not want to extend the season further into May.

Ditch Cleanout Plan

Identify and evaluate ditches with erosion and siltation damage.

Work with adjacent landowners and SCS in developing soil conservation plan to alleviate problem.

Reseed ditch after clean-out by county crews.

Provide weed control and maintenance as needed.

Monitor adjacent land use to prevent reoccurence.

Contact SCS for possible demonstration areas.

Coordinate with County Engineer sites for possible demonstration projects.

Distribute Disturbance Brochure

CHAPTER FOUR

ESTABLISHING VEGETATION BY SEED

HYDRAULIC SEEDING WITH MULCH AND TACKIFIERS

SEED STORAGE

SEED VIABILITY TESTS

SEED COUNTS

SEED POLICY

CULTIVARS

SEED SOURCES

SEED BANK MANAGEMENT

CALCULATING SEED RATES

SEEDING MATRICES

By Scott Zager

ESTABLISHING VEGETATION BY SEED

SEEDING PERIODS

The following dates for various periods of seeding are based on long-term averages compiled by the Iowa Soil Conservation Service. Seasonal conditions can vary by as much as two weeks. It is strongly recommended that a temporary cover be used if a permanent seeding cannot be established during the optimum seeding period.

Cool Season Grasses

March 1 - May 15
August 1 - September 15

Warm Season Grasses

April 1 - June 1

Legume Cultivars

Hairy vetch may be seeded until September 30th.

All other legumes should not be seeded after August 31.

Clovers and Crown vetch should always be seeded in the Spring.

Wildflowers

The proper season for planting forbs is dependant upon the individual species. Unfortunately, there is conflicting information provided in the literature. Optimum forb planting season is probably related to the physiological conditions required to break dormancy in the seed [see germination requirements for seed]. Since a one-time seed planting of native species in the spring will be preferred by most roadside managers, CRAO recommends that forb seed be treated by the methods cited by Sullivan and Daley (1981), Rock (1981), Smith and Smith (1980) and National Wildflower Research Center (1989). Germination requirements of a particular species may vary according to region, therefore it is important to know the origin of the seed, especially for cultivars, e.g., citations for seed treatment of E. angustifolia, and other species, differ according to U.S. regions in Sullivan and Daley (1981). Remember that the breeding and selection process involved in the development of a cultivar may eliminate specific germination requirements otherwise expressed in the species. This is commercially desireable because it yields a "genotype" which will consistently germinate in a predictable manner. Therefore, optimum planting dates of cultivars may not be consistent with indigenous seed of the same species.

The following are the results given by Salac and Traeger (1982) concerning twelve species of native forbs:

> Dates of seeding showed a significant effect on emergence of all the wildflowers used in the study. Depending on the species, emergence were highest among seeds that were sown in November 1978 or in April 1979 (Mead, Nebraska). The dormant seeding in November provided the best conditions for the emergence of Echinacea angustifolium and Penstemon grandiflorus seeds during the 1979 growing season [these species must be stratified to overcome dormancy (See Sullivan and Daley 1981; Region 6)].
>
> The April seeding treatment promoted maximum emergence of Asclepias tuberosa, Salvia pitcheri, Dalea purpureum, Lespedeza capitata and Yucca glauca. The dormancy requirement was fulfilled during dry storage at 4.4 centigrade. Winter conditions had a detrimental effect on the seeds of these species because those planted in October and November 1978 showed significant decreases in emergence compared to those planted in April 1979. [Sullivan and Daley (1981; Region 6) cite that A. tuberosa requires cold/damp stratification, while the above legumes need only scarification. Y. glauca needs cold/damp and one month exposure to light].
>
> November and April were equally effective for planting seeds of Ratibida pinnata, Liatris punctata, L. aspera, L. pycnostachya, and Helianthus maximiliani. [Sullivan and Daley (1981; Region 6) cite cold/damp stratification treatment for the above Liatris spp. and R. pinnata. H. maximiliani is cited as needing no treatment.]

About 10-20% of the seeds planted in October emerged before the onset of winter and failed to survive winter conditions. Many of the species emerged poorly when planted in June to September (these results may be attributed to lower than normal rainfall during those months).

National Wildflower Research Center. 1989. Wildflower handbook. Texas Monthly Press, Austin, 337 p.

Rock, H. 1981. Prairie propagation handbook, sixth ed. Wehr Nature Center, Milwaukee County Department of Parks, Recreation and Culture, Whitnall Park, 9701 W. College Ave., Franklin, WI, 53132, 74 p.

Salac, S. S. and J. M. Traeger. 1982. Seeding dates and field establishment of wildflowers. Hortscience 17(5): 805-806.

Smith, J. R. and B. S. Smith. 1980. The prairie garden. University of Wisconsin Press, Madison, 219 p.

Sullivan, G. A., and R. H. Daley. 1981. Resources on wildflower propagation. National Council of State Garden Clubs, Inc., Missouri Botanical Garden, St. Louis, 331 p.

FROST SEEDINGS

Frost seeding is performed by sowing seed on soil surfaces made friable by freezing and thawing. The soil surface is usually "honeycombed" with small cracks. Frost seedings are usually made in late February and March on seedbeds prepared the previous fall. Depending on soil conditions, lime and fertilizer should be disced into the soil during seedbed preparations (avoid using nitrogen at this time). The seedbed should then be mulched or a temporary cover crop planted to prevent soil erosion from occurring over the winter. Ideally, temporary matrix species should have developed enough roots to stabilize the soil and nutrients over the winter so that no additional ground preparation will be necessary. CRAO recommends that the base seeding rate of 60 seeds per foot be increased by 30-60 percent for frost seeding, depending on the method of application. Frost seedings should not be made on areas covered with ice or snow, nor on extensively eroded seedbeds as evident by numerous rills and gullies.

DORMANT SEEDINGS

Dormant seedings are performed late in the fall just prior to winter freeze. Normally this period begins about November 1 in Northern Iowa and November 15 in southern Iowa. The period would end at the beginning of the frost seeding period. However, no seedings should be made on snow or ice covered surfaces. Cool season seeding mixtures are best for this period but some prairie restorationists claim that dormant seedings of native warm season species imitates nature, however this is hotly disputed by others. Use regular seeding rates if cool season seeds are incorporated into the soil using a no-till range drill. Use of warm season species are not recommended by CRAO, but if attempted, increase the base rate by 30% if incorporated into the soil or increase by 60% if broadcast methods are used. Coating seed with a fungicide such as Captan has been recommended by some agronomists to prevent seedling loss early spring

INOCULATION

Legume inoculants contain rhizobia bacteria necessary to promote maximum production of legume plantings. They insure against low rhizobia populations often found in roadside soils, especially for native small-seeded legumes. It is important to recognize that different legume species require different types of rhizobia bacteria.

Legume seed should be inoculated prior to planting by the slurry method in accordance with the directions given by the supplier. Inoculant needs to be specific to the binomial latin name of legume seeded (genus, species). When more than one legume species is used, each species should be inoculated separately. Inoculated seed should not be exposed to direct sunlight for periods of time exceeding one-half hour, prior to seeding. Seed should be planted within eight hours following inoculation. Proper inoculation of legumes is especially important on roadside soils which are often sterile of bacteria and plant nutrients. Inoculants are perishable and should stored in a cool, dry place and never used past the manufacturer's recommend date.

The following is a brief description of inoculation procedures obtained from Robert S. Dayton, Conservation Agronomist, Iowa Soil Conservation Service:

> Commercial legume inoculants are available in three basic forms: 1) Solid (peat or clay based), 2) Liquid, and 3) Freeze dried. Generally, the solid or peat based inoculums have resulted in the best field inoculation results. Fungicides are sometimes added to inoculants to prevent damping off. Some fungicides can kill rhizobia bacteria. Always follow manufacturer's instructions.
>
> Inoculum can be applied by one of the following methods:
>
> Slurry Method: The inoculant is mixed with the seed in the hopper. A water slurry should be made from the peat inoculant to ensure better adherence to the seed. Various stickers are also available and can be used with the slurry method to facilitate better sticking of bacteria to the seed. This method is generally considered the most effective of all planter box inoculation procedures.
>
> Sprinkle Method: Dry inoculant is mixed with pre-moistened seed. This method is not considered as good as the slurry method but can be adequate under good planting conditions.
>
> Dry Method: Dry inoculum is mixed with dry seed. This is the most common and least effective method of adhering bacteria to the seed.
>
> Pre-Inoculation: Inoculum is applied to the seed prior to sale to the grower. This method is most often used with small seeded legumes such as alfalfa. Seed inoculated in this manner must be stored under cool conditions to insure viability of the bacteria. A new method of pre-inoculation involves application of a peat based inoculum with a sticker producing a pelleted seed. Other products such as fungicides are often included in the mix to help prevent seedling damping off of small seeded legumes. The pelleting process can be done locally insuring viability of the rhizobia bacteria and optimum legume inoculation.

Rhizobia inoculants for various leguminous species can be obtained from:

The Nitragin Company
Division of Lipha Chemicals, Inc.
3101 W. Custer Avenue
Milwaukee, WI 53209
1-800-558-1003

SOIL AMENDMENTS

Fertilizer should be applied according to the results of a soil test or general recommendations. Soil samples should be collected from each soil type found in the Right-of-Way area to be planted. Soil tests can be obtained from Iowa State University Soil Testing Laboratory or other suitable commercial lab. Samples should be tested to determine soil pH, and nutrient content of phosphorus and potassium.

Element	Soil Test Results If test	lb./acre add
Phosphorus (P)	<15 ppm	30 P_2O_5
Potassium (K)	<67	40 K_2O
Nitrogen (N)	Use general recommendation	

SCS General Nutrient Recommendations (lbs/acre)

	N	P_2O_5	K_2O
Introduced Species	0-30	30	40
Native Species	0*	30	50

* time release formulations @ 15 lbs per acre are suggested for sterile soils.

Nitrogen should not be applied at seeding time. Even small amounts will stimulate weedy growth which will retard warm season species establishment. If good weed control has been obtained, an application of 30 lbs per acre of nitrogen in midsummer could stimulate more rapid establishment of warm season species (Iowa State Extension Service, Pamphlet Pm-569: Warm-season grasses for hay and pasture. See also: Pm-869, Fertilizing Pasture).

Fertilizer Conversion Formulas

$P_2O_5 \times 0.44 = P$ $\quad$ $K_2O \times 0.83 = K$

$P \times 2.29 = P_2O_5$ $\quad$ $K \times 1.20 = K_2O$

Fertilizing permanent vegetation: the IaDOT (2601.04 B) specifies 650 lbs/acre of 15-15-15 percentage commercial fertilizer or equivalent. This should probably be trimmed to 400 lbs/acre.

Fertilizing for stabilizing crop seedings: Ia DOT (2601.05 B) specifies 400 lbs/acre of approximately 15-15-15 percentage commercial grade fertilizer. Russ Bennett, Johnson County Roadside Manager, recommends this application be trimmed to 150 lbs/acre.

LIME

Apply lime as specified by a current soil test. For mixed stands of legumes and grasses correct pH to 6.5. The rate to be applied will be based on its content of Effective Calcium Carbonate Equivalent (ECCE) and incorporated during seedbed preparation except in no-till planting. Topdress no-till areas with one-half the rate recommended by the soil test, because the rate depends on the volume of soil to be neutralized (ISU Extension Service Pamphlet Pm-869: Fertilizing Pasture).

SCS SUGGESTED LIMING RATES

Roadside pH	Acre Rate
pH 6.1 or higher	none
ph 6.0 to 5.5	1 to 2 ton ECCE
pH 5.4 to 4.5	3 to 4 ton ECCE
pH 4.4 to 4.0	5 to 6 ton ECCE

COMPANION CROPS

CRAO does not recommend the use of companion crops while planting permanent vegetation on non-erosive slopes. Temporary Matrix Species are very aggressive often outcompeting the slower growing, permanent cover species for light and soil moisture. Companion crop species may reduce the establishment time of the permanent species and/or may result in an incomplete or patchy cover of permanent vegetation. If companion crops are used for either weed control or to provide fuel for prescribed burns, then it is imperative that the companion crop be mowed 2-3 times (or more) during the establishment season. Adjust mower heights to level just above permanent vegetation. Companion crops should never be allowed to set seed. Prescribed burns following the first season (Fall) or second season (Spring or Fall) is recommended for establishing warm season stands and will help eliminate weak perennial species of the Temporary Matrix. The best type of companion crop would be a dead standing litter cover that was planted the growing season prior to the permanent seeding. Plant crop in close rows.

CRAO does recommend the use of both annual and weak perennial Temporary Matrix species on roadsides with erosive conditions (generally CRAO Erodability Classification greater than 3), especially when planting predominantly warm season species. This will supplement temporary erosion control measures and assure adequate protection until the permanent vegetation is fully established. The Temporary Matrix should supplement the CRAO base seeding rate of 60 seeds/ft^2 by an additional 10-30 seeds/ft^2. The seeding mix and rate of the temporary matrix should be determined by the roadside manager based on the erosiveness of the site and other predetermined objectives such as providing fuel for prescribed burns. Species which establish quickly but are not very competitive are highly desireable. Proper post-establishment management techniques, such as mowing, herbicides, or burning can help weaken or eliminate the temporary cover once the permanent vegetation is adequately established. Avoid situations where mature cover crop plants are actively photosynthesizing during early stages of seedling germination, emergence and growth.

Temporary Matrix Cover Mix Examples (Russ Bennett, Johnson Co., IA). Note: the use of Timothy grass or other perennial grasses in the temporary matrix must be followed by post-establishment management. Other temporary matrix species may be used at equivalent seeds per square foot rates.

Hydric sites:

Annual Rye or Oats	20-30 lbs/acre
Timothy	10-15 lbs

Mesic sites:

Timothy	10-20 lbs/acre
Alsike clover	3-5 lbs
Annual Rye (Summer)	20-30 lbs or
Oats (Spring/Fall)	20-30 lbs
Black eyed susan	1-2 lbs
Hairy vetch	2-3 lbs

Xeric sites:

Timothy	10-20 lbs/acre
Oats (Spring/Fall)	20-30 lbs or
Annual Rye (Summer)	20-30 lbs
Alsike clover	4-10 lbs
Birdsfoot Trefoil	3-5 lbs

STABILIZING CROP OR MULCH CROP

Areas need protection during periods when a permanent cover can not be seeded. These areas can be seeded with temporary matrix species for short-term erosion protection. The residue from this crop may be either incorporated into the soil during seedbed preparation at the next permanent seeding period or left either on the soil surface as mulch or as standing litter. Permanent plantings could then be made by frost seeding, or better yet, by incorporating seed directly into the soil with a no-till seeder at the optimum planting time. Do not frost seed in winter wheat or rye.

Possible scenarios for using temporary cover crops in roadsides include situations where construction is completed after the optimum planting period. A temporary matrix should be planted to provide a quick cover to protect the roadside until the following spring when warm season grasses should be planted (or cool season species in the upcoming fall). The permanent seeding can be drilled into the standing litter if minimal erosion has occurred. The litter could then be cut and anchored to the ground as a protective mulch. If numerous rills are present, then the roadside should be disced smooth prior to planting and temporary erosion control measures implemented as needed.

If a stabilizing crop is to be planted in the fall it should be planted before October 15 (some say November) to ensure adequate root development prior to winter dormancy in order to protect the seedbed from early spring runoff. If construction is completed late fall or winter then other temporary erosion control techniques, such as surface mulch coverings which will allow interseeding, must be implemented prior to early spring runoff.

Oats are not winter hardy and the plants will perish. However, winter wheat and rye will begin growth again early in the spring and mature in May. Winter wheat and rye should be killed when the permanent cover is planted because these cereal crops, with fully developed roots, will prevent germinating seedlings from obtaining necessary nutrients and light and thus diminish the permanent stand. The cereal crop could be killed by discing into the ground or use non-residual herbicides to kill the cover crop to leave standing litter. The cereal crop should never be allowed to set seed.

The IaDOT specifies stabilizing crops with perennial grasses, clovers and alfalfa. CRAO recommends that these species be killed or at least weakened when native species are planted. Seeding into previously stabilized roadsides should be done with seed drills to preserve the extant mulch.

Iowa Soil Conservation Service
Rates for Stabilizing Crops

Species	Rate/acre		
	Bushels	Pounds	Seeds/ft^2
Oats	2-3	64-96	20-30
Corn	2	112	
Sudangrass		20-25	20-25
Rye	1-2	56-112	25-50
Wheat	1-2	60-120	20-40

* Winter rye or winter wheat should be destroyed prior to permanent seeding.

Average days to maturity for cereal crops.

Annual Wheat	85-130 days
Winter Wheat	75-110 days
Annual Rye	80-115 days
Winter Rye	60-110 days
Oats	80-125 days
Sorghum	95-190 days
Annual Barley	75-110 days
Winter Barley	65-105 days

JOHNSTON COUNTY FORMULATIONS O STABILIZING CROP SEEDING MIXES (Russ Bennett, Johnson Co., IA):

Spring Seeding Mix (March 1-May 31)

Annual Rye	1 bu/acre
Oats (Otee, Ogle, or Don)	1 bu
Timothy	15 lbs
Alfalfa (Vernal or Ranger)	5 lbs
Clover Red or Alsike	5 lbs
Birdsfoot Trefoil (Empire or Dawn)	5 lbs

Summer Seeding Mix (June 1-August 31)

Annual Rye	2 bu/acre
Timothy	20 lbs
Alfalfa (Vernal or Ranger)	10 lbs
Sweet Clover (Madrid, Yellow or White)	5 lbs *

* Sweet clover is an aggressive biennial species which grows during the summer months, hence it is a fierce competitor with other native species.

Fall Seeding Mix (September 1- November 20)

Annual Rye	1.5 bu/acre
Oats (Ogle, Don, or Otee)	0.5 bu
Timothy	20 lbs
Clover (Medium Red or Alsike)	5 lbs
Birdsfoot Trefoil (Empire or Dawn)	5 lbs

IaDOT STABILIZING CROP MIXTURES (2601.05 A)

Spring (March 1-May 30)

Winter rye	1 bu/acre	25 seeds/ft^2
Sudan grass		
Piper	25 lbs	25
Fescue,		
Kentucky-31	15 lbs	83
Alfalfa		
Ranger or Vernal	5 lbs	27
Total seeds		160 seeds/ft^2

Summer (May 21-July 20)

Sudan grass		
Piper	35 lbs/acre	42 seeds/ft^2
Fescue		
Kentucky-31	15 lbs	83
Alfalfa		
Ranger or Vernal	5 lbs	27
Total seeds		152 seeds/ft^2

Fall (July 21-September 30)

Winter rye	2 bu/acre	50 seeds/ft^2
Fescue		
Kentucky-31	15 lbs	83
Alfalfa		
Ranger or Vernal	5 lbs	27
Total seeds		160 seeds/ft^2

STABILIZING COVER FOR SOILS WITH ATRAZINE CARRY OVER:

Sudangrass	20-25 lbs/acre
Sorghum-sudangrass hybrid	20-25 lbs
Corn-viable shelled	2 bu/acre

SEEDBED PREPARATION

Prior to seedbed preparation, divert any concentrated flow of offsite water from the area. All grading and shaping operations should be completed according to design specifications and conform to desired cross section. Applications of fill soil exceeding 6 inches must be compacted with suitable equipment. Permanent erosion control structures should be in place. If weedy growth is excessive, areas may need to be mowed and stubble disced into the soil. All tillage operations should be performed perpendicular to the slope. Be wary of bulldozer tread groves which create soil indentations parallel to the slope.

The area to be seeded should be reasonably smooth, free from rills and gullies and should meet design specifications before beginning seedbed preparation. Areas should be prepared to a depth of three inches in order to incorporate fertilizer and lime into the soil and/or prepare the seedbed for broadcast seeding. Seedbeds should be friable and firm. The soil may be loosened by discing, harrowing, raking, or similar means. Several preparations may be required. Soils which are compacted because of heavy machinery travel, or other means, should be plowed or chiseled to a depth of at least 8 inches to facilitate root growth. It may be necessary to cultipack areas prior to and following seeding. Seedbed preparation operations should be suspended when the soil is too wet or dry (soil balls up or forms clods when too wet and blows away when dry). Seeding should not be performed during excessively windy weather or when ground is frozen. When seedbed preparation is complete, remove all debris from the area to be planted, including stones, boulders, logs, stumps, cable, etc., i.e, any foreign material that will interfere with the seeding operation.

WEED CONTROL FOR ROADSIDE PLANTINGS

Noted prairie restorationist, Peter Schramm, recommends seedbed preparation as early as possible in the spring followed by several cultivations for controlling germinating weeds prior to prairie plantings. Following final seedbed preparation, wait until weeds emerge and then use a harrow, harrowgator, cultimulcher, or similar implement which shallowly cultivates the soil surface to remove weed seedlings. This can be repeated several times prior to planting. Avoid deep tillage or discing which will uplift buried seeds to the surface. Germinating weeds can be controlled with multiple applications of Round-up, a broad spectrum, non-residual herbicide. Ideally, spray the seedbed 2-3 times as weeds grow to the 2-5 inch stage. Multiple applications of herbicides and/or cultivation will reduce the number of viable seeds contained in the surface soil thereby limiting the number of weeds competing with desired plants as they germinate and grow (Schramm 1992).

Schramm, P. 1992. Prairie restoration: a twenty-five year perspective on establishment and management. Proceedings of the Twelfth North American Prairie Conference 1990, eds D. D. Smith et al., In Press, pp 169-177.

Owen, M. D. K. and R. S. Fawcett. 1986. Weed control in small grains, pastures and legume forages. Iowa State University Cooperative Extension Service Pamphlet Pm-601a, 4p.

SOWING SEED

Seeding should be performed immediately after preparation of the seedbed. Legume and small grass seed should be planted at a depth between 1/4 to 1/2 inch using no-till seeders. Iowa State University recommends a 1/2 inch seed placement depth but this is without the expectation of a mulch covering. Primarily, it is important to place seed at a depth with available soil moisture while still enabling germinating seedlings to reach light. Large grass seed, such as smooth bromegrass, should be planted to a depth not to exceed 3/4 inch, except on sand where the seeding depth should be 1 inch. On all broadcast seedings, seed should be spread uniformly over the area and rolled or harrowed. The soil should be cultipacked just prior to and immediately following seeding. A firm seedbed increases germination success by improving soil to seed contact. This facilitates seed imbibition of water and protects the seed against excessive desiccation. Note however, that soil compaction will increase surface runoff by decreasing infiltration of water. Seeding should be performed as soon as possible after ground is prepared and before any rainfall event which may destroy the prepared seedbed. The Nebraska Department of Roads specifies that seeding should occur within 5 days of ground preparation.

CONVENTIONAL SEEDING

The seedbed should be worked to a depth of 3" before seeding. It should be reasonably smooth, friable and firm before seeding. Seed shall be planted uniformly over the area at a 1/4 to 1/2 inch depth, or broadcast uniformly over the area and rolled or harrowed.

NO-TILL SEEDING

Apply herbicides to kill or suppress existing weed competition as necessary. Use a drill manufactured for no-till planting and plant at a depth of 1/4 to 1/2 inch. Check seed placement depth regularly during planting. Calibrate the drill to ensure the proper seeding rate.

POST-SEEDING MANAGEMENT

Maintenance levels of fertilizer may be necessary. If vegetative cover declines, apply 30 pounds of nitrogen (N), 20 lbs of phosphate (P_2O_5), and 20 lbs of potash (K_2O) per acre (Iowa SCS recommendation).

During the seedling year use spot mowing or spot herbicide treatment to control noxious weeds and other undesirable plant growth. Dr. Paul Christiansen recommends that mower blades be set 8-12 inches above the ground to prevent damage to prairie seedlings. CRAO suggests that 2-3 mowings be performed on or around June 1st, July 15th and September 1st. These are periods of peak weed growth and are times when inflorescences (flower heads) form. Mowing late summer/early fall following growth of warm season species will eliminate snow drifting problems but may promote cool season growth. Ideally it is best to recognize desired seedlings and mow above them.

Burn native or warm season grasses periodically. Dr. Christiansen recommends spring burns during the first few years following planting and periodic burns on 1-3 year interval cycles. In established native stands, it is best to vary burning dates and burn intervals in order to not adversely affect any one set of desireable species.

> ... Burning on an alternating year pattern can favor certain non-prairie biennials and should be avoided. Burning should be done between mid-March and late April in Central Iowa. If burning is not possible, mowing and removal of the dead plant material in the spring, during April, will provide many of the benefits of burning. Fall removal of the vegetation is not as satisfactory because it provides cool season invaders such as bluegrass, dandelion, etc. an opportunity to grow in the fall with the prairie competition; it removes the cover which wildlife might use; and it opens the soil surface up for wind erosion when snow cover is lacking (Christiansen brochure: Iowa Prairie Establishment Guide 1989).

CRAO suggests that fall burning may be considered when specific objectives are desired such as optimum brush control or control of weeds which are actively growing at the time. Proper segmentation of roadsides can assure that adequate cover is available to wildlife in the area. In addition, fall burns effectively expands the burning season. As with all prescribed burns, clear objectives should be determined prior to ignition. Also, two annual burns in successive years may be more effective in eliminating woody plants. Annual burns, performed during the same season every year may eliminate desireable species which are actively growing at burn time.

Addendum: At the least, establishing native species should be mowed when weeds or cover crops shade 70% of the plot area. Stand should be mowed with a rotary shredder just above the growing tips of the developing native plants.

07/26/92

HYDRAULIC SEEDING WITH MULCH AND TACKIFIERS

The IRVM County Roadside Assistance Office (CRAO) actively promotes the use of erosion control surface mulches for 1) providing safe sites for germinating seeds and developing seedlings and 2) reducing surface erosion. While several techniques are available to county roadside managers, each of these strategies has advantages and disadvantages. Roadside managers faced with situations where equipment cannot be operated within the right-of-way because of steep slopes, obstructions, and wet soil should consider hydraulic machines for seeding, mulching and/or tackifying straw. The advantages of hydraulic machines include the one step application of seed, mulch, tackifier and fertilizer; the ability to seed areas inaccessible to seed drills; and as a method of applying tackifiers over straw mulch. Important considerations include the availability of equipment (hydraulic machines, straw blowers, trucks for pulling equipment and hauling supplies, water pumps, hydrant hoses and attachments, etc.), accessibility to water sources, storage of supplies (seed, mulch, fertilizer), and increased seed mortality experienced with hydraulic seeding. On extremely erosive sites, hydraulic mulch must be supplemented by matting, textiles or straw held in place by liquid tackifier or crimping.

Basic Hydraulic machine design includes a slurry tank with an agitation system for keeping seed, mulch, fertilizer, etc. in suspension, an engine-powered pump, and hoses or gun tower for application. Some units can spray slurry to distances of 230 ft. or more. Hydraulic machines range in size from 300 gallon capacity tanks mounted in pick-up trucks to 3,500 gallon tanks mounted on large trucks or trailers. Costs vary from several thousand dollars to over $40,000 (International Erosion Control Association, Spring 1991 Bulletin). The slurry mix must be kept in suspension by an agitation system using either by mechanical paddles and/or recirculating water through the pump.

APPLICATIONS FOR HYDRAULIC SEEDERS

Hydraulic machines can be used in several seeding strategies. On non-erosive roadsides, during favorable seasons, seed can be hydraulically planted with little or no mulch (< 1200 lbs-per-acre). However, typical roadsides will probably require between 1500-2500 lbs-per-acre. The use of tackifier (at least 3 percent or more) is strongly recommended with the hydraulic mulch. If the county roadside manager specifies cereal straw (1.5 or more tons per acre), then hydraulic seeders can be used to apply tackifier over the straw to hold the mulch in place. This scenario could begin with seeding the roadside followed by using a straw blowing machine to spread mulch over the seed (seed should never be applied through straw mulch but can be sprayed through certain types of geotextiles). Then on a third pass, the hydraulic machine would apply tackifier over the straw.

BUDGET CONSIDERATIONS

Equipment and manpower needed for hydraulic seeding operations include 2 to 3 laborers, hydraulic unit and transportation including trucks for hauling supplies. Filling the slurry tank is the most time consuming aspect of the operation. Cycle time for each load is determined by the distance to the water source and the flow rate of water into tank. Depending on the water source, a crew will need a portable water pump and hoses to obtain water from ponds, streams and rivers. Special adaptors and hoses are required for using fire hydrants. A separate water truck may reduce cycle time by transporting water to the job site but will require an extra driver and double filling time. A second crew may be necessary to transport supplies to the job site.

Without considering equipment depreciation, maintenance, and fuel, the costs for hydraulic seeding supplies and labor would be approximately $1,000 per acre. For example, seeding with an 800 gallon hydraulic unit: fertilizer @ 400 lbs/acre (14-14-14); virgin fiber mulch @ 2000 lbs; and 3

laborers. If the cycle time is half an hour per load, an 800 gallon machine will require 5 loads per acre. The expected time to seed, mulch and fertilize an acre would be about 3-4 hours.

Seed: (native seed and flowers)	$ 300.00 per acre
Fertilizer:	$ 75.00
Mulch:	$ 400.00
Labor	$ 30.00 per hour

GROUND PREPARATION

Soil preparation is an important consideration in hydraulic seeding. Roadsides tend to be low in organic material and the exposed subsoil often hardens, forming surface crusts which become barriers to seedling establishment. Smooth surfaces increase surface runoff and need to be roughened by contouring small ridges perpendicular to the slope. Avoid working soil when wet which promotes clods and excessive soil compaction. Spray slurry on freshly-worked, loose soil. The impact of high-pressure water will mix the slurry and soil into a paste creating a patchy appearance when finished.

FERTILIZER

Fertilizers are important when planting seeds on sterile soils commonly found in roadsides. Fertilizers are identified in the following order according to the percent nitrogen (N), percent available phosphoric acid (P_2O_5), and percent water soluble potassium (K_2O). They can be applied hydraulically with the seed in either liquid or solid form. CRAO recommends that a time-release solid formulation should be used when hydraulically seeding native warm-season species. Liquid fertilizer will be used by fast-growing, spring weeds and not by the native grasses which grow predominantly in the summer months. Fertilizer rates should be determined following a soil test. However, standard rates are specified by the IaDOT, or the Soil Conservation Service.

SEEDING RATE ADJUSTMENTS

Seed, mulch, tackifier and fertilizer are added into the water tank to create a slurry which is then sprayed over the prepared ground. Hydraulic seeding is essentially a method to broadcast seed using water as a distributing vehicle. However, seeds are not always distributed on the ground into idyllic sites for germination. A high percentage of the seed is scattered on the soil surface or imbeded in the hydraulic mulch where it is susceptible to desiccation. In addition the seed can be damaged when passing through the pump. Therefore, seeding rates must be adjusted to circumvent expected reduction to seed viability resulting from the hydraulic application of seed. Non-native cool-season grasses, switchgrass and legumes can easily be planted in this manner because they have a higher number of seeds per pound and they are relatively inexpensive. However, many native grasses are more costly per coverage area in comparison and seed mortality must be reduced. Kentucky bluegrass has over 2 million seeds per pound and sells for less than a dollar per pound (1 lb bluegrass per acre places 50 seeds per square foot). In contrast, Indian grass (Sorghastrum nutans) has 175,000 seeds per pound and commercial cultivars sell for 6-10 dollars per pound (1 lb-per-acre places 4 seeds per-square foot. A general rule for native seeds is to increase the seeding rate by 30% over that used for range drills.

Native seed often includes fluffy appendages (glumes, hairs, etc.) which causes them to float on the water surface while the effluent pipe is at the base of the tank. Meanwhile heavier seed can concentrate in low areas on the bottom. Care must be taken to mix seed thoroughly in the water for uniform distribution. It is suggested that seed be soaked in a five gallon bucket while filling the tank and mixed into the slurry prior to seeding. Seed should be mixed with mechanical agitation, but limit the use of pump agitation because seed passing through pumps becomes damaged and seed viability will be lost. Research has documented that

hydraulic seeders with paddle agitation will reduce wheat germination by 15 percent 60 minutes after adding seed to the slurry. In contrast, hydraulic seeders with recirculating pump agitation have reduce wheat germination by as much as 90 percent 60 minutes after mixing. The use of hydraulic mulch will reduce germination loses in recirculating pump-type hydraulic seeders to 50 percent.

The use of mulches and seeding at proper time of the year will increase the probability of establishment success. Some hydraulic seeding specialists suggest that excessive rates (over 2000 lbs/acre) of hydraulic mulch will prevent seeds from germinating in soil because they are impeded in the hydraulic mulch. However, this will not be a problem when adequate moisture is available during seedling establishment. Warm-season species should not be hydraulically seeded in Iowa after June 1. The Iowa DOT does not permit the planting of warm-season grasses in the fall on state roadsides, but other agronomists argue that dormant plantings are feasible (e.g. early spring and late fall, dormant applications). Iowa state agrostologists (grass experts) state that optimum plantings of warm season grasses such as switchgrass are late April, early May. Limited research on native forbs have shown some species have higher germination success in fall plantings while other species germinate better with spring plantings. This is probably due to post-ripening requirements such as cold-moist stratification or dry storage, respectively. True clovers should always be planted in the spring, while annual legumes, such as hairy vetch do well with fall plantings. Cool-season grasses can be planted in early spring until June; and after August 1 to September 15th. Dormant plantings should occur after October 15th. Some nurseries suggest that seeding rates for warm-season grasses can be established at less than optimal seasons but encourage an additional 30% increase in the seeding rate.

TEMPORARY MATRIX SPECIES

Temporary matrix species are those species which are short-lived and are added to the base seed mix because they establish rapidly and provide fuel for prescribed management burns. These species are often used as cover or nurse crops. They supplement the base seeding rate listed above. Temporary species include cereal crops such as oats, perennial rye (Lolium perenne), a short-lived turf grass, or Timothy grass (Phleum pratense), a short-lived pasture grass. Other species may be considered including Hairy vetch (Vicia villosa), Bird's foot trefoil (Lotus corniculata), and Korean lespedeza (Lespedeza stipulacea).

Research has shown that nurse crops are more competitive than weeds during prairie establishment (Christiansen 1967). Therefore roadside mangagers should be cautious when planting temporary matrix species to ensure that the perennial species are not diminished. Reduced rates of temporary matrix species is encouraged when hydraulically seeding native species. These will establish quickly securing the soil but will initially out-compete slower developing native species for sunlight and nutrients, especially water. Post-establishment management is strongly encouraged including mowing at least twice during the establishment season and/or burning that fall or next spring.

Spring Planting Season.

The IRVM County Roadside Assistance Office has recommended a base seeding rate for native species of 60 seeds per square foot when planted by a seed drill (the most effective seeding method). This recommended rate includes prairie biennials and perennial grasses and forbs. It does not include annual cover crops or short-lived (temporary matrix) species which are intended to establish quickly and hold the soil until desireable species are established. When hydraulically seeding native species it is recommended that the base seeding rate be increased by 30% to compensate for seed mortality and ensure adequate coverage.

Inexpensive species of Sporobolus (Dropseed), Eragrostis (Lovegrass), and Bouteloua curtipendua (Side-oats gramma) can be used as cost-effective supplements. These grasses have high germination rates, establish quickly in a wide range of soil types, and are eventually replaced by more permanent native grasses. Other species may fit this criteria as well.

Dormant Seedings.

Dormant seedings of native species using hydraulic seeding machines is not recommended but if attempted then the base seeding rate should be increased by 60% using more cool-season species. Seeding mixes of non-native, cool-season species at rates, such as those specified by the IaDOT, need not be increased for hydraulic seeding.

HYDRAULIC MULCH

Currently there are no standards for hydraulic mulching materials and equivalent rates do not apply for different types of fiber and tackifier. Virgin wood has been considered a superior mulch for erosion control because wood's longer fibers increase it's binding capability and a slightly higher water retention capacity. It is specified by many highway departments. However, recycled fibers (usually paper and cardboard) have captured half the market because of their lower costs while still yielding acceptable results (IECA). The use of hydraulic mulches with a dye maximizes the operator's ability to uniformly spread the seed.

Hydraulic fiber mulches do not have adequate mass or fiber length to prevent erosion on severe sites and are ineffective against mass movement of soil. Effective life of wood fiber mulch was evaluated on a 2.5:1 slope by Horner et al. (1989) for the Washington State Transportation Center. Wood fiber was estimated to have a service life of 6 months. It effectively reduced erosion by 80-100 percent at about 2/3's the cost of straw mulches. Another study rated the erosion control effectiveness wood fiber on a 1:1 slope as a 3 on a scale of 10 but this had an application rate of 1200 lbs per acre and no tackifier (see Burroughs and King 1989). Other studies suggest that hydraulic mulch is ineffective on steep slopes greater than 1:1 with vertical heights greater than 20 feet. Heavy rains may reduce the effectiveness of the hydraulic mulch, especially on steep slopes or non-cohesive soils (high K-values in the Universal Soil Loss Equation). Wood fiber had the highest rating for effective establishment of grass seeded on Lake Tahoe roadsides (Leiser et al. 1974).

Application rates for hydraulic mulch depends upon the site's erosion potential, mulch type and whether tackifier is added. It is difficult to prescribe general formulas therefore roadside managers should depend on manufacturer's recommendations. Roadsides with slopes steeper than 2:1 grades, longer slope lengths, non-cohesive soils (sand) would require some additional type of erosion control, e.g., straw, geotextiles, and/or flow barrier strips (silt fences, staked straw bales, etc.). The IRVM county roadside office recommends that the upper limit for the exclusive use of hydraulic mulch is a 2:1 slope on clay-loam soils with a slope length less than 20 feet (provided that no other erosive conditions exist such concentrated flow from adjacent land, road surfaces or other road structures). According the CRAO Erodibility Tables, category 4 roadsides would be the upper limit for the exclusive use of hydraulic mulch. For roadside situations, Weyerhauser Corporation, a leading manufacturer of virgin fiber mulch, recommends 1800-2500 lbs per acre with 3% tackifier (75 lbs tackifier at 2500 lbs mulch). For a 3:1 slope, they would recommend 1500-2000 lbs mulch with 3% tackifier; or 1800-2500 lbs of mulch alone without tackifier. Rates for recycled fibers would be between 1500-2500 lbs.

Hydraulic mulch is usually supplied in 40-60 # packages. Amounts needed for adequate coverage depends on the site, but on the average about 2000 lbs an acre is common (this requires forty bags of mulch at fifty pounds each. Logistics of handling,

storage and transportation must be considered because one ton of mulch occupies about 200 cubic feet in area (6 x 6 x 6). In contrast, however, a standard straw bale is about 16 cubic feet, with 40 bales per ton; a one ton per-acre-rate storage would require 640 cubic feet of storage (about 9 x 9 x 9).

The type of hydraulic mulch influences the load rate for hydraulic machines. For example, to apply wood fiber mulch at 2000 lbs/acre with a 800 gallon hydraulic seeder would require 5 machine loads per acre (400 lbs wood fiber mulch per load). The same hydraulic seeder could apply 500 lbs of paper mulch per load. The difference is probably due to wood's higher volume increase when saturated. Application of the hydraulic mulch is the limiting factor in applying the proper rate of seed per machine load. Therefore, if mulch specifications require five machine-loads-per-acre then the per-acre-seeding-rate should be divided accordingly per load.

HYDRAULIC TACKIFIERS

Modern tackifiers are biodegradable adhesives available as powders or concentrated liquids. They are formulated to be either sprayed alone or in a slurry of mulch, seed, and fertilizer. Tackifiers function as a binding agent, holding fibers and soil particles together after drying. The tackifier is added into solution at concentrations depending upon the erosion control hazard. The most common material is Guar Gum, a thickening agent used in food processing. It is initially soluble, but after drying it becomes insoluble yet remains semi-permeable to water. It is used as a binding agent for hydraulic mulches (tackified mulch), as an overspray on straw and as a soil sealant to bind soil particles. Guar Gum comes in several formulations. Some fiber companies mix 3% tackifier with the fibers to increase the binding qualities of the hydraulic mulch (60 lbs tackifier per ton of mulch fiber). This has been called a tackified mulch. As a tackifier sprayed over straw mulch, Guar Gum is used either in a pure form or mixed with additives such as silicates and fibers to increase solubility and prevent clumping. Some manufacturers sell tackifier blended with about 100 lbs of mulch fiber. In some formulations, non-toxic polymers (possibly acrylic vinyl acetate) are added with the Guar to make it more effective on highly erosive sites. Guar also functions as a lubricant because it becomes slick when wet, reducing pump friction of the slurry.

Tackifiers are applied as a fine spray over straw. Straw tackifier rates vary from 20-75 lbs per acre of pure Guar Gum mixed in water amounts ranging from 400 to 1500 gallons. One company says their product can be dispersed in 50-250 gallons per-acre-rate. However, covering an acre with this volume of water is difficult when considering that high volume pumps are necessary to prevent clogging of the slurry. Guar tackifier dissolved in 600 gallons of water or more per acre is considered more practical and has proven to be successful. The proper concentration of tackifier in solution is essential as the tackifier readily congeals without continual agitation. The powder must be added slowly into a forceful stream of water otherwise the tackifier will not be uniformly dispersed into the solution and not adhere properly to the mulch.

One company sells a straw tackifier recycled from slick magazine paper with about 10% tackifier. Their suggested rate of this formulation is about 750 lbs per acre sprayed over the straw. They state the high clay and ash content of the slick paper allows the tackifier to flow better through the pump and hose while adding durability to the tackifier. The International Erosion Control Association (IECA) has commented that ground pages of glossy magazines have no tacking capabilities. "Glossy coated paper is generally made up of latex, calcium carbonate and titanium dioxide, in addition to basic bleached pulp. In the amount used, used such coated material has no beneficial or comparative tacking action for any kind of mulch" (IECA 1991).

Other tackifiers include psyllium as the binding agent but the IRVM county office has not reviewed any products incorporating this material. Psyllium

is a plant derivative from species of Plantago or Plantain which are common yard weeds. Application rates for Psyllium cited by one manufacturer is 70-80 lbs per acre of pure psyllium with 1500-3000 gallons of water. However, a review of psyllium suppliers suggests that the optimal rate for psyllium tackifier is 100 lbs per acre or more.

Copolymer emulsions are mostly used as a dust abatement, however they can be hydraulically applied as a "super strength" tackifier over straw. They are a non-toxic blend of acrylic polymers (polyacrylamides), sulfactants, silicants and inert materials which are sprayed over bare soil to form a water resistent membrane. Copolymer emulsions, when sprayed over soil surfaces, coats individual soil, sand and rock particles with a flexible film forming a crust-like surface about 1/4" to 1/2" thick. The vinyl acrylic film allows air exchange when dried but tends to reduce soil moisture loss. However, initial studies have shown them to be ineffective in preventing runoff erosion because the polymer membrane over the soil would crack and shrink permitting surface water to form rills. However, other studies in semi-arid regions have had great success. They are mostly marketed for dust abatement on construction sites, but they could be used as a superior tackifier over straw on severe sites. Some manufacturers sell copolymer emulsion products for mixing with Guar gum for severe sites. Application rates vary widely depending on product used.

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PRESERVE SEED VIABILITY WITH GOOD STORAGE

Dr. Kay Klier and Scott C. Zager

Temperature and moisture content have the greatest effects on seed longevity. With many planting plans having to be shelved, you should protect your seed investment by careful seed storage.

How does a several-year-old seed lot differ from a fresh lot? Although the viability of the seed (the percentage of germinating seeds which develops both roots and shoots under optimum laboratory conditions) may not differ between the two lots, the older seed will generally perform less well in the field. Field emergence may be decreased in the older seed lot, and deeply planted seeds may not have enough food reserves to reach the soil surface. Seed may take longer to germinate. Yield or plant sized may also be affected. Chromosome damage is also known to occur more frequently in aged seeds.

Proper storage conditions helps delay aging by maintaining viability and field vigor for several years. Of course, various species loose viability at different rates even when kept under identical conditions. However, we can still make some predictions about how well a seed lot will survive storage conditions.

A general rule of thumb in seed storage is that most seed will last at least a year at 50 degrees F and 50% RH (relative humidity). For each 10 degree increase in temperature, seed longevity is halved, and for each 1% increase in moisture content of the seed (not RH) seed longevity is also halved. These two factors are independent of one another. Seed stored at 70 degrees and 6% moisture content has only 1/4 of the lifespan of seed stored at 50 degrees and 6% moisture. Likewise, seed stored at 50 degrees and 8% moisture has 1/4 of the expected life of the lot at 50 degrees and 6% moisture. And 60 degree/7% moisture seed also has the 1/4 of the lifespan of the lot at 50 degrees/6%.

Note the following example:

> When dried Chewings fescue seed was shipped by boat in both cloth bags and closed canisters from New Zealand to the United States...[it was found upon arrival that] the samples in the canisters had an average moisture content of 7.3% and average germination of 88.7%. The samples shipped in cloth bags had a moisture content of 11.2% and an average gemination of 54.5% (Wheeler and Hill 1957).

So much for theory. How does it work in practice? Seed tends to take up moisture from the air, and hang onto it quite well. Some seeds -- like grasses -- seem to pick up moisture more easily than others (some of the clovers, for instance). Most seeds exposed to air at 20-25% RH for several weeks are usually dry enough to store well in sealed containers. If seeds have been sitting on a shelf, the moisture level in the seed is probably almost high enough to allow storage fungi to begin growing (some seeds may even begin to sprout!) Seeds may need to be redried slightly if your intend to store them in sealed containers. (Circulating warm, dry air -- not much more than 95-100 degrees F -- through the seed in cloth or net bags is the best and gentlest way of doing this. You may need to dehumidify the air in addition to warming it in order to bring the relative humidity down to 20-25%.) Don't over dry seeds, though -- seeds can crack and the embryo tears when they get too dry. Most seeds will be dry enough for long term storage after 4-8 hours in a stream of warm air at 10% RH.

Temperature is also a problem. Short periods of heat (over 100 degrees F) are tolerated by most seeds, but higher temperatures can cause embryos to crack or to cook. Freezing temperatures are well tolerated by dry seeds, but seeds with high moisture contents (15% plus moisture) often show freeze damage.

Most prairie seed lots should survive a year's storage with little trouble if they can be stored in a refrigerator or cold room. If you cannot provide 50 degrees/50% RH conditions, try; for the coolest storage with good air circulation you can obtain. For instance, sealed plastic bags or garbage cans of seeds can be safely; stored in a basement or root cellar if the seeds were at low moisture content when taken into storage. If the seeds were stored this spring in cloth or paper bags, it may be better to hang the bags in a root cellar and operate a fan to keep the air moving and the fungi at bay. Barn lofts, garages, attics and tool sheds are generally poor places to keep your seed investment. If you must store cloth or paper bags of seed under these conditions, maximize air circulation by hanging the seed, separating bags with pallets, and minimizing the amount of seed in each bag (perhaps less than 1 cu ft of seed per bag).

Insect damage (grain weevils, dermestids, etc.) is also less likely under cool, dry conditions.

Facts to Remember:

Seed keeps best in cool, dry environments.

Seed life doubles for each 10 degrees F decrease in storage temperature (down to freezing).

Seed life doubles for each 1% decrease in moisture content (down to about 5% moisture).

Seedling vigor and field performance can be damaged before a decrease in lab germination is seen.

Storage insects and fungi are more likely to be problems in seed that is kept in warm, moist conditions.

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Wheeler, W. A., and D. D. Hill. 1957. Grassland seeds: a handbook of information about the grass and legume seeds used for forage, pasture, soil conservation and other turf planting in the United States. D. Van Norstrand Company, Inc., Princeton, New Jersey. 734p.

GERMINATION AND VIABILITY TESTS

DEFINITIONS:

Seed germination:

In seed laboratory practice, germination is defined as the emergence and development from the seed embryo of those essential structures which, for the kind of seed in question, are indicative of the ability to produce a normal plant under favorable conditions.

Normal sprouts:

Seedlings which possess healthy and uninjured root, shoot and leaf initials, and which should be capable of continuing growth under favorable conditions.

Hard seed:

Seeds which remain hard at the end of the prescribed test period because they have not absorbed water due to an impermeable seed coat.

Dormant seed:

Viable seeds, other than hard seeds, which fail to germinate when provided the specified germination conditions for the kind of seed in question. Viability of ungerminated seeds may be determined by any appropriate method or combination of germination promoting chemicals. The percentage dormant seeds, if present, shall be reported in addition to the percentage germination [of many native grasses] (i.e., dormant seeds are those seeds which will not germinate even under conditions which are normally favorable to growth).

Quiescent seed:

Is readily germinable seed with non-specific trigger conditions such as sufficient moisture and favorable temperature (i.e., suspension of growth imposed by unfavorable environmental conditions (winter) as opposed to the suspension of growth due to biochemical conditions internal to the seed which is dormancy).

Pure Live Seed (PLS):

Is the product obtained by multiplying the pounds of bulk seed by the percentage purity and by the percent germination plus percent hard seed:

PLS = (lbs Bulk) x (% Purity) x (% Germination + % Hardseed)

Purity analysis:

Is the determination of the kinds of the seed present and the percentage by weight of each of the following components: 1) kind or cultivar to be considered pure seed; 2) other crop seed; 3) inert matter; and 4) weed seed.

Seed unit:

The seed unit is the structure usually regarded as seed in planting practices and in commercial vendors. The seed unit may consist of one or more of the following structures:

a) true seeds; b) Seed units in the grass family including: 1) single caryopsis and florets; multiple florets and spikelets in Oats (Avena spp.), Gramas (Bouteloua spp.), and Bluegrass (Poa spp.); Entire spikelets in Agrostis, Panicum, and Setaria; 4) Spikelet groups that disarticulate

as units with attached rachis and internodes in Andropogon, Schizachyrium scoparium, Bouteloua curtipendula, Sorghastrum nutans, etc.; 6) burs of buffalograss (Buchloe dactyloides).

Pure Seed:

Includes all seed of each kind and/or cultivar under consideration which are present in excess of 5% of the whole.

Debearded seed:

Debearding is a process that removes hulls (lemmas, palea) and other appendages from the true grass seed (caryopsis).

Isely, D. 1954. Seed analysis. Iowa State College, Ames, IA.

Germination tests

Germination tests determine the proportion of seeds which develop normal seedlings under specified conditions within a certain period of time. The seed used in making the germination tests is taken from a sample of pure seed without discrimination as to size or appearance. It is a uniform procedure conducted under the rules of the Association of Official Seed Analysts. Since seeds of different species have various germination requirements, specifications for each species are given for temperature, moisture, oxygen and light.

Tetrazolium Tests

A tetrazolium test is a biochemical test for seed viability. This test detects the activity of dehydrogenase enzymes which are known to disappear rapidly upon the death of the seed. A colorless solution of tetrazolium chloride will change the color of a living seed embryo to cherry red indicating that the seed is viable. The test is also an indicator of seed vigor because partially stained embryos may germinate poorly and yield weak seedlings. Results of the tetrazolium test, when compared with percent germination, is a good index of seed dormancy. Divergences between the germination and tetrazolium test can be attributed to:

1) dormancy or quiescence - the tetrazolium test is a better estimate of potential viability, 2) diseases - may not allow seeds to successfully germinate, 3) immature or poorly developed seed - results in live but less vigorous seed that may not produce viable seedlings or increases susceptibility to disease, 4) injury from mechanical or fumigation damage, 5) sampling error - causing the tetrazolium results to be higher or lower than germination (Grabe 1961).

TETRAZOLIUM SEED TEST:
A quick test for
seed viability

Dr. Kay Klier
Asssistant Professor of Biology
Curator, Martin Grant Herbarium
University of Northern Iowa

The tetrazolium test relies on the ability of dehydrogenase enzymes present in living embryonic cells to change a colorless solution of 2,3,5-triphenyl tetrazolium chloride to an insoluble, red formazan dye. If the embryo stains cherry red, the seed is viable. Partial or patchy staining indicates a damaged seed that may or may not be viable, while embryos that do not stain are dead.

The test was developed to determine viability of crop seeds, but can be used with virtually any seed: crop, weed, or native seeds. With a little training, technicians can predict actual germination rates under laboratory conditions with nearly complete accuracy. These sorts of accuracy rates reflect experience with the seeds being tested.

With a little basic botanical knowledge,

tetrazolium tests can be conducted on virtually any seed with reasonably accurate results. You need to know the location of the embryo within the seed, and you may need to tinker with the testing procedures when you first try a new species. The equipment needed is minimal: single-edge razor blades, a dissecting needle or a sharp sewing needle, tweezers, a medicine dropper, paper towels, and vials or small dishes to hold the seeds and test solution. You will also want some sort of magnification: a 7x-10x hand lens will do for almost everything, but exceptionally tiny seeds like orchids may require a dissecting microscope.

Test Solutions

The tetrazolium testing solution is made by dissolving 2,3,5-triphenyl tetrazolium chloride (TTC) in distilled or deionized water. The solution is usually made as a 1% solution (1 gram of TTC per 100 ml water). 0.1% TTC is used for most tests, and can be made up by diluting 10 ml of the 1% solution with 90 ml of water. The pH of the finished solution should be between 6 and 8. Some labs prefer to use a pH 7 phosphate buffer instead of distilled water in making the solution. To make the buffer, dissolve 3.6 g KH2PO4 and 7.1 g Na2HPO4 . 2 H20 in 1000 ml distilled water. All solutions will keep for several months in a refrigerator, and several years if frozen. 5 grams of TTC costs about $6, and is enough for testing 100 - 5000 batches of seed (depending on seed size and number per batch).

Sampling

The seeds to be tested should be carefully selected from the sample. Heavy seeds, which are more likely to be viable than lighter seeds, may be at the bottom of the bag. Truly random sampling is necessary to get the most accurate results; the easiest way is to draw small samples from all parts of the bag and mix them into a composite sample. Most seed laboratories test 200 seeds per sample (usually as 4 sub-tests of 50 seeds each), but you can get a basic idea of the quality of the seed with 10-25 seeds.

Seed Preparation

Moisten the seeds by placing them in folded, wet paper towels overnight, or soaking in lukewarm water for a few hours. The seeds are ready to test when they can be sliced without breaking.

Most seeds longer than about 1 mm can be sliced with a razor blade to expose the embryo, while smaller seeds are usually stabbed with a dissecting needle (into the endosperm or perisperm, not the embryo). The sketches below illustrate some common methods of cutting or piercing the seeds. If you chose to cut the embryo in half, retain half of the seed for testing, and throw the other half away.

Incubating the Test

Once the seeds are prepared, place them in enough tetrazolium solution to cover the seeds completely. Cut seeds are usually placed in 0.1% tetrazolium solution, and pierced seeds in 1% solution. Cover the dish or vial to keep the solution from evaporating, and incubate for a while.

The amount of time before test results are available depends on the species being tested and on the temperature of the tetrazolium solution. Any temperature between 20 and 45oC (68-113oF) can be used, but the test takes about half the time at 30oC as it does at 20, and about one-quarter of the time at 40oC as at 20. If you're in a hurry, you can improvise an incubator from a heating pad, a hot water bath, or a desk lamp. (I've gotten good results carrying the tests in a tightly capped vial in my pocket.) Be careful about overheating the tests, though -- the seeds die at higher temperatures. If you incubate tests under a strong light, cover the container with something opaque. Normal room light does not affect the test.

Seeds should be submerged in the test solution. Pierced seeds have a tendency to float; sometimes adding a small drop of dilute baby shampoo is enough to get them to sink. If you can place the

seeds in the TTC solution, and apply a vacuum repeatedly until they sink, you will get excellent staining and speed up the staining time. A water aspirator and aspiration flask is quick and convenient. Or you can place the seeds and a small amount of solution in the barrel of a large (10-50 ml) hypodermic syringe (minus the needle), and expel all air from the syringe. Block the tip of the syringe with a fingertip or blob of clay, then withdraw the plunger to create a partial vacuum. You may need to do this several times. Once the TTC solution is in good contact with the seed, you can empty the seeds and solution from the syringe for incubation.

Reading the Results

You can read the test results in 2-8 hours at 35oC, depending on the species. Letting the test go overnight usually does not obscure the results; the red color is stable after it is formed. Remove excess tetrazolium solution with a medicine dropper, and rinse in a little tap water. Examine under magnification.

If the embryo is uniformly cherry red, count the seed as viable. If the embryo remains white, the seed was dead. The problems in interpretation come with partially stained embryos, and pale coloration. In general, if more than 1/2 of the cotyledon, root or shoot tip are unstained, you can probably count the seed as non-viable with a fair degree of confidence, especially if the white spot extends across the entire width of the radicle, hypocotyl or epicotyl (the embryonic root, stem or new shoot).

Pale pink embryos are often just barely alive, and probably will not germinate even under optimum conditions. Other causes for pink coloration include too short an incubation time and a species with a rather waterproof seed coat, or an oily embryo. If none of the seeds are red, lengthen the incubation time, pick off the seed coat, or add a drop of dilute baby shampoo. (Aerosol OT (sodium dioctyl sulfosuccinate) and Tween 80 can also be used for the oily embryo problem). If some seeds in the batch are red, consider the pink ones to be inviable.

Seeds with small patches of white are probably viable, but probably will not produce strong plants under field conditions. Grasses are wrapped in tough, opaque tissues called the lemma and palea. If you pierce grass seeds, rather than cutting them, you need to make these wrappers transparent after the embryos stained. The usual method requires a substance called lactophenol (20 ml lactic acid, 20 ml phenol, 40 ml glycerin, 20 ml water) that is toxic when breathed or absorbed through the skin. I am currently trying to develop a simple, non-toxic clearing agent. If you choose to use lactophenol, wear latex or plastic gloves and work in a well-ventilated area.

More information

Further information about tetrazolium testing can be found in many seed technology textbooks, and in the Tetrazolium Testing Handbook for Agricultural Seeds (Contribution #29 to the Handbook on Seed Testing), Don Grabe, editor; Association of Official Seed Analysts, 1970; pp1-62. Many of the drawings here were redone from that book.

The Iowa State University Seed Testing Laboratory (Seed Science Center, ISU, Ames, IA 50011) and many private seed testing labs perform tetrazolium tests as well as standard seed purity and germination tests.

Seed Counts of Species Planted in Roadsides I (Association of Official Seed Analysts 1981)

Kind of Seed	Approximate number of seeds per ounce
Agropyron desertorum (Link) Schultes standard crested wheatgrass	11,340- 12,925
Agropyron intermedium (Host) Baumgarten var. intermedium intermediate wheatgrass	4,595- 5,415
Agropyron intermedium (Host) Baumgarten var. trichophorum (Link) Halacsy pubescent wheatgrass	4,680- 5,445
Agropyron smithii Rydberg western wheatgrass	7,115
Agropyron trachycaulum (Link) H. F. Lewis slender wheatgrass	8,335
Agrostis gigantea Roth redtop	303,200
Agrostis stolonifera L. var. palustris (Hudson) Farwell--creeping bentgrass	383,115
Agrostis tenuis Sibthorp colonial bentgrass	383,115
Alopecurus pratensis L. meadow foxtail	25,430
Andropogon gerardii Vitman big bluestem	9,015
Andropogon hallii Hackel sand bluestem	6,040
Anthoxanthum odoratum L. sweet vernalgrass	45,360

Avena byzantina K. Koch, and A. sativa L.	
red oat and oats	1,000-1,425
Bouteloua curtipendula (Michaux) Torrey	
side-oats grama	45,640
(other than caryopses)	9,950
Bouteloua gracilis (H. B. K.) Steudel	
blue grama	45,275
Bromus inermis Leysser	
smooth brome	8,475-9,385
Buchloe dactyloides (Nuttall) Engelmann	
buffalograss (burs)	3,120
(caryopses)	20,960
Calamagrostis canadensis (Michaux) Nuttall	
bluejoint	239,842
Cenchrus ciliaris L.	
buffelgrass (caryopses)	55,095
(fascicles)	10,120
Coronilla varia L.	
crownvetch	8,635
Cynodon dactylon (L.) Persoon var dactylon	
bermudagrass (unhulled)	99,140
bermudagrass (hulled)	129,445
Cynodon dactylon (L.) Persoon var. aridus Harlan & de Wet	
giant bermudagrass	83,630
Dactylis glomerata L.	
orchardgrass	23,615-29,825
Desmodium tortuosum (Sweet) DC.	
Florida beggarweed	12,540
Echinochloa crusgalli (L.) Beauvois var frumentacea (Link) Wight	
Japanese-millet	8,930
Elymus canadensis L.	
Canada wildrye	5,385

Eragostis curvula (Schrader) Nees weeping lovegrass	92,645
Eragrostis trichodes (Nuttall) Wood sand lovegrass	101,605
Fagopyrum esculentum Moench buckwheat	1,275
Festuca arundinacea Schreber tall fescue	11,115- 14,600
Festuca pratensis Hudson meadow fescue	14,090
Festuca rubra L. subsp. rubra red and creeping red fescue	22,820
Festuca rubra L. subsp. commutata Gaudin chewings fescue	28,040
Festuca trachyphylla (Hackel) Krajina hard fescue	36,995
Glycine max (L.) Merrill soybean	175-435
Helianthus annuus L. sunflower	
Hordeum vulgare L. barley	850
Lathyrus hirsutus L. rough-pea	1,135
Lespedeza cuneata (Dumont) G. Don sericea lespedeza (Chinese lespedeza)	23,250
Lespedeza stipulacea Maximowicz Korean lespedeza	14,885
Lespedeza striata (J. A. Murray) Hook. & Arn. common lespedeza (striate lespedeza)	21,265
Linum usitatissimum L. flax	5,045

Lolium multiflorum Lamarck annual ryegrass (Italian ryegrass)	11,225- 12,560
Lolium perenne L. Perennial ryegrass	13,155- 16,895
Lotus corniculatus L. birdsfoot trefoil	23,115
Lotus uliginosus Schkuhr big trefoil	55,210
Lupinus albus L. white lupine	200
Lupinus angustifolius L. blue lupine	200
Lupinus luteus L. yellow lupine	225
Medicago lupulina L. black medick	16,615
Medicago sativa L. alfalfa	14,175
Melilotus alba Medikus white sweetclover	16,160
Melilotus officinalis (L.) Lamarck yellow sweetclover	16,160
Oryza sativa L. rice	1,870
Oryzopsis hymenoides (Roemer & Schultes) Ricker Indian ricegrass	10,120
Panicum virgatum L. switchgrass	13,780- 18,595
Paspalum dilatatum Poiret dallisgrass	17,575
Phalaris arundinacea L. reed canarygrass	33,620
Phalaris canariensis L. canarygrass	4,255

Phleum pratense L. timothy	68,150- 77,250
Poa annua L. annual bluegrass	74,730
Poa compressa L. Canada bluegrass	143,165
Poa pratensis L. (incl. all cvs) Kentucky bluegrass	63,845- 109,885
Schizachyrium scoparium (Michaux) Nash little bluestem	14,855
Secale cereale L. rye	1,135
Sesbania exaltata (Rafinesque) Rydberg sesbania	2,980
Sorghastrum nutans (L.) Nash indiangrass	9,865- 12,530
Sorghum bicolor (L.) Moench broomcorn	1,705
Sorghum bicolor (L.) Moench sorghum (incl. grain and sweet cvs.)	850- 2,270
Sorghum halepense (L.) Persoon johnsongrass	7,455
Sorghum sudanense (Piper) Stapf sudangrass	2,355- 3,175
Sporobolus cryptandrus (Torrey) A. Gray sand dropseed	350,005
Stipa viridula Trinius green needlegrass	8,596*
Trifolium hirtum Allioni rose clover	10,280

Trifolium hybridum L. alsike clover	42,525
Trifolium incarnatum L. crimson clover	9,360
Trifolium pratense L. red clover	17,010
Trifolium repens L. white clover and ladino clover	42,000- 55,000
Triticum aestivum L. and other spp. wheat (also durum, emmer, and spelt)	710
Vicia sativa L. subsp. sativa common vetch	540
Vicia villosa Roth subsp. varia (Host) Corbiere winter vetch	710
Vicia villosa Roth subsp. villosa hairy vetch	1,02"0
Zea mays L. field corn and popcorn (var everta)	85
Zoysia japonica Steudel Japanese lawngrass	37,590

Reference:

Association of Official Seed Analysts. 1981. Rules for testing seeds. Journal of Seed Technology 6(2): 1-125

Table of Seed Counts II (Obtained from various seed dealers) **(Warning: reliablity is uncertain).**

Grass List Scientific Name	Common Name	Seeds/lb
Agrostis alba	Redtop	4,990,000
Andropogan gerardi	Big Bluestem	165,000
Andropogan scoparius	Little Bluestem	260,000
Avena sativa	Oats	13,000
Bouteloua curtipendula	Side Oats Grama	200,000
Bouteloua gracilis	Blue Grama	850,000
Bromus inermus	Smooth Brome	136,000
Bromus kalmi	Prairie Brome	136,000
Buchloe dactyloides	Buffalo Grass	56,000
Calamagrostis canadensis	Blue Joint Grass	1,512,000
Echinochloe crusgallis	Barnyard Grass	504,000
Elymus canadensis	Prairie Wild Rye	115,000
Eragrostis tricholdes	Tall Love Grass	1,134,000
Glyceria striata	Fowl Manna Grass	1,814,000
Hystrix patula	Bottlebrush Grass	604,000
Juncus tenuis	Path Rush	4,500,000
Koeleria cristata	Prairie June Grass	3,000,000
Leersia oryzoides	Rice Cut Grass	1,000,000
Leptochloa fascicularis	Salt-Meadow Grass	907,200
Panicum virgatum	Switch Grass	390,000
Phleum praetense	Timothy	1,230,000
Phragmites communis berlandieri	Wild Reed	3,024,000
Poa pratense	Kentucky Bluegrass	2,177,000
Sorghastrum nutans	Indian Grass	175,000
Spartina pectinata	Prairie Cord Grass	150,000
Sporobolus asper	Rough Dropseed	174,000
Sporobolus cryptandrus	Sand Dropseed	174,000
Sporobolus heterolepis	Prairie Dropseed	174,000
Stipa spartea	Porcupine Grass	34,112

Forb List Scientific Name	Common Name	Seeds/lb	Seeds/oz.
Amorpha canescens	Lead Plant	6,593	412
Anschusa azurea	Alsike Clover	700,000	43,750
Aster laevis	Smooth Aster	94,500	5,906
Aster novae-angliae	New England Aster	76,000	4,750
Baptisia lactea	White False Indigo	30,400	1,900
Ceanothus sp.	New Jersey Tea	8,200	512
Coreopsis palmata	Stiff Coreopsis	88,000	5,500
Dalea candida	White P. Clover	379,200	23,700
Dalea purpurea	Purple Prairie	18,000	1,125
Desmodium canadense	Canada Tick-trefoil	72,000	4,500
Echinacea pallida	Purple Coneflower	75,000	4,700
Eryngium yuccifolium	Rattlesnake Master	11,500	719
Lespedeza capitata	Round-Headed Bush	156,800	9,800
Liatris sp.	Blazingstar	11,000	688
Monarda fistulosa	Prairie Bergamon	81,000	5,062
Parthenium integrifolium	Prairie Quinine	13,000	812
Potentilla arguta	Prairie Cinquefoil	113,400	7,088
Ratibida pinnata	Yellow Coneflower	27,800	1,738
Rudbeckia hirta	Blackeyed Susan	61,250	3,828
Rudbeckia subtomentosa	Sweet Coneflower	62,500	3,906
Silphium laciniatum	Compass Plant	750	47

CRAO POLICY ON SEED SOURCE SELECTION

The County Roadside Assistance Office strongly encourages the re-establishment of local native species in roadsides. We advocate a philosophy which seeks to reconstruct natural plant communities found in the vicinity, e.g., prairies, wetlands, etc. Ideally, indigenous seed collected from local plants would be the most desirable. Theoretically, the genetic composition (genotypes) of these plants would be best suited for the area and propagating these plants would help preserve genetic diversity. CRAO also advocates that non-local cultivars of native species SHOULD NOT planted within a one mile radius of an important natural area.

CRAO also recognizes that indigenous seed may not be the most cost-effective seed for establishment along large tracts of roadside. Viability of indigenous seed collected from remnant native areas is often poor and viable seed may be dormant for an uncertain period of time depending on the seed's physiological development. It may not be advisable to disperse scarce seeds of a local genotype into precarious roadside habitats which are subject to many disturbances. These seeds may be better used in increaser plots for seed production where growth and harvest are better monitored and their security is assured.

Cultivars of native prairie species have been developed for commercial distribution. These "designed plants" are bred mainly for forage and seed production. The selection process employed by plant breeders reduces genotypic diversity resulting in the large-scale production of genetically uniform plants. The main advantage of cultivars is their dependability: they are bred for consistent germination and performance.

Given the importance of vegetation in protecting roads, CRAO acknowledges the need for using cultivars in IRVM programs. We suggest that the source of the seed used in an IRVM planting be selected by a predetermined set of criteria by which roadsides segments are categorized. Ultimate responsibility for selecting a seed source should be decided by a governing or advisory board overseeing a local IRVM program.

CRAO believes roadside managers should try to incorporate local seed into their roadside plantings, but we understand the difficulty in obtaining indigenous seed. Recently, the Living Roadway Trust has funded a cooperative venture with Dr. Daryl Smith of the Biology Department, University of Northern Iowa and the USDA Soil Conservation Service to develop Iowa ecotypes of several prairie species for commercial seed distribution. CRAO believes that efforts like these will eventually help make local seed more available to county IRVM programs at a cost effective price

Peter Schramm stated CRAO's objectives most eloquently at the 1990 North American Prairie Conference:

> ... It was well known that naturally selected ecotypes, or genetic variants adapted to local conditions, existed within species of prairie grasses and forbs... First, if the prairie planting is to be a restoration, then we should try to restore what was there originally. Second, we should be concerned with the preservation of local gene pools as part of the vast genetic diversity of this once wide-spread plant community. And finally, natural selection has already determined that these local genotypes are the ones that are best suited to local conditions ... By working within reasonable distance limits in similar climatic regimes, we can preserve local genes and also do some mixing to maintain or recreate the genetic variety that must have been present in the original prairie (Schramm 1992).

LIST OF KNOWN CULTIVARS
OF NATIVE GRASSES
INCLUDING SOME NATIVE FORBS
AND NON-NATIVE GRASSES

UNI COUNTY ROADSIDE ASSISTANCE OFFICE

January 23, 1992

SCIENTIFIC NAME	CULTIVAR^	COMMONMAME	SOURCE	DATE RELEASED
Agropyron [see Elymus or Elytrigia]				
Agrostis alba		Redtop	Uncertain what is available	
Andropogon gerardii var. gerardii	Bonila	Big bluestem	SD	1987
	Kaw		KS	1950
	Niagara		NY	1986
	Roundtree		IA	1983
	Pawnee		NE	1963
	Champ		NE,IA	-
var. paucipilus	Elida	Sand bluestem	NM	1963
*	Garden		NE	1961
	Goldstrike		NE	1973
*	Cherry		NE	1961
*	Woodward		OK,NM	1955
Bouteloua curtipendula	Butte	Sideoats grama	NE	1958
	Coronado		NM	1955
	El Reno		OK	1944
	Haskell		Tx	1983
	Niner		NM	1984
	Premier		Mexico	1960
Bouteloua curtipenduala	Trailway		NE	1958

	Tucson		AZ	-
	Uvalde		TX	1950
	Vauaghn		NM	1940
*	Kildeer		ND	-
*	Pierre		SD	-
Bouteloua gracilis	Hachita	Blue grama	NM	1980
	Lovington		NM	1963
Bromus inermis	Elsbury	Smooth brome	MS,IA	1954
	Fischer		IA	1943
	Manchar		Manchuria	1943
Buchloe dactyloides	Texoka	Buffalograss	KS,Ok,TX	1974
	Mesa		TX	-
	Sharp's improved	(private release)	KS	1972
Calamovilfa longifolia	Goshen	Prairie sandreed	WY	1976
	Pronghorn		UNK	1988
Dactylis glomerata	Akaroa	Orchardgrass	New Zealand	1953
	Berber		Australia	1981
	Latar		USSR	1957
Dactylis glomerata	Palute		Turkey	1983
	Pomar		USSR	1966
	Sandia		Germany	1953
Elymus canadensis	common			
Elymus lanceolatus	Critana	Thickspike wheatgr.	MT	1971

var. lanceolatus [Agropyron dasystachyum]	Sodar	Streambank wheatgr.	OR	1954
Elymus trachycaulum (Agropyron)	Primar	Slender wheatgrass	MT	1946
	San Luis		CO	1984
	Pryor		MT	1988
Elytrigia smithii [Agropyron, Elymus]	Arriba	Western Wheatgrass	CO	1973
	Barton		KS	1970
	Flintlock		NE,KS	1975,
	Rodan		ND	1983
	Rosana		MT	1972
Eragrostis trichodes	Bend	Sand lovegrass	KS,OK	1971
	Nebraska-27		NE	1949
var. pilifera	Mason	Sandhill lovegrass	TX	1971
Festuca arundinacea	Alta	Tall fescue	common	1940
*	Asheville	Tall fescue 283284	NC	1952
	Fawn		common	1964
*	Goar	Tall fescue	Hungary	1946
Festuca arundinacea (cont.)	Kentucky-31		intro	-
Festuca rubra	common	Creeping red fescue		
Lolium perenne	common	Perennial ryegrass		
Panicum virgatum	Alamo	Switchgrass	TX	1978
	Blackwell		OK	1944
	Caddo		OK	1955
	Cave-in-rock		IL	1974

	Forestburg		SD	1987
*	Grenville		NM	1940
	Kanlow		OK	1963
	Nebraska-28		NE	1949
	Pathfinder		NE,KS	1967
	Shelter		NY	1987
	Summer		NE	1963
	Trailblazer	(derived from Pathfinder	NE)	1984
Phlaris arundinacea	Loreed	Reed canarygrass	Composite	1946
Phleum pratense	common	Timothy		
Phragmites australis	Shoreline	Common reed	TX	1978
Poa pratensis	Cougar	Kentucky bluegrass	Denmark	1965
	Newport		OR	1958
Schizachyrium scoparium	Aldous	Little bluestem	KS	1966
	Blaze			
	Camper			
	Cimarron		KS,OK	1979
	Pastura		NM	1963
Sorghastrum nutans	Cheyenne	Indiangrass	OK	1954
	Holt	Indiangrass	NE	1960
	Llano	Indiangrass	NM	1963
	Lometa		TX	1981

	Nebraska-54		NE	1957
	Osage		KS,OK	1966
	Otoe		NE	-
	Rumsey		IL	1983
	Tejas		TX,Ok,NM	
	Tomahawk		ND,SD	1988
Sporobolus airoides	Saltalk	Alkali sacaton	OK	1981
Sporobolus asper	common	Tall, Rough, or Northern Droposeed		
Sporobolus cryptrandus	common	Sand dropseed		
Stipa viridula	Green Stripa	Green needlegrass	ND	1946
Tripsacum dactyloides	K-24 (PMK-24?)	Eastern gamagrass	KS,OK	1974
	Pete		KS,OK	1988

LEGUMES AND FORBS

Chamaecrista fasciculata (Cassia)	Comanche	Partridge pea	TX	1885
Dalea purpurea	Kaneb	Purple prairieclover	KS	1975
Desmanthus illinoensis	Sabine	Illinois bundleflower	TX	1983
Helianthus maximilliani	Aztec	Maximillian s.fl.	TX	1978
	Prairie Gold		KS	1978
Heliopsis helianthoides	Midas	Rough oxeye	KS	1984
Lathyrus latifolius	Lancer	Perrennial pea	MI	1984
Lathyrus sylvestris	Lathco	Flatpea	WA	1972
Liatris pycnostachya	Euroka	Thickspike gayfeather	KS	1975
Lotus corniculatus	Cascade	Birdsfoot trefoil	France	1954
	Mackinaw		IA	1971

	Kalo		France	1974
Ratibida pinnata	Sunglow	Grayhead prairie coneflw.	UNK	1978
Rudbeckia hirta	Golden Jubilee	Blackeye Susan	VT	1985

^ Attributes available from the IRVM County Roadside Assistance Office or the Soil Conservation Service.
* Informal releases
@ common: variety unstated because they are too numerous or uncertified "commonly" available varieties--may or may not be cultivars.
References:

Barnhart, S. 1986. Forage varieties. Cooperative Extension Service, Iowa State University, Pamphlet Pm-1144, 11 p.

Heath, M. E.; R. F. Barnes; D. S. Metcalfe, eds. 1985. Forages. Iowa State University Press, Ames. p643.

Ohlenbusch, P. 1984. Selecting native grasses for erosion control. Kansas State University Cooperative Extension Service. Publication L-703.

Soil Conservation Service. 1988. Improved Plant Materials Cooperatively Released by SCS Through December 1988.

United States Department of Agriculture. 1965. Grass varieties in the United States. Agriculture Research Service, Ag. Handbook No. 170.

SOURCES OF NATIVE VEGETATION IN IOWA

ALLENDAN SEED COMPANY
Rt. #3, Box 31
Winterset, IA 50273
(515) 462-1241
Dan Allen, Owner

FRANKLIN GRASSLAND SEED COMPANY
Rt. #2, Box 132
Hampton, IA 50441
(515) 456-2988
Dennis Strother, Owner

HADFIELD PRAIRIE SEED
Rt. #1, Box 132
McClelland, IA 51548
(712) 484-3326
Allen Hadfield, Owner

HEYNE SEED COMPANY
Rt. #1, Box 78
Walnut, IA 51577
(712) 784-3454
Bruce Heyne, Owner

ION EXCHANGE
Rt. #1, Box 48C
Harper's Ferry, IA 52146
(319) 535-7231
Howard Bright, Owner

IOWA PRAIRIE SEED COMPANY
Rt. #1 Box 259
Cresco, IA 52136
(319) 547-3824
Daryl Kothenbeutel, Owner

MARK SEED COMPANY
Box 67
Perry, IA 50220
(515) 465-2122
Mark Terpstra, Owner

McGINNIS TREE AND SEED COMPANY
309 East Florence
Glenwood, IA 51534
Keith McGinnis, Owner

NATURE'S WAY
RR #1, Box 62
Woodburn, IA 50275
(515) 342-6246
Dorothy Baringer, Owner

NAYLOR SEED COMPANY
Box 16
Scotch Grove, IA 52331
1-800-747-7333
(319) 465-3035
Jerry Naylor, Owner

OSENBAUGH GRASS SEEDS
RR #1, Box 76
Lucas, IA 50151
(515) 766-6476
John Osenbaugh, Owner

QUEST DEVELOPMENT CORP.
PO Box 1015
Centerville, IA 52544
(515) 437-7212
Rick Ahee, Director

SHIVVER'S SEED FARM
614 W. English
Corydon, IA 50060
Doug Shivver's, Owner

STONER SEED FARMS
Rt. #1, Box 48
South English, IA 52335
1-800-383-2089

STRAYER SEED FARMS INC
162 West HWY 58
Hudson, IA 50643
1-800-728-4187
Berton Strayer, Manager

VAN GUNDY SEED FARM
6650 SE 6th Ave
Des Moines, IA 50317
(515) 266-6739
Richard Van Gundy, Owner

SOURCES OF NATIVE VEGETATION OUTSIDE OF IOWA

BALD EAGLE NURSERY, INC.
1010 9th Street
Fulton, IL 61252
(815) 589-4121
Gerry Koph, Owner

BLUESTEM SEED COMPANY
Rt 3, Box 32
Grant City, MO 64456
1-800-BLU-STEM (258-7836)
Dave Kean, Owner

GENESIS NURSERY, INC.
Rt. #1 Box 32
Walnut, IL 61376
(815) 379-9060
(815) 894-3329
Kathy Motto, President

JOHNSON PRAIRIE SEED COMPANY
Rt 1
Windom, MN 56101
Judy Johnson, Owner

LAFAYETTE HOME NURSERY, INC.
PO Box 1A
La Fayette, IL 61449
(309) 995-3311
Ingels Bros., Owners

MOHN SEED CO.
Rt. #1, Box 152
Cottonwood, MN 56229
(507) 423-6482
Robert Mohn, Owner

P.E. ALLEN FARM SUPPLY
Rt 2 Box 8
Bristow, NE 68719-9407
(402) 583-9924

PRAIRIE MOON NURSERY
Rt. #3, Box 163
Winona, MN 55987
(507) 452-1362
Alan Wade, Owner

PRAIRIE NURSERY
PO Box 306
Westfield, WI 53964
(608) 296-3679
Brian Bader, General Manager

PRAIRIE RIDGE NURSERY
Rt 2, 9738 Overland Rd
Mt. Horeb, WI 53572-2832
(608) 437-5245
Joyce Powers, Consultant

SHARP BROS. SEED CO.
PO Box 665
Clinton, MO 64735
1-800-451-3779

STOCK SEED FARM, INC.
Rt. #1, Box 112
Murdock, NE 68407
(402) 867-3771
Lyle & David Stock, Owners

SEED BANK MANAGEMENT FOR RESTORATION OF NATIVE PRAIRIE

This is a review of a paper by Lippert and Hopkins (1950), whose results have important management implications in re-establishing vegetation in roadsides where native seeds are present in the soil.

The study sought to determine what viable seeds were present in the surface soil of various plant communities in the mixed prairie association several years after the drought. Soil samples were taken from 22 representative habitats (3 trials each of one square foot by 0.5 inches in depth). A total of 18,539 seeds germinated in all the samples, an average of 280 plants per square foot. There were 8 species of weedy grasses, 12 non-weedy grasses, 26 weedy forbs, and 17 non-weedy forbs. Downy brome , Little barley, Pigweed (Amaranthus retroflexus), Mat spurge (Chamaesyce glyptosperma) and Sticktight; together furnished 29 percent of all species.

Sand dropseed (Sporobolus cryptandrus) furnished 42 percent of the total seedlings. Sand dropseed is a perennial grass and climax species in the mixed prairie. In the burnt vegetation area, there was an average of 1,931 seedlings per square foot. A single panicle is known to produce as much as 10,000 seeds and large amounts of seed are produced even in dry years.

Maximum emergence of weedy grasses and forbs occurred during the first week of the study, but the peak germination of non weedy plants was not reached until the sixth week. Germination of weedy species rapidly declined after the first week, while germination of non-weedy species were more evenly distributed throughout the period. Well over half of all the weedy plants had emerged by the end of the 4th week. Annual sunflower produced 69 percent of its seedlings in the first 10 days. Only one non-weedy species produced seedlings in the first 5 days. There were no seedlings of Western ragweed (Ambrosia psilostachya) and Blue gramma until the 6th and 7th weeks. More than 30 percent of the total plants of several non-weedy species emerged during the 5-10 week period. Species dependent on vegetative propagation, produced comparatively few seedlings. There were never more than 3 seedlings of buffalo grass per square foot. Seedlings of perennial forbs were not abundant in any trial.

Few to no weedy species were produced in moderately grazed mid-grass prairie and mixed-grass prairie. While the overgrazed short-grass community, denuded pasture, and weedy meadow produced copious amounts of weeds. Burning had eliminated seedlings of Downy brome, however, another warm season grass (Chloris verticillata) produced 330 seedlings. Sand dropseed produced more than 6 times as many seedlings on burned areas as those found on unburned areas. Other studies also found that burning increased the seed yield of several species of grasses.

The roadside management implications of this study are: 1) A large proportion of weeds may be controlled by non-residual herbicides during the first two weeks following planting with minimal effect to desireable species (this serves to diminish the quantity of viable weed seeds in the soil); (2) disturbed roadsides with prairie species need not be seeded to be restored to prairie but weed control will be necessary if weeds were present prior to disturbance. (3) Fire treatment to an area greatly reduces plant numbers at time of burn, especially annual species, while stimulating germination of fire adapted species.

Lippert, L. D. and H. H. Hopkins. 1950. Study of viable seeds in various habitats in mixed prairie. Transactions of the Kansas Academy of Science 53(3): 355-364.

CALCULATING SEEDING RATES

Successful seeding depends upon planting the proper amount of viable seed at a rate which ensures uniform establishment (viable seed is determined by the Pure-Live-Seed -PLS- formula). The IRVM philosophy advocates using seed mixtures of grasses, forbs and legumes when planting roadsides. Since seeds vary in size and weights among species, it is important to use seed density (number of viable seeds to be sown on a given area) instead of weights while mixing. For purposes of documenting seeding successes and failures, CRAO recommends that seeding rates be considered according to the number of seeds sown per square foot. Once this objective is meet then a per-acre seeding rate using weights for each species in the mix can be calculated. After roadsides are seeded, establishment success can be determined by a system which counts the number of desireable seedlings found in square foot plots; and later by the percent coverage in square yard plots. Results from the evaluation process can then be used to determine if a follow-up seeding is necessary to obtain adequate vegetation coverage. Evaluation will also enble roadside managers to determine if seed mixes are successful and whether seeding rates should be increased or decreased.

Presently CRAO is recommending that a base rate of 60 pure-live-seeds per square foot should be planted using a no-till range drill. While seed mixtures should be determined by the roadside managers, we advocate that a target square-foot objective should include 40 grass seeds and 20 forb and legume seeds (this ratio is subject to change following a period of evaluation). An example of such a mixture is given in Tables 1 and 2 where each species of a theoretical mix is given with its pounds or ounches per-acre-rate, number of estimated seeds per pound or ounch, and expected number of seeds planted per square foot.

1) Determine number of seeds per square foot for each species.

Seed number per unit weight (lbs or oz) divided by 43,560 square feet per acre equals the number of seeds of a particular species planted at the unit rate per acre (e.g., Big-bluestem grass with 165,000 seeds per pound, divided by 43,560 per acre, will nearly have 4 seeds per square foot at 1 lb planted per acre).

2) Determine the desired percentage of each species in the mix.

The grass seeding mix in Table 1 includes 15 Big-bluestem; 22% Little-bluestem; 13% Side-oats gramma; etc.

3) Determine the number of seeds per ft^2 for each species.

Multiply the total number of seeds desired in a square foot (40) by the decimal percentage of the desired quantity ratio for each species.

Big-bluestem:
40 (total seeds/ft^2) x 0.15 = 6 seeds/ft^2.

Little-bluestem:
40 x 0.225 = 9 seeds/ft^2.

Side-oats gramma:
40 x 0.13 = 5 seeds/ft^2.

4) Determine seeding rate in unit weight per acre for each species.

Calculate the total number of pounds or ounches per acre of each species in the seeding mix by dividing the desired number of seeds per square foot for each species (step 3) by the number of seeds per square foot obtained when planted at the

unit weight per acre (step 1). This ratio will yield the total amount (weight) of seed to be planted of that species in the mix.

Big-bluestem: 6/4 = 1.5 lbs/acre.
Little-bluestem: 9/6 = 1.5 lbs/acre.
Side-oats gramma: 5/5 = 1.0 lbs/acre.

Association of Official Seed Analysts. 1981. Rules for testing seeds. Journal of Seed Technology 6(2):1-125.

National Wildflower Research Center. 1989. Wildflower handbook. Texas Monthly Press, Austin, pp. 337.

Table 1. Example of roadside seeding mix sowing 60 seeds/ft^2

Grasses	#/acre	Seeds/#	Seeds/ft^2
Big bluestem	1.5	165,000	6
Little bluestem	1.5	260,000	9
Side oats grama	1.0	200,000	5
Indiangrass	1.5	175,000	6
Western wheatgrass	0.5	160,000	2
Switchgrass	0.5	390,000	5
Canada wild rye	0.25	115,000	1
Sand dropseed	1.5	174,000	6
Total grasses	8.25		40
Forbs	Ozs/acre	seeds/oz	seeds/sq. ft.
Black eyed susan	6.00	61,250	8
New England aster	1.00	76,000	2
Prairie blazingstar	16.00	11,000	4
Purple coneflower	20.00	5,300	2
Purple prairie clover	8.00	18,300	4
Total forbs	51.00		20

Table 3. Contrasting Iowa DNR seed mix rates for wildlife areas and erosion areas.

	Wildlife Use		Erosion Area		
Grass Species	lbs/acre	seeds/ft^2	lbs/acre	seeds/ft^2	Seeds/lb
Big bluestem	2.0	8	2.0	8	165,000
Indian grass	1.5	6	2.0	8	175,000
Switchgrass	0.5	5	1.0	9	390,000
Little bluestem	1.0	6	1.0	6	260,000
Sideoats grama	1.0	5	2.0	9	200,000
Sand lovegrass	0.25	7	1.0	26	1,134,000
Totals	6.75	42	9.0	66	

MATRIX SPECIES

Many restoration ecologists have recognized that plant communities are established in successional stages. Some species are adapted to be colonizers while others, which may be more difficult to establish from seed, are more competitive over time. Often there are "sets" of species which succeed one another in sequential periods of time. The more aggressive species with wider ecological tolerances enter first and prepare the way for the other species with narrower tolerances (Betz 1986). Many species are not able to survive in large numbers when sown directly onto plowed and disked soil. Others are not able to withstand the initial stage characterized by intense weedy competition, despite the fact that often large amounts of seeds are often sown. Native species which are easily established from seed and can survive weedy competition are the most desireable for erosion control. Later, more difficult species can be introduced to improve the plant community.

Robert Betz (1986) coined the term "matrix" to describe the first assemblage of species in prairie succession, but CRAO has expanded the definition of matrix to be any set of species which become established together during a particular stage. Species are classified into a matrix according to the ease by which they are established. Therefore, the higher the matrix order, the more difficult it is to establish those species in abundance. The matrices used by CRAO are: Temporary Matrix, comprised of annuals and short-lived perennials, often called cover or nurse crops; Matrix I, native species easily established by seed (many of which are developed as cultivars); and Matrix II, those species which have narrow ecological niches or are difficult to establish from seed.

TEMPORARY MATRIX SPECIES

ANNUALS

GRASSES		
Avena sativa	Oats	
Avena byzantina	Red oats	
Echinochloa crusgalli	Japanese millet	
Secale cereale	Rye	(Allelopathic)
Sorghum bicolor	Broomcorn, Sorghum, cvs.	
Sorghum sudanense	Sudan grass	
Triticum aestivum	Wheat (differing cvs characteristics)	
LEGUMES		
Vicia villosa	Winter and Hairy vetch	
Trifolium hybridum	Alsike clover	
Lotus corniculatus	Birdsfoot-trefoil	
Cassia fasiculata	Partridge pea	

SHORT-LIVED PERENNIALS -- (under prairie management)

GRASSES		
Phleum pretense	Timothy grass	
Elymus canadensis	Canada wild-rye	
Dactylis glomerata	Orchard grass	
Bouteloua curtipendula	Side-oats grama	
Sporobolus asper	Rough or Northern dropseed	
Sporobolus cryptandrus	Sand dropseed	
Lolium perenne	Perennial rye	
Rudbeckia hirta	Black-eyed susan	
Trifolium repens	White clover	(aggresive non-native)

MATRIX I

GRASSES	
Andropogon geraldii	Big bluestem
Bouteloua curtipendula	Side-oats grama
Carex molesta	
Carex brevior	
Carex scoparia	(wet soils)
Carex bicknellii	Bicknell's sedge
Eragrostis trichodes	Sand lovegrass
Panicum virgatum	Switch grass
Schizachyrium scoparium	Little bluestem
Sorghastrum nutans	Indian grass
Spartina pectinata	Prairie cordgrass (transplants are best)
Sporobolus cryptandrus	Sand dropseed
Sporobolus asper	Rough or Northern dropseed
FORBS	
Anemone cancadensis	Canada anemone
Anemone cylindrica	Wind flower
Asclepias tuberosa	Butterfly plant
Coreopsis palmata	Prairie coreopsis
Echinacea pallida	Pale-purple coneflower
Eryngium yuccifolium	Rattlesnake master
Euthamia graminifolia	Grass-leaved goldenrod
Monarda fistulosa	Horsemint
Parthenium integrifolium	Wild quinine
Ratibida pinnata	Yellow coneflower
Rudbeckia laciniata	Green-headed coneflower (wet soils)
Silphium laciniatum	Compass plant
Silphium perfoliatum	Cup plant (rank aggressive in wet areas)
Silphium integrifolium	Rosin weed
Solidago rigida	Prairie goldenrod
Solidago nemoralis	Gray goldenrod
Verbena hasta	Blue vervain
LEGUMES	
Astragalus canadensis	Canada milkvetch (poisons livestock)
Babtisia leucantha	White wild indigo
Cassia fasciculata	Partidge pea
Dalea pupureum	Purple prairie clover
Dalea candidum	White prairie clover
Desmodium illinoense	Illinois tick trefoil
Desmodium canadense	Showy tick trefoil
Fragaria viginiana	Wild strawberry
Helianthus laetiflorus	Showy sunflower
Helianthus grossesrratus	Big-toothed sunflower (tall aggressive)
Heliopsis helianthoides	Ox-eye sunflower
Lespedeza capitata	Round-headed bush clover
Rosa suffalta	Prairie rose
Zizia aurea	Golden alexanders

MATRIX II

GRASSES

Sporobolus heterolepis	Prairie dropseed
Stipa viridula	Green needle grass
Stipa spartea	Porcupine grass

FORBS

Aster ericoides	Heath aster
Aster laevis	Smooth blue aster
Aster azureus	Sky-blue aster
Dodecatheon meadia	Shooting star
Galium boreale	Northern bedstraw
Liatris aspera	Rough blazing star
Liatrus pycnostachya	Prairie blazing star
Lobelia spicata	Spiked lobelia
Phlox pilosa	Prairie phlox
Potentilla arguta	Prairie cinquefoil
Pycnanthemum virginianum	Mountain mint
Thalictrum dasycarpum	Purple meadow rue

LEGUMES

Amorpha canescens	Lead plant
Baptisa leucophaea	Cream wild indigo

Betz, R. 1986. One decade of research in prairie restoration at the Fermi nation al acceleratior laboratory (Fermilab) Batavia, Illinois. In: G. K. Clambey, R. H. Rambley, eds. The prairie: past, present and future-proceedings of the Ninth North American Prairie Conference, pp 179-185.

CRAO POLICY ON SEED SOURCE SELECTION

The County Roadside Assistance Office strongly encourages the re-establishment of local native species in roadsides. We advocate a philosophy which seeks to reconstruct natural plant communities found in the vicinity, e.g., prairies, wetlands, etc. Ideally, indigenous seed collected from local plants would be the most desirable. Theoretically, the genetic composition (genotypes) of these plants would be best suited for the area and propagating these plants would help preserve genetic diversity. CRAO also advocates that non-local cultivars of native species SHOULD NOT planted within a one mile radius of an important natural area.

CRAO also recognizes that indigenous seed may not be the most cost-effective seed for establishment along large tracts of roadside. Viability of indigenous seed collected from remnant native areas is often poor and viable seed may be dormant for an uncertain period of time depending on the seed's physiological development. It may not be advisable to disperse scarce seeds of a local genotype into precarious roadside habitats which are subject to many disturbances. These seeds may be better used in increaser plots for seed production where growth and harvest are better monitored and their security is assured.

Cultivars of native prairie species have been developed for commercial distribution. These "designed plants" are bred mainly for forage and seed production. The selection process employed by plant breeders reduces genotypic diversity resulting in the large-scale production of genetically uniform plants. The main advantage of cultivars is their dependability: they are bred for consistent germination and performance.

Given the importance of vegetation in protecting roads, CRAO acknowledges the need for using cultivars in IRVM programs. We suggest that the source of the seed used in an IRVM planting be selected by a predetermined set of criteria by which roadsides segments are categorized. Ultimate responsibility for selecting a seed source should be decided by a governing or advisory board overseeing a local IRVM program.

CRAO believes roadside managers should try to incorporate local seed into their roadside plantings, but we understand the difficulty in obtaining indigenous seed. Recently, the Living Roadway Trust has funded a cooperative venture with Dr. Daryl Smith of the Biology Department, University of Northern Iowa and the USDA Soil Conservation Service to develop Iowa ecotypes of several prairie species for commercial seed distribution. CRAO believes that efforts like these will eventually help make local seed more available to county IRVM programs at a cost effective price

Peter Schramm stated CRAO's objectives most eloquently at the 1990 North American Prairie Conference:

> ... It was well known that naturally selected ecotypes, or genetic variants adapted to local conditions, existed within species of prairie grasses and forbs... First, if the prairie planting is to be a restoration, then we should try to restore what was there originally. Second, we should be concerned with the preservation of local gene pools as part of the vast genetic diversity of this once wide-spread plant community. And finally, natural selection has already determined that these local genotypes are the ones that are best suited to local conditions ... By working within reasonable distance limits in similar climatic regimes, we can preserve local genes and also do some mixing to maintain or recreate the genetic variety that must have been present in the original prairie (Schramm 1992).

LIST OF KNOWN CULTIVARS
OF NATIVE GRASSES
INCLUDING SOME NATIVE FORBS
AND NON-NATIVE GRASSES

UNI COUNTY ROADSIDE ASSISTANCE OFFICE

January 23, 1992

SCIENTIFIC NAME	CULTIVAR^	COMMONMAME	SOURCE	DATE RELEASED
Agropyron [see Elymus or Elytrigia]				
Agrostis alba		Redtop	Uncertain what is available	
Andropogon gerardii var. gerardii	Bonila	Big bluestem	SD	1987
	Kaw		KS	1950
	Niagara		NY	1986
	Roundtree		IA	1983
	Pawnee		NE	1963
	Champ		NE,IA	-
var. paucipilus	Elida	Sand bluestem	NM	1963
*	Garden		NE	1961
	Goldstrike		NE	1973
*	Cherry		NE	1961
*	Woodward		OK,NM	1955
Bouteloua curtipendula	Butte	Sideoats grama	NE	1958
	Coronado		NM	1955
	El Reno		OK	1944
	Haskell		Tx	1983
	Niner		NM	1984
	Premier		Mexico	1960
Bouteloua curtipenduala	Trailway		NE	1958

	Tucson		AZ	-
	Uvalde		TX	1950
	Vauaghn		NM	1940
*	Kildeer		ND	-
*	Pierre		SD	-
Bouteloua gracilis	Hachita	Blue grama	NM	1980
	Lovington		NM	1963
Bromus inermis	Elsbury	Smooth brome	MS,IA	1954
	Fischer		IA	1943
	Manchar		Manchuria	1943
Buchloe dactyloides	Texoka	Buffalograss	KS,Ok,TX	1974
	Mesa		TX	-
	Sharp's improved	(private release)	KS	1972
Calamovilfa longifolia	Goshen	Prairie sandreed	WY	1976
	Pronghorn		UNK	1988
Dactylis glomerata	Akaroa	Orchardgrass	New Zealand	1953
	Berber		Australia	1981
	Latar		USSR	1957
Dactylis glomerata	Palute		Turkey	1983
	Pomar		USSR	1966
	Sandia		Germany	1953
Elymus canadensis	common			
Elymus lanceolatus	Critana	Thickspike wheatgr.	MT	1971

var. lanceolatus [Agropyron dasystachyum]	Sodar	Streambank wheatgr.	OR	1954
Elymus trachycaulum (Agropyron)	Primar	Slender wheatgrass	MT	1946
	San Luis		CO	1984
	Pryor		MT	1988
Elytrigia smithii [Agropyron, Elymus]	Arriba	Western Wheatgrass	CO	1973
	Barton		KS	1970
	Flintlock		NE,KS	1975,
	Rodan		ND	1983
	Rosana		MT	1972
Eragrostis trichodes	Bend	Sand lovegrass	KS,OK	1971
	Nebraska-27		NE	1949
var. pilifera	Mason	Sandhill lovegrass	TX	1971
Festuca arundinacea	Alta	Tall fescue	common	1940
*	Asheville	Tall fescue 283284	NC	1952
	Fawn		common	1964
*	Goar	Tall fescue	Hungary	1946
Festuca arundinacea (cont.)	Kentucky-31		intro	-
Festuca rubra	common	Creeping red fescue		
Lolium perenne	common	Perennial ryegrass		
Panicum virgatum	Alamo	Switchgrass	TX	1978
	Blackwell		OK	1944
	Caddo		OK	1955
	Cave-in-rock		IL	1974

	Forestburg		SD	1987
*	Grenville		NM	1940
	Kanlow		OK	1963
	Nebraska-28		NE	1949
	Pathfinder		NE,KS	1967
	Shelter		NY	1987
	Summer		NE	1963
	Trailblazer	(derived from Pathfinder	NE)	1984
Phlaris arundinacea	Loreed	Reed canarygrass	Composite	1946
Phleum pratense	common	Timothy		
Phragmites australis	Shoreline	Common reed	TX	1978
Poa pratensis	Cougar	Kentucky bluegrass	Denmark	1965
	Newport		OR	1958
Schizachyrium scoparium	Aldous	Little bluestem	KS	1966
	Blaze			
	Camper			
	Cimarron		KS,OK	1979
	Pastura		NM	1963
Sorghastrum nutans	Cheyenne	Indiangrass	OK	1954
	Holt	Indiangrass	NE	1960
	Llano	Indiangrass	NM	1963
	Lometa		TX	1981

	Nebraska-54		NE	1957
	Osage		KS,OK	1966
	Otoe		NE	-
	Rumsey		IL	1983
	Tejas		TX,Ok,NM	
	Tomahawk		ND,SD	1988
Sporobolus airoides	Saltalk	Alkali sacaton	OK	1981
Sporobolus asper	common	Tall, Rough, or Northern Droposeed		
Sporobolus cryptrandus	common	Sand dropseed		
Stipa viridula	Green Stripa	Green needlegrass	ND	1946
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Desmanthus illinoensis	Sabine	Illinois bundleflower	TX	1983
Helianthus maximilliani	Aztec	Maximillian s.fl.	TX	1978
	Prairie Gold		KS	1978
Heliopsis helianthoides	Midas	Rough oxeye	KS	1984
Lathyrus latifolius	Lancer	Perrennial pea	MI	1984
Lathyrus sylvestris	Lathco	Flatpea	WA	1972
Liatris pycnostachya	Euroka	Thickspike gayfeather	KS	1975
Lotus corniculatus	Cascade	Birdsfoot trefoil	France	1954
	Mackinaw		IA	1971

	Kalo		France	1974
Ratibida pinnata	Sunglow	Grayhead prairie coneflw.	UNK	1978
Rudbeckia hirta	Golden Jubilee	Blackeye Susan	VT	1985

^ Attributes available from the IRVM County Roadside Assistance Office or the Soil Conservation Service.
* Informal releases
@ common: variety unstated because they are too numerous or uncertified "commonly" available varieties--may or may not be cultivars.
References:

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Heath, M. E.; R. F. Barnes; D. S. Metcalfe, eds. 1985. Forages. Iowa State University Press, Ames. p643.

Ohlenbusch, P. 1984. Selecting native grasses for erosion control. Kansas State University Cooperative Extension Service. Publication L-703.

Soil Conservation Service. 1988. Improved Plant Materials Cooperatively Released by SCS Through December 1988.

United States Department of Agriculture. 1965. Grass varieties in the United States. Agriculture Research Service, Ag. Handbook No. 170.

SOURCES OF NATIVE VEGETATION IN IOWA

ALLENDAN SEED COMPANY
Rt. #3, Box 31
Winterset, IA 50273
(515) 462-1241
Dan Allen, Owner

FRANKLIN GRASSLAND SEED COMPANY
Rt. #2, Box 132
Hampton, IA 50441
(515) 456-2988
Dennis Strother, Owner

HADFIELD PRAIRIE SEED
Rt. #1, Box 132
McClelland, IA 51548
(712) 484-3326
Allen Hadfield, Owner

HEYNE SEED COMPANY
Rt. #1, Box 78
Walnut, IA 51577
(712) 784-3454
Bruce Heyne, Owner

ION EXCHANGE
Rt. #1, Box 48C
Harper's Ferry, IA 52146
(319) 535-7231
Howard Bright, Owner

IOWA PRAIRIE SEED COMPANY
Rt. #1 Box 259
Cresco, IA 52136
(319) 547-3824
Daryl Kothenbeutel, Owner

MARK SEED COMPANY
Box 67
Perry, IA 50220
(515) 465-2122
Mark Terpstra, Owner

McGINNIS TREE AND SEED COMPANY
309 East Florence
Glenwood, IA 51534
Keith McGinnis, Owner

NATURE'S WAY
RR #1, Box 62
Woodburn, IA 50275
(515) 342-6246
Dorothy Baringer, Owner

NAYLOR SEED COMPANY
Box 16
Scotch Grove, IA 52331
1-800-747-7333
(319) 465-3035
Jerry Naylor, Owner

OSENBAUGH GRASS SEEDS
RR #1, Box 76
Lucas, IA 50151
(515) 766-6476
John Osenbaugh, Owner

QUEST DEVELOPMENT CORP.
PO Box 1015
Centerville, IA 52544
(515) 437-7212
Rick Ahee, Director

SHIVVER'S SEED FARM
614 W. English
Corydon, IA 50060
Doug Shivver's, Owner

STONER SEED FARMS
Rt. #1, Box 48
South English, IA 52335
1-800-383-2089

STRAYER SEED FARMS INC
162 West HWY 58
Hudson, IA 50643
1-800-728-4187
Berton Strayer, Manager

VAN GUNDY SEED FARM
6650 SE 6th Ave
Des Moines, IA 50317
(515) 266-6739
Richard Van Gundy, Owner

SOURCES OF NATIVE VEGETATION OUTSIDE OF IOWA

BALD EAGLE NURSERY, INC.
1010 9th Street
Fulton, IL 61252
(815) 589-4121
Gerry Koph, Owner

BLUESTEM SEED COMPANY
Rt 3, Box 32
Grant City, MO 64456
1-800-BLU-STEM (258-7836)
Dave Kean, Owner

GENESIS NURSERY, INC.
Rt. #1 Box 32
Walnut, IL 61376
(815) 379-9060
(815) 894-3329
Kathy Motto, President

JOHNSON PRAIRIE SEED COMPANY
Rt 1
Windom, MN 56101
Judy Johnson, Owner

LAFAYETTE HOME NURSERY, INC.
PO Box 1A
La Fayette, IL 61449
(309) 995-3311
Ingels Bros., Owners

MOHN SEED CO.
Rt. #1, Box 152
Cottonwood, MN 56229
(507) 423-6482
Robert Mohn, Owner

P.E. ALLEN FARM SUPPLY
Rt 2 Box 8
Bristow, NE 68719-9407
(402) 583-9924

PRAIRIE MOON NURSERY
Rt. #3, Box 163
Winona, MN 55987
(507) 452-1362
Alan Wade, Owner

PRAIRIE NURSERY
PO Box 306
Westfield, WI 53964
(608) 296-3679
Brian Bader, General Manager

PRAIRIE RIDGE NURSERY
Rt 2, 9738 Overland Rd
Mt. Horeb, WI 53572-2832
(608) 437-5245
Joyce Powers, Consultant

SHARP BROS. SEED CO.
PO Box 665
Clinton, MO 64735
1-800-451-3779

STOCK SEED FARM, INC.
Rt. #1, Box 112
Murdock, NE 68407
(402) 867-3771
Lyle & David Stock, Owners

SEED BANK MANAGEMENT FOR RESTORATION OF NATIVE PRAIRIE

This is a review of a paper by Lippert and Hopkins (1950), whose results have important management implications in re-establishing vegetation in roadsides where native seeds are present in the soil.

The study sought to determine what viable seeds were present in the surface soil of various plant communities in the mixed prairie association several years after the drought. Soil samples were taken from 22 representative habitats (3 trials each of one square foot by 0.5 inches in depth). A total of 18,539 seeds germinated in all the samples, an average of 280 plants per square foot. There were 8 species of weedy grasses, 12 non-weedy grasses, 26 weedy forbs, and 17 non-weedy forbs. Downy brome , Little barley, Pigweed (Amaranthus retroflexus), Mat spurge (Chamaesyce glyptosperma) and Sticktight; together furnished 29 percent of all species.

Sand dropseed (Sporobolus cryptandrus) furnished 42 percent of the total seedlings. Sand dropseed is a perennial grass and climax species in the mixed prairie. In the burnt vegetation area, there was an average of 1,931 seedlings per square foot. A single panicle is known to produce as much as 10,000 seeds and large amounts of seed are produced even in dry years.

Maximum emergence of weedy grasses and forbs occurred during the first week of the study, but the peak germination of non weedy plants was not reached until the sixth week. Germination of weedy species rapidly declined after the first week, while germination of non-weedy species were more evenly distributed throughout the period. Well over half of all the weedy plants had emerged by the end of the 4th week. Annual sunflower produced 69 percent of its seedlings in the first 10 days. Only one non-weedy species produced seedlings in the first 5 days. There were no seedlings of Western ragweed (Ambrosia psilostachya) and Blue gramma until the 6th and 7th weeks. More than 30 percent of the total plants of several non-weedy species emerged during the 5-10 week period. Species dependent on vegetative propagation, produced comparatively few seedlings. There were never more than 3 seedlings of buffalo grass per square foot. Seedlings of perennial forbs were not abundant in any trial.

Few to no weedy species were produced in moderately grazed mid-grass prairie and mixed-grass prairie. While the overgrazed short-grass community, denuded pasture, and weedy meadow produced copious amounts of weeds. Burning had eliminated seedlings of Downy brome, however, another warm season grass (Chloris verticillata) produced 330 seedlings. Sand dropseed produced more than 6 times as many seedlings on burned areas as those found on unburned areas. Other studies also found that burning increased the seed yield of several species of grasses.

The roadside management implications of this study are: 1) A large proportion of weeds may be controlled by non-residual herbicides during the first two weeks following planting with minimal effect to desireable species (this serves to diminish the quantity of viable weed seeds in the soil); (2) disturbed roadsides with prairie species need not be seeded to be restored to prairie but weed control will be necessary if weeds were present prior to disturbance. (3) Fire treatment to an area greatly reduces plant numbers at time of burn, especially annual species, while stimulating germination of fire adapted species.

Lippert, L. D. and H. H. Hopkins. 1950. Study of viable seeds in various habitats in mixed prairie. Transactions of the Kansas Academy of Science 53(3): 355-364.

CALCULATING SEEDING RATES

Successful seeding depends upon planting the proper amount of viable seed at a rate which ensures uniform establishment (viable seed is determined by the Pure-Live-Seed -PLS- formula). The IRVM philosophy advocates using seed mixtures of grasses, forbs and legumes when planting roadsides. Since seeds vary in size and weights among species, it is important to use seed density (number of viable seeds to be sown on a given area) instead of weights while mixing. For purposes of documenting seeding successes and failures, CRAO recommends that seeding rates be considered according to the number of seeds sown per square foot. Once this objective is meet then a per-acre seeding rate using weights for each species in the mix can be calculated. After roadsides are seeded, establishment success can be determined by a system which counts the number of desireable seedlings found in square foot plots; and later by the percent coverage in square yard plots. Results from the evaluation process can then be used to determine if a follow-up seeding is necessary to obtain adequate vegetation coverage. Evaluation will also enble roadside managers to determine if seed mixes are successful and whether seeding rates should be increased or decreased.

Presently CRAO is recommending that a base rate of 60 pure-live-seeds per square foot should be planted using a no-till range drill. While seed mixtures should be determined by the roadside managers, we advocate that a target square-foot objective should include 40 grass seeds and 20 forb and legume seeds (this ratio is subject to change following a period of evaluation). An example of such a mixture is given in Tables 1 and 2 where each species of a theoretical mix is given with its pounds or ounches per-acre-rate, number of estimated seeds per pound or ounch, and expected number of seeds planted per square foot.

1) Determine number of seeds per square foot for each species.

Seed number per unit weight (lbs or oz) divided by 43,560 square feet per acre equals the number of seeds of a particular species planted at the unit rate per acre (e.g., Big-bluestem grass with 165,000 seeds per pound, divided by 43,560 per acre, will nearly have 4 seeds per square foot at 1 lb planted per acre).

2) Determine the desired percentage of each species in the mix.

The grass seeding mix in Table 1 includes 15 Big-bluestem; 22% Little-bluestem; 13% Side-oats gramma; etc.

3) Determine the number of seeds per ft^2 for each species.

Multiply the total number of seeds desired in a square foot (40) by the decimal percentage of the desired quantity ratio for each species.

Big-bluestem:
40 (total seeds/ft^2) x 0.15 = 6 seeds/ft^2.

Little-bluestem:
40 x 0.225 = 9 seeds/ft^2.

Side-oats gramma:
40 x 0.13 = 5 seeds/ft^2.

4) Determine seeding rate in unit weight per acre for each species.

Calculate the total number of pounds or ounches per acre of each species in the seeding mix by dividing the desired number of seeds per square foot for each species (step 3) by the number of seeds per square foot obtained when planted at the

unit weight per acre (step 1). This ratio will yield the total amount (weight) of seed to be planted of that species in the mix.

Big-bluestem: 6/4 = 1.5 lbs/acre.
Little-bluestem: 9/6 = 1.5 lbs/acre.
Side-oats gramma: 5/5 = 1.0 lbs/acre.

Association of Official Seed Analysts. 1981. Rules for testing seeds. Journal of Seed Technology 6(2):1-125.

National Wildflower Research Center. 1989. Wildflower handbook. Texas Monthly Press, Austin, pp. 337.

Table 1. Example of roadside seeding mix sowing 60 seeds/ft^2

Grasses	#/acre	Seeds/#	Seeds/ft^2
Big bluestem	1.5	165,000	6
Little bluestem	1.5	260,000	9
Side oats grama	1.0	200,000	5
Indiangrass	1.5	175,000	6
Western wheatgrass	0.5	160,000	2
Switchgrass	0.5	390,000	5
Canada wild rye	0.25	115,000	1
Sand dropseed	1.5	174,000	6
Total grasses	8.25		40
Forbs	Ozs/acre	seeds/oz	seeds/sq. ft.
Black eyed susan	6.00	61,250	8
New England aster	1.00	76,000	2
Prairie blazingstar	16.00	11,000	4
Purple coneflower	20.00	5,300	2
Purple prairie clover	8.00	18,300	4
Total forbs	51.00		20

Table 3. Contrasting Iowa DNR seed mix rates for wildlife areas and erosion areas.

	Wildlife Use		Erosion Area		
Grass Species	lbs/acre	seeds/ft^2	lbs/acre	seeds/ft^2	Seeds/lb
Big bluestem	2.0	8	2.0	8	165,000
Indian grass	1.5	6	2.0	8	175,000
Switchgrass	0.5	5	1.0	9	390,000
Little bluestem	1.0	6	1.0	6	260,000
Sideoats grama	1.0	5	2.0	9	200,000
Sand lovegrass	0.25	7	1.0	26	1,134,000
Totals	6.75	42	9.0	66	

MATRIX SPECIES

Many restoration ecologists have recognized that plant communities are established in successional stages. Some species are adapted to be colonizers while others, which may be more difficult to establish from seed, are more competitive over time. Often there are "sets" of species which succeed one another in sequential periods of time. The more aggressive species with wider ecological tolerances enter first and prepare the way for the other species with narrower tolerances (Betz 1986). Many species are not able to survive in large numbers when sown directly onto plowed and disked soil. Others are not able to withstand the initial stage characterized by intense weedy competition, despite the fact that often large amounts of seeds are often sown. Native species which are easily established from seed and can survive weedy competition are the most desireable for erosion control. Later, more difficult species can be introduced to improve the plant community.

Robert Betz (1986) coined the term "matrix" to describe the first assemblage of species in prairie succession, but CRAO has expanded the definition of matrix to be any set of species which become established together during a particular stage. Species are classified into a matrix according to the ease by which they are established. Therefore, the higher the matrix order, the more difficult it is to establish those species in abundance. The matrices used by CRAO are: Temporary Matrix, comprised of annuals and short-lived perennials, often called cover or nurse crops; Matrix I, native species easily established by seed (many of which are developed as cultivars); and Matrix II, those species which have narrow ecological niches or are difficult to establish from seed.

TEMPORARY MATRIX SPECIES

ANNUALS

GRASSES		
Avena sativa	Oats	
Avena byzantina	Red oats	
Echinochloa crusgalli	Japanese millet	
Secale cereale	Rye	(Allelopathic)
Sorghum bicolor	Broomcorn, Sorghum, cvs.	
Sorghum sudanense	Sudan grass	
Triticum aestivum	Wheat (differing cvs characteristics)	
LEGUMES		
Vicia villosa	Winter and Hairy vetch	
Trifolium hybridum	Alsike clover	
Lotus corniculatus	Birdsfoot-trefoil	
Cassia fasiculata	Partridge pea	

SHORT-LIVED PERENNIALS -- (under prairie management)

GRASSES		
Phleum pretense	Timothy grass	
Elymus canadensis	Canada wild-rye	
Dactylis glomerata	Orchard grass	
Bouteloua curtipendula	Side-oats grama	
Sporobolus asper	Rough or Northern dropseed	
Sporobolus cryptandrus	Sand dropseed	
Lolium perenne	Perennial rye	
Rudbeckia hirta	Black-eyed susan	
Trifolium repens	White clover	(aggresive non-native)

MATRIX I

GRASSES	
Andropogon geraldii	Big bluestem
Bouteloua curtipendula	Side-oats grama
Carex molesta	
Carex brevior	
Carex scoparia	(wet soils)
Carex bicknellii	Bicknell's sedge
Eragrostis trichodes	Sand lovegrass
Panicum virgatum	Switch grass
Schizachyrium scoparium	Little bluestem
Sorghastrum nutans	Indian grass
Spartina pectinata	Prairie cordgrass (transplants are best)
Sporobolus cryptandrus	Sand dropseed
Sporobolus asper	Rough or Northern dropseed
FORBS	
Anemone cancadensis	Canada anemone
Anemone cylindrica	Wind flower
Asclepias tuberosa	Butterfly plant
Coreopsis palmata	Prairie coreopsis
Echinacea pallida	Pale-purple coneflower
Eryngium yuccifolium	Rattlesnake master
Euthamia graminifolia	Grass-leaved goldenrod
Monarda fistulosa	Horsemint
Parthenium integrifolium	Wild quinine
Ratibida pinnata	Yellow coneflower
Rudbeckia laciniata	Green-headed coneflower (wet soils)
Silphium laciniatum	Compass plant
Silphium perfoliatum	Cup plant (rank aggressive in wet areas)
Silphium integrifolium	Rosin weed
Solidago rigida	Prairie goldenrod
Solidago nemoralis	Gray goldenrod
Verbena hasta	Blue vervain
LEGUMES	
Astragalus canadensis	Canada milkvetch (poisons livestock)
Babtisia leucantha	White wild indigo
Cassia fasciculata	Partidge pea
Dalea pupureum	Purple prairie clover
Dalea candidum	White prairie clover
Desmodium illinoense	Illinois tick trefoil
Desmodium canadense	Showy tick trefoil
Fragaria viginiana	Wild strawberry
Helianthus laetiflorus	Showy sunflower
Helianthus grossesrratus	Big-toothed sunflower (tall aggressive)
Heliopsis helianthoides	Ox-eye sunflower
Lespedeza capitata	Round-headed bush clover
Rosa suffalta	Prairie rose
Zizia aurea	Golden alexanders

MATRIX II

GRASSES

Sporobolus heterolepis	Prairie dropseed
Stipa viridula	Green needle grass
Stipa spartea	Porcupine grass

FORBS

Aster ericoides	Heath aster
Aster laevis	Smooth blue aster
Aster azureus	Sky-blue aster
Dodecatheon meadia	Shooting star
Galium boreale	Northern bedstraw
Liatris aspera	Rough blazing star
Liatrus pycnostachya	Prairie blazing star
Lobelia spicata	Spiked lobelia
Phlox pilosa	Prairie phlox
Potentilla arguta	Prairie cinquefoil
Pycnanthemum virginianum	Mountain mint
Thalictrum dasycarpum	Purple meadow rue

LEGUMES

Amorpha canescens	Lead plant
Baptisa leucophaea	Cream wild indigo

Betz, R. 1986. One decade of research in prairie restoration at the Fermi nation al acceleratior laboratory (Fermilab) Batavia, Illinois. In: G. K. Clambey, R. H. Rambley, eds. The prairie: past, present and future-proceedings of the Ninth North American Prairie Conference, pp 179-185.

CHAPTER FIVE

TRANSPLANTS

By Carole Kern

Transplants

The Site

The first step in planting an area to native vegetation is understanding the attributes of the planting site. Aspect and angle of slope will effect the plants and planting method selected. South facing slopes receive longer periods of direct sun, therefor are normally drier than north facing slopes. West facing slopes are subject to prevailing winds which can dry out new plantings. If the slope is steep it is in greater danger of erosion, especially in areas subject to high velocity water during certain times of the year.

Another attribute of the planting site which will play an important role in plant selection is soil type. Sandy soils have a gritty texture and will drain more readily than clay soils which tend to feel sticky and flour-like. Loams contain some grit as well as the flour-like feel of silt present in clay soils. Loam and clay soils retain moisture and nutrients better than sandy soils, but they also drain less readily.

The combination of drainage ability of the soil and slope of the site will to a great extent determine what plants will be able to survive there. Dry species are found in areas with high loess or sand content, places where the slopes are steep and may have areas of fractured rock. Mesic species tend to be found in areas with rolling topography or midway up steeper slopes. They often occur in soils high in organic matter. Where drainage is poor such as ditch bottom, potholes, fens, and river lowland areas, wet species are found.

Once you have developed a feel for the site's attributes you can consider your planting options. If the slope is not too great and access is good, you may wish to consider seeding (see chapter on seeding). However, when there is a need for rapid

establishment transplanting may be your answer. In some cases a combination of seeding and transplanting can be used to give good forb establishment in areas newly seeded to native grasses.

Choices

Transplanting is a labor intensive method of establishing native vegetation, but it may be the best solution in certain situations. By using transplants the critical stages of germination and early seedling establishment occur in a controlled environment. This is important with hard-to-come-by forb species, expensive seed, and seed which requires special treatment. The use of transplants also offers fast establishment where quick cover is needed in highly erodible areas as well as quick show in highly visible areas. Transplants can also be used to introduce species into already established plantings.

Once you've decided that transplanting is an option, you need to decide whether to purchase plants or to grow your own. This decision may depend upon whether you have access to the necessary facilities or whether the plants you desire are available for purchase at reasonable prices. If you have access to labor and greenhouse facilities growing your own transplants will give you better control on the size of the plants as well as giving you the option of collecting seeds from nearby areas. If you do not have the necessary facilities or labor, there are a number of sources which carry native plants (see native plant and seed source list).

When purchasing plants ask where their stock originated as you'll want to get as close to local genotype as possible. Also ask about the age and size of the material they will be sending and their method of growing. You'll want to get plants with healthy root systems that will be able to withstand the shock of being

transplanted. Arrangements should be made to insure delivery of plants early enough for them to be hardened off properly before planting.

Growing Prairie for Transplant

Seeds for growing your own plants may be collected from local sources or purchased (see native plants and seed source list). When purchasing seed from a seed producer or nursery operation, ask for the source of the seed, whether it has been pretreated in any manner, what its germination rate is and if it is being sold by pure live seed weights. Make sure the seed they send has little or no non-seed material in it.

Collecting seed can be very labor intensive. Volunteer help can often be obtained by involving local garden clubs, school programs or local environmental groups (such as the Sierra Club or the Iowa Prairie Network). Combines and hand held harvesters can be used in some cases to speed up harvest and decrease labor requirements. Mechanical collection will not allow species selection or assure only ripe seed is harvested, however in large projects this may be the best solution. Though not specifically for prairie, the USDA manual "Collecting, processing, and germinating seeds of western wildland plants" is a good source of information on seed collection and handling.

When collecting seed, get permission from the land owner, never collect on a preserve, and be sure to take no more than one third of the seed of any species at each collection site. This will insure that there are sufficient seed left to sustain the population. If there are only a small number of plants present at the site, it may be best not to collect any seed until the population has had a chance to increase.

Before collecting make sure the seed is fully ripened. Ripe seed will be hard and look dark and plump. The seed should be easy to remove from the plant. The

stem feeding the seed head should be brown and pods or capsules may be starting to open. In a handout produced by the International Crane Foundation, Wayne Pauley notes that it often takes about a month after flowering for seed to be ripe.

After collecting, allow the seed to dry completely, then store them in labeled paper or burlap bags hung in a cool, dry location. Good air circulation, low relative humidity (about 50%) and cool temperatures (near 50^{o}F) are necessary to preserve seed viability. Long storage periods will decrease viability. Some species will need special treatment to insure germination. In most cases the necessary treatment is cold stratification. Germination requirements can be found in many prairie seed catalogs. Sullivan and Daley's book "Resources on Wildflower Propagation is also a good source for germination specifications. The included species list notes some species which require special treatment to insure germination.

To stratify seed, mix the seed with an equal amount of damp sand and place them in a labeled, sealed plastic bag. Store this at 33^{o} to 38^{o} F for about two months. It is important to check the seed occasionally in case it begins sprouting. (Seed which has begun to sprout will need to be planted immediately.) Another method of stratifying seed is to overwinter the seed where it will be subjected to natural winter temperatures yet will be in a dry place secure from pests.

Pauline Drobney (1992) recommends starting plants in March for planting in late May or early June. Most prairie germinates at a soil temperature of 70^{o}F. Plants can be grown in a greenhouse at 50^{o} to 60^{o}F. This temperature range will allow the plants to grow strong and rapidly. Plants may also be grown in a coldframe, however they tend to grow slower.

There are a number of container systems that have been used for growing seedling in greenhouses. Burkhart (1987) has tested Leach Tubes, D-pots, paperpots and pulp pots. He recommends choosing containers at least two inches in diameter and six to eight inches deep. Conetainers (see list of transplant supplies)

have been used successfully at the University of Northern Iowa greenhouse (Drobney, 1992). The Leach Tube conetainers are one inch diameter plastic tubes which fit into a preformed rack. The tubes vary in depth from six to eight inches, though the deeper tube is preferred for prairie propagation. These tubes can be purchased new or used from the company and are reusable.

The soil mix should be porous to allow proper drainage and make removing the seedling from the container less difficult. The University of Northern Iowa greenhouse uses a mixture of 1/3 sterilized sandy loam, 1/3 peat and 1/3 perlite (or a little less than 1/3 perlite). This mixture can also be varied slightly for special plant requirements.

Watering the seedlings a few hours before planting will make the seedlings easier to remove from the conetainers and lessen the shock of transplanting. To remove the plant turn the tube upside down and hold the plant in place by laying a finger across the top of the conetainer, then give the top a sharp rap. This will remove the seedling easily from the conetainer without damaging the root system.

Transplants can also be grown in an outdoor nursery plot if a greenhouse is unavailable. Dave Wendling has had success germinating and growing prairie and other plants to transplantable size by planting seed in a sand bed. His nursery bed was constructed of a border of cement blocks filled with six to seven inches of porous sand. The bed was kept moist by misting nozzles set two foot apart and connected with 1/8 inch microtubes to a 1/2 inch main line. The system was placed on a timer which watered the seedbed one minute out of every ten. During hot summer days he found hog panels covered with shade cloth sufficient to protect the young plants.

Proper care of germinating seed and young plants will insure healthy root systems which are essential for the success of your prairie planting.

Salvaging Prairie Plants

A third option would be to obtain plants from an established prairie. This method is strongly discouraged unless the original site is going to be destroyed. S. Kelly Kearns (1986) found transplanting from an existing prairie could be done at any time of the year with good survival rates if weather conditions were favorable, ie. cool temperatures, high humidity, and overcast sky. Survival rates are increased by getting the majority of the root system and avoiding exposure of the roots to air. Quick transfer to the new planting site or a situation where the plants can be watered and placed out of direct sun also increases survival rates.

If there is sufficient time, species with thick roots should be root-pruned a few months before their removal. This will allow species which are normally difficult to transplant, such as *Lithospermun*, to develop a more compact root mass (Kearns, 1984).

Plants to be salvaged can be taken as individual plugs or as sod sections. Christiansen and Landers (1969) used a sod cutter attached to a post hole digger to successfully transplant 25 cm diameter plugs of prairie species into a cultivated plot. The already established plants in the plugs were able to dominate weedy species starting from seed. The plugs were less successful when placed in established areas of *Bromus inermis*. They recommended cutting sod strips with a tractor mounted blade held several inches below ground level for large scale salvage. These sod strips could then be transplanted into cultivated ground or an area recently seeded to prairie grasses.

Planting

Whether your plants were purchased, salvaged, or grown on your own, it is essential to follow proper planting techniques. Train your planting crew and try to have someone with prior experience at the site to supervise. Burkhart notes that at least 50% of the plants lost in the field are due to improper planting.

It is important to dig the holes deep enough so the roots of the plant will not be curled when placed in the hole. If the crown (where the stem meets the roots) is at ground level when the plant is placed in the hole, the hole is the proper depth. The hole should be wide enough so the root mass slides in with room to spare on all sides. If standardized containers were used to grow the plants a hole punch can be made similar to that used for planting bulbs. The punch can be attached to a handle like a shovel to save hours of back-breaking labor.

The roots need to be kept moist at all times, so try to avoid exposing them to air any longer than necessary. Carefully pack soil in around the roots as you refill the hole. The area transplanted should be watered as soon as you are through planting to remove air pockets, settle the soil and help the plants recover from the shock of transplanting. If you must plant them during hot days, it is best to plant in sections, watering each completed section before moving on to plant the next.

In areas with steep slopes mulches can be applied around new plantings to prevent erosion, hold moisture and reduce competition from weeds (see chapter on Surface coverings and mulches). Instead of mulch, you may wish to use a native grass for a cover crop. Pauline Drobney recommends Canada wild rye *Elymus canadensis*. Its roots have an excellent capacity for holding soil and it will germinate in two to five days. In sandy areas Pauline recommends sand love grass as a cover crop. Annual forbs, such as partridge pea *Cassia fasiculata*, can also be added to the cover crop.

Spring, late May or early June is the best time for starting a new planting. However, transplanting can be done at any time of the year successfully if the newly planted site can be watered as needed until the plants root systems are established.

During very dry years it is best to water the site to be planted two days before plants are set out. Water again after the plants are in place once a week for two to three weeks. Check plantings occasionally to see if an additional watering is needed.

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Aggressive Native Forbs		W-M-D
Allium canadense	Wild Garlic	-XXX-
Allium cernuum	Nodding Onion	-XXX- *
Anemone canadensis	Canada Anemone	-XX--
Angelica atropurpurea	Angelica	-X--- *
Antennaria neglecta	Pussytoes	---XX
Asclepias verticillata	Whorled Milkweed	--XXX
Aster ericoides	Heath Aster	-XXXX
Aster novae-angliae	New England Aster	XXX-- *
Aster oblongifolius	Aromatic Aster	---XX
Cacalia atriplicifolia	Pale Indian Plantain	--XX- *
Cassia fasciculata	Partridge Pea	---XX
Coreopsis lanceolata	Sand Coreopsis	---XX
Coreopsis palmata	Prairie Coreopsis	-XXXX *
Coreopsis tripteris	Tall Coreopsis	-XXX-
Desmodium canadensis	Showy Tick Trefoil	-XXX- *
Desmodium illinoensis	Illinois Tick Trefoil	--XXX * +
Eupatorium altissimum	Tall Boneset	---X- * +
Eupatorium maculatum	Joe Pye Weed	XX---
Euphorbia corollata	Flowering Spurge	-XXXX *
Euthamia graminifolia	Grass-leaved Goldenrod	-XXXX
Fragaria virginiana	Wild Strawberry	-XXXX
Galium boreale	Northern Bedstraw	XXXX-
Glycyrrhiza lepidota	Wild Licorice	-XXXX
Helenium autumnale	Sneezeweed	XX---
Helianthus laetiflorus	Showy Sunflower	---XX
Helianthus mollis	Downy Sunflower	--XX-
Helianthus occidentalis	Western Sunflower	--XXX
Helianthus rigidus	Stiff Sunflower	-XXXX *
Heliopsis helianthoides	Early Sunflower	-XXX- *
Kuhnia eupatorioides	False Boseset	---XX
Lythyrus venosus	Showy Wild Pea	--XX- * +
Lespedeza capitata	Round-headed Bush Clover	--XXX * +
Monarda fistulosa	Wild Bergamot	-XXXX
Monarda punctata	Spotted Bee Balm	---XX
Oenothera biennis	Evening Primrose	-XXXX
Pycnanthemum tenuifolium	Slender Mountain Mint	--XX-
Ratibida pinnata	Yellow Coneflower	-XXX- *
Rudbeckia hirta	Black-eyed Susan	-XXXX *
Rudbeckia laciniata	Green-headed Coneflower	-XX-- *
Rudbeckia subtomentosa	Sweet Black-eyed Susan	-XXX- *
Silphium perfoliatum	Cup Plant	-XX-- *
Solidago nemoralis	Old Field Goldenrod	---XX *
Solidago speciosa	Showy Goldenrod	--XXX *
Thalictrum dasycarpum	Purple Meadow Rue	-XX-- *
Verbena hastata	Blue Vervain	-XX-- *
Verbena stricta	Hoary Vervain	---XX
Vernonia fasciculata	Ironweed	-XX--

*Require cold stratification or over-wintering on site before germination.

+Require scarification

w = wet m = mesic d = dry

Agressive Native Grasses

		W-M-D
Andropogon gerardi	Big Bluestem	-XXXX
Bouteloua curtipendula	Side-oats Grama	---XX
Calamagrostis canadensis	Blue Joint Grass	XXX--
Carex brevoir	Hammer's Sedge	-XXX-
Panicum virgatum	Switch Grass	-XXXX
Scirpus atrovirens	Dark-green Bulrush	XX---
Sorghastrum nutans	Indian Grass	--XXX
Sporobolus asper	Rough Dropseed	---XX

w = wet m = mesic d = dry

Plants Which May Be Seeded Directly

		W-M-D
Dalea candida	White Prairie Clover	-XXXX *+
Dalea purpureum	Purple Prairie Clover	--XXX *+
Echinacea pallida	Pale Purple Coneflower	-XXXX *
Eryngium yuccifoolium	Rattlesnake Master	-XXX- *
Prenanthes aspera	Rough White Lettuce	-XXXX *
Prenanthes racemosa	Smooth White Lettuce	-XXXX *
Pycnanthemum virginianum	Mountain Mint	XXX-- *
Rosa carolina	Prairie Rose	-XXX- *
Ruellia humilis	Wild Petunia	---XX *
Silphium integrifolium	Rosinweed	-XXX- *
Silphium laciniatum	Compas plant	-XXX- *
Silphium terebinthinaceum	Prairie Dock	--XXX *
Solidago riddellii	Ridell's Goldenrod	XXX-- *
Solidago rigida	Stiff Goldenrod	--XXX *
Solidago speciosa	Showy Goldenrod	--XXX *

*Require cold stratification or over-wintering on site before germination.
+Require scarification
w = wet m = mesic d = dry

Native Forbs Best Established By Transplants

		W-M-D
Agoseris cuspidata	Prairie Dandelion	----X *
Allium stellatum	Prairie Onion	-XXX- *
Amorpha canescens	Lead Plant	-XXXX * +
Anemone cylindrica	Prairie Anemone	--XXX *
Anemone patens	Pasque Flower	---XX *
Asclepias amplexicaulis	Sand Milkweed	----X *
Asclepias hirtella	Tall Green Milkweed	-XXX- *
Asclepias tuberosa	Butterfly Milkweed	-XXXX *
Asclepias viridiflora	Short Green Milkweed	-XXXX *
Aster azureus	Sky-blue Aster	-XXXX *
Aster laevis	Smooth Blue Aster	-XXXX *
Aster sericeus	Silky Aster	----X *
Baptisia leucantha	White False Indigo	-XXX- +
Baptisia leucophaea	Creamy False Indigo	-XXXX +
Callirhoe triangulata	Clustered Poppy Mallow	----X *
Ceonothus americanus	New Jersey Tea	-XXX- !
Dodecatheon meadia	Shooting Star	--XXX *
Gentiana andrewsii	Bottle Gentian	-XXX- *
Gentiana flavida	Yellow Gentian	-XXX- *
Gentiana puberula	Prairie Gentian	-XXX- *
Geum triflorum	Prairie Smoke	-XXXX *
Heuchera richardsonii	Alum Root	-XXX- *
Hypoxis hirsuta	Yellow Star Grass	-XXXX *
Krigia biflora	False dandelion	-XXX- *
Liatris aspera	Rough Blazingstar	--XXX *
Liatris cylindracea	Cylindrical Blazingstar	---XX *
Liatris pycnostachya	Prairie Blazingstar	-XX-- *
Lobelia spicata	Pale Spiked Lobelia	-XXXX *
Parthenium integrifolium	Wild Quinine	-XXX- *
Phlox pilosa	Prairie Phlox	-XXXX *
Physostegia virginiana	False Dragonhead	-XXX- *
Polygala senega	Senega Snakeroot	--XXX *
Potentilla arguta	Prairie Cinquefoil	--XXX *
Psoralea renuiflora	Scurfy Pea	----X +
Sisyrinchium albidum	Blue-eyed Grass	--XXX *
Veronicastrum virginicum	Culver's Root	-XXX- *
Viola pedata	Birdsfoot Violet	---XX..*
Viola pedatifida	Prairie Violet	-XXX-..*
Zizia aptera	Heart-leaved Parsnip	-XXX- *
Zizia aurea	Golden Alexander	XXX-- *

*Require stratification
+Require scarification
!Boil seeds in water for 2 minutes
w = wet m = mesic d = dry

Tables compiled from: Schramm, 1976; Prairie Moon, 1990;

Iowa

Allendan Seed Company
R.R. 2, Box 31
Winterset, Iowa 50273
(515) 462-1241
Dan Allen, Owner

Franklin Grassland Seed Company
R.R. 2, Box 132
Hampton, Iowa 50441
(515) 456-2988
Dennis Strother, Owner

Hadfield Prairie Seed
R.R. 1, Box 132
McClelland, Iowa 51548
(712) 484-3326
Allan Hadfield, Owner

Heyne Seed Company
R.R. 1, Box 78
Walnut, Iowa 51577
(712) 784-3454
(712) 784-2230
Bruce Heyne, Owner

Holmes Company
Box 182
Madrid, Iowa 50156
(515) 795-3366

Ion Exchange
R.R. 1, Box 48C
Harpers Ferry, Iowa 52146
(319) 535-7231
Howard and Donna Bright, Owners

Iowa Prairie Seed Company
R.R. 1, Box 259
Cresco, Iowa 52136
(319) 547-3824
Daryl Kothenbeutel, Owner

Mark Seed Co.
Box 67
Perry, Iowa 50220
1-800-383-6375

McGinnis Tree and Seed Company
309 East Florence
Glenwood, Iowa 51534
Keith McGinnis, Owner

Nature's Way
R.R. 1, Box 62
Woodburn, Iowa 50275
(515) 342- 6246
Dorothy Baringer, Owner

Naylor Seed Company
Box 16
Scotch Grove, Iowa 52331
1-800-747-SEED
Jerry Naylor, Owner

Olympic Seed Co., Inc.
Box 752, Hwy S. 248
Independence, Iowa 50644
(319) 334-7373

Osenbaugh Grass Seeds
R.R. 1, Box 76
Lucas, Iowa 50151
(515) 766-6476
(515) 766-6792
John Osenbaugh, Owner

Quest Development Corp.
P.O. Box 1015
Centerville, Iowa 52544
(515) 437-7212
Rick Ahee, Director

Shivver's Seed Farm
614 W. English
Corydon, Iowa 50060
Doug Shivvers, Owner

Stoner Seed Farms
R.R. 1, Box 48
South English, Iowa 52335
1-800-383-2089

Strayer Seed Farms, Inc.
162 West Hwy 58
Hudson, Iowa 50643
1-800-772-2958
Jim Strayer

Van Gundy Seed Farm
6650 SE 6th Ave
Des Moines, Iowa 50317
(515) 266-6739
Richard Van Gundy, Owner

Illinois

Genesis Nursery
R.R. 1, Box 32
Walnut, IL 61378
(815) 379-9060
(815) 894-3329
Kathy M. Motto, Snr. Partner

LaFayette Home Nursery, Inc.
R.R. 1, Box 1A
LaFayette, IL 61449
(309) 995-3311
FAX 309-995-3909
Ingels Bros., Owners

Minnesota

Johnson Prairie Seed Company
R.R. 1
Windom, MN 56101
Judy Johnson, Owner

Mohn Seed Co.
R.R. 1, Box 152
Cottonwood, MN 56229
(507)423-6482
Robert, Mohn, Owner

Prairie Moon Nursery
R.R. 3, Box 163
Winona, MN 55987
(507) 452-1362
Alan Wade, Owner

Prairie Restorations, Inc.
R.R. 3
Princeton, MN 55371

Missouri

Blue Stem Seed Company
R.R. 3, Box 32
Grant City, MO 64456
1-800-BLU-STEM
Dave Kean, Owner

Sharp Bros. Seed Co.
P.O. Box 665
Clinton, MO 66735

Nebraska

P.E. Allen Farm Supply
R.R. 2, Box 8
Bristow, NE 68719-9407
(402) 583-9924

Stock Seed Farm, Inc.
R.R. 1, Box 112
Murdock, NE 68407
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Lyle and David Stock, Owners

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Little Valley Farm
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Neil Diboll

Prairie Ridge Nursery
R.R. 2, 9738 Overland Road
Mt. Horeb, WI 53572-2832
(608) 437-5245
Joyce Powers, Consultant

Wildlife Nurseries
Box 2724
Oshkosh, WI 54903

Transplant Supplies

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Stueive and Sons, Inc.
2290 SE Kiger Island Dr.
Corvallis, OR 97333
1-800-553-5331

CHAPTER SIX

EVALUATING ESTABLISHMENT SUCCESS

By Scott Zager

EVALUATING VEGETATION ESTABLISHMENT SUCCESS

The County Roadside Assistance Office is attempting to establish a uniform method for evaluating vegetation establishment success. This will enable CRAO to monitor statewide activities and document successful procedures. It will also provide roadside managers with criteria for determining whether or not roadside plantings were successful. Currently, the CRAO recommended seeding rate for permanent matrix species is 60 seeds per square foot using range drills or 80 seeds per square foot using broadcast and hydraulic seeders. This may be supplemented with temporary matrix species at the rate of 20-40 seeds per square foot. These rates are contingent upon planting during the proper season in conjunction with proper methods of erosion control including mulch and filter barriers. While these rates are within SCS guidelines for critical area plantings of native grasses, they may not be optimal rates for roadsides where vegetation needs to be established in one or two years. Therefore, CRAO is promoting routine evaluation of seedling establishment during the first growing season and/or percent cover evaluation following the third growing season.

Since the primary objective of roadside vegetation is to secure the soil, it is imperative that an adequate number of plants are established within a given area. Evaluation methods are therefore asking how abundant is the extant vegetation and is this cover adequate to accomplish the job. In the past, evaluating vegetation abundance was determined subjectively by an experienced individual and often no permanent record of the observations were made. However, knowledge is often lost when that individual leaves the organization. Objective methods quantify vegetation within sample plots in an attempt to characterize the vegetation stand with minimal effort. While objective methods are more labor intensive, they have the advantage of becoming a permanent record which can be interpreted by others.

CRAO is proposing two objective methods for evaluating abundance of herbaceous vegetation: plant density and cover abundance. Plant density is determined by counting the number of plants within a specified area or plot. Cover abundance is concerned with the area dominated by desired vegetation and is only relevant in terms of percent coverage of the total area within the sampled plot. In order to accurately "represent" the vegetation stand as a whole without personal bias, it is important that an adequate number of plot samples are taken in a random manner. The number of samples depends upon the uniformity of the stand and the number of species to be counted.

It is important that the sampled vegetation stand is uniform throughout or homogeneous. Stands on different soil types or hydrologic conditions (hydric, mesic or xeric) should also be sampled separately without combining results. Foreslopes, ditch bottoms and backslopes should be recorded separately so problem areas can be identified within the roadside. Also, roadside segments with different management levels and vegetation cover types should be evaluated separately (native grasses vs bluegrass or burned vs non burned). The observer must not be biased by dense or sparse stands, but needs to sample each in a systematic manner.

Stands can be evaluated anytime during the growing season but late fall works best for most species. The ability to identify species by vegetative characteristics is necessary to ensure accuracy. References describing vegetative characteristics of the species to be sampled can be obtained from CRAO. Young seedlings can be identified by seeds that are still attached to the roots if the site is sampled soon after emergence.

SEEDLING DENSITY PLOTS

An accurate assessment of forb and grass seeding success can be obtained in a short period of time by sampling a series of plots laid down over a vegetation stand in a prescribed manner. Estimates of seedling density are obtained for the stand by counting the number of desired plants

rooted within sample plots and averaging the results. The plots are usually sampled along a transect. This frame counting technique has been adapted from the SCS "Guidelines for Herbaceous Stand Evaluation" which sets criteria for adequate seedling density according to species planted.

Sample plots are taken using a circular or square shaped frame which encloses exactly one-square-foot in area. The number of seedlings counted per frame indicates whether a stand is adequate, or inadequate according to SCS density values. If the actual count is between those listed as adequate or inadequate; the stand is classified as "questionable" and will need to reevaluated. Only seedlings which are rooted within the frame will be counted and used in determining stand adequacy. A one square foot frame is easily constructed with a variety of materials. Sampling error increases as the ratio of border to area increase (the smaller the sampling area, the greater is the border error), therefore a circular frame will present the least edge to area ratio. A circular one-square-foot frame will have an approximate circumference of 42.5 inches. It can be constructed from 3/16 inch plastic covered cable. The ends can be joined with a short section (1 inch) of 1/4 inch outside diameter copper tubing.

In order to evaluate roadside vegetation, plot samples should be taken on both sides of the road along transects traversing the right-of-way, perpendicular to the traveledway. Ideally, the transect should be perpendicular or diagonal to the rows of planted seed. There should be at least one transect every half mile along the traveledway using the front bumper of the parked vehicle as a reference point. In order to maintain a straight transect, locate a distant landmark along the direction of the transect and orient toward it while sampling. The exact location of the plots along the transects should be predetermined by the roadside manager and sampled consistently throughout that segment. Suggested plot locations include: shoulder edge (foreslope crest or top), mid-foreslope, foreslope base (above ditch), ditch bottom, backslope base, mid-backslope, and backslope crest. Not all of these locations may need to be sampled depending on the physical conditions of the roadside. In order to minimize sampling bias, a predetermined number of steps should be taken along the transect and the frame placed at the toe of your shoe on the final step.

The roadside manager can determine what data is to be recorded from the sample depending upon his objectives and the amount of time available for study and analysis. If the objective is to determine stand adequacy with minimal effort, then the manager should choose to record the total seedling count of all planted species into one lumped sum for each plot. The manager could then average all the plots to determine total stand adequacy or he could average foreslopes, ditch bottoms and backslopes separately and isolate problem areas. If the manager desires to determine establishment success for each species planted and/or weed abundance, he may choose to record separately the seedling count of each species present within the plot.

A form is provided to record plot data for seedling density. This form can be used to record total density for seven plot locations along transects (See example Form A). However, sample plots from each side of the road and median should be recorded on separate forms so that problem areas can be delineated and recognized more easily. Transect locations can be recorded using IaDOT's eight digit numbering system. The form can also be adapted to record each species separately for plot sampled along one transect of a particular location (example Form B).

Total seedling density counts can be averaged for all plots sampled along a transect and recorded in the last column along the right hand side of the form. These means can then be averaged to produce an overall mean for the stand -- recorded in the lower right hand corner. In addition, plot locations can be averaged and the means recorded at the base of the column. This will show establishment success along foreslopes, ditch bottoms, etc. These averages are then compared to

Table: "SCS Seedling Density Criteria for Stand Adequacy". Those evaluating roadside plantings should use the critical areas column for the appropriate species planted. Stand adequacy for a Big bluestem planting is greater than 4 seedlings per square foot. Stand inadequacy -- which indicates that reseeding is required -- is less than 1 seedling per square foot. Questionable stands are those with seedling densities that fall between adequate and not-adequate criteria and should be reevaluated after another growing season.

Different species have different density criteria for adequacy. Criteria for mixed stands should be determined by weighting each species in the mix by its proportion of the total seed planted. For example, a dry-mesic seed mix has 60% Little bluestem; 20% Indiangrass; and 20% Redtop grass, therefore the weighted average should be: (0.60 x 6) + (0.20 x 4) + (0.20 x 10) = 6.4 total seedling density. The number of forb seedlings should not exceed 50 percent of the total number of seedlings in an adequate stand.

EVALUATING COVER ABUNDANCE

Cover abundance, recorded in terms of percent cover, is an effective method of evaluating mature vegetation using square meter plots. Percent cover is measured according to the percentage of the soil surface area dominated by the vegetation. Universal Soil Loss Equation (USLE) defines cover as "canopy cover" which essentially is the surface area protected from falling rain by the vegetation. This could be living plants, duff or crop residues. Canopy cover dissipates the energy of falling rain, however it does not ensure protection from surface runoff. For CRAO's purpose, cover will be defined as area surrounding the base of grass culms or forb stems -- otherwise known as basal area. Basal area gives a better indication of the amount of soil held in place by living plants and their fibrous roots. Basal area is easy to determine for bunch grasses because the culms are connected by tillers or short rootstocks (rhizomes) forming a dense clump which can be circumscribed with an imaginary circle. The area within the circle is the basal area for that clump. The total area of all the clumps is then compared to the total area of the plot to derive "percent cover". Determining basal area for rhizomatous or stoloniferous grasses is a little trickier because the roadside manager must "guess" whether the soil between culms is bound by roots or otherwise protected from eroding away. If this is so, then the area beneath a "combined" set of culms can be circumscribed similarly to bunch grasses. The soil area protected by the roots of single plant is termed a "rhizosphere", so therefore, this technique is essentially measuring the surface area of the estimated rhizoshere. The same is true for evaluating forbs.

Cover abundance within the sampled plots is not actually measured but is estimated. A roadside manager would place the plot on the ground and visually estimate the proportion of the plot covered by the vegetation. A square shaped one-meter-square plot works best because the area can be quartered and each quarter section can be quartered again into eighths, etc. This facilitates the imaginary combination of individual plants into groupings which cover 50%, 25%, 12.5% ... of the sampled plot (See illustration). One can be constructed using 1/2 inch PVC pipe. Total percent cover of a particular plot is recorded and averaged on the provided data sheet in a manner similar to seedling counts. CRAO is proposing that the minimum criteria for grass cover abundance should be 50% after the second growing season. This method for evaluating stands may be less reliable for determining the effectiveness of forb cover for erosion control because of the different rooting patterns of the different species. Plots are located in same manner described above.

A GENERALIZED PROCEDURE FOR EVALUATING ROADSIDE VEGETATION

Random sampling is useful for determining overall success of a seeding project, but it is still necessary to ensure that all areas within the right-of-way are protected by an adequate stand of vegetation. CRAO strongly encourages that all critical areas within the right-of-way be inspected

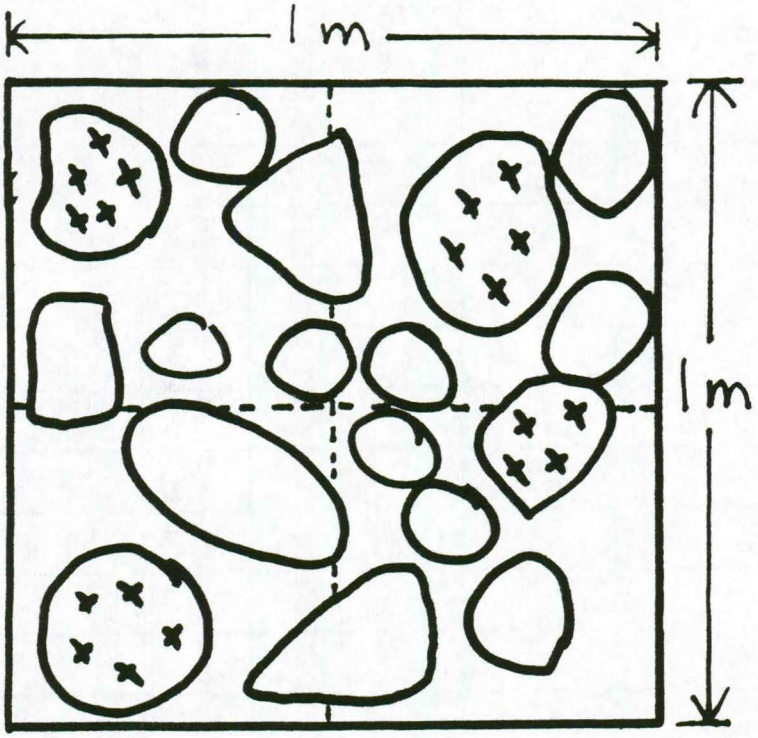
and evaluated according to the above criteria. Critical areas include those portions of the roadside which receive concentrated flow from the road surface: including bridges, inside curves, steep gradients and low elevations between hills or ridges. Managers should also check important structures such as culverts and field entryways. Roadside managers should delineate areas in the ROW planting which are obviously inadequate during a thorough survey of the planted area. Areas which need reseeding should be marked on a map. A list of critical areas and their location should be prepared during the design and establishment process so that they can be inspected following seeding in a systematic manner and checked off if the stand is adequate.

SCS SEEDING DENSITY CRITERIA FOR STAND ADEQUACY

	Seedlings needed per square foot					
	Critical areas		Forage		Idle land	
	A	N	A	N	A	N
Species						
Big bluestem, Indiangrass, Sideoats grama	>4.0	<1.0	>2.0	<0.5	>1.0	<0.25
Switchgrass	>4.0	<2.0	>2.0	<0.5	>1.0	<0.25
Little bluestem	>6.0	<1.5	>3.0	<0.75	>1.5	<0.38
Smooth bromegrass, Reed canarygrass	>4.0	<2.0	>2.0	<1.0	>1.0	<0.5
Tall fescue	>4.0	<2.0	>1.0	<1.0	>1.0	<0.5
Crownvetch, Ladino clover, Orchardgrass	>8.0	<4.0	>4.0	<2.0	>2.0	<1.0
Kentucky bluegrass, Redtop, Timothy	>10.0	<5.0	>5.0	<2.5	>2.5	<1.25
Alfalfa, Alsike clover, Birdsfoot trefoil, Red clover	>12.0	<6.0	>6.0	<3.0	>3.0	<1.5

>=greater than <=less than A=adequate N=not adequate

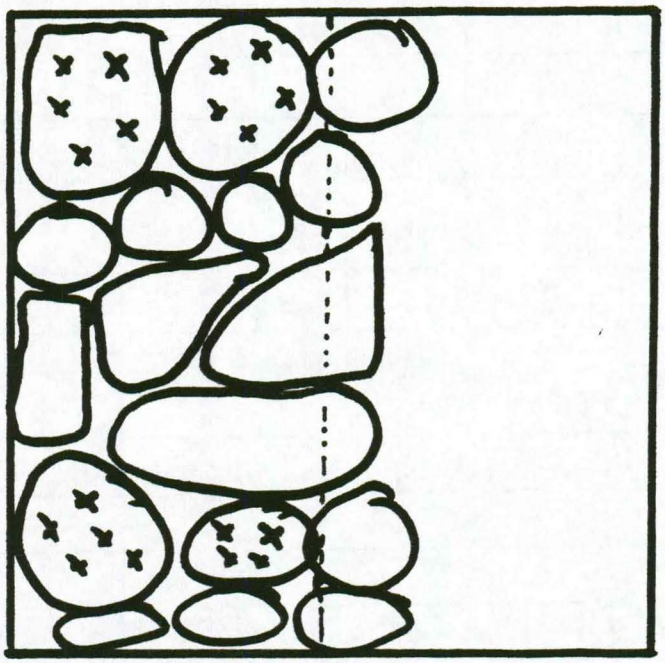
Illustration: Evaluating Cover Abundance (Percent Cover)



Bunch Grass

Forb

60% Cover



ROADSIDE SEEDLING DENSITY EVALUATION FORM (Plants/ft²)
record each roadside and median on separate forms

A

Roadside segment Beginning 1234-0101 Ending 1234-0165
(use IaDot Coordinate Numbering System)

Date evaluated 9-01-91 Date Planted 5-15-91 Reference Beaman Road East side

Number of transects Interval length

Transect: location or species	Plot location: Foreslope T	Foreslope M	Foreslope B	Ditch B	Backslope B	Backslope M	Backslope T	Total	Average
0109	3	2	3	2	3	2		15	2.5
0117	3	2	1	3	2	2		13	2.1
0125	2	2	2	3	3	2		14	2.3
0133	2	2	3	2	2	2		13	2.1
0141	2	2	2	1	1	1		9	1.5
0149	3	2	1	1	1	1		9	1.5
0157	3	2	1	0	0	1		7	1.1
0165	3	3	2	2	2	2		14	2.3
Location: Totals	21	17	15	14	14	13			
Average	2.6	2.1	1.9	1.75	1.75	1.6			

need to mow next year

Backslope plots not due to slope

Total this form 94 1.92*

* Acceptable ≥ 1.5 seedlings/foot
Non Acceptable < 1.5 seedlings/foot

Plant vigor: Drought stress evident

Weed competition: Mow immediately to prevent ragweed seed set.

Comments and Recommendations: Disk and cultipack ditch and backslope (0141-0165) — loss due to field runoff during big stormfuse straw bale filter barriers). Use drill and Mulch and reseed next May '92. Interseed and mow — NO mulch necessary except above.

ROADSIDE SEEDLING DENSITY EVALUATION FORM (Plants/ft²)
record each roadside and median on separate forms

B

Roadside segment Beginning 1234-0101 Ending 1234-0165
(use IaDot Coordinate Numbering System)

Date evaluated 9-01-92 Date Planted 5-01-92 Reference Beaman Road East Side

~~Number of transects~~ 8 ~~Interval length~~ ½ mile

Transect: 0109

~~location~~ or species	Foreslope T	Foreslope M	Foreslope B	Ditch B	Backslope B	Backslope M	Backslope T	Total	Average
Big Bluestem	2	1	3	4	2	0	0	12	1.7
Indiangrass	1	1	0	0	2	2	0	6	0.9
Side Oats	3	1	0	0	1	5	0	10	1.4
Western Wheat	0	2	3	3	5	1	3	17	2.4
Blackeyed Susan	1	1	0	0	0	2	3	7	1.0
P. Prairie Clover	0	0	2	0	0	1	1	4	.6
Butterfly Weed	0	0	0	0	0	0	0	0	0.0
Tick Trefoil	0	0	1	1	0	0	0	2	.3
									8.3
Green Foxtail	2	3	1	1		2	1		
Pigweed		1		2		2			
Ragweed			1	1	2	2	2		
Lambsquarter			1						
Total Weed	2	4	3	4	2	6	3		
Location: Totals	7	6	9	8	10	11	6	58	8.2
% FORB ~~Average~~ SEEDLING	14	16	33	12	0	27	6 (*)		

Total this form 58 8.3

Acceptable > 5
Non acceptable < 1.5

Plant vigor: Excellent

Weed competition: Backslope top = Forbs exceeds 50% - Continue

~~Comments~~: Monitoring for erosion problems

~~Comments and Recommendations~~: Mowing routine has kept weed vigor down. Should continue problems at base

second year

ROADSIDE SEEDLING DENSITY EVALUATION FORM (~~Plants/ft²~~) Cover Abundance
record each roadside and median on separate forms

C

Roadside segment Beginning 1234-0101 Ending 1234-0165
(use IaDot Coordinate Numbering System)

Date evaluated 9-01-93 Date Planted 5-15-91 Reference Beaman Rd East side

Number of transects Interval length

Transect: location or species	Plot location: Foreslope T	Foreslope M	Foreslope B	Ditch B	Backslope B	Backslope M	Backslope B		Total	Average
0109	45	50	60	75	50	60			340%	56.6%
0117	75	90	75	75	50	65			430	71.7
0125	60	75	50	45	55	75			360	60.0
0133	40	50	50	40	40	50		NOT NEEDED	270	45.0
0141	10	10	60	65	75	75			295	49.2
0149	55	50	45	55	60	60			325	54.2
0157	75	80	80	90	75	60			460	76.7
0165	75	60	65	50	55	75			380	63.3
Location: Totals	435	465	485	495	460	520				
Average	54.3	58.1	60.6	61.8	57.5	65			2,860	59.6

Adequate Stand Total this form _____ 59.6%

Plant vigor: Good -

Weed competition: Reduced Cover abundance of some areas — SPOT SPRAY and Reseed

Comments and Recommendations: Cover Abundance - OK
Follow up as stated above.

ROADSIDE SEEDLING DENSITY EVALUATION FORM (Plants/ft^2)
record each roadside and median on separate forms

Roadside segment Beginning Ending
(use IaDot Coordinate Numbering System)

Date evaluated Date Planted Reference
Number of transects Interval length

Transect: location or species	Plot location: Foreslope T	Foreslope M	Foreslope B	Ditch B	Backslope T	Backslope M	Backslope B	Total	Average
Location: Totals									
Average									

Total this form _____ _____

Plant vigor: _____

Weed competition: _____

_____

_____

Comments and Recommendations: _____

_____

_____

CHAPTER SEVEN

TEMPORARY EROSION CONTROL

By Scott Zager

SURFACE COVERINGS AND MULCHES

It is a calculated risk every time a roadside manager sows seeds. However, there are many things a manager can do to increase the likelihood of success. These include hiring knowledgeable staff, using the right equipment, and planting quality seed at the proper rate. Temporary erosion control is one of the most important steps in establishing vegetation by seed. Unfortunately, it is too often neglected because of the added costs of materials and manpower. Before deciding against erosion control, a prudent manager should consider the costs of redoing the job, the effect of failure on an IRVM program's creditability, and the possibility of leaving a road vulnerable to erosion for a year or more. Research by Horner et al. (1989) demonstrated that controlling erosion and pollution at the source by using slope coverings is more cost effective than trapping eroded material later with filter fabric fences or sediment ponds. Controlling sediments at the source also saves the costs of restoring eroded slopes. Studies have shown that mulching and interrupting surface flow significantly reduces sedimentation (Burroughs and King 1989). This will increase the probability and quality of grass establishment (Leiser et al. 1974). Doubrava and Raulston (1978) found that mulch increased forb establishment in nearly all species tested and mulched plots increased flowering length and effective display of Coreopsis. In general, mulching has the following advantages: (1) it absorbs and dissipates energy released by falling rain; (2) reduces runoff water velocity; (3) moderates weather conditions including soil temperature while increasing moisture retention; (4) secures soil and materials in place; and (5) promotes sod development through decomposing mulch. In addition, geotextile nets are designed to secure slopes from mass erosion by adding cohesive strength. The Iowa Department of Transportation (IDOT) specifies the following seeded areas will always be mulched: backslopes and foreslopes 5 feet or more in vertical height; foreslopes 2 feet or more in vertical height on multi-lane or divided highways; and shoulders and foreslopes on the inside of all superelevated curves.

General Comments

Soil type is the predominate factor in determining the amount of sedimentation that occurs and the distances particles will be transported. A soil's erodiblity is largely a function of its size and cohesive qualities. Weathering forces, such as alternate freezing and thawing, contribute to erosion by loosening and dislodging soil particles. Slope length and grade will increase the erodiblity of soils. Longer and steeper slopes increase surface runoff velocity making lower slope segments more vulnerable. Generally the siltier the soil, and the steeper the slope, the more erosion control treatments become necessary. Road design and construction greatly influences the roadside's susceptibility to erosion. During planning stages, roadside managers should consider the direction of surface runoff from traveledways, the elevation and length of slopes, as well as drainageway design including substrate composition and culvert location. Do not allow slopes to be cultipacted to a smooth evened surface. Compaction decreases water infiltration into soils resulting in more surface runoff. In studies of compacted soils, it was found that sediment yields increased by 107 to 532 percent over controls (Burroughs and King 1989). It is better to create roughed contoured ridges horizontally along slopes as this will greatly reduce sedimentation from sheet erosion. Cultipacting slopes after seeding is unnecessary because rainfall will ensure adequate soil to seed contact. However, smooth slopes may increase the effectiveness of erosion control blankets by increasing the blanket's contact with the soil. IDOT specifies that crawler-type or dual-wheeled tractors be used during mulching in order not to disrupt soil surface and further compact soils. The season after planting, examine projects for on-going erosion, especially locations where concentrated

drainage occurs from traveledways, culverts, farm entryways, and watersheds.

Types of Erosion

There are six categories of erosion: splash, sheet, rill, gully, slumping and ravelling. Splash Erosion initiates the erosional process as individual raindrops strike the earth with enough force to dislodge soil particles placing them into suspension. The quantity of sediments transported away from a given area is related to rainfall intensity during a specified time, the combined force at the moment of impact, and the percent cover of the surface area protected by vegetation or mulch. Sheet Erosion is the uniform removal of a thin layer of sediments over the surface. It is necessary that the surface must be uniformly smooth for sheet erosion to occur on its own. Usually slight differences in elevation direct surface flow into channels creating surface cuts at innumerable locations. This results in a dendritic pattern of shallow trenches called rill erosion. Generally, sheet and rill erosion operate together to uniformly move sediments across the overall surface. Water accumulates as it flows down the slope, concentrating enough force along drainageways to form gullies. The depth and shape of gullies are determined by time, soil type, quantity of water flow, and its velocity. Gullies are very damaging and threaten the slope's structure. They represent extensive soil loss, remove road structure support and intensify future soil movement. The sediment deposits themselves can choke vegetation, fill drainage ways, and pollute fluvial systems. Soil slumping is massive soil movement down a slope. It occurs when the weight of saturated soil exceeds the soil's cohesive capabilities. The problem is intensified by adding fill on a pre-existing slope or by redirecting natural water flow. Dry Raveling can exceed rain generated erosion on non-cohesive soils. It occurs when soils crumble and are pulled downslope by gravitation.

Temporary Erosion Control Techniques

Erosion and pollution control objectives should be considered in the planning stage of roadside projects. Roadside managers should review project blueprints to partition roadsides according to expected erosion control needs. Erosion control treatments should be prescribed according to site requirements and project goals. Roadsides receiving effluent from large watersheds should receive special protection e.g. high velocity linings of ditch, riprap, filtration barriers or even sediment ponds. Other sensitive areas include fillslopes on inside curves and low elevations between hills as these areas receive large amounts of drainage from traveledways.

This section will examine the following erosion control techniques: (1) Straw and excelsior mulching, (2) anchoring techniques, (3) erosion control mats and geotextiles, (4) hydromulching with wood fibers or recycled paper. Tables and graphs for evaluating erosion control techniques are provided in the appendix.

The type of surface coverings used will depend on roadside conditions and individual IRVM programs. Some techniques may be more cost-effective while others will have a longer service life or function under highly erosive conditions e.g. lower slopes or channel bases. Straw mulching and wood fiber techniques can cost-effectively reduce erosion on most roadside slopes when vegetation will be established quickly. While erosion blankets will be needed to prevent sedimentation, albeit at a much higher cost, in roadsides with extreme situations or when late season construction requires longer protection through the winter. Some situations, such as hillcrests and level roads, may not require coverings. When considering application rates of mulches, remember erosion control becomes permanent only when a vegetation cover is established. Straw mulching at 4 tons per acre may be the most effective rate for reducing erosion and pollutants, but heavy mulching may reduce seed germination. Therefore, straw applied

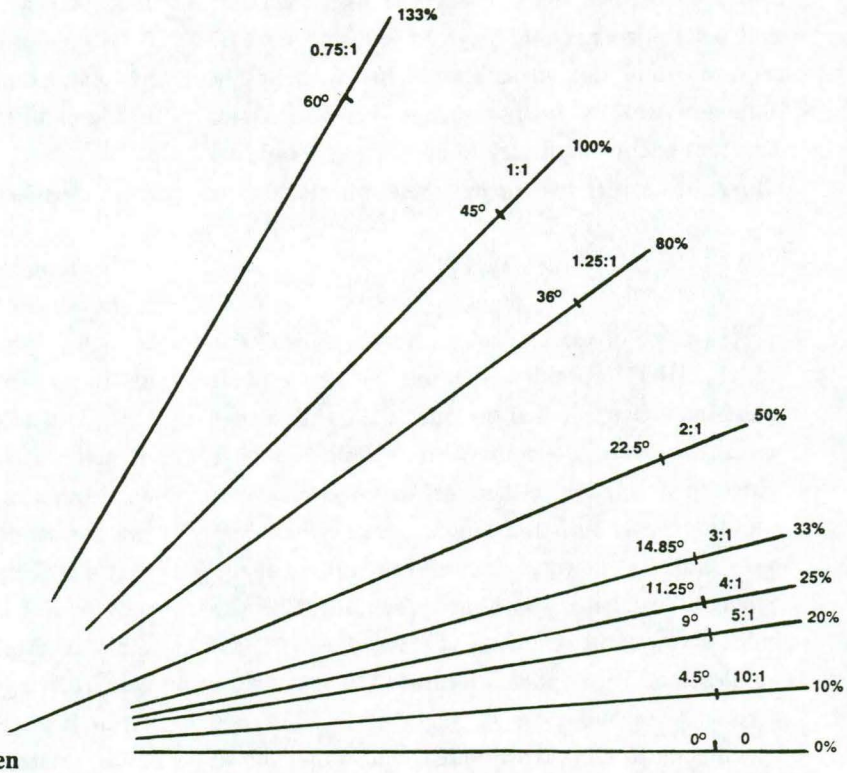
at 2 tons/acre could be a better rate for vegetation establishment.

Straw Mulching

In Oregon, straw mulch applied at 2 tons/acre resulted in first year sediment reductions averaging about 85% on new 1:1 cutslopes, composed of non-cohesive soil and rock, and with vertical heights of 20 to 25 feet (Burroughs and King 1989). Straw mulch applied with a tackifier is substantially more effective in reducing cutslope sediment production than just straw mulch. Straw mulch at 2 ton/acre was found to have a 35% sediment reduction on 0.75:1 slopes (see slope conversion figure) and 40% reduction for slopes less than 1:1. With tackifiers, effectiveness was increased to 40% for 0.75:1 slopes, and 75% on 1:1 or less. A straw mulch (2 tons/acre) with asphalt tackifier (250/gal/acre) seed and fertilizer on 0.75:1 new cutslopes in borderzone gneiss and schist material reduced sediment by 32-47% over a three year period on slopes with vertical heights ranging 3-40 feet (Burroughs and King 1989). Sediment reduction on 1.25:1 slopes or flatter exceeded 90% and a uniform grass stand was established.

IDOT specifies that mulch must be uniformly distributed and anchored to the soil. The application rate must be 1.5 tons of dry cereal straw or 2 tons of prairie hay. Straw at 1.25 tons/acre had the highest overall effectiveness rating in a study by the Washington State Highway Department (Horner et al. 1989). Its cost-effectiveness rating was 80 on a 100 scale. Ironically in the same study, a higher application rate of 4 tons/acre was less effective. All straw treatments were applied without tackifiers and were stable through winter periods of monitoring. The effective life of straw mulch alone is less than 3 months (Horner et al. 1990).

Figure 1. Slope coversion graph: lines in compass degrees, run/rise ratio, and percent slope *



* Adapted from North American Green

Applying Straw Mulch

Commercial bale choppers are straw-mulching machines which grind standard straw bales and apply mulch uniformly through a six inch hose or stationary gun. Some models claim a thirty foot discharge from hose end with hoses up to 100 feet long. Trailer-pulled mulch spreaders can discharge mulch up to 100 feet and have conveyer belt feeds. They are powered by a small engine or implement power-take-off. They can be adapted to pickup beds, trailers or wheeled manually. Some counties have used wood chippers for dispersing straw. The IDOT requires that the straw should be consistently 6 inches or longer after application.

Mechanical Mulch Anchoring

Straw can be mechanically anchored to soil by commercial crimpers or mulch stabilizers which literally stitch straw into the ground. Some counties have used tiller wheels of seed drills to crimp straw into soil. The IDOT specifies that mulch stabilizers should weigh 1,000 lbs or more (if required) and that disks should be 20 inches in diameter with 8 inch spacings between rows. Tractors anchoring mulch after seeding should be either the crawler-type or have duel wheels.

Mulch Tackifiers

In place of mechanical anchoring to stabilize mulch, IDOT specifies the use of an asphalt emulsion tack applied at the rate of 150 gallons per acre. There are alternatives to asphalt tackifiers which are applied either as an overspray or simultaneously with the mulch. Straw tackifiers have silicate powders as a cementing agent, hydrophilic polymers for binding, cellulose fibers to hold straw and coloring agents for efficient application. The application rate is 120 pounds per acre. A second type of tackifier is designed specifically to bind hydromulch materials such as virgin wood fibers or recycled paper. It has the same components listed above except there are no biodegradable cellulose fibers. Likewise, this product can be applied simultaneously with the hydromulch, or later as an overspray. The manufacturers recommended application rate is 100 pounds per acre. More tackifier is required if mulching material is increased for severe conditions. The tackifiers can be applied by a hydroseeder, but it may be more cost efficient to use a small recirculating tank and centrifugal pump. These are necessary to keep tackifier slurry in suspension. Commercial outfits designed specifically for this use are available or perhaps other existing systems could be adapted for this use.

Excelsior

IDOT specifies 2 tons of wood excelsior per acre weighed at the time of baling. Wood excelsior shall be composed of wood fibers (shavings), a minimum of 8 inches long, based on an average of 100 fibers, and approximately 0.024 inch thick and 0.031 inch wide. The fibers shall be cut from green wood and shall be reasonably free of seeds or other viable plant material.

Erosion Control Mats and Geotextiles

Erosion control mats or blankets vary in material and construction depending on type of intended use. Blankets are evaluated for their ability to reduce surface runoff velocity and soil loss. Other considerations include the percentage of soil surface covered by material and water absorption capacity of materials. Some products can absorb nearly 4 times its weight in water with only a 50% increase in volume. Excelsior absorbs only twice its weight of water but expands over 5 time its original volume. In general, mats are constructed with paper, excelsior (wood shavings), straw, jute, coconut fibers, and synthetic materials. These materials are held together by cotton or nylon netting on one or both sides. Manufacturers

can incorporate seed into the mat.

Blanket weight, material composition and anchoring method is determined by the following site conditions: (1) slope grade; (2) slope length; (3) slope position - upper, middle, or base; (4) expected water flow and velocity. Wood excelsior mats are interlocking wood fibers with a plastic netting applied to both sides to hold excelsior in place. IDOT specifies that the netting should have a mesh size of approximately 5/8 by 3/4 inch. The mat should come in rolls with a minimum length of 180 feet and a uniform width of 45 inches. The mat should have a minimum weight of 0.88 pound per square yard. Woven straw mats designed for gentle slopes (4:1 or less) usually are made with 100% straw 0.5 lbs/sq.yd. Stitching can be either cotton thread or adhesive, both are biodegradable. Mats designed for 3:1 or 2:1 slopes require stronger nylon netting. On longer and steeper slopes (1:1), coconut or jute fibers are added to straw mats to increase their durability in heavy water flow. These strong cellulose fibers also trap soil particles. Mats constructed with 100% coconut fibers or synthetic materials are designed for adverse conditions in ditch channels, shorelines, and slope bases. These mulch blankets are intended to establish vegetation in one or two growing seasons. Coconut fiber mats will last 3-5 years in very wet situations and 7-9 years in arid environments (Deas 1990). Wire staples are needed to anchor mats in place. The quantity and placement pattern of the staples is dependent on the site. IDOT specifies sturdy 11 gauge, U-shaped wire staples, minimum length 6" or 12" in sand.

The performance of any mat or geotextile will depend on the uniformity of the slope. Rill erosion is possible under matting that does not have good contact with the ground. Erosion control mats were evaluated on border-zone gneiss and schist soils with 1:1 cutslopes and vertical heights of 8-12 feet. The tested mats reduced sediments about 98%, which was comparable manufactures' recommendations. No slumping was observed from snow pack. Products used were MIRAMAT, a plastic net-type mat, and HOLD/GRO, a nylon-reinforced paper mat (Burroughs and King 1989). A trade study by North American Green showed their products reduced actual soil loss by 97.5 - 99.8% over bare ground plots on a 9% slope. Other products reduced soil loss by 80-90%.

Burroughs and King (1989) recommend a sediment reduction of 75% for excelsior mats on 1:1 slopes and 60% on 0.75:1 slopes. Horner et al. (1989) reported that the excelsior blanket treatment had a relatively poor performance -- only 26% as effective in reducing overall erosion as the best treatment. The spring-like quality of excelsior reduced adherence to the soil contours, resulting in rill erosion beneath the mat (Horner et al. 1990). Excelsior erosion control blankets had an effective grass establishment rating of 7 on a scale of 10 in the Lake Tahoe region (Leiser et al 1974).

Geotextiles

Geotextiles are knitted fabrics designed for protecting slopes from mass erosion during vegetation establishment. They are not a mulch blanket, but a woven mesh of synthetic and natural fibers which stabilizes newly constructed banks while enabling plants to develop without constriction. The fabric is designed to decompose as plant roots become capable of stabilizing the slope themselves. The apertures in the fabric allow seedlings to become established. The horizontal weave is composed of a natural fiber which decomposes after 1-2 years. This provides flexibility in the fabric as established plants grow and expand. The vertical weave is composed of a polypropylene knit with a high tensile strength. This synthetic fiber maintains slope reinforcement on the longitudinal axis as the plants mature. Their high tensile strength consolidates loose soil materials on slopes. Mainly, geotextiles are combined with other materials in stabilizing shoreline banks. Geotextiles do not have the insulating qualities or moisture retention of mulch type blankets. Although, mulching could be applied

beneath geotextile netting.

Hydromulching

Hydromulch is a ground or milled product made up of either virgin wood or a variety of paper products such as newsprint, corrugated cardboard of other recycled paper materials. It is sprayed in a water slurry with seed, tackifier, and fertilizer. Recycled paper mulch is relatively inexpensive, easy to apply, and reputed to have better moisture retention and erosion control than virgin wood fibers. However, the longer fibers of virgin wood may increase its binding capabilities with tackifiers and other mulch materials. According to Horner et al. (1990), hydromulch does not provide enough erosion protection by itself because it lacks sufficient mass per unit volume to absorb energy from rainfall and flowing water. Its main qualities are to hold seed, retain moisture and moderate soil temperature. Tackifiers are required to bind mulch to soil. Latex or oil-based emulsions stabilize the soil while holding seed to the ground. Burroughs and King (1989) cited one study where the addition of asphalt tackifier (150 gallons/acre, 1:5 emulsion) to 1,000 lbs of wood fibers, decreased sedimentation by 35% over the same application rate of wood fibers alone.

It is possible to hydroseed successfully without mulch, but topography, season and seed type will determine the most effective application rate for hydromulching. Hydromulching is most effective in spring and early summer. The force of the hydroseed solution hitting the ground should integrate soil, mulch, and seed into a blend. Coloring the slurry with dye will help monitor application. The area sprayed should be "splotchy" and covered with rills of soil, seed and mulch. It should not be an even undisturbed blanket (Agro Diversified Industries Brochure).

Hydromulch is usually applied at 1200 - 1500 pounds per acre for 4:1 or flatter slopes. Steeper slopes may require 1,500 - 3,000 lbs per acre. Excessive rates over 1500 lbs/acre may reduce seed germination.

On fillslopes with a vertical height of less than 20 feet, the use of hydromulch at 1,500 lb per acre reduced sedimentation 46-58%. These results were equivalent with straw mulching at 2 tons per acre with an asphalt tackifier (250 gal per acre). Both of the above treatments significantly reduced erosion 24 to 30 percent on fillslopes that were 20-40 feet high. Horner et al. (1989) determined that wood fiber mulch at 1.25 tons/acre without tackifier was the lowest cost option and exhibited the highest cost-effectiveness index. While the most effective treatment for reducing overall erosion and pollution was 1.25 tons/acre wood fiber mulch with the maximum amount of tackifier (120 gallons/acre).

Wood fiber at 1,000 lbs/acre with seed and fertilizer had the highest rating for establishing grass stands at Lake Tahoe (8 on a scale to 10) (Leiser et al 1974). Hydromulching is not very effective on steep cutslopes where mass erosion is more prevalent. On 80% cutslopes with vertical heights less than 20 feet treated with hydromulch, no significant reduction in sediments occurred in 3 years of monitoring because bank sloughing during saturated soil conditions produced more sediment than surface erosional processes (Burroughs and King 1989).

Purchasing Tips

When discussing price with dealers ask for discounts. Often times they may offer functional factory seconds at a substantially lower price. Also, purchase supplies through your local USDA Soil Conservation Office which will enable you to obtain high volume discounts on some products.

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APPENDIX

Note: Table 1 is adapted from Leiser et al. (1974); Tables 9, 10, 11, and 12 are taken directly from the final research report of Horner et al. (1989) and the Washington State Highway Department.

Table 1. Effect of surface coverings on grass establishment at Ward Valley, CA. Seeded October 1971;evaluated June 1974. (Adapted from Leiser et. al. 1974).*

Treatment	Rate	Grass Stand
Control A	Seed alone, no fertilizer, no cover	4
Control B	Seed + fertilizer, no cover	7
Wood Fiber	1000 lb/A, 3000 gpa water	8
Ecology Control	80 lb/A, + wood fiber 1000lb/A + 3000 gpa water	6
Terra Tack I	20 lb/A, + ground barley straw @ 1000 lbs/A + 1000 gpa	7
Terra Tack I	30 lb/A in 1000 gpa water applied over whole straw 2000 lbs/A	6
Terra Tack I	30 lb/A in 1500 gpa water	5
Excelsior Erosion Control Blanket		7

* 10 = Excellent, 1 = none.

TABLE 11. SUMMARY OF ESTIMATED SERVICE LIVES AND COSTS (1988 BASE)

Technique[a]	Estimated Service Life (months)	Estimated Cost ($/(acre served) (6 months service)
Straw (4 T/ac)	3	3,200
Straw (1.25 T/ac)	3	2,500
Straw (4 T/ac) manure-mulched, fertilized, seeded	6	2,400
Jute mat	6	3,700
Excelsior	6	3,600
Woven straw blanket	6	4,100
Synthetic fiber blanket	6	3,300
Wood fiber mulch (1.25 T/ac) fertilized, seeded	6	1,300
Wood fiber mulch (1.25 T/ac) with tackifier (50 gal/ac), fertilized, seeded	6	1,900
Wood fiber mulch (1.25 T/ac) with tackifier (90 gal/ac), fertilized, seeded	6	2,100
Wood fiber mulch (1.25 T/ac) with tackifier (120 gal/ac), fertilized, seeded	6	2,300
Chemical agent	6	2,100
Plastic sheeting	6	2,300
Designed sedimentation pond	> 6	< 4,200
Non-designed pond	> 6	< 7,500

[a] The estimated cost of seeding where it was used is based on hydro-seeding (approximately $500/acre).

TABLE 9. MEAN FLOW RATE AND POLLUTANT REDUCTIONS (%) ACHIEVED BY SLOPE COVERING TECHNIQUES COMPARED TO CONTROLS AND FILTER FABRIC FENCE

Technique	Flow Rate[a]	Settleable Solids[a]	Turbidity[a]	TSS	Organics[b]	Total P	Metals[c]	Overall Loading[d]
Straw (4 T/ac)	29.3	89.9	~ 86.9[e]	88.9	43.1	78.2	81.4	72.9
Straw (1.25 T/ac)	48.8	93.2	~ 36.5[e]	94.8	81.9	89.9	86.8	89.7
Straw (4 T/ac), manure-mulched, fertilized, seeded (M.F.S)	15.9	99.6	~ 96.9[e]	97.6	17.6	3.3	84.7	50.8
Straw (2.75 T/ac), manure-mulched, fertilized, seeded	13.4	99.1	~ 94.6[e]	97.6	50.4	38.4	88.5	68.7
Jute mat	18.5	29.9	~ 2.8[e]	60.6	45.9	28.2	62.6	49.3
Excelsior	- 8.5	58.4	~ 51.6[e]	28.8	12.6	22.2	27.9	22.9
Woven straw blanket	1.2	95.1	~ 81.4[e]	92.8	53.1	87.8	78.0	77.9
Synthetic fiber blanket	24.8	47.7	~ 3.4[e]	71.2	53.9	62.3	66.6	63.5
Wood fiber mulch (1.25 T/ac), fertilized, seeded (F.S)	8.5	89.1	~ 77.1[e]	87.0	43.6	63.9	71.5	66.5
Wood fiber mulch (1.25 T/ac) with tackifier (50 gal/ac), fertilized, seeded (1987-88) (T.F.S)	0.0	85.9	~ 77.6[e]	86.1	23.6	63.7	63.0	59.1
Wood fiber mulch (1.25 T/ac) with tackifier (90 gal/ac), fertilized, seeded (1988-89)	62.2	99.1	~ 97.6[e]	99.5	82.7	38.0[g]	96.3	79.1
Wood fiber mulch (1.25 T/ac) with tackifier (120 gal/ac), fertilized, seeded	80.3	98.9	~ 96.0[e]	99.5	87.6	58.7[k]	96.2	85.5
Chemical agent	4.5	- 91.7	~ 7.3[e]	- 47.7	- 37.1	- 65.9	- 24.4	- 43.8
Filter fabric fence	51.2	25.7	~ 2.9[e]	85.7	74.1	74.0	70.5	76.1

[a] Based on L/h for flow, m/L for settleable solids, or NTU for turbidity; all others based on mass loading.

[b] Based on mean of VSS and COD reductions.

[c] Based on mean of total Cu, Pb, and Zn reductions.

[d] Based on mean of TSS, organics, Total P, and metals reductions.

[e] Approximation because of occurence of values that were too large to measure. Such values were set equal to the upper detection limit of 1,000 NTU.

[f] Wood fiber mulch (1 T/ac) with tackifier was retested in 1988-89, when there was an opportunity for better grass growth than in the first year.

[g] 88.6% reduction excluding first two events.

[h] 95.6% reduction excluding first two events.

TABLE 12. PERFORMANCE AND ECONOMY INDICES FOR SLOPE COVERINGS AND SEDIMENTATION PONDS

	Relative Economy		Effectiveness Measure	Relative Effectiveness		Relative Cost-Effectivness	
Technique	Index	Rank[a]		Index	Rank[a]	Index	Rank[a]
Straw (4 T/ac)	41	8/14	Preventing erosion	89	7/12	41	7/14
			Reducing phosphorus yield	87	7/14	50	5/15
			Reducing metals yield	85	5/13	46	8/14
			Reducing organics yield	49	11/15	34	8/14
			Overall	81	615	44	7/13
Straw (1.25 T/ac)	52	6/14	Preventing erosion	95	4/12	56	6/14
			Reducing phosphorus yield	100	1/14	73	2/15
			Reducing metals yield	90	3/13	63	5/14
			Reducing organics yield	93	3/15	83	4/14
			Overall	100	1/15	70	4/13
Straw (4 T/ac), manure-mulched, fertilized, seeded	50	7/14	Preventing erosion	98	2/12	56	6/14
			Reducing phosphorus yield	4	13/14	3	14/15
			Reducing metals yield	88	4/13	59	7/14
			Reducing organics yield	20	13/15	17	12/14
			Overall	57	12/15	38	8/13
Straw (2.75 T/ac), manure-mulched, fertilized, seeded	54	5/14	Preventing erosion	98	2/12	61	5/14
			Reducing phosphorus yield	43	10/14	32	10/15
			Reducing metals yield	92	2/13	67	4/14
			Reducing organics yield	58	8/15	53	5/14
			Overall	77	8/15	56	6/13
Jute mat	35	11/14	Preventing erosion	61	10/12	24	11/14
			Reducing phosphorus yield	31	11/14	15	12/15
			Reducing metals yield	65	10/13	31	12/14
			Reducing organics yield	52	9/15	32	10/14
			Overall	55	13/15	26	10/13
Excelsior	36	10/14	Preventing erosion	29	11/12	12	13/14
			Reducing phosphorus yield	25	12/14	13	13/15
			Reducing metals yield	29	12/13	14	13/14
			Reducing organics yield	14	14/15	9	13/14
			Overall	26	14/15	12	12/13
Woven straw blanket	32	12/14	Preventing erosion	93	5/12	34	8/14
			Reducing phosphorus yield	98	2/14	43	6/15
			Reducing metals yield	81	6/13	35	10/14
			Reducing organics yield	61	7/15	33	9/14
			Overall	87	5/15	37	9/13
Synthetic fiber blanket	39	9/14	Preventing erosion	72	9/12	32	10/14
			Reducing phosphorus yield	69	9/14	38	8/15
			Reducing metals yield	69	9/13	37	9/14
			Reducing organics yield	62	6/15	42	7/14
			Overall	71	10/15	38	8/13
Wood fiber mulch (1.25 T/ac), fertilized, seeded	100	1/14	Preventing erosion	87	8/12	100	1/14
			Reducing phosphorus yield	71	8/14	100	1/15
			Reducing metals yield	74	8/13	100	1/14
			Reducing organics yield	50	10/15	85	3/14
			Overall	74	9/15	100	1/13

CHAPTER EIGHT

PRESCRIBED BURN MANAGEMENT OUTLINE

SITE PRE-EVALUATION

CONTROLLED BURN CONDITIONAL REPORT

By Russ Bennett

PRESCRIBED BURN MANAGEMENT

I. Introduction to Roadside Burning
  A. Why burn in roadside areas
    1. Effects and benefits
    2. Integrated management approach
    3. Burning vs. herbicides
    4. Burning as a tool
  B. Exploring the concept as an alternative
  C. Ecopyrology vs. Arson
II. The Chemistry of Burning
  A. The chemistry of fire
  B. The biology of fire in the plant community
  C. The biology of fire in the animal community
  D. The chemistry of smoke
  E. The physical effects of fire on soils and the environment

III. The Politics of Fire
  A. Accepting the unacceptable
    1. History and prehistory
    2. Overcoming the fear of fire
  B. IRVM and other agencies
    1. County Road Departments and engineers
    2. Fire departments and controlled burning
    3. DOT, DNR and SCS-friends or foes?
  C. Controlled burning and neighbors
    1. Farmers and suspicions
    2. Lets not burn down that house
    3. Burning and environmental advocates
  D. Controlled burning as a social phenomenon
1. Legalities + Liabilities 3. Logistics
2. Protocol 4. Psychology
IV. Planning a controlled burn
  A. Selecting an appropriate area to burn
    1. Benefits vs. Costs
    2. Controlability and security
    3. The goal of setting a fire in an area
  B. Conducting an imaginary burn
    1. Site examinations
      A. Exploring and visualizing
      B. The first run-through
    2. Planning and rethinking
      A. Control and escapes
      B. Planning for the unexpected
      C. Traffic and the human element
      D. Details of planning the imaginary burn-contingencies
        1. Equipment
        2. Goals and timing
        3. Alternative timing
        4. Fire Districts and assistance
        5. The fire crew
  C. The site prescription
    1. On-site notes
    2. Imaginary burn notes
    3. Documenting a simple plan (see attachment #1)
    4. Reviewing the prescription

5. Additional notes
   A. Fire Districts and attitudes
   B. Adjacent landowners and attitudes
   C. County personnel and attitudes
   D. Inventories and weather conditions

V. Preparing for the burn experience
  A. Tools and equipment for controlled burning
    1. Basic tool kits
    2. The fire truck-what is necessary
    3. Minimizing investments in equipment
    4. The perfect set-up and other dream situations
  B. The fire crew
    1. The fire boss
    2. Deciding on crew size
      A. Rules of thumb for personnel
      B. Training and compatibility-the team
      C. Avoiding casual/inexperienced assistance
    3. Communications and understandings
    4. Burning as a priority activity for personnel
  C. Safety planning
    1. Traffic hazards
    2. Spectator hazards
    3. Area control and management
    4. The fire boss as dictator
    5. Notifying authorities
  D. Burning and the weather
    1. Determining acceptable ranges of conditions
    2. Advance planning and the weather
    3. Knowing when to say no
    4. Weather monitoring and measurement devices
    5. Plotting trends and making projections
  E. Sticking to a checklist
  F. Heading out to burn

VI. The burn site
  A. Selecting areas to burn
    1. Reasons for the burn
    2. Controlability revisited
    3. Condition of the groundcover
    4. Stand improvement
    5. Altering the community for better or worse
  B. Sizing up the site
  C. Sizing up the neighborhood
  D. Burning and the ability to change plans at the last moment
  E. Can we enter your land?
  F. Burning and non-target (crop residue) vegetation
  G. Burning and fences/utilities

VII. Preburn set-up
  A. Locating equipment and crew
  B. Checklisting and back-up plans
  C. Notifications and communications
  D. Signing and traffic control
  E. Assigning tasks and coordinating personnel

VIII. The time has come to set it off
  A. Wet lines and bare ground firebreaks
  B. Backfires and headfires
  C. Managing the wind and other factors
  D. Building a safe zone downwind
  E. Controlling speed of progression
  F. Sectioning and running into the backfire--the updraft
  G. Moment by moment monitoring-the dictator returns
  H. Isolating non-target objects as you go
  I. Control and the end of the burn
  J. Smoke control and traffic

IX. Run-through of an idealized ROW burn

X. The aftermath and recovery
  A. Immediate effects and concerns
  B. Site improvement--passive and active
  C. Site study and prolonged monitoring
  D. Time frames for cool and warm-season groundcovers
  E. How often should a site be burned?

XI. Controlled burning as a management tool--a retrospective

XII. Lists of equipment and information sources

CONTROLLED BURN CONDITIONAL REPORT

SITE #:

DATE & TIME OF BURN:

SITE DESCRIPTION:

WEATHER CONDITIONS

- Temperature-
- Wind Speed-
- Wind Direction-
- Humidity-
- Moisture Level (est. %)-
- Cloud Cover %-

SHORT-RANGE FORECAST:

SPECIAL CONSIDERATIONS

- Have signs been posted?
- Was local Fire Dept. notified?

NAME & PHONE # OF FIRE CHIEF:

TRAFFIC CONDITIONS DURING BURN:

ACTIONS TAKEN:

RESULTS OBSERVED:

PROBLEMS ENCOUNTERED:

CONTROLLED BURN SITE PRE-EVALUATION

SITE #:

LOCATION OF SITE

Township/Range/Section:

Road Name/Compass Point:

Fire District & Number:

DESCRIPTION OF SITE

General Layout:

Vegetation Type:

Proximity of Fences, etc.:

ADJOINING PROPERTIES CONDITION:

SECTIONING STATUS FOR CONTROL:

SPECIAL CONSIDERATIONS:

PREFERRED CONDITIONS

Wind Speed/Direction:

Fuel Load (1 low- 10 high):

Timing of Burn/Dates:

Approximate Acreage:

RATING (1 low- 10 high):

PLAN/METHOD OF BURN:

IOWA ★ PRAIRIE BLAZING STAR

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FIRE a natural phenomena

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Members of our North American modern society normally encounter fire in a controlled technological form in furnaces and internal combustion engines. Although people may occasionally sit around an open campfire or fireplace, fire in the natural environment is alien to them. This alien viewpoint of fire has been entrenched by a societal policy of fire suppression for the past century or more. However, fires during the drought-dominated summer of 1988 have called the fire suppression policy into question and have heightened societal awareness of fire in the natural environment.

Contrary to our present day concept of fire, fire has been a part of the natural environment of the earth since the origins of climate, land vegetation, and oxygen in the atmosphere. These three elements provided the necessary prerequisites for fire, namely a fuel source, something to ignite it and oxygen to sustain the burning. Lightning has always served as a natural ignition source (Komarek, 1966). Evidence of fire has been found as far back in time as the coal swamps of the Carboniferous period and there were probably earlier fires (Pyne, 1982). Although subsequent evidence is scanty, it can be assumed that fires became more prevalent during and after the Miocene period with the development of grasslands. Dry lightning storms in continuous grassland fuels on gentle to rolling terrain could result in extensive burns under conditions of high winds and temperatures and low humidities (Wright and Bailey, 1982).

Fire was a natural catalyst for diversity that provided stability for many ecosystems (Vogl, 1970b). In the absence of fire, forest communities tend toward monocultures with excessive fuel accumulation, stagnation and inadequate reproduction, with certain species becoming prime targets for disease and for insect damage (Vogl, 1970a). Grasslands lose their vigor and are subject to invasion by shrubs; trees and shrublands become decadent or impenetrable thickets (Wright, 1974). Only deserts with less than 7 inches of annual precipitation probably didn't burn, due to a lack of fuel (Wright and Bailey; 1982).

There is considerable debate concerning fire and the origin of prairie. Many early ecologists considered the North American prairie as "climatic climax" and essentially ignored fire except for possible detrimental effects (Daubenmire, 1968; Weaver and Albertson, 1956). Sauer (1950) and Stewart (1956, 1963) considered fire the most important or controlling factor in the origin and development of prairie and designated it as a "fire grass climax."

A number of researchers (Harper, 1911; Gleason, 1913; Aikman, 1955; Curtis, 1959; Cooper, 1961; Domarek, 1956) presented evidence that fire was a natural and integral part of most prairie environments prior to European settlement in North America. The origin of prairie is undoubtedly due to a combination of factors since grassland species respond to climatic extremes created by variations in rainfall and/or temperature as well as certain parent-soil materials. Fire probably didn't become an important evolutionary force among grassland species until large prairie areas became established to permit widespread repeated fires. You can't have a prairie fire without a prairie (Gleason, 1913).

Two types of grassland exist in mid-continent North America. One type is derived or secondary grasslands which are scrub vegetation or scattered trees that occur in areas capable of supporting forests. They usually result from and are maintained by naturally occurring fires that often combine with climatic, soil and biotic factors to form more or less permanent grasslands, existing as either open grasslands or savannas. The second type is natural or primary grasslands which originated primarily because climatic or soil conditions favored grassland species and adversely affected woody plants. The second type was well represented in northern Iowa prior to settlement whereas the first type was probably predominant in southern Iowa. There is general agreement that fire is an important factor in the development and maintenance of secondary or derived grassland and savannas. However, opinion differs regarding the role of fire in the origin and maintenance of natural or true grasslands.

Fire benefits grasslands in a number of ways:

- by stimulating growth (above and below ground) and flowering of individual plants as well as increasing diversity of native plants
- by killing or stunting woody species capable of invading and shading-out grassland species
- by removal of litter to recycle nutrients
- by creating darkened exposed soil that warms quickly in the spring to favor warm season species over cool season invaders
- by delaying or preventing senescence of certain plants.

Prairie plants have adapted to fire by maintaining 65-90% of their biomass (even during growing season) below ground with extensive root and food storage systems and either by developing buds just below ground level to shield them from fire damage or by having above ground buds that resprout easily after fire.

Human use of fire, along with lightning, intensified the effect of fire in many ecosystems. Man has probably used or kept fire for more than 500,000 years, but only in the last 20,000 years was it used as a tool that influenced the development of vegetation (Johnson, 1970). The

Pleistocene "big game" hunters first brought man-initiated fire to North America when they crossed the Bering Strait. They used fire to hunt game animals or to make the prairies more attractive to grazing game and as a weapon in warfare (Daubenmire, 1968). They also started accidental fires when signaling or leaving fires burning in abandoned camps (Madson, 1982). Native Americans used fire extensively and accounts of early explorers often describe vegetation which had been or was being burned by the natives. Undoubtedly, man's use of fire along with lightning-ignited fire maintained and expanded the prairies.

Following the arrival of European settlers, fires tended to increase somewhat as there was greater potential for accidental fires from pasture-burning, out-of-control firebreak burning as well as sparks from chimneys and wadding of muzzle-loaders. As settlement increased, the frequency and extent of fires declined. Road construction and cultivation of fields created fire breaks and reduced fuel. In addition, with more people fire suppression was used to prevent loss of buildings, fence rails and hay stacks. During the latter part of the nineteenth century, fire suppression activities increased. The suppression was stimulated in part by the fatal fires in the slash-intensified logged areas of Peshtigo, Wisconsin, and Hinckley, Minnesota, and by the increasing conviction that fire was "bad" for natural areas. In addition, about this time European trained foresters in the forest industry and in government began to influence policy. Basically, they believed that fire was bad because it killed trees. The effects of this European fire protection policy spilled over into the prairie and other plant communities (Madson, 1982; Wright and Bailey, 1982.)

With fire suppression, vegetation changes soon became obvious. The changes were most apparent in grassland ecotones and savannas capable of supporting woody vegetation where grazing often removed fuels or destroyed the continuous nature of the ecosystem (Vogl, 1974). Grassland areas with much growth but slow decomposition, change most dramatically when fire is eliminated (Hulbert, 1969; Kucera and Ehrenreich, 1962). Although grassland expansion or retraction was primarily controlled by climatic conditions, the elimination of fire tipped the balance in favor of woody species; many savannas reverted to forests and grassland species were replaced by forest, brush and scrub species (Vogl, 1974).

Since the early 1960s, a change in philosopphy has occurred regarding fire and many biologists have started taking a constructive view of fire in North America. The Leopold Report of 1963 (Leopold et al, 1963) informed the general public that protecting all plant communities from fire could be bad—excessive fuel buildups could lead to catastrophic stand-replacing forest fires, decadent shrub and grassland communities, encroachment of shrubs and trees in grasslands, monocultures of trees increasing the risk of disease and insect damage as well as decreasing diversity in numbers and species of wildlife (Wright and Bailey, 1982).

Fire was reintroduced as a natural agent in the southeast and northwest and spread quickly on a limited scale to all areas of the United States; the Flint Hills of Kansas are an exception as they have been burned regularly since 1880 (Wright and Bailey, 1982). Recently, interest in the use of fire as a management tool has accelerated because other management tools such as chemicals or mechanical removal are either environmentally unacceptable, not effective or too expensive. Use of fire as a management tool for natural ecosystems must capitalize on the beneficial nature of fire to the ecosystem and take into account the potential hazards of fire. Therefore, prescribed burning, as it is called, is conducted under specified conditions with proper timing to meet both of those objectives.

There is a growing need to educate the public on the role of fire in wildland management (Gruell, 1989). This will occur when it is better understood that fire was and is a natural phenomena and an integral part of most ecosystems. Researchers and most managers of natural areas agree that prescribed fire is a reasonable way to reintroduce fire into many ecosystems (Wright and Bailey, 1982). Hopefully an educated public will understand and support prescribed burning as good land stewardship in managing our natural resources. ◆

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Fire Studies at Tucker Prairie

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Prairie fires were a conspicuous element in the pre-settlement environment of the Middle West. According to early chronicles wildfires were frequent and often widespread. One such report by Wells in 1819 described uncontrolled burns driven by high winds, filling the sky with ash and smoke for days at a time. In the assessment of fire as an ecological factor in prairie development, the role of primitive man is thought by some to have had considerable impact. Numerous studies of fire in contemporary prairie stands suggest that it is an important requisite in maintaining species diversity and stability of structure lest deterioration occurs, often within a few years. Yet, a given fire regime as a management tool may not be universally applicable for sustaining prairie equilibrium. What is a workable program for one locale may not be as successful in another. The variables to consider are numerous. They include terraine and drainage, soil moisture availability, past use factors, current fuel accumulation, and the potential for woody invasion. Thus, the seasonal timing and frequency of fire and its possible integration with other program options such as grazing should be evaluated on a periodic basis.

The following discussion of fire and its various interactions with the tallgrass prairie is based on a single tract in east-central Missouri. The findings thus are interpreted in the context of its physical, chemical, and biological attributes, representing a certain type of prairie in this region of the Middle West. Fire research was initiated at the University of Missouri Tucker Prairie Research Station in 1958. This tract consists of 145 acres (58 ha) of unbroken bluestem prairie, located in Callaway County (T48N, R10W, Section 12, SW 1/4), 17 miles (28 km) east of Columbia, on Interstate 70. This region of the state represents a prairie-forest transition zone near the southern limits of Kansan glaciation. The terrain is flat to gently rolling, poorly drained, and has a thin mantle of fine loess overlying glacial till. The soil profile is characterized by strong horizon differentiation with heavy claypan development, and is frequently water-logged. Annual precipitation for the region averages 900-1000 mm with about 60% occurring in the growing season. This distribution indicates a more equable climate than that for prairies to the north and west where rainfall is not only less but has a higher summer percentage. More continental conditions with relatively drier winters are thereby effected. The annual air temperature averages 12.5°C (55°F) and ranges from a mean weekly maximum of 26°C (70°F) in late July-early August, to a minimum -3°C (27°F) in January. Water balance in most years is distinguished by two principal periods. These are June through August when evaportranspiration exceeds rainfall with plants drawing on subsoil reserves during critical periods, and the nonactive season when precipitation exceeds losses and the surplus (minus run-off) recharges the soil profile.

The vegetation is dominated by warm-season grasses. The principal species are the bluestems, prairie dropseed and Indian grass (*Andropogan geradi* and *Schizachyrium scoparium, Sporobolus heterolepis,* and *Sorghastrum nutans,* respectively). Among herbs, the goldenrods (*Solidago missouriensis* and *S. gymnospermioides*) are most ubiquitous, with sunflower (*Helianthus mollis*), aster (*Aster spp.*) and fleabane (*Erigeron spp.*) also commonly distributed but less abundant. A scattering of American elm, eastern red cedar, and woody members of the Rosaceae, including hawthorn, plum and roses also occurs. Approximately 250 plant species have been recorded for the site.

Burning at Tucker Prairie is conducted in the spring. Our plan is to complete the schedule within a 2-week period in the latter part of March or the first week of April. Frequency of burning for experimental studies includes three schedules, annual, biennial and every fifth year (quinquennial) on permanent plots. In addition, representative controls were established for comparative measurements. The effect of spring burning on herbage yield, flower stalk production, root biomass development, organic turnover and nutrient circulation, and dominance-diversity relationships has been assessed in varying degrees covering a span of nearly 30 years. The following brief discussion will attempt to summarize some of the principal findings from these observations, several of which are being continued on an on-going basis.

Almost invariably annual production of grass herbage was greater on fire plots with annual and biennial schedules when compared to controls. Flower stalks were also more numerous in these plots. The difference in production between treatment (fire vs. control) varied from year to year depending on timing and availability of moisture during the growing season. In dry years, the advantages of fire were lessened because of higher evaporation losses from mulch-free plots. When moisture supplies were adequate, the stimulus of burning by elimination of heavy litter accumulation more than doubled above ground production (Table 1). Note, however, the sharp reduction

Table 1

Mean annual dry matter production for three consecutive years (g/m^2)*. Fire plots burned only once, in the year of sampling. Litter values in parentheses.

Year	Fire	Control
1st	1250	570 (410)
2nd	933	509 (429)
3rd	522	482 (474)

*$g/m^2 \times 8.8 = Lbs/A$.

in yield in the third year when moisture was deficient, with the relatively greater impact on fire plots. Similar responses to fire have been noted for other tracts in the Prairie Peninsula, including Iowa, Illinois, Wisconsin western to eastern Kansas, North and South Dakota and Oklahoma. Westward, however, the positive effects of fire on grass production and stability are lessened due to decreasing rainfall and the greater value of litter in reducing water evaporation in soil. A survey of summer precipitation patterns indicated that in study areas with about 42 cm. (17 in.) or less, control plots had higher production than burned plots. In our studies, there was little or no difference in production between the controls and plots burned every fifth year. Apparently the interval between fires is too long to sustain any beneficial effect from litter removal. By the fifth year, litter build-up was approaching equilibrium and was similar to that on control plots.

Since herbage production was maintained at relatively high levels by burning, the question was raised concerning the effect of fire on biomass development of the root system. In a preliminary study conducted earlier, it was observed that about 60% of the biomass in the A_1 horizon (0-25 cm. depth) was concentrated in the upper 5 cm. zone (2 inches). Our objective was to assess any changes in quantity and structure for this critically-important part of the profile. Of particular interest were the rhizomes of the dominant grasses occurring at this level where the heat of the fire might have a deleterious effect. Dry matter measurements based on soil cores (0-5 cm.), separated at mid-level, after nine and ten seasons of annual burning showed that fire plots had the higher production values (Table 2). These effects are the consequence of more photosynthate being produced, making available more carbohydrate for storage in underground organs. Note that rhizomes were most concentrated in the upper 2.5 cm. and roots more diffusely distributed between the two levels. Using the percentage values provided for rhizomes applied to total biomass, the root-rhizome fractions are easily translated to relative decreases from upper to lower zones. The comparative decreases shown for control plots is attributed to thinning grass stands and diminished leaf area caused by litter accumulation. These adverse effects on plant structure in the absence of fire are, in turn, probably the result of several factors including less light intensity at ground level, tie-up of nutrients in litter, and delayed soil warming.

Table 2

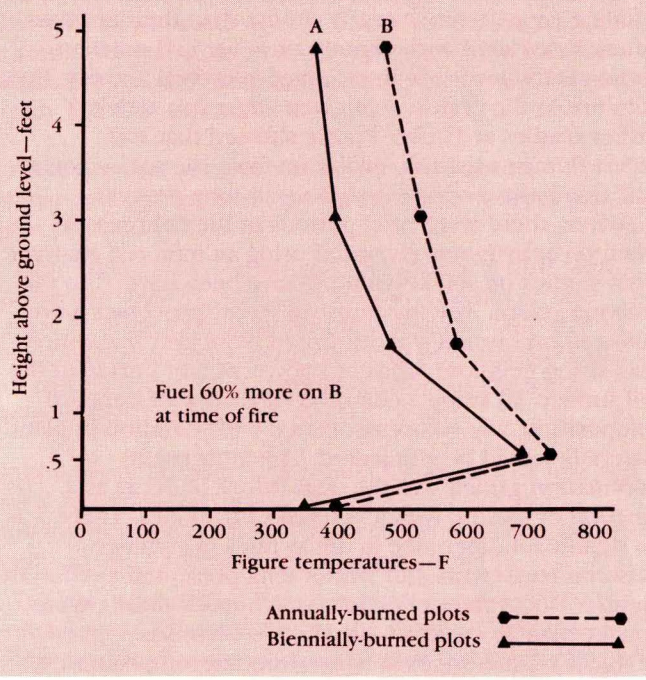
Mean root system biomass for fire plots and control plots (g/m^2). The percentage of total biomass attributed to rhizomes in parentheses.

Depth - cm	Fire - 9 yrs.	Control*	Fire - 10 yrs.	Control*
0-2.5	594 (23)	534 (28)	678 (28)	385 (27)
2.5-5.0	314 (7)	207 (3)	326 (8)	211 (2)
Total	908	741	1104	596

*Control plots not burned for at least 5 years.

No tissue damage to rhizomes was noticed, due probably in part to the usually cool, wet conditions of the soil at the time of burning. Fall burning, on the other hand, possibly would have different results with higher temperatures and typically drier conditions. Monitoring fire temperatures indicated that maximum readings occurred approximately 15 cm. (6 in.) above the ground level, with a rapid drop to the soil surface (Figure 1). Readings at 1/3 cm. depth in the soil itself (not shown) indicated further decreases to about 60°C (150°F).

Figure 1. Temperature Profile, Tucker Prairie, April 18, 1984. A.M.



An important aspect of the fire studies program dealt with the chemical changes associated with organic turnover and the circulation of nutrients. For this purpose, foliage collections of big bluestem were made beginning one month after fire and continued at bi-monthly intervals for one year. Several key elements and oxides were analyzed for each of the sampling dates. Total NPK levels showed the most decline through the observation period. Calcium trends were less distinct and probably reflected its role in cell wall structure. SiO_2 and total ash showed relative increases, as might be expected. In general, plant tissue from control plots had the higher concentrations for all elements analyzed. This increase was probably due to slower or restrictive growth on unburned plots, thereby reflecting a higher concentration on a dry matter basis. Thus, there would seem to be a compensatory effect, within limits, between total biomass produced and its

nutrient level. Selected data in condensed form are presented in Table 3. Using a 3:2 grass production ratio as

Table 3

Total nitrogen, silica, and total ash values expressed as percent dry matter of big bluestem foliage, for burned (B) and control (C) plots.

Collection Period	Nitrogen		SiO_2		Ash	
	B	C	B	C	B	C
1st month	1.99	2.45	3.62	4.48	9.50	11.10
6th month	0.52	0.60	8.24	9.02	10.40	10.90
12th month	0.51	0.76	7.00	10.51	8.92	12.49

an average for burned and unburned plots, respectively, we can calculate that total nutrient content of the standing crops is more nearly similar than their biomass values. Associated with organic turnover and nutrient cycling is the level and duration of microbial activity. How does fire in the prairie ecosystem affect this activity? Earlier studies at Tucker Prairie showed that *soil respiration* or total CO_2 evolution from the surface on a unit area basis was essentiallly a year-long process. However, there were brief periods in the cold season when no activity was recorded using an infra-red analyzer. Most studies on soil respiration have been limited to the growing season. For our purpose, decay processes were followed on burned and unburned plots over the entire year, using cellulose strips of known weight buried in the soil surface. By using a common substance of standard composition, any errors associated with variation in plant materials would be eliminated. The most useful information gained was the dual nature of decay as a function of season, which verified CO_2 studies. There was no significant difference in decay rates in summer between treatments, but winter data presented a different picture. Decay rates of cellulose in burned prairie were greater than on controls, or where mulch was applied (Table 4). Differences in winter-time decomposition is

Table 4

Mean annual and seasonal decay values (k), expressed as percent lost on a 12-month basis for cellulose strips placed in the soil surface.

Treatment	Annual - %	Warm Season - %	Cool Season - %
Fire	0.57	0.94	0.22
Control	0.49	0.86	0.14
Mulched artifically	0.50	0.88	0.13

probably a function of temperature. A surface free of insulating ground litter would warm faster on sunny days and would allow greater microbial activity, albeit for brief periods. In another study it was shown that the total microbial biomass in the upper 5 cm. of soil consisting of bacterial cells and fungal hyphae was approximately 23 and 7% greater, respectively, on plots burned at least 18 years. The combined increase was 14%, thus supporting, at least in part, the more rapid turnover of organic products and the cycling of nutrients.

Little work has been done on the effect of long-term fire regimes on dominance-diversity relationships in tallgrass prairie. Recently we completed a study which assessed the effect of burning over a period of 27 years. The relative importance of each species to total community production was analyzed for fire plots and control plots. The effect of fire frequency was evaluated and compared. Thus, the assessment included 27 consecutive spring fires, 13 fires in alternate years, and 6 fires every fifth year. Green foliage samples from replicated 0.5 m^2 plots were harvested in June, July and late August, separated by species, oven-dried, and weighed. In addition, litter and dead standing crop were measured as total values. Preliminary examinations of the data, even prior to statistical analysis, revealed two major points. The warm-season grasses were the dominant group on fire plots burned annually or biennially. The dominant group on control prairie and that burned every fifth year consisted of composites, principally two species of goldenrod. In all plots, regardless of treatment, quadrat frequency was similar for the dominant grasses but not for goldenrod species. Thus, quadrat representation remained relatively high even on control plots and 5th-year burns for grasses although biomass was much attenuated by maximum mulch accumulation. The goldenrod species, however, were less frequenlty represented on annual and biennial plots, particularly the former. The functional difference in the effect of fire frequency on plant composition and biomass production at Tucker Prairie probably occurs between two and five years. The percentage of total community production contributed by major groups is presented in Table 5. The pattern shown here apparently

Table 5

Green biomass by plant groups harvested in late August expressed as percent of the total production for different fire treatments and controls. Total burning events in parentheses.

Group	Fire Interval - yrs. 1 (27)	2 (13)	5 (6)	Controls A (0)	B (0)
Grasses					
BB/LB/DS*	77	42	34	24	29
Other spp.**	12	43	7	14	20
Subtotal	89	85	41	38	49
Composites					
Goldenrod	8	8	50	51	34
Other spp.	2	4	7	6	12
Subtotal	10	12	57	57	46
Other herbs	1	2	1	3	1
Woody spp.	0	1	1	2	4
Total	100	100	100	100	100

*Principal dominants: big bluestem, little bluestem, and prairie dropseed

**Includes also grass-like plants, e.g., rushes and sedges

represents equilibrium conditions under current burning regimes. These relationships began to emerge within the first 5-10 year period of the burning program. There was no significant difference in species richness among treatments. At present, however, the difference in dominance patterns separating annual and biennial burning response from 5-year cycles and controls is clear-cut and statistically significant (Table 6). Continued observations are planned to monitor these relationships and to detect any future changes in either taxonomic composition, community dominance, or both. ◆

Table 6

Tests of significance of difference between treatments affecting biomass production of grass- and composite-dominant groups sampled in late August.

Treatment Comparison	Green Biomass Production	
	Grass	Composite
1 vs. 2	n.s.*	n.s.*
1 vs. 5	P. 05	P. 01
1 vs. C-A	P. 05	P. 01
1 vs. C-B	P. 01	P. 05
2 vs. 5	P. 01	P. 01
2 vs. C-A	P. 01	P. 01
2 vs. C-B	P. 01	P. 01
5 vs. C-A	n.s.*	n.s.*
5 vs. C-B	n.s.*	n.s.*
C-A vs. C-B	n.s.*	n.s.*

*Treatment comparison not significantly different at 5% level.

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Prairie Smoke

Pauline Drobney
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Flames and Emotion

The crest of the savanna ridge where I stood posted as fire spotter provided an excellent vista of two merging fire lines at twilight. The decreasing light and muted sound of distant crackling through trees heightened the quiet drama of the moment.

Watching fire seems to be a fascination of our species, and perhaps emotional response to fire is a characteristic woven into our genetic fabric. Fire *is* after all, tied to our survival. It is a source of life and security in cold climates, is used to prepare food, and can cause destruction and death in uncontrolled situations. I am not the first person to be enchanted by the sight of fire in the prairie region; the abundant prairie vegetation provided ample fuel for autumn fire and the fires resulted in diverse reaction to it by early Euro-Americans.

A prairie fire that occurred in 1928 in Wisconsin, commanded a powerful response from this anonymous author (Curtis, 1971):

> *"How shall I describe the sublime spectacle that then presented itself? I have seen the old Atlantic in his fury, a thunderstorm in the Alps, and the cataracts of Niagra; but nothing could be compared to what I saw at this moment. . . . It passed me like a whirlwind, with a fury I shall never forget."*

The prairie settler had good reason for feelings of fear and anxiety regarding the prairie fire, however, as the following excerpt from the Pioneer History of Pocahontas County, Iowa (Flickinger, 1904), illustrates:

> *"It [Fire] was just as liable to come upon the lonely settler during the night as in the daytime; and it has been said that many of them, in this section in dry seasons, 'did fret both day and night' lest they should be surprised by finding they were in the way of one of these raging demons of the wilderness that should arouse them from their midnight slumber and sweep away their property. His only protection from the prairie fire-fiend was the fire-guard which consisted of a number of fresh furrows plowed around his buildings or stacks; and if the wind was high these afforded but little or no protection."*

Although the unfenced, unplowed prairie and sweeping prairie fires are a thing of the past, prairie remnants are still burned and people still display diverse reaction to their burning. Most prairie managers acknowledge the importance of fire in maintaining prairie communities, yet in burning natural areas, they are often met by two extreme reactions from the public. The eager but

uninitiated person, often romanticizes the excitement of a burn, not realizing the purpose or the dangers involved or that participating in a burn crew is such strenuous work. At the other extreme, are those who perhaps cherish a natural area, and perceive the natural areas manager using fire management as a fire-crazed fanatic, destroying the preserve. This response is understandable when all one sees immediately after the burn is a smoking, blackened landscape.

In the many burns I have experienced during the last 13 years, I have never ceased to be fascinated by the spectacle and behavior of fire. A six week burn internship with The Nature Conservancy in Missouri last spring, however, brought my understanding of fire as a natural areas management tool into sharp focus. During these six weeks, we were ever alert to the weather, watching for a "burn window" so that we could burn according to prescription. Preparing an area for a burn was arduous work, with adverse weather affecting not only the burn date, but also the ease of site preparation. We became keenly aware of specific management objectives projected for each burn, and of the fact that the crew was necessarily a team, each member being responsible for a successful and safe burn. Although there is beauty and inspiration in watching fire, fire behavior can be extremely variable and potentially dangerous, and burning is physically exhausting. Being on a burn crew is not glamorous, it is hard work. The essence of this work seemed distilled in a single statement made by our burn boss as a very tired crew trudged through mop-up on one of our final burns. "Perhaps you understand what I mean when I say that if there was an easier way to meet the management goals for these areas," he said simply, "I would gladly use it."

Scientists are also human, and as such, we often evaluate the application of fire to natural areas emotionally in protection of the sacred cows which are our pet projects or ideas. In a panel discussion at a recent scientific meeting, a colleague was discussing the stages people go through as their perspective on burning matures. "At first people tend to be overeager and can want to burn too much. This person might be called . . ." as he paused to think of a suitable label, a lepidopterist blurted out "A botanist!" and good natured laughter followed. This incident, however jovial, typifies a classic struggle among different disciplines within the scientific community, who often seriously differ in their opinion of ideal management techniques for a prairie. What is best for the butterfly (plant, mammal, turtle), it is argued, may not be best for the plant (mammal, turtle, butterfly). Although these organisms evolved synergistically, we have little scientific information about the ecological nature of the prairie prior to Euro-American settlement, and today's prairies are in effect, small islands surviving in an ocean of humanity. The underlying crux of the issue of burning natural areas is, of course, the achievement of management objectives for the areas. The thoughtful and informed establishment of these objectives need be coupled with use of an unbiased method of evaluation of the success of the management technique, which in this case is fire. Without these tools, we enter the realm of emotion and conjecture, and can argue endlessly while our prairies flounder uncertainly between health and oblivion. The collective information gained from well organized sampling in several disciplines transcends the individual limitations of the botanist, the entomologist, the mammalogist, and the herpetologist.

This issue of the Iowa Prairie Blazingstar focuses on current and historical application of fire to the prairie landscape. There are many more perspectives and important issues regarding the use of fire in management of the small bits of prairies that remain in the tallgrass prairie region than can possibly be printed in a single publication of the Blazingstar. It is hoped that future issues can communicate data collected from various disciplines, so that concerns about prairie management can be more clearly addressed. ◆

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The first issue of the Iowa Prairie Blazingstar was well received with requests for copies coming from throughout the midwest and as distant as California and New York. The editorial staff wishes to thank all those who have contributed time and financial support to the Blazingstar, often far beyond the amount asked. We appreciate your continued understanding and support during this embryonic stage of the Blazingstar, when the work has been shouldered by volunteers, and financial needs have been met through generous donation. Although your support has not been personally acknowledged, it is sincerely appreciated. Perhaps one day, when we are better established with a permanent staff, we can acknowledge these individual donations.

Please send comments, questions, suggestions, article submissions, and donations to:

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Planning for Fire

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Why Use Fire?

Why use a tool as risky as fire to manage prairies and other natural areas? How do you plan a burn that will be both effective and as safe as possible?

Fire is an integral process in many ecosystems. In the Midwest, fire is known to be beneficial to the structure and diversity of many native plant communities. Fire maintains the open character of grasslands, wetlands and savannas by girdling woody vegetation which might otherwise encroach and take over. Fire encourages most native prairie species, stimulating reproduction and growth by removing dead plant material. And spring fires can be used to set back the invasion of exotic species like bluegrass, bromegrass and sweet clover by burning them as they green up.

The invention of the steel-bladed plow nearly doomed the Midwest's prairies to extinction. The few areas that remained unplowed were further stressed by continued fire suppression. Remaining natural areas are small, dissected and often adversely affected by long-term fire suppression. Wise management of these areas requires special considerations, both biological and political/economic.

From the biological perspective, invertebrates and native species not well adapted to frequent fire must be accommodated in planned burning. Fire should be managed to leave unburned areas in each preserve as refuges for these species. Of course, this concern must be balanced against the reality that prairies, wetlands and open woodlands or savannas need fire or some other disturbance to maintain their biological integrity.

The political/economic perspective considers the risks and costs involved in using fire, whether more cost-effective tools are available, and if fire is used, whether those risks can be avoided or minimized.

Use of prescribed fire is risky, as is use of other management tools like tractors or chain saws. Not burning is also risky, increasing the chances of unplanned fire by allowing fuels to accumulate. The trick is finding a balance between opposing risks. If burns are limited by overly tight prescriptions to times when conditions are the safest possible in order to minimize the risk of damaging neighboring property, biological objectives may not be met. Conversely, burning under marginal conditions may produce the desired biological result, but increase the liability.

Could the risks be avoided altogether by using other tools besides fire? Because fire's role in prairie and savanna communities is complex, simulating its effects by other means is usually not practical and, in any case, not entirely possible. Attempting to simulate the effects of fire mechanically involves using techniques that are expensive in terms of up-front cost and labor, and/or in terms of potential long-term environmental effects. Alternatives include:

- mowing once a year, then periodically removing mowed material in order to avoid fuel build-up;
- repeatedly spraying exotics with herbicides;
- removing trees by hand, followed by herbicide applications to stumps of persistent sprouters; and
- fertilizing periodically on sites with low-nutrient soils.

Research shows that repeated haying (mowing and removing mowed material) changes species composition and reduces overall diversity of prairies.

Grazing is sometimes touted as a way to simulate or compliment fire. Prior to European settlement, grazing and fire probably acted synergistically on prairies. Bison and other grazers favored areas where the dead growth had been removed by fire. But today's conditions are different. On prairie tracts under 5,000 acres, grazing is simply impractical. In order to simulate bison or elk movement and minimize disturbance to community composition and plant vigor, animals must be rotated frequently (very few weeks or more) throughout the tract. The ratio of costs (fencing material, maintenance, and moving animals) versus benefits derived from grazing increases dramatically as grazing acreage decreases. Further, fencing is a distinct visual intrusion which affects the aesthetic quality of prairie landscapes dramatically.

Although very limited grazing or late fall haying may be options in a few situations, planned fire, despite its risks, is arguably the more efficient, less disruptive, as well as the least expensive, tool to manage prairies and savannas.

Establishing Burn Objectives

Before planning any individual burn, burn objectives must be set. Burn timing and other factors can then be planned to best reach the goals of the burning program. Although objectives will vary for different areas, they should include biological and operational considerations.

Burns should be designed to meet these basic biological objectives:

- Burn completeness: burn more than 70% of the area of the burn unit, and reduce brush and litter accumulations.
- Target species: trees and brush should be girdled and 90% of the bluegrass cover should be removed.
- Community dynamics: native species should increase after a successful burn, habitat for both orchids and xeric species should improve.
- Site conditions: minimal disturbance to soils, especially in fragile wet areas.

Burn operations should: avoid fire and/or smoke hazard to adjacent properties, avoid smoke accumulations on roads, and be conducted safely, without endangering crew members or others.

Setting Up a Prescribed Burn

If you decide to burn, how do you plan a burn that will be effective and as safe as possible? Who should conduct the burn?

Since each area is different, no one set of instructions could be written to cover every burn. But certain guidelines are common to all prescribed burns. **Successful and effective prescribed burning requires careful planning and preparation, appropriate equipment, experienced crews and well-defined objectives.** As with any endeavor involving risks, there is simply no substitute for planning, experience and specific knowledge of fire behavior.

PLANNING. Much of the work of a prescribed burn should be done well before the day of the fire. First, the area is divided into burning units. Unit(s) are delineated on the basis of landform, natural firebreaks, burn objectives and other practical considerations. Within each unit, fuel types—from fine types, such as dried grass, to large fuels like brush and trees—are assessed to help predict fire behavior. Control lines are planned and constructed by mowing and/or blacklining (charring) boundaries.

Timing for the prescribed burn(s) is decided, based on the burning objectives, physical characteristics and neighboring land uses for each burn unit. Prairie burns are done either in the fall after the first frost, in early winter when oak leaf duff is thickest, or in spring when cool season grasses (like brome and bluegrass) are near flowering stage. Spring burns generally are more effective in killing invading cool season grasses, while fall and winter burns are more effective for other problems.

A burn prescription is determined for each fuel type and each step of the burn. The prescription describes the conditions under which a safe and effective burn can occur—including wind speed, fuel moisture and weather conditions. Logistics, including the number of crew members required, the amount of time necessary to accomplish the planned burn, the kind of equipment required, and coordination with local governments and fire departments, are established. Smoke management hazards must be considered, particularly where burn units exist near major highways, electrical transmission lines and/or population centers. Public relations steps are planned. All of these planning steps are vital to the success of a prescribed burning program.

Setting the prescription before the burn means deciding under what conditions the burn would have to be cancelled. This allows the burn manager to make a rational judgement about whether to burn or not—without being swayed by having everything prepared and the crew assembled, ready to burn. If conditions are clearly unsafe, follow the prescription; don't burn.

Burn logistics, including crew size and assignments, firebreaks, equipment and contingency plans are also crucial to a successful prescribed burn. What will you do if something goes wrong? Who will call for assistance in the event of an emergency? How will the local fire departments be alerted, and by whom? What backups are available in case of equipment failure? These questions must be answered *before* the burn. Burn crews should be briefed and everyone's assignment clear. Good communication with all members of the burn crew during the burn is essential. Make sure that radio contact with spotters and other crew members can be maintained, even through thick columns of smoke and crackling flames.

EXPERIENCE. Each burn is unique. Learning about fire behavior is an ongoing process; managing prescribed burns is a skill which improves with each burn conducted.

Furthermore, although some general truths about fire hold everywhere, the crucial details of fire behavior are different for each plant community and for varying topography and weather. Knowing how fire works in the tallgrass prairies of Iowa is of little use in understanding fire behavior in California chaparral. Even the steep topography and unique fuels of the Loess Hills of Western Iowa involve a different burning approach than the gently rolling landscape of Central Iowa tallgrass prairies.

The best way to learn about fires and fire behavior is through training combined with direct experience. Training should come first, preferably an organized training session led by experienced burn leaders. Look for sessions on planning and conducting prescribed burns, not on wildfire suppression. Understanding the principles of fire behavior, coupled with sufficient time spent at the business end of a swatter or rake, or running a drip torch can teach volumns about how fire behaves in different conditions.

The most important variables in fire behavior for prescribed burns are fuel type (large, small; upright, matted; etc.) and condition (moisture content), wind speed, temperature and landform or slope. These variables all affect the speed a fire will move and how hot it will

burn. For instance, living or green material, because of its high moisture content, usually burns more slowly and with lower intensity than dead or cured material. Recent rain or high relative humidity act to slow a fire down, often making the difference between a fire that is easy to stop at a break and one with a higher risk of escape. Large accumulations of dry fuel burning under dry conditions and/or high air temperatures can produce an intense fire, with flames too hot to be easily approached and controlled. Topography primarily affects fire speed. Fires race up hills and move more slowly down or across slopes.

Fire is a dynamic, constantly changing process, affected by interactive variables which create a complex set of possible conditions. A planned burn unit which encompass varying conditions such as shorter grasslands, tall grasses, wetlands and wooded areas will produce widely differing fire behaviors as the fire moves from one area to another.

Conducting the Burn

The day of the burn arrives, the crew is assembled, the equipment sorted out and checked, local governments and fire departments alerted, any necessary permits obtained. . . . Is it time to light the first drip torch? Not quite. Several crucial steps remain before beginning the burn. First, check the weather, both the day's predicted forecast and the weather on site. It must fall within the bounds allowed by the burn prescription. Second, walk the burn unit, checking firelines and firebreaks carefully. Third, brief the crew on the burn plan and emergency contingencies. Each person must understand their role and responsibilities. Fourth, move crews and equipment to their places and check communications. Now comes the time to light that drip torch.

Prescribed prairie burns usually begin with lighting the backfire. This involves burning a wide swath along a mowed, pre-burned or mineral soil break in the vegetation, beginning from the most vulnerable downwind perimeter of the area to be burned. The vegetation immediately inside the fire break is lit and the flames allowed to burn into the wind (usually resulting in a slow, creeping fire that is relatively easy to control) a sufficient distance so that the larger flames from the main fire cannot jump over the firebreak area. The fire is controlled at the firebreak with equipment such as swatters, backpack water pumps, fire rakes or vehicle-mounted water pumps with extension hoses.

Once the backfire has burned a wide swath along the most vulnerable portions of the firebreak, and the downwind burning edge is secure, the main fire or head fire is lit. This involves simply lighting the vegetation along the upwind (or downhill) boundary of the unit and allowing the fire to move with the wind, into the prepared firebreaks. Head fires are usually the most risky fires of a planned burn, since they are pushed ahead by the wind, with consequent speed and long flame lengths. Where backfires usually creep along, head fires under extreme conditions can outrun people or vehicles.

After the headfire has swept the burn unit, mop-up begins. The entire burn area must be checked and any remaining fires or smokes watched until they burn themselves out or are extinguished. Take time to gather equipment and check its condition, and to talk to each crew member about the fire. Before leaving the burn site, walk the burn perimeter and make sure that the fire is completely out. Make notes about what seemed successful, as well as what didn't, about all aspects of the burn.

Reviewing the Burn

A prescribed burn is not over when the last wisp of smoke has dissipated. Equally important to prior planning are a post-burn critique and long-term monitoring of the burn site. A post-burn meeting should include as many of the participants as possible, and should review every aspect of the burn—planning, burning techniques, logistics, etc. Here is the chance to reinforce knowledge gained from the burn. Successful techniques can be shared, differences about burn management can be aired, mistakes discussed, corrections made to the prescription, and so on. Monitoring the burn site—observing species composition, vigor, effects on invading species, etc.—is equally important. Without monitoring, it is quite difficult to assess the effectiveness of the burn.

In summary, prescribed burns are integral to the continuing existence of many Midwestern natural areas. To use fire safely and effectively requires planning, including planning for emergency situations, and experience, especially knowledge of fire behavior in similar plant communities. Each prescribed burn is unique; no set of instructions applies universally. In managing fire, experience is truly the best teacher, and planning is all important. ◆

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Pre-Burn Fire Unit Checklist

Checklist for burn unit _____ , Site _____

Date(s) of burn: projected _____, attempted _____

Fire leader: initial each item to indicate compliance.

( ) Authorized fire leader present.

( ) All required permits are obtained, at the burn site, examined and valid at time of burn.

( ) Adjacent residents notified within past seven days of plan to burn.

( ) Professional forecast, obtained within two hours of ignition time, indicates weather is not expected to exceed maximum temperature or prescribed wind directions for at least two hours beyond projected fire duration.

( ) On-site check shows wind (speed and direction), temperature, and relative humidity (or fune fuel moisture) to be in prescription and consistent with forecast. Fuel conditions are within prescription.

( ) Equipment as required in fire prescription and logistics plan.

( ) Firebreaks as required in fire prescription and logistics plan.

( ) Crew number and qualifications as required in fire prescription and logistics plan.

( ) Each crew member with proper personal gear and clothing, matches.

_____ _____

Fire leader Date

Crew Briefing

( ) Objectives of burn.

( ) Exact area of burn.

( ) Hazards in and close to unit; volatile fuels, heavy fuels, spotting, crowning, fire whirls, poisonous plants, rough terrain, weak points in firebreak, burning under electrical lines.

( ) Defenses against hazards.

( ) Crew assignments: ignition, holding, mop-up patrol, fire behavior and weather, traffic, other.

( ) Ignition technique and pattern. Holding method.

( ) Locations of extra equipment, fuel, water, and vehicle keys.

( ) Equipment function checked.

( ) Authority and communications.

( ) Contingency plans following wind shift, equipment or firebreak failure, etc. Escape routes. Use of fire tent and/or black spotting method.

( ) Sources of assistance and how to get it. Nearest phone and emergency numbers.

( ) Special instructions regarding smoke management, contact with the public, other.

( ) Questions.

( ) Crew members given opportunity to decline participation.

So You Want to Burn? Getting a Taste of Smoke

For those interested in acquiring practical field experience, the Iowa Field Office of the Nature Conservancy is collecting names of people interested in attending a prescribed burning seminar planned for sometime in 1990. The Field Office also occasionally needs physically fit and experienced volunteers to staff its burning crews. Contact the Iowa Field Office, 431 E. Locust, Suite 200, Des Moines, Iowa 50312 (phone: 515-244-5044) if you are interested in the seminar or burn crew opportunities. The regional field staff of the Iowa Department of Natural Resources and many County Conservation Boards also conduct prescribed burns.

Before volunteering for any burn crew, you must be able to answer yes to the two following questions:

- Am I in good enough aerobic and physical condition to be able to work safely under continuing strenuous emergency conditions?
- Am I free from any other physical conditions which would limit my usefulness or functioning under a heavy workload?

Fires are dangerous and crew work is physically and mentally stressful—no matter how much you would like to participate in an prescribed burn, if you cannot answer both questions positively, find other ways to help out besides joining the burn crew.

At the request of an Iowa Prairie Blazingstar reader, the following account of a fire excerpted from Pioneer History of Pocahontas County (1904) is being reprinted here. This account is especially interesting because it describes weather conditions preceding the burn, mentions the season, and describes the movement of fire across the landscape. Historic accounts such as these are valuable in understanding what fire was like on the prairie landscape. If you are aware of additional accounts, however brief, please send them to Daryl Smith, Biology Dept., UNI, Cedar Falls, Iowa 50614. Daryl has been compiling similar accounts for several years.

The prairie fire, as it used to be, is now an event of the past in this county, and the following vivid description of a fearful one that passed over the county during this period of its history, (just after the war) from the pen of John M. Russell, of Lizard township, will be read with interest:

"One fine evening, about the middle of autumn and after the close of the war, the wind, as it ofttimes does, suddenly turned and came from the northwest. The weather for several weeks had been dry, and a hot wind from the south had prevailed for several days, withering the ripened grass on the prairie and rendering it inflammable as tinder.

About dusk a faint glow was observed in the sky to the northwest, the appearance of which was similar to that seen in the east on a clear night just before the rising of the full moon. This glow, as it was afterward learned, was caused by a fire on the prairie started by a settler several days previous along the Little Sioux river far to the southwest. Driven by the hot wind it had moved northward many miles through an uninhabited section and the side-fire had widened eastward to the west line of Pocahontas county. When the wind changed, this long line of fire began to move in a southeasterly direction over a vast expanse of territory.

To the observer in the Lizard settlement no flame was at first visible, but as the moments passed the horizon gradually grew brighter and about eight o'clock the flames of the "head-fire" could be distinctly seen. A little later several fine, luminous lines, like threads of tiny, sparkling beads, became visible. "Distance lends enchantment to the view" but the observers well knew that in those faint, glimmering lines of beauty there dwelt, in an ungovernable form, the most fiendish of devouring elements, fed by an abundance of dry prairie grass and driven by a powerful wind. In this instance the warning came before bedtime and opportunity was afforded to provide some protection against it. Those who were not already secure now went scurrying about with plows, scythes, matches, mops and buckets of water.

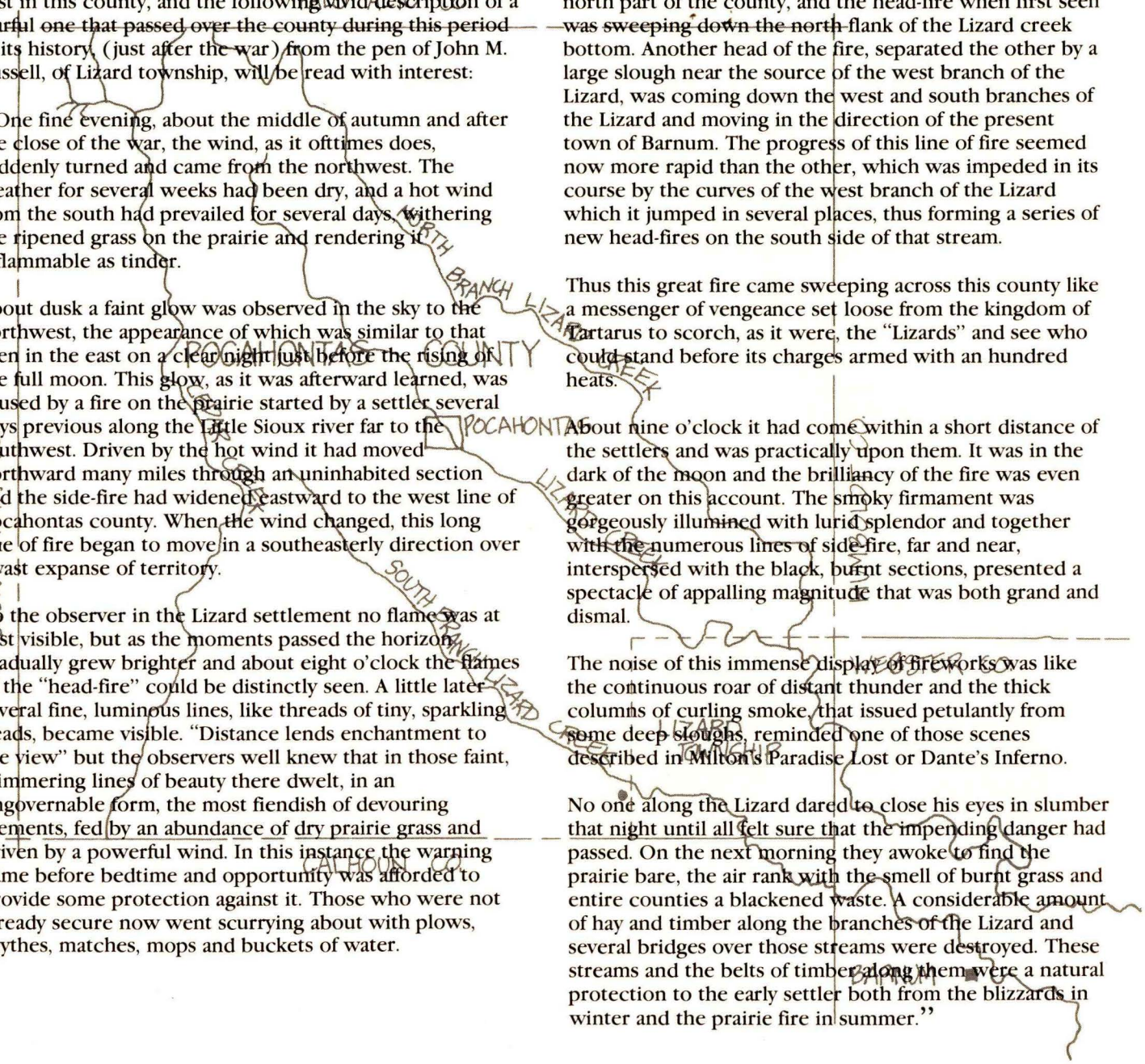
The fire had crossed Cedar creek in several places in the north part of the county, and the head-fire when first seen was sweeping down the north flank of the Lizard creek bottom. Another head of the fire, separated the other by a large slough near the source of the west branch of the Lizard, was coming down the west and south branches of the Lizard and moving in the direction of the present town of Barnum. The progress of this line of fire seemed now more rapid than the other, which was impeded in its course by the curves of the west branch of the Lizard which it jumped in several places, thus forming a series of new head-fires on the south side of that stream.

Thus this great fire came sweeping across this county like a messenger of vengeance set loose from the kingdom of Tartarus to scorch, as it were, the "Lizards" and see who could stand before its charges armed with an hundred heats.

About nine o'clock it had come within a short distance of the settlers and was practically upon them. It was in the dark of the moon and the brilliancy of the fire was even greater on this account. The smoky firmament was gorgeously illumined with lurid splendor and together with the numerous lines of side-fire, far and near, interspersed with the black, burnt sections, presented a spectacle of appalling magnitude that was both grand and dismal.

The noise of this immense display of fireworks was like the continuous roar of distant thunder and the thick columns of curling smoke, that issued petulantly from some deep sloughs, reminded one of those scenes described in Milton's Paradise Lost or Dante's Inferno.

No one along the Lizard dared to close his eyes in slumber that night until all felt sure that the impending danger had passed. On the next morning they awoke to find the prairie bare, the air rank with the smell of burnt grass and entire counties a blackened waste. A considerable amount of hay and timber along the branches of the Lizard and several bridges over those streams were destroyed. These streams and the belts of timber along them were a natural protection to the early settler both from the blizzards in winter and the prairie fire in summer."



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Integrated Roadside Vegetation Management

Integrated Roadside Vegetation Management (IRVM) is a county program using current management practices to establish and maintain a safe, stable, low maintenance roadside that is healthy and attractive for man and wildlife. Management practices include seeding regraded and bare roadsides with native prairie grasses and flowers, and spot spraying to control noxious weeds. Using safe and properly timed roadside burns to promote native vegetation and eliminating roadside disturbances that cover or kill established vegetation (such as soil deposition, herbicide drift, and refuse dumping). About one third of Iowa's 99 counties are implementing all or parts of the integrated roadside program on their county roads. An additional 50 counties are interested in working this program into their established roadside management program.

Many times the IRVM program begins with interested people and county policy makers joining together to explore the existing county roadside situation. First, a county roadside inventory is conducted to evaluate rural roadside conditions. Using the inventory, a County Roadside Plan is developed to clearly define county roadside goals and prioritize appropriate roadside activities. Public and private groups and individuals can become involved in roadside plantings and local community gateway projects. Landowners and communities alike benefit from an Integrated Roadside Vegetation Management program.

Twelfth North American Prairie Conference

The University of Northern Iowa at Cedar Falls will host the Twelfth North American Prairie Conference on August 5-9, 1990. The conference is a national event held biennially, which focuses on a broad range of topics including scientific studies of prairies and prairie organisms, prairie reconstruction and management as well as historical, aesthetic, anthropological, interpretive, and educational aspects of prairie. Conferences are attended by scientists, federal, state, and county conservation personnel, and prairie enthusiasts, and provide opportunity to sample a broad range of prairie information and experiences.

A tentative schedule of conference events has been established. Field trips will illustrate a variety of Iowa prairies, including the bluff prairies in the northeast part of the state; Hayden Prairie, a mesic swell-and-swale blacksoil prairie; the Loess Hills, an internationally unique ecosystem; Cedar Hills Sand Prairie, on eolian sand with plant communities similar to the Nebraska Sandhills; and sites illustrating prairie roadside management. Since the human perspective of the prairie is as diverse as the prairie itself, suggested topics for the conference include prairie management, prairie preservation, restoration and reconstruction, fire ecology, prairie roadside vegetation management, prairie systematics and ecology, prairie settlement, and prairie landscaping. Contests in prairie photography, art, landscape design, and floral design have been requested.

The 1990 prairie conference is expected to draw large participation due to Iowa's central location within the tallgrass prairie region. Dr. Daryl Smith, the conference director, has organized several committees including program, publicity, competition, accommodations, entertainment, and finances.

Those who wish to assist in some of the many aspects of planning, and those wishing to receive further information should contact Daryl Smith at 319-273-2238, or 319-273-2456, or write him at the 2759 McCollum Science Hall, UNI, Cedar Falls, Iowa 50614.

Current Prairie Literature

John Pearson
Des Moines, Iowa

Pyne, Stephen J. 1982. *Figure in America—A cultural history of wildland and rural fire.* Princeton University Press, Princeton, NJ.

This is a powerful book. Pyne's basic thesis is that fire has been a long-standing and pervasive influence on the natural history of the United States. Adopting an integrated ecological, sociological, and historical approach, Pyne outlines the importance of natural fire, Indian burning, frontier fire ethics, fire suppression, and modern fire management among several geographic regions: the Great Plains, the South, the Lake States, the Northern Rockies, the Northwest, southern California, and Alaska. It is *not* a scientific essay on the ecological effects of fire, but rather a philosophical discussion of the history of fire use (and non-use) in America. It is thought-provoking as well as informative. It challenges some beliefs closely held by naturalists, foresters, and lay people concerning the "naturalness" of fire and its influence on prairies, savannas, and forests.

I found the second chapter, "The Fire From Asia," to be especially interesting because it discusses the use of fire by Indians in the forest/prairie ecotone. Pyne strongly states that fire was widely and routinely used by Indians prior to settlement (and perpetuated for a time by transient white trappers, hunters, traders, and others), as illustrated by the following sample passages: "It is often assumed that the American Indian was incapable of greatly modifying his environment and that he would not have been much interested in doing so if he did have the capabilities. In fact, he possessed both the tool and the will to use it. That tool was fire. . . ." (p. 71) and ". . . so extensive were the cumulative effects of [Indian fire] modifications that it may be said that the general consequence of the Indian occupation of the New World was to replace forested land with grassland or savannah. . . ." (p. 79) and ". . . the evidence for aboriginal burning in nearly every landscape of North America is so conclusive, and the effects of fire suppression so visible, that it seems fantastic that a debate about whether Indians used broadcast fire or not should ever have taken place. . . ." (p. 81).

The view that prairies, savannas, and forests are merely expressions of a culturally controlled fire regime is controversial and cuts against the grain of the naturalistic philosophy of some traditions in ecological theory which view "natural" vegetation as communities in equilibrium with climate and soils (remember the "climatic climax" of Clements?). Pyne's thesis challenges the belief closely held by many preservationists that old-growth forests (or extensive forests of any age, for that matter) are "natural"; in general, he views forests as fire-deprived savannas and prairies which came into being after European settlement, especially upon the advent of modern industrial forestry. Regardless of whether you agree with this view of not, **Fire in America** is well worth reading.

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CHAPTER NINE

HERBICIDES

CHEMICALS

2,4-D

1. amine salt (extremely soluble in water)
    a. Tordon 101 R
    b. Tordon RTU
    c. Tordon 101 Mixture
       (Dow)
    d. Hi-Dep
       (PBI/Gordon)
    e. Banvel 720
    f. Banvel + 2,4-D
       (Sandoz)
2. low-volatile ester (insoluble in water)
    a. Crossbow
       (Dow)
    b. Weedone LV-4
    c. Weedone 638
    d. Weedone CB
    e. Envert 171
       (Rhone-Poulenc)
    f. Banvel 520
       (Sandoz)

3. Use- 2,4-D is a systemic herbicide and is widely used for control of broadleaf weeds in cereal crops and non-cropland. Most dicots are susceptible at normal herbcide rates. Salt formulations are the safest; they do not release enough vapors to cause damage off the treated areas. Spray apoplication is usually postemergence. Esters are absorbed most readily by leaves. Salts are absorbed most readily by roots. Following root absorption, 2,4-D translocates within the phloem. Following root absorbtion, it may move upward in the transpiration stream.

2,4-D causes abnormal growth response and affects respiration , food reserves and cell division; but the the primary mode of action has not been clearly established.

Bromacil

Hyvar XL (DuPont)- Used on non-cropland areas for control of a wide range of annual and perennial grasses and broadleaf weeds, and certain woody species. Bromacil is sprayed or spread dry as granules on the soil surface, preferably just before or during a period of active growth of weeds.

Chlorsulfuron

Telar (DuPont)- It has activity on most broadleaf weeds and some annual grass weeds. Certain perennials such as Canada thistle are sensitive. Preemergence or early postemergence treatments show the most activity to annual grass weeds and broadleaf weeds. Later postemergence traetments are effective to most broadleaf weeds but less effective on grasses. Thoroughly systemic after absorption by either the foliage or roots.

Dave Webber of Story County used a solution of Telar (2%) and 2,4-D that was very effective on equisitum.

Clopyralid

Transline (Dow Mike Stafford 317-471-3735)- As good as Tordon but not harmful to trees and shrubs. Best applied in the last week of May-June 10 or late vegetative stage after the thistle is up out of the grass no later than early bud stage, before the bud starts to swell and open. Once the bud starts to swell the carbohydrates are moving in the direction of the bud. We want the clopyralid to flow to the roots. Spraying can also be done in the fall. Not quite as effective as spring. Spray to wet. Anything that runs off is wasted. Transline costs $234.00 per gallon. For backpack sprayers mix 1/4 percent solution, one quart to 100 gallons. Use 50-70 gallons/acre. For larger systems such as hand gun mounted on a truck use one and half pints to 100 gallons of water. Use 70-80 gallons/acre. No your equipment output. Spray water into a bucket and time how long it takes to spray a gallon. Then you know how much chemical you have applied after spraying an area for five minutes. Practice spraying water on pavement to learn how fast you must walk to apply the right amount of chemical/acre.
Studies of Transline showed 26% of the herbicide applied is in the roots within 24 hours of spraying and it does not increase very much after that. So it gets there quickly which is good for rain washoff reduction.
To spot spray canada thistle use a 1/2 percent solution.

In the spring will get 98-100% control. In fall 60-70% control.

Dichlorprop

a. Weedone CB
b. Weedone 2,4-DP
c. Weedone 170
d. Envert 171
   Rhone-Poulenc

An effective herbicide in the control of some weeds also used for brush control in nonagricultural land.

Diuron

Karmex (DuPont)

A general weedkiller. For selective weed control is sprayed on soil as a preemergence. For general weed control diuron is sprayed or spread dry at any time except when the ground is frozen. Best results are obtained if sprayed just before weed growth begins; dense growth should be removed before application. Diuron is primarily absorbed through the root system and is translocated upward in the xylem.

Fosamine

a. Krenite Brush Control Agent
b. Krenite S Brush Control Agent
   (Du Pont)

A foliar spray for control of many woody species and field bindweed. Applied to woody plants during the 2 month period prior to fall coloration. There is no apparent affect until the

following spring. Plants fail to refoliate and subsequently die.

Glyphosate

Round Up (Monsanto)

A broad spectrum herbicide useful in crop, non-crop and aquatic weed control. It is non-selective and is very effective on deep rooted perennial species and on annual and biennial species of grasses, sedges and broadleaf weeds. Apply as postemergence spray to foliage of vegetation to be controlled. Glyphosate is absorbed through the foliage and translocated throughout the plant. Visible effects on annual species normallly appear in 2-4 days and on perennials in 7-10 days. Glyphosate uptake through the root system is precluded by soil inactivation of this product.

Roundup is the best fall herbicide application and it does the best job when applied in the fall.
If broadcasting roundup to kill canada thistle in the fall you will also kill your grasses. So must spot spray or wear rubber gloves and sponge it on.

Imazapyr

Arsenal (American Cyanamid)

For industrial and right-of-way use. Imazapyr has demonstrated excellent activity with residual control of a wide variety of annual and perennial weeds, deciduous trees, vines and brambles in non-cropland situations. Postemergence is the preferred application, especially for control of perennial species. For maximum herbicidal activity, weeds should be growing actively at the time of appplication. Absorbs actively through foliage and translocates actively from the soil via root systems.

Pendimethalin

? Stomp (American Cyanamid) ?

For use in crops as preemergence/early postemergence.

Picloram

Pathway RTU (A cut stump treatment.)
Tordon
Tordon K
Tordon 101 R and Tordon RTU
Tordon 101 Mixture
(Dow)

For control of most annual and perenial broadleaf weeds and woody plants. Most grasses are resistant at label rates. Readily absorbed by both tops and roots. Translocates both up and down in plants. Accumulates in new growth.

Simazine

Princep 4L (Ciba-Geigy)

Widely used selective herbicide for control of broadleaf and grass weeds in cropland and perennial grasses grown for seed or pasture. Also used as a Non-selective herbicide for vegetation control in non-cropland. Applied as either spray or granules. Simazine has little or no foliar activity and must be absorbed by

plant roots. Translocates to leaves and apical meristems and inhibits photosynthesis. It also has secondary effects which are responsible for the usually rapid plant death.

Sulfometuron Methyl

Oust (DuPont)

Effective broad spectrum herbicide with both pre and postemergence activity against many annual and perennial grasses and broadleaf weeds in non-cropland. Absorbed by leaves or roots, will move systemically by mass flow action with phloem solutes and in xylem. Suppresses and stops plant growth by arresting cell division in the growing tips or roots and shoots.

Tebuthiuron

Spike (Elanco)

Spike is used for brush and weed control in rangeland, for spot treatment in pastures and on noncropland areas for control of grasses, broadleaf weeds and woody plants. Tebuthiuron is sprayed or spread dry on the soil surface, preferably just before or during the period of active growth. Initial herbicidal response is enhanced by rainfall. Tebuthiuron is readily absorbed through roots, less so through foliage.

Triclopyr

Garlon 4(Dow)

Crossbow (Dow)

Tordon 1 plus 2 Mixture

An auxin type selective herbicide for control of many woody plants and broafdleafweeds. Most grasses are tolerant. Used for brush control on permanent grass pasture. Applied as aerial foliage spray, basal or tree injection. Readily absorbed by foliage or roots. Translocates both up and down in plants. Accumulates in meristematic tissue.

CHEMICALS USED BY IRVM COUNTIES

	Weeds	Brush
2,4-D	CG, GR, HO, MU, PA, PO, SA	WA
2,4-D amine	CLI, HU,	CLI
2,4-D ester	CLI	CLI
AM 40	WB	
Arsenal	LI	
Banvel	BH	
Banvel CST		ST
Brayton Brushkiller		BUC, WB
Chopper		WB
Crossbow	WA	HA
Envert 171	SA, WA	
Esteron 99	BH	
Garlon 4	BH, ST, WA	
Hi Dep	BH, CLI	
Hyvar	ST	
Hyvar XL	JO	
Karmex DF	LI	
Krenite	DM	CG, PO
Krenite S	BH, CLA	ST
LV-4 2,4-D	GU, BUT	
Mirage	CLI	
Oust	LI	
Pathway		HA, LI, PO, CLA
Pathfinder		HA
Princep 4L	LI	
Round Up	CLI, DM, FA, LE, LI, MU, PA, PO, SA,	CG, WA
Spike	FA	
Stomp	LI	
Telar	CG, HA, HU, SA, ST, WB	
Tordon RTU	BUC, DM	BUC, CG, FA, LI, MU, PA, WA, WS
Tordon		HO, LE
Transline	FA, HA	
Visko-Rhap RTU	GU	
Weedone LV-4	WE	
Weedone DPC	HA,	
Weedone DPC amine	HA	
Weedone 638	CR, FA	FA
Weedone CB		WB
Weedone 170		LI
Weedone	LE	

Vegetation Management Guideline: Multiflora Rose: (*Rosa multiflora* Thunb.)

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(Note: The following vegetation management guideline was produced by the Illinois Nature Preserves Commission for controlling numerous exotic and native aggressive plant species in natural areas. Individual guidelines are based on current knowledge of Illinois natural areas managers, and was written by the author indicated and edited by Mary Kay Solecki of the Illinois Nature Preserves Commission.)

Multiflora rose, originally introduced from eastern Asia for wildlife cover and food, has become a serious invader of agricultural lands, pastures, and natural areas. This shrub readily invades prairies, savannas, open woodlands, and forest edges. It also may occur in dense forests, particularly near disturbances such as treefall gaps. It is a thorny, bushy shrub that can form impenetrable thickets or "living fences" and smother other vegetation. It is a serious pest species throughout the eastern United States.

Multiflora rose is named for the clusters of many white flowers born on this perennial bramble during May or June. The flowers develop into small, hard fruits called hips that remain on the plant throughout winter. The great majority of plants develop from seeds remaining in the soil relatively close to plants from which they were produced. Birds and mammals also consume the hips and can disperse them greater distances. Rose seeds may remain viable in the soil for 10 to 20 years. Multiflora rose also spreads by layering, i.e., where tips of canes touch the ground and form roots, and by plants that arise from shallow roots.

In high quality natural areas, multiflora rose can be controlled by removing individual plants, prescribed burning, repeated cutting, or cutting followed by cut-stem treatment with herbicide. Pulling, grubbing, or removing individual plants from the soil are effective when all roots are removed or when plants that develop from severed roots are subsequently destroyed. These approaches are most practical for light, scattered infestations. In fire-adapted communities, a routine prescribed burn program will hinder invasion and establishment of multiflora rose.

Research indicates that three to six cuttings or mowings per growing season for more than one year can achieve high plant mortality. Such treatment may need to be repeated for two to four years. Increased mowing rates (6+/season) did not increase plant mortality. In high quality communities, repeated cutting is preferred overmowing, because repeated mowing will damage native vegetation as well as multiflora rose.

Cutting stems and either painting herbicide on the cut stem with a sponge applicator (sponge-type paint applicators can be used) or spraying herbicide on the cut stem with a low-pressure hand-held sprayer, kills root systems and prevents resprouting. Roundup herbicide (a formulation of glyphosate) has effectively controlled multiflora rose when used as a 10- 20% solution and applied directly to the cut stem. Although the Roundup label recommends a higher concen-tration for cut-stem treatment (50100%), the lower concentration has proven effective. With this technique, herbicide is applied specifically to the target plant, reducing the possibility of damaging nearby, desirable vegetation. Cut-stem treatment is effective late in the growing season (July-September), and also during the dormant season. Dormant season application is preferred because it will minimize potential harm to nontarget species. Glyphosate is a nonselective herbicide, so care should be taken to avoid contacting nontarget species.

In addition, triclopyr (trade name Garlon 3A) can be applied to cut stems or canes for selective control of multiflora rose. Use a hand sprayer to spray Garlon 3A, diluted in water at a rate of 50%, on the cut surface; application should be within a few

hours of cutting. Use of Garlon 3A is best done in the dormant season to lessen damage to nontarget species. Great care should be exercised to avoid getting any of the herbicide on the ground near the target plant since nontarget species may be harmed. Avoid using triclopyr if rain is forecast for the following one to four days; otherwise run off will harm nontarget species. By law, herbicides must be applied according to label directions and by licensed herbicide applicators or operators when working on public properties.

For large populations on severely disturbed areas, mowing can be substituted for cutting of individual plants. However, mowing multiflora rose can result in flat tires; filling mower tires with foam is recommended.

On degraded areas, fosamine (trade name Krenite) can be applied as a foliar spray in a 2% solution plus 0.25% surfactant (2.5 ounces of Krenite plus 0.5 ounce surfactant per gallon of water). The Krenite S formulation contains the appropriate amount of surfactant. Coverage of foliage should be complete. Krenite should be applied only during July-September. No effects will be observed during the autumn season following application. Slight regrowth may occur the following season but canes will die during summer. Fosamine kills only woody species, is nonvolatile, and therefore is the preferred foliar spray treatment.

Dicamba (trade name Banvel) is an effective foliar spray that can be used in severely disturbed sites, though Krenite is preferred. Banvel is selective against broad leaf plants, so care must be taken to avoid contacting desirable, broadleaf vegetation. It can be applied as a foliar spray in a 1% solution (1.3 ounces of Banvel per gallon of water). Though this solution can be applied any time during the growing season, best results are obtained during May and June when plants are actively growing and flow ering, following full emergence of leaves. One-half ounce of a surfactant should be added when treating dense foliage; complete coverage of all green leaves will enhance control in late season applications.

Do not spray Krenite or dicamba so heavily that herbicide drips off the target species. Foliar spray of herbicides should only be used in less sensitive areas because of problems with contacting nontarget species. By law, herbicides must be applied according to label directions and by licensed herbicide applicators or operators when working on public properties.

Glyphosate (trade name Roundup) is an effective foliar spray when applied as a 1% solution to multiflora rose plants that are flowering or in bud. Roundup is not a recommended chemical treatment, however, since it is nonselective and the selective herbicides mentioned above are effective. Nevertheless, Roundup can be used as a foliar spray during the growing season on severely disturbed sites if care is taken to avoid contacting nontarget plants. Roundup should not be used as a foliar spray during the growing season in high quality natural areas because it can result in damage to nontarget species. Roundup is useful as a foliar spray for target plants that remain green and retain their leaves after native vegetation is dormant or senescent.

Multiflora rose does not fit this description adequately and is controlled most effectively when treated during the growing season.

No effective biological controls that are feasible in natural communities are known. Rose rosette disease is a sometimes fatal viral disease that attacks multiflora rose and other roses. It is not considered a useful biological control at this time because it also may infect native roses and plums, as well as commercially important plants in the rose family such as apples, some berries, and ornamental roses.

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Vegetation Management Guideline: Cut-Leaved Teasel (*Dipsacus laciniatus* L.) and Common Teasel (*D. sylvestris* Huds.)

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The genus *Dipsacus,* commonly known as teasels, includes aggressive exotic species with the capacity to dominate prairies and savannas once established. Lack of natural enemies allows teasel to proliferate. If left unchecked, teasel quickly forms large monocultures that exclude other native vegetation. Cut-leaved teasel is more aggressive than common teasel and has severely threatened several northern and central Illinois natural areas.

A single teasel plant can produce over 3000 seeds and, depending on conditions, up to 30-80% of these seeds will germinate. Seeds may also remain viable for at least two years. Seeds typically don't disperse far; most seedlings will be located around the parent plant. Parent plants often provide an optimal nursery site for new teasel plants after the adult dies. Dead adult plants leave a relatively large area of bare ground, formerly occupied by their own basal leaves, which new plants readily occupy. It is possible that teasel seeds can be water-dispersed, which would allow them to be dispersed over longer distances.

Cutting, removal, burning, and herbicides offer the best solutions for control of these two species. Each of these control methods is being researched.

In small natural areas, rosettes can be dug up using a dandelion digger. As much of the root as possible must be removed to prevent resprouting, just as with dandelions. As an alternative, the flowering stalks can be cut at ground level once flowering has initiated. The plant should not reflower and will die at the end of the growing season. Cut flowering stalks should be removed from the natural area because immature seed heads can produce viable seed on the stem even after cutting. A very small percentage of cut plants may reflower if they are not cut low enough. The area should be visited again to cut any reflowering stems. Cutting the stalk before flowering should be avoided because the plant will usually send up one or more new flowering stalks. This treatment (cutting of flowering stems) may have to be repeated for several years to control teasel. Teasel in nearby areas should also be eliminated to prevent introduction of new seed.

Foliar application of glyphosate, triclopyr amine, or 2,4-D amine herbicide is recommended where cutting (and removal) or digging-up is not feasible. Glyphosate is available under the trade name Roundup, triclopyr amine is available under the trade name Garlon 3A, and 2,4-D amine is available under various trade names.

Glyphosate is nonselective, so care should be taken not to let it come in contact with nontarget plants. Although glyphosate is most effective during the summer when the plant is actively growing, it is also effective in late fall or early spring. In the fall, teasel rosettes remain green and active after most prairie plants have died back. They green up and start growing again in the spring before many of the prairie plants. Application at these times will result in less harm to nontarget species.

Roundup should not be used to control teasel in natural areas during the active growing season of most native plants because other native species could be injured. Roundup should be applied carefully by hand sprayer to individual teasel rosettes at a 1.5% solution (2 oz. Roundup/gallon of clean water) during late fall or early spring.

Application should be made on a spray-to-wet basis. Spray coverage should be uniform and complete. Do not spray so heavily that herbicide drips off the target species.

Triclopyr and 2,4-D amine are selective for broadleaf plants; they will not harm most grasses. These herbicides can be applied to the rosettes when green. Flowering plants should be treated early to prevent the possibility of viable seed production. 2,4-D amine and triclopyr should be applied by hand sprayer at the recommended application rate on the label for spot-spraying weeds. Application should be uniform: the entire leaf should be wet. The amine formulations of 2,4-D and triclopyr should be used rather than the ester formulations to reduce vapor drift.

Which ever herbicide is used, it should be applied while backing away from the treated area to avoid contacting the wet herbicide. By law, herbicides must be applied according to label instructions and by licensed herbicide applicators or operators when working on public properties. Spraying of herbicide on the rosettes should be followed by cutting of flowering stalks that survive spraying. Late-spring burns may be useful for controlling teasel before it becomes dense. Once an area is densely covered with teasel rosettes, fire does not carry well through the teasel-infested area. Prescribed burns probably work best in conjunction with other methods indicated above.

Natural areas should be monitored periodically for teasel invasion. New plants should either be dug up or flowering stems should be cut and removed as described above. Periodic fall or late-spring prescribed burns should help control teasel.

No biological control of teasel is known that is feasible in natural areas.

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Leafy Spurge (*Euphorbia esula* L.) A Challenge in Natural Areas Management

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Leafy spurge *(Euphorbia esula)* L. is an enterprising weed with a 3 million acre roothold which, according to recent studies, is expanding (Sun 1981). Many natural area managers are faced with control problems, yet there has been no research designed to determine management for control of leafy spurge on nature preserves and other areas managed for natural integrity. The following review briefly summarizes existing research in leafy spurge control and points out important considerations which can be used to counter its invasion in natural areas.

Leafy spurge has a high degree of resistance to most standard treatments for three main reasons. First, it is very persistent, having a high proportion of its biomass located in relatively inaccessible roots. Bakke (1936) has shown two years of repeated plowing throughout the growing season to be the only means of directly attacking the roots.

Plowing is not a viable option for treating leafy spurge on natural areas, but herbicide application is a frequent choice. The roots seem resistant or only partially susceptible to some major herbicides, probably due to differential absorption and translocation (Bybee 1979). For example, one of the most widely used herbicides, 2,4,-D, has only moderate impact except at very heavy application rates (Alley 1979, Vore and Alley 1980) or with multiple applications per year (Selleck et al. 1962). Some applications of the phenoxy herbicide, Tordon, have been 100% effective (Alley 1979, Alley and Vore 1980), but even those well planned cases of apparent complete effectiveness deserve monitoring for a couple years, and must be weighed in light of other impacts.

A second factor in controlling leafy spurge is its resistance to stress. It is moderately drought resistant, having a thick leaf cutinization, sunken stomates, and a thick cork layer surrounding the roots (Hanson and Rudd 1933). The viscous white latex throughout the plant has its own distinctive starch grain (Hanson and Rudd 1933). The extensive root system has enormous starch deposits in both translocation and storage tissue (Bakke 1936). These carbohydrate reserves are readily built up so that a seedling seven days after germination can grow back when its stem is clipped (Selleck et al. 1962). No studies to date have demonstrated a treatment timing, effective in depleting carbohydrate reserves, except that chemical treatments have had a relatively high success rate when employed at the end of seed production (Messersmith pers. comm.).

Stress put on leafy spurge in most non-chemical treatment studies is not adequately severe to eradicate the plant. Mowing initially increases stem density (Selleck et al. 1962); results of repeated mowing have not been reported. Sheep have shown a preference for leafy spurge and have reduced it to a nonspreading stubble over four years (Johnston and Peck 1960). Fire impact seems to have varied with season, though results are inconclusive. Only four studies are known to have recorded leafy spurge fire response. These were conducted at different times in the growing season, and only two were deliberately aimed at controlling leafy spurge. A summary of these studies is presented in Table 1. The remaining non-chemical option, biological control, is in an exploratory phase. Release of the spurge hawkmoth (*Hyles euphorbiae*) has not proven adequate in itself (Forwood and McCarty 1980; Montana Agricultural Experiment Station 1979), but some select combination of leafy spurge's 96 European pests might together effect control (Harris 1979). These methods have not been tried in concert. Only mowing has been tried in conjunction with chemical control to break leafy spurge resistance.

TABLE 1. Leafy spurge response to fire

Author	Time of Burn	Site	Research Question	Response Measure	Result
Barker, W *	Early May 1979-81	Sheyenne Nat'l Grass lands, ND	General control by fire	Stem counts	Increase
"	Early Oct 1980	"	"	"	"
Bjustad, A. * & D. Noble	Oct. 20-23, 1980	Western SD	Seed viability	Seedling Counts	Decrease
Dix, R.L.	Sept 30, 1958	Roosevelt Nat'l Mem. ND	Vegetation comparison of burn vs unburned areas	Frequency	Decrease
Olson, W.W	June, 1973	Tewaukon Nat'l WR, ND	"	% Canopy Coverage	No Change
"	August, 1973	"	"	"	"
"	June, 1974	"	"	"	Increase
"	August, 1974	"	"	"	"

* Personal Communication

The third reason that leafy spurge is difficult to control is the readiness with which it reproduces. Vegetative reproduction is the primary means of increasing stem density. Seeds are capable of starting new colonies through dissemination by water, animals, and self-propulsion over short distances. They retain their viability in the soil for up to five years (Bakke 1936). Furthermore, the species is a habitat generalist, occupying a wide range of soil textures, topographic positions, and sunlight exposures (Selleck et al. 1962). Though it is usually most severe on the most highly disturbed mesic sites, it can inhabit a broad range of disturbance conditions. Consequently, it cannot be locally isolated within some single habitat or disturbance condition.

Generally when control is attempted, coordinated management efforts are necessary for optimal effectiveness. Noble and McIntyre (1979) found that range condition is important in affecting both seedling vigor and population density. Other studies have shown that leafy spurge seedlings seem to be sensitive to competition, thereby reducing shoot vigor (Morrow 1979) and fecundity (Bakke 1936, Selleck et al. 1962). As a result, early spring grazing may complicate the spurge problem by decreasing the ability of cool season grasses to compete for water. The same affects have not been studied in relation to native grasslands but the vigor of a surrounding native plant community could be a deterrent to leafy spurge population explosions.

In addition, land managers must consider specific local problems. For example, natural area sites must be viewed in light of leafy spurge occurrence on nearby properties. Eliminating leafy spurge infestations is a local all-or-none effort. A perspective on the extent of local management problems should be gained from the local experts.

The urgency of the situation must also be carefully assessed. Factors which would in most cases warrant immediate action are large leafy spurge populations or extensive areas of potential habitat near existing populations. There are potential alternatives to immediate action. Experimental designs might be established using chemical or the under-documented non-chemical controls, either alone or in combination. A land manager might also wait in dealing with the problem until local support is rallied or until more experimental results come in, while continuing to monitor the leafy spurge population.

Vegetation Management Guideline: Siberian elm *(Ulmus pumila* L.)

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If a nearby seed source exists, Siberian elm *(Ulmus pumila)* L. invade, and in a few years, dominate dry and mesic prairie areas particularly if they have been subjected to past disturbance. Because Siberian elm tolerates a variety of conditions, such as poor soils and low moisture, it occurs in dry regions, along roadsides, in pastures, in grasslands, as well as in moist soils along streams.

Siberian elm flowers in spring before leaves begin to unfold. The samaras follow quickly and are disseminated by wind, allowing the species to form thickets of hundreds of seedlings on bare ground. Seeds germinate readily and seedlings grow rapidly.

Control of this alien tree can be achieved through girdling, cutting, burning, or herbicides. No biological controls are known that are feasible in natural areas.

Girdling trees is the preferred management technique where practical. It should be performed in late spring to mid-summer when the bark easily peels away from the sapwood. Girdled trees die slowly over one to two years and do not resprout. The bark and phloem must be removed from a band around the tree trunk and the xylem must remain intact. If a tree is girdled too deeply, it will respond as if it had been cut down and will resprout from the roots.

Two parallel cuts 7-10 cm apart, cutting through the bark slightly deeper than the cambium, are needed. The bark is knocked off using a blunt object such as an ax head. The girdles should be checked every few weeks at first to make sure bark does not develop over the cut area.

If girdling is not an option, trees and any subsequent resprouts can be cut. If time or personnel constraints prevent cutting the new sprouts, the stumps created by the initial tree cutting can be treated with Roundup (a formulation of glyphosate) to prevent resprouting. While the Roundup label recommends a 50 to 100% concentration of Roundup for stump treatment, a 10 to 20% concentration has proven effective. Roundup can be applied to the cut stump either by spraying the stump with a low pressure hand sprayer or wiping the herbicide on the stump with a sponge applicator. Care should be taken to prevent contacting nontarget plants with the herbicide, especially in high-quality natural areas. By law, herbicides must be applied according to label instructions and by licensed herbicide applicators or operators when working on public properties.

Seedlings can be pulled out by hand and small trees can be removed carefully with a grub hoe. Elm seeds blowing in from nearby areas are often a greater threat than resprouting of established elms.

A regular fire regime should control Siberian elm in fire-adapted communities. Annual mowing may be appropriate in some situations, especially where nearby seed sources cannot be removed. Siberian elms should be controlled in areas surrounding a preserve whenever possible.

various ecotypes may respond differently to similar control practices (Barreto et al. 1980). There are also no foolproof techniques; the methods of application, phenological timing, and weather conditions, each call for independent considerations.

In summary, there is not a perfect prescription for control of leafy spurge in natural areas. Citations in this review provide an overview of the options and points to consider. County agents, state experimental stations, and the new Leafy Spurge Newsletter serve as clearinghouses for new developments in the field at large. A review of leafy spurge biology is being prepared by Galitz (in press). Finally, we must make the results of leafy spurge control efforts on natural areas available to other land managers and the scientific community.

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Vegetation Management Guideline: Leafy Spurge *(Euphorbia esula* L.)

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Leafy spurge *(Euphorbia esula* L.) is a deep-rooted perennial plant that is adapted to a wide range of soil moisture conditions from moist to dry. It is aggressive especially in very dry situations where competition from native species is not intense. Areas most sensitive to leafy spurge infestation include pastures, roadsides, abandoned fields, railroad right-of-ways, disturbed and undisturbed mesic to dry prairies, and possibly open natural communities such as savannas.

Leafy spurge emerges in the early spring when temperatures fluctuate around freezing. At this time seedlings may be deep red or purplish in color. As the temperature rises, the main stem is replaced by rapidly growing adventitious stems and, if the plant is over a year old, flowers may appear as early as May. After 4-6 weeks, each stalk may produce and disperse over 200 seeds with a germination rate of 60-80%. However, in spite of this impressive germination rate, the key reproductive capabilities of leafy spurge remain underground: the root system of the plant is very extensive. Vegetative reproduction from both crown buds and root buds explain not only the persistence of this weed, but the difficulties encountered in eradicating it as well. Even if the foliage of the plant is removed or destroyed, the living root tissue will regenerate new shoots, and the new shoots can emerge from buds located anywhere along the length of the root.

Leafy spurge is well-established in the central plains of the United States where much time and effort is directed at its control. Most agree that the key to stopping this pest is the ability to destroy its root system. Until a biological control can be found, herbicides appear to be a temporary solution. Picloram (trade name Tordon) is the most effective herbicide being used against leafy spurge on rangelands, but it has not yet been recommended for high-quality natural areas in Illinois.

It is important to recognize leafy spurge as a pest immediately; the initial invading populations must be treated to prevent the plant from spreading any farther. The sooner one attacks leafy spurge--in its first year if possible--the better the chances of controlling it. All of the methods below may need to be repeated annually for 5-10 years.

On natural areas, prescribed burning in conjunction with herbicides may be more effective than either method alone. Burning stimulates vegetative growth, making the plant more vulnerable to herbicides. Plants can be sprayed with 2,4-D in autumn (September) and burned the following spring (April). This should be followed by another 2,4-D treatment in June and a fall burn in October. The process may have to be repeated many times.

For top-growth control, the herbicide 2,4D amine can be sprayed on the foliage in a 2% solution twice a year. The most effective time to apply the herbicide is mid- to late June when the true flowers (not the bracts) begin to appear. The second spray application should be made in early to mid September when fall regrowth has begun but before a killing frost occurs.

The nonselective herbicide Roundup (a formulation of glyphosate) sprayed on leafy spurge foliage as a 5% solution will provide 80-90%

top-growth control if applied between mid-August and mid-September. A follow-up treatment with a 2% solution of 2,4-D amine between mid-June and mid-July of the following year is necessary to control seedlings.

Apply the herbicide with a hand-sprayer until the spray coverage is uniform and complete. Do not spray so heavily that herbicide drips off the target species. Roundup is a nonselective herbicide that kills grasses and broadleaf plants. 2,4-D is a selective herbicide that kills broadleaf plants, but not grasses. Try to spray leafy spurge only, and carefully avoid contacting nontarget species. Native nontarget plants must be available to recolonize the site after leafy spurge is controlled. The herbicide should be applied while backing away from treated areas to avoid walking through the wet herbicide. By law, herbicides must be applied according to label instructions and by licensed herbicide applicators or operators when working on public properties.

Mowing or hand-cutting is not completely effective because the root remains undamaged and new sprouts will reappear rapidly Also, mowing would have to be done continuously because it stimulates development of inflorescences on the lateral branches.

Hand-pulling, digging, or tilling is not effective because the entire root system must be excavated for complete control of leafy spurge.

Pulling or digging can rip or cut the root into smaller pieces, leaving portions to resprout. This method could actually increase the number of plants.

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Vegetation Management Guideline: White and Yellow Sweet Clover *[Melilotus alba* Desr. and *Melilotus officinalis* (L.) Lam.]

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White and yellow sweet clover readily invade open areas and have successfully exploited many native prairies and open, unflooded communities. These sweet clovers are adapted to a variety of conditions, withstanding both hot and cold climates. They grow well in direct sunlight and partial shade, but do not tolerate dense shade. The dense growth of a second-year sweet clover plant produces enough shade to cause its own lower leaves to fall. Sweet clovers prefer calcareous or loamy soils with a pH level of 6.5 or greater. These two species occur in roadsides, abandoned fields, pastures, on railroad ballast, and in any unflooded, open natural community such as prairie.

Sweet clover is an obligate biennial; the plant puts its energy into developing a healthy root system during the first season and during the second season it flowers, sets seed, and dies. In the first growing season, sweet clover is entirely vegetative. A small, branched stem with pinnately compound, trifoliate leaves is visible. In late summer, the root continues to develop. By the second year sweet clover has a strong taproot and root crown from which new shoots emerge. The plants flower May-September, producing hardy little seeds that may remain viable in the soil for up to 30 years or more. After setting seed, the plant dies. Because sweet clover dies after the second year, seed production is critical for its continued existence; this is the key to controlling it. If the flowering stage of sweet clover is halted, so is the spread of the plant--as long as management procedures continue long enough to deplete viable seeds remaining in the soil.

Hand-pulling sweet clover is an effective control if done when the ground is moist and most of the root can be removed. The best times to hand pull sweet clover are in the late fall after the first-year plant root-crown buds have developed, or anytime early in spring before second-year plants develop flower buds. Fall weeding is recommended because (1) the bright green sweet clover is easily spotted within the yellowing prairie, (2) moist fall conditions and an immature first-year root make pulling easier, and (3) fall weeding is less stressful to native vegetation. However, sweet clover also is easily located in the spring because it greens up before native prairie vegetation. Hand-pulling in summer is labor-intensive and must be done consistently. This treatment is feasible for light and moderate infestations, but may be too time-consuming in heavy infestations.

In large, dense colonies of sweet clover, cutting first- and second-year stems close to the ground with a hand-held scythe is effective if done after leaves on the lower stems have died (before flowering occurs) and up to early stages of flowering (before seeds form). Sweet clover usually does not resprout when the stems are cut close to the ground during this time.

Prescribed burning can control sweet clover. A combination of an April burn in the first year, followed by a May burn the next year is most successful in eradicating an even-aged stand of sweet clover. A hot, complete, first-year April burn scarifies sweet clover seeds, stimulating them to grow. A late-fall burn will also have this effect. A hot, complete, second-year May burn kills the emerging shoots before they go to seed. Heavily infested stands are best controlled performing the above sequence twice, separating each

treatment by two years without burning. Problems with this method may arise if the burn is patchy, leaving viable seeds or second-year shoots unscathed.

In an uneven-aged stand of sweet clover, second-year clover may escape the harmful effects of the early first-year burn because their shoots were not fully emerged. These plants would live to set seed. In this case, a combination of other procedures can be used: (1) later spring burns (after shoots emerge, but before second-year plants set seed) in a sequence of three to five years, or (2) follow up the early burn with handpulling, if practical.

In an even-aged stand of sweet clover, fall mowing can speed up the two-year burn program: burn in April; mow first-year plants in August, leaving the stems behind to dry; and burn again in mid-late September.

Herbicide can be useful for controlling large sweet clover populations. Following a fall burn, hand spray individual seedlings with an amine formulation of 2,4-D according to label instructions in spring, before native prairie vegetation emerges. This treatment also is effective when plants are in the cotyledon stage (i.e., when seed leaves appear in the development of the seedling). To reduce vapor drift, use an amine formulation of 2,4-D rather than an ester formulation. A 1% solution of Mecamine (2,4-D plus Dicamba) applied to the foliage as a spray is very effective. The herbicide, 2,4-D amine is selective for broadleaf plants.

When applying either herbicide described above, spot application should be done such that coverage is uniform and the entire leaf gets wet. Precautions should be taken to avoid contacting nontarget plants with the solution. Do not spray so heavily that herbicide drips off the target species. By law, herbicides must be applied according to label instructions and by licensed herbicide applicators or operators when working on public properties.

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Vegetation Management Guideline: Canada Thistle (*Cirsium arvense* (L) Scop.)

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Canada thistle (*Cirsium arvense* (L.) Scop.), an alien species, is capable of crowding out and replacing native grasses and forbs. It is detrimental to natural areas, particularly nonforested communities, and it can alter the natural structure and species composition where it becomes well established. Prairies, barrens, savannas, and glades that have been disturbed or are undergoing manipulative restoration management are susceptible to invasions. In addition, it can spread from adjacent disturbed sites into sedge meadows and wet prairies.

This dioecious, weedy perennial occurs in patches and thrives in disturbed areas such as overgrazed pastures, old fields, waste places, fencerows, and roadsides. Occasionally, it occurs in wet areas where water levels fluctuate, such as stream banks and ditches. This thistle is not usually a problem in undisturbed prairies, good to excellent pastures, or woodland. Plants are tall and the sparse flower cluster is lax on sites that are shaded most of the day.

Introduction of Canada thistle into new areas occurs mostly by windborn seed. Sometimes seeds are carried by run-off in ditches. Once introduced, the species spreads rapidly by rhizomes or root segments. Lateral roots 0.9 m or more deep spread from a fibrous taproot. Aerial shoots occur at 0.8- to 2.4-cm intervals. Basal leaves are produced the first year and flowering stems the next. Pollination is mostly by honeybees; wind pollination is limited. Most seeds germinate within one year. Some seeds immediately produce rosettes before winter and emerge to flower the next spring.

Seeds remain viable in soil up to 20 years in some cases. Emergence typically occurs in May, and vertical growth follows in June. As frequency of Canada thistle increases at a site, species diversity decreases, possibly as a result of allelopathic substances produced by the thistle.

Prescribed fire is an effective and preferred treatment for controlling this species. Late spring burns, between May and June, are most detrimental to this noxious weed and should be used whenever possible. Burns should not be conducted early in the spring, as early spring fires can increase sprouting: and reproduction of this species. During the first three years of control efforts, burns should be conducted annually.

Management practices that maintain and encourage the development of healthy stands of native species will help prevent establishment of Canada thistle or help shade and weaken plants on sites already infested.

Repeated and frequent pulling or handcutting of individual plants will eventually starve underground stems. Cutting or pulling should be done at least three times each season, in June, August, and September. This treatment is feasible for light and moderate infestations but may be relatively time consuming in heavy infestations. Grazing is not an effective control measure as prickles on the plant prevent livestock from grazing near Canada thistle.

Spot application of the amine formulation of 2,4-D used according to label instructions can control this plant. Individual plants of Canada thistle should be treated with a wick applicator or hand sprayer. The herbicide 2,4-D amine is selective for broadleaf plants. To reduce vapor drift, use an amine formulation of 2,4-D rather than an ester

formulation. Precautions should be taken to avoid contacting nontarget plants with the solution. Do not spray so heavily that herbicide drips off the target species. Chemicals should be applied while backing away from the areas to avoid walking through the wet herbicide. By law, herbicides may be applied on public properties only according to label directions and by licensed herbicide applicators or operators.

On large disturbed or buffer sites (old fields, ditch banks, roadsides) with heavy infestations, Canada thistle should be mowed when in full bloom, and as close to the ground as possible. Cut flower heads should be removed to prevent scattering seeds on site. Repeated mowing may be needed for several years to obtain adequate control.

A foliar application of a 1-2% solution of Roundup (a formulation of glyphosate) applied in spring when plants are 15 to 25 cm tall is an effective herbicide treatment on disturbed sites. Individual plants should be spot-treated with a wick applicator. Roundup normally kills the entire plant, including the roots, when applied in this manner. Roundup is a nonselective herbicide and precautions should be taken to avoid contacting nontarget plants with the solution. Do not spray so heavily that herbicide drips off the target species. As with 2,4-D amine, Roundup should be applied while backing away from the areas to avoid walking through the wet herbicide. Roundup should not be used in high-quality natural areas during the growing season because of the possibility of harming nontarget plants.

On severely disturbed sites with heavy infestations, such as cropland or abandoned cropland, the site could be plowed and sowed to a cover crop (wheat, alfalfa, rye), if practical and desirable. The following May, the cover crop should be plowed under and desired native species should be seeded. Tillage disturbance of soil that is not followed by sowing a cover crop may provide favorable conditions for reinvasion and for introduction of other exotics.

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Canada Thistle (*Cirsium arvense*): A Literature Review of Management Practices

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INTRODUCTION

Canada thistle (*Cirsium arvense* L.) Scop. was introduced to North America in the early 1600s and is now widespread throughout the northern United States and all provinces of Canada (Detmers 1927, Hodgson 1968, Moore 1975) where it is considered one of the most tenacious and economically important agricultural weeds. It is responsible for tens of millions of dollars in direct crop loss annually and additional costs for herbicides and other control practices (Hodgson 1968, Messersmith 1980, Wilson 1980). Canada thistle is also known to harbor destructive insects and plant pathogens, to cause infections in grazing animals, and to seriously complicate mechanical harvesting and processing of certain vegetables (Link and Kommedahl 1958).

Much has been written about Canada thistle but little has been applied to management of natural areas. Two particularly valuable reviews are by Hodgson (1968) and Moore (1975).

BIOLOGY

Description and Habitat. Canada thistle is in the family Asteraceae. It is a slender, branching, perennial herbaceous plant standing up to 1.5 m (Figure 1). Detailed descriptions are available in botanical texts (e.g., Steyermark 1963). Canada thistle has optimal growth with 50 to 75 cm annual rainfall and on irrigated land (Hodgson 1968). It is occasionally found in droughty areas, such as sand dunes (Moore 1975). It also occurs in wet areas such as stream banks, lakeshores, along ditches, marshes, or in muskeg (Moore 1975); however, several botanists have observed that high water tables or poorly aerated soils limit growth (Rogers 1928; Bakker 1960, Hodgson 1968, Moore 1975).

Canada thistle seedlings are vulnerable to shading with mortality occurring at light intensities 20% or less of full daylight, and development delayed in seedlings exposed to 60% to 70% of full sunlight (Bakker 1960). Shading and day length are apparently the most impo1xant factors determining the local distribution of Canada thistle. Canada thistle may flower under 18 hours of light per day, but produces few flowers in the range of 8 to 12 hours. (Link and Kommedahl 1958; Hodgson 1968). Moore (1975) observes that in shaded areas Canada thistle becomes tall and lax, producing few flowerheads. Bakker (1960) reports an average density of 39 shoots per m^2 with an average of 41 flower heads per shoot in open sites, and a density of 11 shoots per m^2 with an average of 18 flower heads per shoot in shaded areas. Patches of Canada thistle are characteristically found in disturbed areas such as agricultural land, roadsides, ditch spoil banks, gopher mounds, and overgrazed pastures (Moore 1975) where shade is absent.

Vegetative Reproduction. Vegetative reproduction is by rhizomes and creates the characteristic colonies or beds (Steyermark 1963). Seedlings first develop a fiberous taproot that thickens and produces lateral roots within several months. Nodes are produced at the lateral roots at 6 to 12 cm intervals and produce an aerial shoot and numerous small rootlets that act as absorption and storage sites (Moore 1975). Lateral root growth can exceed 6 m in one growing season (Rogers 1928, Hayden 1934) and vertical roots have been traced to 6.75 m depth (Rogers 1928). Thus, a single seedling can produce a large patch through vegetative propagation alone. Each clone can expand indefinitely, breaking into smaller patches.

Canada thistle also regenerates from root cuttings. Tests show that 14% of pieces as small as 3 to 6 mm thick and 8 mm in length could produce shoots, while 100% of pieces 12.5 mm long could produce shoots

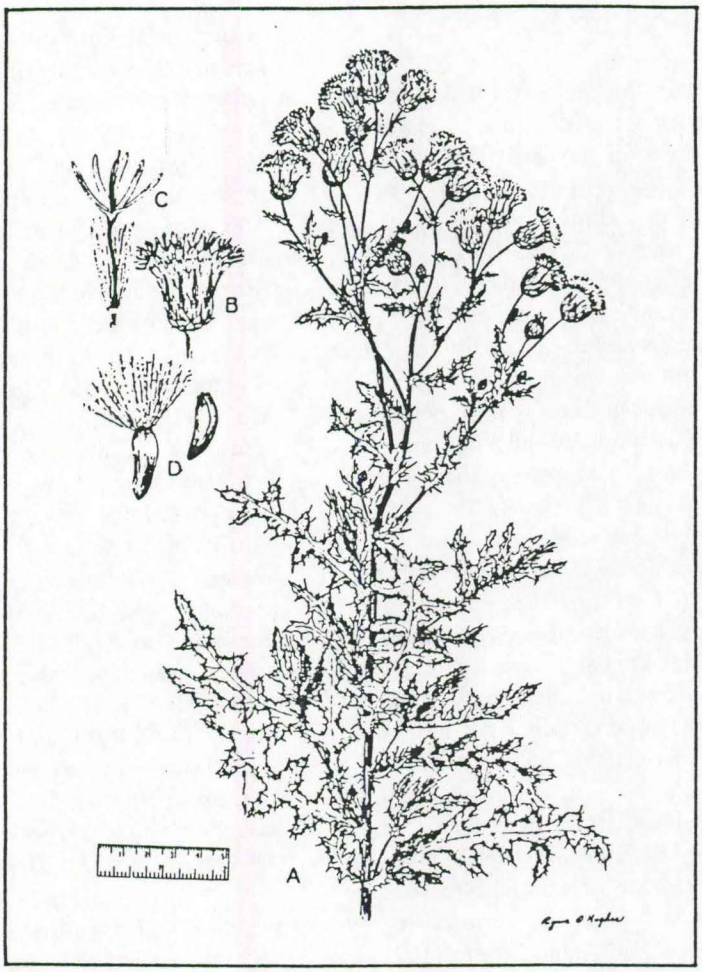

Figure 1. *Cirsium arvense*. A. Habitat; B. Head; C. Flower; D. Achnes
Reprinted with permission from: Selected Weeds of the United States, U.S. Department of Agriculture, Government Printing Office, 1970.

(Prentiss 1889, Hayden 1934). Root segments 3 cm thick and 6 cm in length could regenerate shoots in as short an interval as 5 days (Sagar and Rawson 1964).

Seed Production and Germination. Canada thistle is dioecious. Staminate flowers are easily recognized in the field by abundant pollen, and pistillate flowers can be distinguished as the seed matures by the large pappus on the flower (Hodgson 1968). Cross-pollination success is a function of distance. Hodgson (1964) reports that a high proportion of seeds are produced when parent plants are 17 m apart. Seed production decreases as the distance between parent plants increases from 33 to 200 m (Hayden 1934) and only a small percentage of seeds are produced from plants up to 390 m apart (Amor and Harris 1974).

Pollination is mostly by honeybees (Detmers 1927) and wind pollination is limited (Derscheid and Schultz (1960).

Each carpellate head produces up to 83 seeds (Derscheid and Schultz 1960) and one plant can produce up to 5,300 seeds, with an average annual production of 1,530 seeds per plant (Hay 1937). Seed size varies among different ecotypes, ranging from 298,000 to 677,000 seeds per pound (Hodgson 1968).

Thistle germination studies report that maximum germination rates occur at a constant 30°C (Bakker 1960, Wilson 1979) or alternating temperatures of 20 to 30°C or 30 to 40°C (Wilson 1979). Germination rates are as high as 95% (Hayden 1934) and vary among different ecotypes (Hodgson 1964). Germination is inhibited at osmotic pressures greater than 5 bars, but 2% germination occurs even at 15 bars (Wilson 1979). Optimal pH for germination is 5.8 to 7.0 (Wilson 1979). Canada thistle seeds have remained viable in soil for more than 20 years (Goss 1924, Toole and Brown 1946). Canada thistle seeds retain viabililty after storage in water for four months, but viability declines greatly after this (Bruns and Rasmussen 1957).

Seed dispersal is poorly documented. The pappus, a modification of the calyx in composites, is an aid in wind dispersal of thistle seed. Bakker (1960) reports seed dispersal by wind. There is some evidence for seed dispersal by run-off in drainage ditches (Wilson 1979).

Canada thistle produces a succession of seedlings from a single crop of seeds. Some seeds germinate immediately, produce rosettes before winter, and emerge to flower the first spring. Other seeds germinate in spring and even later (Moore 1975). About 90% of all seeds germinate within one year after dispersal (Roberts and Chancellor 1979).

Heitlinger (pers. comm.) has observed that many of the Canada thistle patches on natural areas managed by The Nature Conservancy are on areas around ponds and wetlands where water levels fluctuate, areas around old haystacks that are burned off as part of prairie management, areas of soil erosion, gopher mounds, old fields and abused pastures, and areas impacted by deposition of a mixture of snow and dirt blown from agricultural fields during winter. On these types of disturbed sites, Canada thistle seedlings can grow rapidly, taking

advantage of reduced competition in disturbed patches.

Canada thistle apparently cannot become established or spread in undisturbed or good to excellent condition pastures. Amor and Harris (1975) report no seedlings established from seed artificially sown in pastures, while 7% to 13% of seeds sown in bare dirt nearby emerged and 78% to 93% of these seedlings survived. Hodgson (1968) states that within spring wheat plots, Canada thistle increased in abundance by 192% in 4 years, while over the same interval it declined to 1% of its previous value in alfalfa fields mowed twice yearly for hay.

Phenology and Physiology.
Emergence time varies locally with different ecotypes (Hodgson 1968) but generally begins in early May when mean weekly temperatures reach 5° C. Rosette formation follows, with the period of most active vertical growth (about 3 cm per day) in mid-to-late June. Growth declines in July and is about zero in August. Flowering in Montana and South Dakota is from early June to August (Hodgson 1968, Van Bruggen 1976) and from mid June to September in western Canada (Moore 1975).

Minimal root carbohydrate reserves occur immediately prior to flowering. The amount of water soluble sugars in the roots declines from early spring until the onset of flowering (June), remains constant during flowering (June to August), and then increases in the early fall (September to October) (Bakker 1960). Root carbohydrates decline from emergence until the onset of flowering (late June), then increase from June to September, and remain about constant in the fall (Hodgson 1968).

Allelopathy. There is some evidence that Canada thistle produces allelopathic substances. Aqueous extracts from roots and shoots inhibit wheat (*Triticum aestivum*), flax (*Linum usitatissimum*) pigweed (*Amaranthus retroflexus*) and green foxtail (*Setaria viridis*) (Helgeson and Konzak 1950, Stachon and Zimdahl 1980). Species diversity in pastures declines as the relative frequency of Canada thistle increases (Stachon and Zimdahl 1980, Wilson 1981). Crop growth is inversely proportional to the amount of treated thistle residue in the soil and leaf leachate has an inhibitory effect on adjacent crop plants (Wilson 1981). Although the toxin has not been isolated, allelopathy may explain the absence of annual broadleaf plants from thistle patches (Stachon and Zimdahl 1980) and the absence of other species such as annual thistles (Bendall 1975). In addition, autotoxicity has been advanced as an explanation for the degeneration of patches of Canada thistle (Amor and Harris 1975).

MANAGEMENT

Thistle control problems on natural areas fall into two general categories (M. Heitlinger, pers. comm.). First, on high quality portions of a natural area, certain management practices, such as broadcast use of herbicides, are not desirable. Here, managers should consider low impact treatments such as fire, spot mowing, spot chemical or wick applicatians of herbicides and possibly biological control. A second category includes areas heavily infested with thistle, such as old pastures, ditches, or buffer lands. In these cases management practices used in agriculture may be the most cost effective treatment.

Cultivation. Cultivatian can be used to control Canada thistle, but plowed areas are susceptible to re-invasion. The most effective cultivation technique is to plow to a soil depth of 10 cm when new thistle shoots are 8 to 10 days old and to repeat this at 21 day intervals (Seely 1952) thus destroying all shoots so that no new food is stored in the root stocks (Hodgson 1968).

Mowing. Repeated mowing at 21 day intervals will weaken surviving stems and prevent seed production (Seely, 1952). Hodgson (1968) found that mowing alfalfa fields twice annually, at early-bud to preflowering stage (early-to-mid June in Montana) and early fall (September) reduces thistle to 1% of its initial value in four years. A single mowing at early-bud stage accomplishes top removal when Canada thistle root carbohydrate reserves are minimal (Hodgson 1968).

Grazing. There are no available data on the effect of different stocking rates or grazing intensities on Canada thistle. It seems likely that some grazing practices would encourage the spread of Canada thistle, both from the spread of seed and from the localized disturbances created by grazing, such as animal trails and wallows. Other thistle species (*C. lanceolatum* and *C. undulatum*) have been observed to increase with grazing (Tomanek and Albertson 1953, Ankle 1963, Hetzer and McGregor 1951). Additional information is needed to adequately determine the effect of grazing on Canada thistle.

Prescribed Fire. Olson (1975) contrasted the response of warm season dominated grassland to May and June burns. May burns produce short-term increases in Canada thistle compared to a control, but thistle abundance declines below that of the control within two growing seasons. Immediate reductions in thistle are found following June burns. In the same study, May burns in cool season grassland produced immediate reduction of thistles in comparison to a control.

Chemical Control. One problem in thistle control is that herbicide translocatian to the deep and extensive root system and numerous root buds is often insufficient to kill root buds (Mc Intyre and Hunter 1975, Baradari et al. 1980). When herbicides are applied to foliage, translocation in

Canada thistle is reduced toward shoots and roots below the area of application. The herbicide picloram tends to accumulate in shoot apices when applied through leaves or roots (Sharma and Vanden Born 1973). Burt (1974) observed that 14C-labelled atrazine moves with the transpiration system in the shoot but has only a slight effect on areas of the plant below herbicide application. Baradari et al. (1980) report similar results with 14C-labelled dicamba: about 32% of the foliar-applied herbicide is absorbed, but almost all of this remains in young growing leaves, with only 0.6% moving to the roots.

Improving herbicide translocation to root buds in Canada thistle has been a major focus for recent research. Lish and Messersmith (1979) report greater translocation of glyphosate plus 2,4-D to leaves and stems below the treated area when the herbicide is applied to stems instead of leaf surfaces.

Translocation to roots was greater when the herbicide was applied on the upper leaf surface. While translocation to the roots is not affected by herbicide concentrations on the treated leaf surface, translocation to plant parts above that surface increases with increasing herbicide concentrations and with increasing treated leaf surface area.

Plant age may have an effect on glyphosate translocation (Sprankle et al. 1975). In older plants, at bud to flowering stage, translocation was significantly less than in younger plants.

Drought stress also may affect herbicide absorption and translocation. Lauridson et al. (1980) conducted laboratory experiments on Canada thistle with 14C-labelled picloram, dicamba, and glyphosate at three moisture stress levels. Total plant absorption of glyphosate and dicamba decreases with increasing water stress, while picloram absorption remains constant. Translocation to apical meristems declines for dicamba with increasing water stress and remained constant for the other chemicals. Translocation to root buds declines for glyphosate with increasing water stress, while translocation of the other chemicals tested was not affected. Related field studies in Nebraska show that glyphosate effectiveness declines overall with increasing drought stress, while picloram and dicamba effectiveness were not as changed.

Baradari, et al. (1980) show that increased translocation of certain herbicides to the root buds of Canada thistle can be caused by growth regulators, such as morphactins, that act to inhibit auxin transport and thus stimulate lateral bud growth. Leaf absorption of dicamba is doubled (64% versus 32%) and basipetal translocation is increased more than 10 fold (9.0% versus 0.6%) with simultaneous addition of a plant growth regulator compared to application of dicamba alone.

Herbicide translocation is also stimulated by the simultaneous addition of nitrogen fertilizer. The application of 30 lbs. nitrogen and 100 lbs. phosphate per acre annually in combination with 0.75 to 2.0 lb/A of 2,4-D was more effective in controlling Canada thistle than the herbicide alone (Hodgson 1968). When Canada thistle is grown in a low nitrogen environment, a subsequent increase of nitrogen stimulates root bud growth and production of aerial shoots (McIntyre and Hunter 1975). Translocation of stored carbohydrates to the root buds at this time would make Canada thistle vulnerable to herbicides.

Numerous herbicides have been used for Canada thistle control. Some of the earliest chemicals used for thistle control were saline brines (Hodgson 1968) which are presently not used due to their expense. Other studies are summarzied in Table 1 [note the effectiveness of a rope-wick applicator to apply glyphosate (Poisson 1981)].

Biological Control. Moore (1975) and Maw (1976) review the native insect species found in Canada that might limit the spread of Canada thistle. There are at least 80 species of phytophagous insects as well as 51 species of visitors, parasites, and predators on Canada thistle. [The most important of these are the two beetles (*Cassia rubiginosa* Muell. Coleoptera: Chrysomelidae, and *Cleonus piger* Scop., Coleoptera: Curculionidae), a fly (*Orellia ruficauda* Fab., Diptera: Tephritidae) and the painted lady butterfly (*Vanessa cardui* L., Lepidoptera: Nymphalidae).] Maw reports that none of these are effective in controling Canada thistle in any area, even though *C. rubiginosa* can be numerous enough to defoliate the thistle in local areas, and *O. ruficauda* may destroy up to 70% of thistle seeds in some areas. In addition to these insects, the American goldfinch, as well as other birds, eat Canada thistle seed (Detmers 1927).

There has been an extensive search for natural control agents for Canada thistle in Europe and Asia. Peschken (1971) identified more than 80 insects that feed on Canada thistle in Europe. Attention has focused on four species. The gall fly *Urophora cardui* (Diptera: Tephritidae), the stem-mining weevil *Ceutorhynchus litura* (Coleoptera: Curculionidae), the flea beetle *Altica carduorum* (Coleoptera: Chrysomelidae) and the leaf weevil *Lema cyanella* (Coleoptera: Chrysomelidae). There is also interest in species of rusts of the genus *Puccinia*. The gall fly *Urophora cardui* is a native of Europe, ranging from Sweden to France to southern Russia. The life history has been summarized by Peschken et al. (1982). The female lays eggs in the growing tips of terminal or side shoots of Canada thistle. The larvae produce multilocular galls that have a thick nutritive layer which acts as a food source for the larvae. The mature

Table 1. Summary of Herbicide Treatments for Canada Thistle

Herbicide	Application Rate	Locality	Date of Application	Effectiveness	Reference
2,4-D	1 to 2 lb/A	n.a.	early bud stage plus early fall	"control"	Bakke (1947)
2,4-D	2 lb/A	Montana	June 12 & Oct.12 (8 leaf rosette to early bud stage)	89% in 3 mo. 35% in 1 yr.	Hodgson (1968)
2,4-D	1 to 1.5 lb/A	n.a.	newly emerged (10 to 15 cm tall)	"control"	Sylvester (1974)
Glyphosate	1 kg/ha	Montana	June 10 (15 to 20 cm tall) June 24	80% "not as good"	Brattain and Fay (1980)
Glyphosate	2 kg/ha	Idaho	emergence	"control"	Belles, et al. 1980
Glyphosate	various	na.	various. early	"control"	Schumacher, et al. 1980
Glyphosate	1-2 lb./A	South Dakota	June & Sept.	92% 1st year. Came back strongly after second year.	Messersmith 1978
Alyphosate	20%-50% conc. sol. in rope-wick applicator	n.a.	n.a.	"control"	Poisson 1981
Amitrole	4 lb/A	Montana	June 12 & July 8	100% in 3 mos. 89% in 1 yr. 82% in 2 yr.	Hodgson 1968
Picloriam (plus 2,4 D)	1 + 1 lb/A	n.a.	n.a.	97-99%	Alley & Humburg 1979
Picloriam	0.5-1.1 lb/A	Montana	early July	90-100% over 2 yrs.	Hodgson 1968
Dicamba	0.5-1.0 lb/A	Montana	early July	80-94% first year but 10% 2nd year	Hodgson 1968
Dicamba	4 lb/A	n.a.	n.a.	"control"	Alley & Humburg 1979
3,6-dichloro-picolinic acid	0.1-0.2 kg/ha (3,6-DCP)	n.a.	rosette stage (5-25 cm tall)	"control"	Benndoin, et al. 1981 Lake & Bennett 1980
3,6-DCP	0.7 kg/ha	n.a.	early bud stage	"control"	Cagnieul, et al. 1981

larvae overwinter and pupate in the early spring inside the gall. The adults emerge in spring through channels prepared by the larvae the previous fall.

The effect of *U. cardui* on Canada thistle is reduction of shoot size and vigor (Peschken and Harris, 1975). Seedhead production is also inhibited (Laing, 1978). The net effect on the plant is determined by the size of the gall, which is correlated to the number of larvae in each plant. Unfortunately, studies in western Canada have shown that *U. cardui* tends to spread out before reaching a dense population. The same study found that even an average of 13 galls per shoot did not reduce thistle abundance in the absence of other factors (Peschken et al. 1982).

Host specificity studies have shown that *U. cardui* is strongly attracted to Canada thistle, but also will utilize *Cirsium vulgare* Ten. and *Carduus*

acanthoides L. (Peschken and Harris 1975,. *U. cardui* has been released at different sites in Canada since 1975. It has become established in Ontario, Quebec and New Brunswick, but not in western Canada. Winter mortality in the west apparently does not entirely explain the failure of these colonies (Peschken et al. 1982).

The stem-mining weevil *Ceutorhynchus litura* is also European. The female lays eggs in the main vein of leaves in the rosette stage. When the larvae hatch, they mine from the veins into the stem and root collar. At one site in Ontario, *C. litura* reduced Canada thistle to 4% of the initial density within four years (Peschken and Beecher 1973), although part of this decline is attributed to the presence of the rust *Puccinia punctiformis* (Moore 1975). *C. litura* is established in the Canadian provinces of British Columbia, Alberta, Saskatchewan, Ontario, and New Brunswick (Peschken and Wilkinson 1981) and Montana (Story 1979). A related species, *C. trimaculatus*, has been imported for control of musk thistle (*Carduus nutans*) and also preys on Canada thistle to some extent (Kok et al. 1982).

The flea beetle *Altica carduorum* is a European species. The adult consumes leaves anly of certain *Cirsium* species including Canada thistle. The females lay eggs on the undersides of leaves along the edges of veins in June. The adults feed continuously on thistle leaves throughout the summer, and then overwinter in the soil. Some adults survive to emerge next spring and lay eggs (Schaber et al. 1975). *A. carduorum* has been introduced in Canada and South Dakota, but is not yet established. In South Dakota, high temperatures, low humidity, and predators limited the beetle (Schaber et al. 1975). In Canada, colonies survive only in situations where larvae are protected from predators by cages (Peschken, et al. 1970).

The leaf-eating beetle *Lema cyanella* is widespread in Europe, Siberia, Mongolia, and Manchuria (Peschken and Johnson 1979). The life history has been summarized by Peschken and Johnson (1979). The female lays eggs on both sides of thistle leaves while in the rosette stage. The larvae hatch in 8 to 17 days and feed on both sides of the leaves. The larvae pupate in the soil in a cell constructed of soil particles cemented together. Pupation lasts 8 to 21 days, and *L. cyanella* overwinters as an adult. Host specificity studies in North America reveal a strong preference for Canada thistle, but other species that are eaten include *Silybum marianum, Carduus nutans, C. crispus, Cirsium undulatum, C. flodmanii, C. occidentale, C. quercetorum, C. brevistylum,* and *C. foliosum*. Further studies will be conducted before any releases (Peschken and Johnson 1979).

There are a number of rust species having all stages of the life cycle occur on the same host that are co-extensive with Canada thistle. Tumer et al. (1981) found that different ecotypes of Canada thistle had different resistance levels to the rust *Puccinia obtegens*. Because Canada thistle patches often consist of a single ecotype, infections have been proposed as a way to reduce field populations. Turner et al. (1981) found that Canada thistle inoculated with urediospores produces only small, localized pustules. Inoculations using teliospores prevented seed production and reduced the competitive ability of adult plants (Ososki et al. 1979). Watson and Keogh (1981) inoculated Canada thistle with the rust *P. punctiformis*. Almost 100% of the plants died after inoculations with urediospores of this rust, and secondary infections were observed on all healthy plants adjacent to those which were diseased.

INTEGRATED PEST MANAGEMENT AND SUMMARY

Many researchers have stated that no single control method is effective for Canada thistle. This species is a prime candidate for an integrated pest management (IPM) program where a combination of management treatments is designed to magnify the strengths and minimize the weaknesses of each treatment.

There are three important characteristics of the biology of Canada thistle that help in designing an IPM program. First, carbohydrate reserves are minimal in the time interval from early-bud stage to immediately prior to flowering. This is the time top removal treatment (mowing, prescribed fire) would most stress Canada thistle. Second, herbicide translocation to root buds is stimulated by the simultaneous addition of nitrogen fertilizer, or the addition of plant growth regulators, such as Chlorflurenol (a morphactin). There are a number of factors to consider about herbicide application, such as drought stress, method of application, and target treatment areas on the plants. In general, there is greater translocation to the root buds during the rosette stage (approximately 5 to 25 cm tall). Third, shading can prevent seedling establishment of Canada thistle, and may inhibit the spread of established patches (Hodgson 1968). Good grassland management is a key to reducing Canada thistle. This observation may modify some control practices. For example, as discussed in the section on prescribed fire, areas dominated by cool-season grasses might be better burned in May than June. Although this is not the time of minimal root carbohydrates for Canada thistle, it will be less stressful on the co-occurring grasses than a June burn.

Integrated pest management programs for Canada thistle in agricultural areas involve a combination of plowing to 10 cm depth in the spring or fall,

Vegetation Management Guideline: Wild parsnip *(Pastinaca sativa* L.)

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Note: The following vegetation management guideline was produced by the Illinois Nature Preserve Commission for controlling numerous exotic and native aggressive plant species in natural areas. Individual guidelines are based on current knowledge of Illinois natural areas managers, and was written by the authors indicated and edited by Mary Kay Solecki of the Illinois Nature Preserves Commission.

Wild parsnip *(Pastinaca sativa* L.) has become a serious problem in some mesic prairies. Well-established prairies are not likely to be invaded by parsnip, but it can become quite abundant on prairie edges and in disturbed patches within otherwise high-quality prairies. Once established at the edges, parsnip can spread into adjacent high-quality areas.

Although this Eurasian native thrives in rich, alkaline, moist soils, it can survive under almost any conditions. Wild parsnip commonly can be found along roadsides, in pastures, and in fields.

Wild parsnip exists as a basal rosette for at least one year and then flowers and dies. Wild parsnip produces a rosette of large, grooved, upright leaves and stores reserves in a large, fleshy taproot during the first year. A hollow flowering stem is sent up from the center of the rosette the following growing season. Wild parsnip often flowers and sets seed during its second year, although it may not flower until subsequent years.

Many people are sensitive to the touch of the leaves and soon develop a rash if their skin contacts the leaves or plant sap in the presence of sunlight. A very painful rash can develop, which in some people leaves scars that persist for several months or longer. Wild parsnip is most irritating at the time of flowering. When undertaking control measures, care should be taken to avoid skin contact with the toxic sap of the plant tissues by wearing gloves, sleeves, and long pants.

Although eradication of this exotic is desirable from an ecological as well as human safety standpoint, in some situations one control measure is to do nothing. In high quality prairies, aggressive growth by other species can sometimes eventually displace the parsnip.

The best control is achieved mainly through hand-pulling. Plants should be pulled and removed so that seeds do not develop and plants do not resprout. Wild parsnip is easiest to pull right after rain or during a drought, when the root shrinks. Another effective practice involves cutting the plant below the root crown before seed set during spring of the second year. It is best to do this as soon as flowers appear but have not matured. Since the plants do not all flower at once, the area should be rechecked several weeks after the first cutting and the following two or three years for newly flowering plants. After a spring burn, wild parsnip rosettes are among the first plants to emerge and may be detected easily and dug out to control their abundance along prairie edges. Seeds do not remain viable if dormant in the ground more than four years, so the species can be controlled if there is no outside seed source. Although the practices of hand-pulling, cutting, and digging have been successful in small areas with scattered plants, these practices can become difficult and time-consuming if patches containing hundreds of plants have been allowed to spread unchecked.

Mowing or cutting the base of the stem with a scythe can be effective if it takes place after flowering when the plant is mature and blooming, but before seed set. Parsnip must be removed or recut often and checked later for small flowering shoots near the ground. Poorly timed mowing, as is likely along roadsides, may increase both number of seedlings and percentage surviving to maturity. Mowing probably favors parsnip maturation by allowing more sunlight to reach immature parsnip plants,

which are too low to be damaged by the mower. Mowing also reduces the density, height, and flowering of other species that are potentially good competitors against parsnip, such as common goldenrod.

If mechanical methods have failed to control wild parsnip or are not

feasible, a 2% spot application of the herbicide Roundup (glyphosate) to basal rosettes is a recommended treatment. Roundup should be applied to individual plants with a hand sprayer in late fall after most native vegetation is dormant. Late fall application minimizes the potential harm to nontarget species. It may be necessary to treat the same area again annually until missed plants and plants originating from the seed bank are eliminated. Roundup is a nonselective herbicide and should not be used in high-quality natural communities during the growing season because of the possibility of harming nontarget plants.

The herbicide 2,4-D (available under a variety of trade names), mixed according to label directions and applied to individual parsnip basal rosettes between March and May or between August and October, is effective. This herbicide should only be used on buffer or severely disturbed sites, and not in high-quality natural communities if it is applied during the growing season. Repeated early spring applications of this chemical before the flower stalk begins to elongate will reduce infestation of wild parsnip.

Care should be used to avoid contacting nontarget plants when applying either herbicide. Do not spray so heavily that herbicide drips off the target species. Native nontarget species will be important in recolonizing the site once the parsnip dies. The herbicide should be applied while backing away from the treated area to avoid contact with herbicide. By law, herbicides must be applied according to label directions and by licensed herbicide applicators or operators when working on public properties.

Burning does not successfully control parsnip because it removes litter and taller plants, providing favorable conditions for parsnip rosettes to develop. However, periodic burning maintains the vigor of native plants, allowing them to compete with parsnip.

The parsnip web worm damages some individual plants severely, but is not known to eradicate whole patches and is not likely to be useful as a biocontrol agent.

GENERAL REFERENCES

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CHAPTER TEN

APPENDIX:

IRVM DIRECTORY

IRVM LEGISLATION

IOWA WEED LAW

PRODUCT LIST

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314.16 to 314.18 Reserved.

314.19 Reseeding open ditches.

The department shall have the topsoil of each open ditch along the side of a highway reseeded with prairie grass seed and the seed of other adapted grass and legumes including native grass species after the construction, reconstruction, improvement, repair, or maintenance of a highway whenever feasible.

84 Acts, ch 1114, §1

314.20 Utility easements on highway right-of-way.

The department shall develop an accommodation plan for the longitudinal utility use of freeway right-of-way, in consultation with the utilities board. The plan shall be consistent with the rules of the federal highway administration of the United States department of transportation and shall be submitted to the federal highway administration for its approval by January 1, 1989. In developing the plan, the department shall provide for extended payment and lease agreements to provide continuous funding for the living roadway trust fund. The plan shall provide for charges for the use of the right-of-way and all moneys collected shall be credited to the living roadway trust fund established under section 314.21.

88 Acts, ch 1019, §9; 89 Acts, ch 246, §4

Use of moneys in fund for other projects; §314.21

314.21 Living roadway trust fund.

1. The living roadway trust fund is created in the office of the treasurer of state. The moneys in this fund shall be used exclusively for the development and implementation of integrated roadside vegetation plans. Except as provided in subsections 2 and 3, the moneys shall only be expended for areas on or adjacent to road, street, and highway right-of-ways. The state department of transportation in consultation with the department of natural resources shall establish standards relating to the type of projects available for assistance. For the fiscal period beginning July 1, 1988, and ending March 31, 1990, the moneys in the fund shall be expended as follows: fifty-six percent on state department of transportation projects; thirty percent on county projects; and fourteen percent on city projects.

A city or county which has a project which qualifies for the use of these funds shall submit a request for the funds to the state department of transportation. A city or county may, at its option, apply moneys allocated for use on city or county projects under this subsection toward qualifying projects on the primary system. The state department of transportation in consultation with the department of natural resources shall determine which projects qualify for the funds and which projects shall be funded if the requests for the funds exceed the availability of the funds. In ranking applications for funds, the department shall consider the proportion of political subdivision matching funds to be provided, if any, and the proportion of private contributions to be provided, if any. In considering the proportion of political subdivision matching funds provided, the department shall consider only those moneys which are in addition to those which the political subdivision has historically provided toward such projects. Funds allocated to the cities, the counties, and the department which are not programmed by the end of each fiscal year shall be available for redistribution to any eligible applicant regardless of the original allocation of funds. Such funds shall be awarded for eligible projects based upon their merit in meeting the program objectives established by the department under section 314.22. The department shall submit a report of all projects funded in the previous fiscal year to the governor and to the general assembly on January 15 of each year.

Beginning April 1, 1990, the moneys in the living roadway trust fund shall be allocated between the state, counties, and cities in the same proportion that the road use tax funds are allocated under section 312.2, subsections 1, 2, 3, and 4. However, after April 1, 1990, a city or county shall not be eligible to receive moneys from the living roadway trust fund unless the city or county has an integrated roadside vegetation management plan in place consistent with the objectives in section 314.22.

2. *a.* The department may authorize projects which provide grants or loans to local governments and organizations which are developing community entryway enhancement and other planting demonstration projects. Planning, public education, installation, and initial maintenance planning and development may be determined by the department to be eligible activities for funding under this paragraph. Projects approved under this paragraph require a local match or contribution toward the overall project cost.

b. The department may authorize projects which provide grants or loans to local governments for the purchase of specialized equipment and special staff training for the establishment of alternative forms of roadside vegetation. Projects approved under this paragraph require a local match or contribution toward the overall project cost.

c. The department, in order to create greater visual effect, shall investigate alternatives for concentrating plantings at strategic locations to gain a greater visual impact and appeal as well as stronger scenic value. Equal attention shall be given to providing safe and effective habitats for wildlife which can coexist with highways.

d. The department may authorize projects which provide grants or loans to local jurisdictions for increased protection through the use of easements, fee title acquisition, covenants, zoning ordinances, or other provisions for protection of vegetation and desirable environment adjacent to the right-of-way. Off-right-of-way projects shall emphasize vegetation protection or enhancement, scenic and wildlife values, erosion control and enhancement of vegetation management projects within the right-of-ways.

3. *a.* Moneys allocated to the state under subsection 1 shall be expended as follows:

(1) Fifty thousand dollars annually to the department for the services of the integrated roadside vegetation management coordinator and support.

(2) One hundred thousand dollars annually for education programs, research and demonstration projects, and vegetation inventories and strategies, under section 314.22, subsections 5, 6, and 8.

(3) All remaining moneys for the gateways program under section 314.22, subsection 7.

b. Moneys allocated to the counties under subsection 1 shall be expended as follows:

(1) For the fiscal period beginning July 1, 1989, and ending June 30, 1991, fifty thousand dollars in each fiscal year to the university of northern Iowa to maintain the position of the state roadside specialist and to continue its integrated roadside vegetation management pilot program providing research, education, training, and technical assistance.

(2) All remaining money for grants or loans under subsection 2, paragraph *"a"*.

c. Moneys allocated to the cities shall be expended for grants or loans under subsection 2, paragraph *"a"*.

88 Acts, ch 1019, §5; 89 Acts, ch 246, §5; 89 Acts, ch 317, §28

Limitation on use of moneys collected as charges for utility use of right-of-way; §314.20

Transportation department to report by January 15, 1992, on living roadway trust fund's allocation of moneys and recommended changes in allocations; 89 Acts, ch 246, §12

314.22 Integrated roadside vegetation management.

1. *Objectives.* It is declared to be in the general public welfare of Iowa and a highway purpose for the vegetation of Iowa's roadsides to be preserved, planted, and maintained to be safe, visually interesting, ecologically integrated, and useful for many purposes. The state department of transportation shall provide an integrated roadside vegetation management plan and program which shall be designed to accomplish all of the following:

a. Maintain a safe travel environment.

b. Serve a variety of public purposes including erosion control, wildlife habitat, climate control, scenic qualities, weed control, utility easements, recreation uses, and sustenance of water quality.

c. Be based on a systematic assessment of conditions existing in roadsides, preservation of valuable vegetation and habitats in the area, and the adoption of a comprehensive plan and strategies for cost-effective maintenance and vegetation planting.

d. Emphasize the establishment of adaptable and long-lived vegetation, often native species, matched to the unique environment found in and adjacent to the roadside.

e. Incorporate integrated management practices for the long-term control of damaging insect populations, weeds, and invader plant species.

f. Build upon a public education program allowing input from adjacent landowners and the general public.

g. Accelerate efforts toward increasing and expanding the effectiveness of plantings to reduce wind-induced and water-induced soil erosion and to increase deposition of snow in desired locations.

h. Incorporate integrated roadside vegetation management with other state agency planning and program activities including the recreation trails program, scenic highways, open space, and tourism development efforts. Agencies should annually report their progress in this area to the general assembly.

2. *Counties may adopt plans.* A county may adopt an integrated roadside vegetation management plan consistent with the integrated roadside vegetation management plan adopted by the department under subsection 1.

3. *Integrated roadside vegetation management technical advisory committee.*

a. The director of the department shall appoint members to an integrated roadside vegetation management technical advisory committee which is created to provide advice on the development and implementation of a statewide integrated roadside vegetation management plan and program and related projects. The department shall report annually in January to the general assembly regarding its activities and those of the committee. Activities of the committee may include, but are not limited to, providing advice and assistance in the following areas:

(1) Research efforts.

(2) Demonstration projects.

(3) Education and orientation efforts for property owners, public officials, and the general public.

(4) Activities of the integrated roadside vegetation management coordinator for integrated roadside vegetation management.

(5) Reviewing applications for funding assistance.

(6) Securing funding for research and demonstrations.

(7) Determining needs for revising the state weed law and other applicable Code sections.

(8) Liaison with the Iowa state association of counties, the league of Iowa municipalities, and other organizations for integrated roadside vegetation management purposes.

b. The director may appoint any number of persons to the committee but, at a minimum, the committee shall consist of all of the following:

(1) One member representing the utility industry.

(2) One member from the Iowa academy of sciences.

(3) One member representing county government.

(4) One member representing city government.

(5) Two members representing the private sector including community interest groups.

(6) One member representing soil conservation interests.

(7) One member representing the department of natural resources.

(8) One member representing county conservation boards.

Members of the committee shall serve without compensation, but may be reimbursed for allowable expenses from the living roadway trust fund created under section 314.21. No more than a simple majority of the members of the committee shall be of the same gender as provided in section 69.16A. The director of the department shall appoint the chair of the committee and shall establish a minimum schedule of meetings for the committee.

4. *Integrated roadside vegetation management coordinator.* The integrated roadside vegetation management coordinator shall administer the department's integrated roadside vegetation management plan and program. The department may create the position of integrated roadside vegetation management coordinator within the department or may contract for the services of the coordinator. The duties of the coordinator include, but are not limited to, the following:

a. Conducting education and awareness programs.

b. Providing technical advice to the department and the department of natural resources, counties, and cities.

c. Conducting demonstration projects.

d. Coordinating inventory and implementation activities.

e. Providing assistance to local community-based groups for undertaking community entryway projects.

f. Being a clearinghouse for information from Iowa projects as well as from other states.

g. Periodically distributing information related to integrated roadside vegetation management.

h. General coordination of research efforts.

i. Other duties assigned by the director of transportation.

5. *Education programs.* The department shall develop educational programs and provide educational materials for the general public, landowners, governmental employees, and board members as part of its program for integrated roadside vegetation management. The educational program shall provide all of the following:

a. The development of public service announcements and television programs about the importance of roadside vegetation in Iowa.

b. The expansion of existing training sessions and educational curriculum materials for county weed commissioners, government contract sprayers, maintenance staff, and others to include coverage of integrated roadside management topics such as basic plant species identification, vegetation preservation, vegetation inventory techniques, vegetation management and planning procedures, planting techniques, maintenance, communication, and public relations. County and municipal engineers, public works staffs, planning and zoning representatives, parks and habitat managers, and others should be encouraged to participate.

c. The conducting of statewide and regional conferences and seminars about integrated roadside vegetation management, community entryways, scenic values of land adjoining roadsides, and other topics relating to roadside vegetation.

d. The preparation, display, and distribution of a variety of public relations material, in order to better inform and educate the traveling public on roadside vegetation management activities. The public relations material shall inform motorists of a variety of roadside vegetation issues including all of the following:

(1) Benefits of various types of roadside vegetation.

(2) Long-term results expected from planting and maintenance practices.

(3) Purposes for short-term disturbances in the roadside landscapes.

(4) Interesting aspects of the Iowa landscape and individual landscape regions.

(5) Other aspects relating to wildlife and soil erosion.

e. Preparation and distribution of educational material designed to inform adjoining property owners, farm operators, and others of the importance of roadside vegetation and their responsibilities of proper stewardship of that vegetation resource.

6. *Research and demonstration projects.* The department, as part of its plan to provide integrated roadside vegetation management, shall conduct research and feasibility studies including demonstration projects of different kinds at a variety of locations around the state. The research and feasibility studies may be conducted in, but are not limited to, any of the following areas:

a. Cost effectiveness or comparison of planting, establishing and maintaining alternative or warm-season, native grass and forb roadside vegetation and traditional cool-season nonnative vegetation.

b. Identification of the relationship that roadsides and roadside vegetation have to maintaining water quality, through drainage wells, sediment and pollutant collection and filtration, and other means.

c. Impacts of burning as an alternative vegetation management tool on all categories of roads.

d. Techniques for more quickly establishing erosion control and permanent vegetative cover on recently disturbed ground as well as interplanting native species in existing vegetative cover.

e. Effectiveness of techniques for reduced or selected use of herbicides to control weeds.

f. Identification of cross section and slope steepness design standards which provide for motorist safety as well as for improved establishment, maintenance, and replacement of different types of vegetation.

g. Identification of a uniform inventory and assessment technique which could be used by many counties in establishing integrated roadside management programs.

h. Equipment innovations for seeding and harvesting grasses in difficult terrain settings, roadway ditches, and fore-slopes and back-slopes.

i. Identification of the perceptions of motorists and landowners to various types of roadside vegetation and configuration of plantings.

j. Market or economic feasibility studies for native seed, forb, and woody plant production and propagation.

k. Impacts of vegetation modifications on increasing or decreasing wildlife populations in rural and urban areas.

l. Effects of vegetation on the number and location of wildlife road-kills in rural and urban areas.

m. Costs to the public for improper off-site resource management adjacent to roadsides.

n. Advantages, disadvantages, and techniques of establishing pedestrian access adjacent to highways and their impacts on vegetation management.

o. Identification of alternative techniques for snow catchment on farmland adjacent to roadsides.

7. *Gateways program.* The department shall develop a gateways program to provide meaningful visual impacts including major new plantings at the important highway entry points to the state and its communities. Substantial and distinctive plantings shall also be designed and installed at these points. Creative and artistic design solutions shall be sought for these improvements. Communications about these projects shall be provided to local groups in order to build community involvement, support, and understanding of their importance. Consideration shall be given to a requirement that gateways projects produce a local match or contribution toward the overall project cost.

8. *Vegetation inventories and strategies.*

a. The department shall coordinate and compile integrated roadside vegetation inventories, classification systems, plans, and implementation strategies for roadsides. Areas of increased program and project emphasis may include, but are not limited to, all of the following:

(1) Additional development and funding of state gateways projects.

(2) Accelerated replacement of dead and unhealthy plants with native and hardy trees and shrubs.

(3) Special interest plantings at selected highly visible locations along primary and interstate highways.

(4) Pilot and demonstration projects.

(5) Additional snow and erosion control plantings.

(6) Welcome center and rest area plantings with native and aesthetically interesting species to create mini-arboretums around the state.

b. The department shall coordinate and compile a reconnaissance of lands to develop an inventory of sites having the potential of being harvested for native grass, forb, and woody plant material seed and growing stock. Highway right-of-ways, parks and recreation areas, converted railroad right-of-ways, state board of regents' property, lands owned by counties, and other types of public property shall be surveyed and documented for seed source potential. Sites volunteered by private organizations may also be included in the inventory. Inventory information shall be made available to state agencies' staffs, county engineers, county conservation board directors, and others.

89 Acts, ch 246, §6

314.23 Environmental protection.

It is declared to be in the general public welfare of Iowa and a highway purpose that highway maintenance, construction, reconstruction, and repair shall protect and preserve, by not causing unnecessary destruction, the natural or historic heritage of the state. In order to provide for the protection and preservation, the following shall be accomplished in the design, construction, reconstruction, relocation, repair, or maintenance of roads, streets, and highways:

1. *Woodlands.* Woodland removed shall be replaced by plantings as close as possible to the initial site, or by acquisition of an equal amount of woodland in the general vicinity for public ownership and preservation, or by other mitigation deemed to be comparable to the woodland removed, including, but not limited to, the improvement, development, or preservation of woodland under public ownership.

2. *Wetlands.* Wetland removed shall be replaced by acquisition of wetland, in the same general vicinity if possible, for public ownership and preservation, or by other mitigation deemed to be comparable to the wetland removed, including, but not limited to, the improvement, development, or preservation of wetland under public ownership.

3. *Public parks.* Highways, streets, and roads constructed on or through publicly owned lands comprising parks, preserves, or recreation areas, shall be located and designed, in consultation with the public entity owning the land, so as to blend aesthetically with the areas and to minimize noise. When land is taken from the areas for highway construction and if, in consultation with the public entity owning the land, mitigation is deemed necessary, the land shall be replaced by an equal or greater amount for public use, or by other mitigation, undertaken in consultation with the public entity owning the land, and deemed to be appropriate to the amount of land taken, including, but not limited to, the improvement, development, or preservation of the areas.

4. *Prime agricultural lands.* Topsoil removed may be utilized for landscaping and other necessary construction. Excess topsoil shall be made available to the former landowner or other landowners whose land was purchased for the construction or others, and if not acquired by one of these parties, it may be disposed.

89 Acts, ch 311, §26

314.24 Natural and historic preservation.

Cities, counties, and the department shall to the extent practicable preserve and protect the natural and historic heritage of the state in the design, construction, reconstruction, relocation, repair, or

THE IOWA WEED LAW
CHAPTER 317, CODE OF IOWA
1990

317.1 NOXIOUS WEEDS.

The following weeds are hereby declared to be noxious and shall be divided into two classes, namely:

1. Primary noxious weeds, which shall include quack grass (Agropyron repens), perennial sow thistle (Sonchus arvensis), Canada thistle (Cirsium arvense), bull thistle (Cirsium lanceolatum), European morning glory or field bindweed (Convolvulus arvensis), horse nettle (Solanum carolinense), leafy spurge (Euphorbia esula), perennial pepper-grass (Lepidium draba), Russian knapweed (Centaurea repens), buckthorn (Rhamnus, not to include Rhamnus frangula, and all other species of thistles belonging in genera of Cirsium and Carduus.)

2. Secondary noxious weeds, which shall include butterprint (Abutilon theophrasti) annual, cocklebur (Xanthium commune) annual, wild mustard (Brassica arvensis) annual, wild carrot (Daucus carota) biennial, buckhorn (Plantago lanceolata) perennial, sheep sorrel (Rumex acetosella) perennial, sour dock (Rumex crispus) perennial, smooth dock (Rumex altissimus) perennial, poison hemlock (Conium maculatum), multiflora rose (Rosa multiflora), wild sunflower (wild strain of Helianthus annus L.) annual, puncture vine (Tribulus terrestris) annual, teasel (Dipsacus)* biennial, and shattercane (Sorghum bicolor) annual.

The multiflora rose (Rosa multiflora) shall not be considered a secondary noxious weed when cultivated for or used as understock for cultivated roses or as ornamental shrubs in gardens, or in any county whose board of supervisors has by resolution declared it not to be a noxious weed. Shattercane (Sorghum bicolor) shall not be considered a secondary noxious weed when cultivated or in any county whose board of supervisors has by resolution declared it not to be a noxious weed.

317.2 STATE BOTANIST.

The secretary of agriculture shall appoint as state botanist the head of the botany and plant pathology section of the Iowa agricultural experiment station whose duty shall be to co-operate in developing a constructive weed eradication program.

317.3 WEED COMMISSIONER — STANDARDS FOR NOXIOUS WEED CONTROL.

The board of supervisors of each county shall annually appoint a county weed commissioner who may be a person otherwise employed by the county and who passes minimum standards established by the department of agriculture and land stewardship for noxious weed identification and the recognized methods for noxious weed control and elimination. The county weed commissioner's appointment shall be effective as of March 1 and shall continue for a term at the discretion of the board of supervisors unless the commissioner is removed from office as provided for by law. The county weed commissioner may, with the approval of the board of supervisors, require that commercial applicators and their appropriate employees pass the same standards for noxious weed identification as established by the department of agriculture and land stewardship. The name and address of the person appointed as county weed commissioner shall be certified to the county auditor and to the secretary of agriculture within ten days of the appointment. The board of supervisors shall fix the compensation of the county weed commissioner and deputies. In addition to compensation, the commissioner and deputies shall be paid their necessary travel expenses. At the discretion of the board of supervisors, the weed commissioner shall attend a seminar or school conducted or approved by the state department of agriculture and land stewardship relating to the identification, control and elimination of noxious weeds.

The board of supervisors shall prescribe the time of year the weed commissioner shall perform the powers and duties of county weed commissioner under this chapter which may be during that time of year when noxious weeds can effectively be killed. Compensation shall be for the period of actual work only although a weed commissioner assigned other duties not related to weed eradication may receive an annual salary. The board of supervisors shall likewise determine whether employment shall be by hour, day or month and the rate of pay for the employment time.

317.4 DIRECTION AND CONTROL.

As used in this chapter, "commissioner" means the county weed commissioner or the commissioner's deputy within each county. Each commissioner, subject to direction and control by the county board of supervisors, shall supervise the control and destruction of all noxious weeds in the county, including those growing within the limits of cities, within the confines of abandoned cemeteries, and along streets and highways unless otherwise provided. A commissioner may enter upon any land in the county at any time for the performance of the commissioner's duties, and shall hire the labor and equipment necessary subject to the approval of the board of supervisors.

317.5 WEEDS IN ABANDONED CEMETERIES.

The commissioner shall control the weeds growing in abandoned cemeteries in the county as needed. Spraying for control of weeds shall be

limited to those circumstances when it is not practical to mow or otherwise control the weeds.

317.6 ENTERING LAND TO DESTROY WEEDS — NOTICE.

In case of a substantial failure by the owner or person in possession or control of any land to comply with any order of destruction pursuant to the provisions of this chapter, the county weed commissioner, the weed commissioner's deputies and employees acting under the weed commissioner's direction shall have full power and authority to enter upon any land within their county for the purpose of destroying noxious weeds. Such entry may be made without the consent of the landowner or person in possession or control of the land but actual work of destruction shall not be commenced until five days after the service of a notice in writing on the landowner and on the person in possession or in control of the land. The notice shall state the facts as to failure of compliance with the county program of weed destruction order or orders made by the board of supervisors and shall be served in the same manner as an original notice except as hereinafter provided. The notice may be served by the weed commissioner, the weed commissioner's deputies or any person designated in writing by the weed commissioner and filed in the office of the county auditor. Provided, however, that service on persons living temporarily or permanently outside of the county may be made by sending the written notice of noncompliance by certified mail to said person at the last known address to be ascertained, if necessary, from the last tax list in the county treasurer's office. Where any person, firm or corporation owning land within the county has filed a written instrument in the office of the county auditor designating the name and address of its agent, the notice herein provided may be served on that agent. In computing time hereunder it shall be from the date of service as evidenced on the return or if made by certified mail, from the date of mailing as evidenced by the certified mail book at the post office where mailed.

317.7 REPORT TO BOARD.

Each weed commissioner shall for the territory under the commissioner's jurisdiction on or before the first day of November of each year make a written report to the board of supervisors. Said report shall state:

1. The name and location of all primary noxious weeds, and any new weed which appears to be a serious pest.
2. A detailed statement of the treatment used, and future plans, for eradication of weeds on each infested tract on which the commissioner has attempted to exterminate weeds, together with the costs and results obtained
3. A summary of the weed situation within the jurisdiction, together with suggestions and recommendations which may be proper and useful, a copy of which shall be forwarded to the state secretary of agriculture.

317.8 DUTY OF SECRETARY OF AGRICULTURE OR SECRETARY'S DESIGNEE.

The secretary of agriculture or the secretary's designee is vested with the following duties, powers and responsibilities:

1. The secretary or the secretary's designee shall serve as state weed commissioner, and shall cooperate with all boards of supervisors and weed commissioners, and shall furnish blank forms for reports made by the supervisors and commissioners.
2. The secretary or the secretary's designee may, upon recommendation of the state botanist, temporarily declare noxious any new weed appearing in the state which possesses the characteristics of a serious pest.
3. The secretary or the secretary's designee shall aid the supervisors in the interpretation of the weed law, and make suggestions to promote extermination of noxious weeds.
4. The secretary or the secretary's designee shall aid the supervisors in enforcement of the weed law as it applies to all state lands, state parks and primary roads, and may impose a maximum penalty of a ten dollar fine for each day, up to ten days, that the state agency in control of land fails to comply with an order for destruction of weeds made pursuant to this chapter.

317.9 DUTY OF BOARD TO ENFORCE.

The responsibility for the enforcement of the provisions of this chapter shall be vested in the board of supervisors as to all farm lands, railroad lands, abandoned cemeteries, state lands and state parks, primary and secondary roads; roads, streets and other lands within cities unless otherwise provided.

317.10 DUTY OF OWNER OR TENANT.

Each owner and each person in the possession or control of any lands shall cut, burn, or otherwise destroy, in whatever manner may be prescribed by the board of supervisors, all noxious weeds thereon as defined in this chapter at such times in each year and in such manner as shall be prescribed in the program of weed destruction order or orders made by the board of supervisors, and shall keep said lands free from such growth of any other weeds, as shall render the streets or highways adjoining said land unsafe for public travel.

37.11 WEEDS ON ROADS — HARVESTING OF GRASS.

The county boards of supervisors and the state department of transportation shall control noxious weeds growing on the roads under their

jurisdiction. Spraying for control of noxious weeds shall be limited to those circumstances when it is not practical to mow or otherwise control the noxious weeds. Nothing under this chapter shall prevent the landowner from harvesting, in proper season, the grass grown on the road along the landowner's land except for vegetation maintained for highway purposes as part of an integrated roadside vegetation management plan which is consistent with the objectives in section 314.22.

317.12 WEEDS ON RAILROAD OR PUBLIC LANDS AND GRAVEL PITS.

All noxious weeds on railroad lands, public lands and within incorporated cities shall be treated in such manner, approved by the board of supervisors, as shall prevent seed production and either destroy or prevent the spread of noxious weeds to adjoining lands. Gravel pits infested with noxious weeds shall not be used as sources of gravel for public highways without previous treatment approved by board of supervisors.

317.13 PROGRAM OF CONTROL.

The board of supervisors of each county may each year, upon recommendation of the county weed commissioner by resolution prescribe and order a program of weed control for purposes of complying with all sections of this chapter. The county board of supervisors of each county may also by adopting an integrated roadside vegetation management plan prescribe and order a program of weed control for purposes of complying with all sections of this chapter. The program for weed control ordered or adopted by the county board of supervisors shall provide that spraying for control of weeds shall be limited to those circumstances when it is not practical to mow or otherwise control the weeds.

317.14 NOTICE OF PROGRAM.

Notice of any order made pursuant to section 317.13 shall be given by one publication in the official newspapers of the county and shall be directed to all property owners.

Said notice shall state:

1. The time for destruction.
2. The manner of destruction, if other than cutting above the surface of the ground.
3. That unless said order is complied with the weed commissioner shall cause said weeds to be destroyed and the cost thereof will be taxed against the real estate on which the noxious weeds are destroyed.

317.15 LOSS OR DAMAGE TO CROPS. The loss or damage to crops or property incurred by reason of such destruction shall be borne by the titleholder of said real estate, unless said real estate shall be sold under contract whereby possession has been delivered to the purchaser, in which event such purchaser shall bear such loss or damage, excepting where a contract has been entered into providing a different adjustment for such loss or damage.

317.16 FAILURE TO COMPLY. In case of a substantial failure to comply by the date prescribed in any order of destruction of weeds made pursuant to this chapter, the weed commissioner or the deputies may, subsequent to the time after service of the notice provided for in section 317.6 enter upon the land and cause the weeds to be destroyed, or may impose a maximum penalty of a ten dollar fine for each day, up to ten days, that the owner or person in control of the land fails to comply. If a penalty is imposed and the owner or person in control of the land fails to comply, the weed commissioner shall cause the weeds to be destroyed. If the weed commissioner enters the land and causes the weeds to be destroyed, the actual cost and expense of cutting, burning or otherwise destroying the weeds, along with the cost of serving notice and special meetings or proceedings, if any, shall be paid by the county and, together with the additional assessment to apply toward costs of supervision and administration, be recovered by an assessment against the tract of real estate on which the weeds were growing, as provided in section 317.21. Any fine imposed shall be recovered by a similar assessment.

317.17 ADDITIONAL NOXIOUS WEEDS.

The board of supervisors shall order the weed commissioner, or commissioners, to destroy or cause to be destroyed any new weeds declared to be noxious by the secretary of agriculture, the cost of which shall be borne by the county.

317.18 ORDER FOR DESTRUCTION ON ROADS.

The board of supervisors may order all noxious weeds, within the right-of-way of all county trunk and local county roads to be cut, burned or otherwise controlled to prevent seed production, either upon its own motion or upon receipt of written notice requesting the action from any residents of the township in which the roads are located, or any person regularly using the roads. The order shall be consistent with the county integrated roadside vegetation management plan, if the county has adopted such a plan, and the order shall define the roads along which noxious weeds are required to be cut, burned or otherwise controlled and shall require the weeds to be cut, burned or otherwise controlled within fifteen days after the publication of the order in the official newspapers of the county or as prescribed in the county's integrated roadside vegetation management plan. The order shall provide that spraying for control of noxious weeds shall be limited to those circumstances when it is not practical to mow or otherwise control the weeds.

317.19 ROAD CLEARING APPROPRIATION.

The board of supervisors may appropriate moneys to be used for the purposes of cutting, burning, or otherwise controlling weeds or brush within the right-of-way of county trunk roads and local county roads in time to prevent reseeding or in a manner consistent with the county's roadside vegetation management plan, if the county has adopted such a plan. The moneys appropriated shall not be spent on spraying for control of weeds except in those circumstances when it is not practical to mow or otherwise control the weeds. The board of supervisors may purchase or hire necessary equipment or contract with the adjoining landowner to carry out this section.

317.20 EQUIPMENT AND MATERIALS — USE ON PRIVATE PROPERTY.

The board of supervisors may appropriate moneys for the purpose of purchasing weed eradicating equipment and materials to carry out the duties of the commissioner for use on all lands in the county, public or private, and for the payment of the necessary expenses and compensation of the commissioner, and the commissioner's deputies, if any. When equipment or materials so purchased are used on private property within the corporate limits of cities by the commissioner, the cost of materials used and an amount to be fixed by the board of superviors for the use of the equipment shall be returned by the county treasurer upon the collection of the special assessment taxed against the property. In the certification to the county treasurer by the county auditor this apportionment shall be designated along with the special tax assessed under section 317.21. The equipment and its use are subject to the authorization and direction of the county board of supervisors.

317.21 COST OF SUCH DESTRUCTION.

When the commissioner destroys any weeds under the authority of section 317.16, after failure of the landowner responsible to destroy such weeds pursuant to the order of the board of supervisors, the cost of the destruction shall be assessed against the land and collected from the landowner responsible in the following manner:

1. Annually, after the weed commissioner has completed the program of destruction of weeds by reason of noncompliance by persons responsible therefor, the board of supervisors shall determine as to each tract of real estate the actual cost of labor and materials used by the commissioner in cutting, burning or otherwise destroying said weeds, the cost of serving notice and special meetings or proceedings, if any. To the total of all such sums expended, they shall add an amount equal to twenty-five percent thereof to compensate for the cost of supervision and administration and assess the resulting sum against said tract of real estate by a special tax, which shall be certified to the county auditor and county treasurer by the clerk of the board of supervisors, and shall be placed upon the tax books, and collected, together with interest and penalty after due, in the same manner as other unpaid taxes. Such tax shall be due on March 1 after such assessment, and shall be delinquent after March 30. When collected, said funds shall be paid into the fund from which said costs were originally paid.

2. Before making any such assessment, the board of supervisors shall prepare a plat or schedule showing the several lots, tracts of land or parcels of ground to be assessed which shall be in accord with the assessor's records and the amount proposed to be assessed against each of the same for destroying or controlling weeds during the fiscal year.

3. Such board shall thereupon fix a time for the hearing on such proposed assessments, which time shall not be later than December 15 of the year, and at least twenty days prior to the time thus fixed for such hearing shall give notice thereof to all concerned that such plat or schedule is on file, and that the amounts as shown therein will be assessed against the several lots, tracts of land or parcels of ground described in said plat or schedule at the time fixed for such hearing, unless objection is made thereto. Notice of such hearing shall be given by one publication in official county newspapers in the county in which the property to be assessed is situated; or by posting a copy of such notice on the premises affected and by mailing a copy by certified mail to the last known address of the person owning or controlling said premises. At such time and place the owner of said premises or anyone liable to pay such assessment, may appear with the same rights given by law before boards of review, in reference to assessments for general taxation.

317.22 DUTY OF HIGHWAY MAINTENANCE PERSONNEL. It shall be the duty of all officers directly responsible for the care of public highways to make complaint to the weed commissioners or board of supervisors, whenever it shall appear that the provisions of this chapter may not be complied with in time to prevent the blooming and maturity of noxious weeds or the unlawful growth of weeds, whether in the streets or highways for which they are responsible or upon lands adjacent to the same.

317.23 DUTY OF COUNTY ATTORNEY.

It shall be the duty of the county attorney upon complaint of any citizen that any officer charged with the enforcement of the provisions of this chapter has neglected or failed to perform the officer's duty, to enforce the performance of such duty.

317.24 PUNISHMENT OF OFFICER.

Any officer referred to in this chapter who

neglects or fails to perform the duties incumbent upon the officer under the provisions of this chapter shall be guilty of a simple misdemeanor.

317.25 TEASEL, MULTIFLORA ROSE, AND PURPLE LOOSESTRIFE PROHIBITED.

A person shall not sell, offer for sale, or distribute teasel (Dipsacus) biennial, the multiflora rose (rosa multiflora), purple loosestrife (lythrum salicaria), or seeds of them in any form in this state. However, the multiflora rose (rosa multiflora) may be sold, offered for sale, or distributed when used for understock for either cultivated roses or ornamental shrubs in gardens. Any person violating the provisions of this section is subject to a fine of not exceeding one hundred dollars.

317.26 ALTERNATIVE REMEDIATION PRACTICES.

The director of the department of natural resources, in cooperation with the secretary of agriculture and county conservation boards or the board of supervisors, shall develop and implement projects which utilize alternative practices in the remediation of noxious weeds and other vegetation within highway rights-of-way.

This list is provided as a service to Roadside Managers and does not constitute an endorsement.

HYDROSEEDERS AND OTHER EQUIPMENT

Aero Industries Division
Highway Equipment co.
616 "D" Ave. N. W.
Cedar Rapids, IA 52405
319-363-3281

Aero-spread all purpose spreader

Bowie Industries, Inc.
1004 E. Wise
P O Box 931
Bowie, TX 76230
1 (800) - 433-0934
Hydroseeders, Straw mulchers, Tackifiers.

Finn Corporation
9281 Le Saint Dr.
Fairfield, OH 45014
1 (800) - 543 -7166

Bill Pressler
(708) 560-0610
Hydroseeders, Straw mulchers, Tackifiers

Reinco Hydrograssers/Power Mulchers
P O Box 512
Plainfield, NJ 07061
(800) 526-7687

Hydroseeders, Mulchers and Tackifiers

Goosen Industries
P O Box 705
Beatrice, NE 68310
(800) 228-6542
Straw bale chopper

HYDROSEEDING MULCH AND TACKIFIERS

*Applegate Mulch
Environmental Erosion Systems
P O Box 292
Okemos, MI 48864
517-349-0466
recycled mulch
Ships directly to customer

*Central Fiber Corporation
Fiber Lane Rd.
P O Box 749
Wellsville, KS 66092
(800) 654-6117
Ships directly to customer

*Erosion Control Systems
Suite 180
1800 McFarland Boulevard N.
Tuscaloosa, Alabama 35406
1-800-942-1986

*Exacto Chemical Co.
Kenneth Cox, Vice-president
P O Box 90
Solon Mills, Il 60080
800-798-9761
PRSM, Inc.
882 S. Matlack -E
West Chester, PA 19382
Iowa: Quick Supply

*Weyerhaeuser Engineered Fiber
Silva-Fiber Mulch and Tack.
Rob Perez
P O Box 434
Montclair, NJ 07042
201-744-2625
Tacoma, WA
(800) 443-9179
Iowa distributor: Ford & Sons

EROSION CONTROL BLANKETS

*American Excelsior Co.
3101 Talmadge Ave.
S. E. Minneapolis, MN 55414
612-331-1831
Attn: Keith
Arlington, TX
(800) 777-SOIL
Iowa: Quick Supply

Belton Industries
Anti-wash/Geojute and DeKoWe Matting
8613 Roswell Rd.
Atlanta, GA 30350
(800) 225-4099
Iowa Distributor: Agri-drain
(800) 232- 4742

BonTerra America
P O Box 9485
Moscow, Idaho 83843
(208)-882-9489

Dayton Bag and Burlap
Drawer 8
Dayton, OH 45401
513-258-8000
Mfg of jute erosion control blankets
Ship directly from factory

*Erosion Control Systems
Suite 180
1800 McFarland Boulevard N.
Tuscaloosa, Alabama 35406
1-800-759-5151
[Includes an entire line of products]
*Greenstreak, Inc.
3400 Tree Ct. Industrial BLVD.
St. Louis, MO 63122
(800) 325-9504

*North American Green
14649 Hwy 41 North
Evansdale, IN 47711
(800) 772-2040
Iowa Distributor: Quick Supply

Xcel Excelsior Blankets
PPS Packaging Co.
204 North 7th St.
Fowler, CA 93625
(209) 834-1641

Proseed USA
P O Box 1250
San Marcos, Texas 78667
(512) 392-1900

Phillips Fibers Corp.
Engineered Products Marketing
421 North, Northwest Highway
Suite 201
Barrington, Il 60010
708-382-9666
Gerald F. Barry
Sales Engineer
Iowa Distributor: Quick Supply

Research Products Corporation
PO Box 1467
Madison, WI 53701-1467
608-257-8801
Jim Howery, Chief Sales Engineer
Earth-Gard
Biodegradable erosion blanket
Quick Supply

GEOTEXTILES

American Engineering Fabrics
1 Coffin Ave.
New Bedford, MA 02746
(508) 993-9622

Geoweb
Presto Products Co.
P O Box 2399
Appleton, WI 54913
(414) - 739-9471

Synthetic Industries
4019 Industry Dr.
Chattanooga, TN 37416
(615) 892

Tensar Earth Technology, Inc.
1210 Citizens Parkway
Morrow, Georgia 30260

Webtec, Inc.
P O Box 240302
Charlotte, NC 28224
(800) 438-0027

MISCELLANEOUS

Roots Inc.
25 Science Park
New Haven, Connecticut 06511
(203) - 786-5295
Root growth enhancers

Agriculture Fiber Association
5475 S W Arrowwood Lane
Portland, OR 97225
(503) 292-0107
Straw Trade Association

PRODUCT DISTRIBUTORS

*Stetson Building Products,Inc.
320 West 18th ST.
P O Box 1655
Waterloo, IA 50704
(800) 383-2959
(319) 236-5074

*SAN-SPEC, Inc.
8704 Maple St.
Omaha, NE 68134
(402) 391-4102

Agri-Drain
P O Box 458
Adair, IA
(800) 232-4742

Distributors for Belton Industries (Geojute).

Agro Diversified Industries
Chimney Rock Road,
BLDG 3W,
Bound Brook, New Jersy 08805
(201) 805-9336

*Central Fiber Corporation
P O Box 749
Wellsville, KS 66092
913-883-4600
Vince Meyer
913-884-7792
recycled mulch products

*Ford & Sons
Box 300
Geneseo, Il 61254
1-800-383-4661
Weyerhauser Engineered Fiber

Erosion Control Systems
Suite 180
1800 McFarland Boulevard N.
Tuscaloosa, Alabama 35406
1-800-942-1986

Quick Supply
Charles Woodall
6620 Northwest Toni Dr.
Des Moines, IA 50313
515-289-1271

International Crane Foundation
Baraboo, WI

PRAIRIE SEED COLLECTING DATES (MAY - NOVEMBER)

compiled by
Laura Luthin and Konrad Liegel
November 1983

Plants are listed under the optimal collecting dates for southern Wisconsin using seven years of data.

Habitat code: D = dry; M = mesic; W = wet

Wet prairie - Has more water than rainfall with water running on from surrounding land. A flat and poorly drained area.
Mesic prairie - The water soaks in and there is no standing water. It has good internal drainage.
Dry prairie - It has less water than rainfall because the water runs off, often on thin soil, limestone ridges, or steep hillsides.

Note:

* species whose seed heads are ripe for just a short time.
** species whose seed heads explode when ripe.
*** species whose seed heads ripen at different times through the season.

Example:

DM Ceanothus americanus (9/25 - 6)
New Jersey Tea

DM: Found in dry and mesic prairies
Ceanothus americanus: Latin name
New Jersey Tea: Common name
9/25: Median date. The collector will be virtually sure of finding ripe seed to gather at this time.
6: The number of years of data used out of a total of seven years to obtain the median date.

June 1-15

*DM Anenome patens (6/1 - 4)
Pasque-flower
*DM Antennaria neglecta (6/1 - 4)
Field pussy-toes
*DM Antennaria plantaginifolia (6/4 - 2)
Plantain-leaved pussy-toes
*DM Ranunculus fascicularis (6/10 - 4)
Tufted buttercup

June 1-15 (Cont.)

*DM Ranunculus rhomboideus (6/10 - 4)
Prairie buttercup
**DM Viola pedata (6/13 - 3)
Bird foot violet

June 16-30

*DM Stipa spartea (6/28 - 7)
Needle grass
DM Geum triflorum (6/23 - 7)
Prairie smoke
DM Sisyrinchium campestre (6/27 - 3)
Blue-eyed grass

July 1-15

MW Allium canadense (7/5 - 5)
Wild garlic
D Aquilegia canadensis (7/13 - 5)
Columbine
DMW Heuchera richardsonii (7/12 - 6)
Alumroot
**DM Lupinus perennis (7/5 - 6)
Wild lupine
**DMW Phlox pilosa (7/10 - 5)
Downy phlox
DMW Smilacina stellata (7/15 - 3)
Starry solomon's plume

July 16-31

*MW Calamagrostis canadensis (7/31 - 3)
Blue joint reed
DMW Dodecatheon meadia (7/28 - 6)
Shooting Star
DM Koleria cristata (7/20 - 6)
June grass
DMW Galium boreale (7/31 - 4)
Northern bedstraw

August 1-15

***DMW Tradescantia ohiensis (8/3 - 7)
Spiderwort

August 16-31

D Desmodium illionense (8/25 - 4)
Illinois tick-trefoil

September 1-15

DMW Panicum virgatum (9/13 - 7)
Switch grass
DM Amorpha canescens (9/5 - 7)
Lead-plant
DM Asclepias hirtella (9/9 - 5)
Green milkweed
DMW Cacalia atriplicifolia (9/7 - 2)
Pale Indian-plantain
**D Euphorbia corollata (9/9 - 3)
Flowering spurge
***D Lithospermum caroliniense (9/11 - 6)
Puccoon
DM Parthenium integrifolium (9/6 - 4)
Wild quinine
D Penstemon grandiflorus (9/6 - 4)
Beardtongue
DM Petalostemum candidum (9/15 - 6)
White prairie clover
DMW Rudbeckia hirta (9/12 - 7)
Black-eyed Susan
DMW Zizia aptera (9/2 - 3)
Heartleaf golden alexanders
DMW Zizia aurea (9/4 - 3)
Golden alexanders

September 16-30

D Bouteloua hirsuta (9/30 - 5)
Grama grass
DMW Baptisia leucantha (9/27 - 7)
White wild Indigo
DM Baptisia leucophaea (9/17 - 5)
Creamy wild Indigo
D Cassia fasciculata (9/24 - 4)
Partridge pea
DM Ceanothus americanus (9/25 - 6)
New Jersey tea
MW Desmodium canadense (9/24 - 7)
Canada tick-trefoil
DM Echinacea pallida (9/23 - 5)
Pale purple coneflower
***D Hieracium longipilum (9/18 - 4)
Longhair hawkweed
DM Liatris aspera (9/28 - 7)
Rough blazing star
MW Liatris pycnostachya (9/30 - 7)
Prairie gayfeather
DM Oenothera biennis (9/23 - 5)
Evening primrose
D Opuntia compressa (9/29 - 4)
Prickly pear cactus
DM Petalostemum purpureum (9/20 - 7)
Purple prairie clover

September 16-30 (cont.)

DM Potentilla arguta (9/20 - 6)
Tall cinquefoil
DMW Ratibida pinnata (9/27 - 6)
Yellow cone flower
DMW Rosa sp. (9/22 - 6)
Rose
DMW Silphium integrifolium (9/29 - 7)
Rosin-weed
MW Silphium perfoliatum (9/29 - 6)
Cup-plant
MW Silphium terebinthinacium (9/24 - 6)
Prairie dock
**D Tephrosia virginianum (9/24 - 5)
Goat's Rue
MW Thalictrum dasycarpum (9/17 - 3)
Meadowrue
W Veronicastrum virginicum (9/18 - 5)
Culver's root

October 1-15

DM Andropogon scoparius (10/12 - 7)
Little blue stem
D Bouteloua curtipendendula (10/2 - 7)
Side oats grama
DM Elymus canadensis (10/10 - 7)
Wild rye
DM Sorghastrum nutans (10/9 - 7)
Indian grass
DM Sporobolus heterolepis (10/3 - 7)
Prairie dropseed
M Allium cernuum (10/3 - 5)
Nodding wild onion
DM Anenome cylindrica (10/4 - 7)
Thimbleweed
W Asclepias incarnata (10/1 - 4)
Swamp milkweed
DM Asclepias tuberosa (10/1 - 7)
Butterfly-weed
D Callirhoe triangulata (10/12 - 2)
Poppy mallow
DM Coreopsis palmata (10/2 - 7)
Tickseed
DMW Echinacea purpurea (10/6 - 3)
Purple coneflower
DMW Helianthus laetiflorus (10/9 - 7)
Showy sunflower
DM Helianthus occidentalis (10/6 - 7)
Naked sunflower
DMW Heliopsis helianthoides (10/5 - 6)
Ox eye
DM Kuhnia eupatoroides (10/4 - 5)
False boneset

October 1-15 (cont.)

DM Lespedeza capitata (10/9 - 7)
Bush clover
D Liatris cylindracea (10/8 - 6)
Cylindric blazing star
DMW Monarda fistulosa (10/3 - 7)
Bergamot
D Monarda punctata (10/3 - 6)
Horse mint
D Oenothera rhombipetala (10/10 - 4)
Slender evening-primrose
DMW Pycnanthemum virginianum (10/10 - 7)
Mountain mint
W Rudbeckia subtomentosa (10/5 - 4)
Branched coneflower
DM Silphium laciniatum (10/1 - 7)
Compass-plant
D Verbena stricta (10/2 - 4)
Hoary vervain
MW Veronia fasciculata (10/13 - 4)
Western ironweed

October 16-31

DMW Andropogon gerardii (10/20 - 7)
Big blue stem
D Aristida basiramea (10/19 - 2)
Three-awn grass
W Spartina pectinata (10/22 - 3)
Slough grass
D Artemesia ludoviciana (10/18 - 3)
White sage
DM Aster azureus (10/24 - 6)
Sky-blue aster
DM Aster ericoides (10/26 - 4)
Heath aster
DM Aster laevis (10/19 - 4)
Smooth aster
D Aster linariifolius (10/22 - 7)
Stiff aster
DM Aster ptarmicoides (10/16 - 7)
Upland white aster
DM Aster sericeus (10/23 - 7)
Silky aster
DM Eryingium yuccifolium (10/16 - 6)
Rattlesnake-master
MW Gentiana andrewsii (10/26 - 3)
Bottle gentian
W Gentiana crinata (10/28 - 4)
Fringed gentian
DM Gnaphalium obtusiifolium (10/16 - 4)
Sweet everlasting
DMW Prenanthes racemosa (10/27 - 5)
Rattlesnake root