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DEPARTMENT OF NATURAL RESOURCES

# RESEARCH

## REPORT 102

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### ESTABLISHMENT OF NATIVE WARM SEASON GRASSES IN WISCONSIN

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#### ABSTRACT

Research and experimentation on warm season grasses (and three species of cool season wheat-grasses) are summarized as guidelines for their establishment by land managers for wildlife cover.

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## INTRODUCTION

Switchgrass (*Panicum virgatum*) was first recommended for wildlife cover in 1972, 5 years after establishment and evaluation on the Waterloo Wildlife Area. The most desirable characteristic of switchgrass is the capacity for its residual cover (the fruiting culm) to remain upright after maturity in September. This exceptional standability persists through the following reproductive season despite occasional heavy wet winter snows that flatten most types of residual cover. The resiliency of switchgrass stems after prolonged snow cover has been a surprising but consistent attribute of the species and in this regard exceeds all common cool season, exotic grasses such as brome, timothy and orchard grass.

Switchgrass is a native grass widely distributed throughout North America from Nova Scotia to North Dakota, Wyoming and Nevada and throughout all eastern and southern states to Mexico and Central America. Obviously, many ecotypes of the species exist. Curtis (1959) referred to the species only in his description of the "sand-blow" plant community. Hitchcock and Chase (1950) described the native habitat of switchgrass as "prairie, open ground, open woods and brackish marshes". Throughout Wisconsin, switchgrass is a minor species in relic prairie stands but occurs commonly along roadsides, railroads, open woods and other relatively undisturbed sites on sandy soils in the unglaciated southwestern part of the state. These clones also show the typical standability of the residual vegetation.

Most commercial varieties of switchgrass originated from selections collected in Nebraska, Kansas and Oklahoma. Currently, plant materials centers of the U.S. Soil Conservation Service are evaluating ecotypes from many parts of the original range. In the central plains region switchgrass is used in a mixture of warm and/or cool season grasses for pasture renovation or re-establishment of grazing lands. Only in the past decade has switchgrass been considered and evaluated for wildlife cover and related purposes. Where it has been successfully established in the upper Midwest, wildlife managers have generally been very enthusiastic about switchgrass as an excellent all purpose cover. In North and South Dakota (Duebbert 1978) and Iowa (George et al. 1978) waterfowl and pheasant nest densities and nesting success were higher in switchgrass or warm season grass mixtures than in other types of nesting cover. To assist wildlife managers and technicians in establishing switchgrass and/or other native warm season grasses, this report summarizes research results from Wisconsin and other states plus assorted opinions from a variety of professional workers in the field.

Wildlife managers have successfully established acceptable stands of warm season grasses on some sites and have experienced failures on others. Neither successes nor failures have been sufficiently documented in many plantings to identify factors contributing to the good or bad results. Consensus among managers is that results are highly variable but many stands do not approach desirable plant density until the third or fourth growing season. Collectively, there has not evolved a single procedure whereby successful establishment can be assured, but the following recommendations will help in decision-making and give the highest probability of success.

## SEEDBED PREPARATION

### Conventional Tillage

The most common seedbed preparation on cultivated lands is plowing, discing and harrowing. Where potential soil erosion is not regarded as a serious problem, fields should be fall plowed. Frost action and winter snow accumulation, plus early spring rains, will mellow the clods and a single spring field operation of discing once with the harrow attached may be the only pre-plant field work necessary. A second discing may be necessary on mid- or late season plantings to eliminate all weed seedlings. Discing should be limited to a maximum of 2 to 3 inches to reduce the number of weed seeds brought close to the surface or germination zone.

Spring plowing should only be considered as a second choice if fall plowing is feasible. Where it is the only choice, early spring is preferable to late spring, but in either situation discing should be delayed until just prior to planting. Whatever method is used, the operator must keep in mind that the objective is to prepare a firm, but not necessarily smooth, seedbed initially free of weeds. If a grass drill is used for seeding a loose or soft seedbed should be covered with a cultipacker to secure a firm surface. A rainfall in the interim will serve the same purpose.

### No-Till Seeding

A second method of seedbed preparation includes the use of herbicides only; contingent upon the use for seeding of a grass drill capable of penetrating sod or stubble and placing seed at a depth of  $\frac{1}{2}$  to 1 inch (or 0.6 to 2.5 cm). The specifically designed Truax grass drill, a Zip seeder or a Nesbit drill is required. Only switchgrass (plus legumes and some cool season grasses) can be seeded with a Zip seeder, whereas the Truax or Nesbit drill can seed either warm or cool season grasses and legumes. There are other similar type drills manufactured but they are probably not readily available in Wisconsin.

No-till refers to establishment of a crop without conventional tillage operations. Herbicides are used to kill existing vegetation prior to seeding. Generally, no-till should be considered when seeding is contemplated on overgrazed grassy pastures, on stubble fields (corn, small grain sorghum or soybeans) or in idled cropland where slope, soil type, trees or stones make conventional tillage impractical. No-till methods are still experimental and all recommended procedures are the result of testing to date and should not be regarded as conclusive. Assuming that no-till is clearly the best means to establish warm season grasses, the selection of herbicides should be based on the dominant weeds present or anticipated from earlier cropping history. If quackgrass is the dominant weed present on more than 50% of the total area, no-till is a questionable practice because quack has remarkable capacity to recover following most single herbicide treatments and can become very competitive after the fall growth. Fields containing a large amount of dead residual cover should be burned off early in the spring prior to new growth to ensure good coverage of contact herbicides and prompt penetration of systemic herbicides into the soil.

Currently, Atrazine, Paraquat and Roundup are the herbicides most frequently used in no-till operations, either separately or in mixtures. Herbicide label directions should be followed. Stubble fields and early successional idled croplands generally have a high percentage of annual weeds. These are most easily destroyed with the use of Paraquat or Roundup when weed growth is 2 to 6 inches in height. Annual weed growth can be quite rapid if warm temperatures persist following germination. Weed identification is necessary to determine the appropriate application rate, especially in using Roundup and/or Atrazine. To secure recommended herbicide rates, the spray equipment must be calibrated properly. Separate bulletins are available through agricultural extension offices detailing procedures in calibrating spray equipment, and these or equipment manuals should be referred to for accurate calibration. After completion of the herbicide application, the spray equipment should be cleaned and rinsed according to recommendations unless additional spraying is scheduled.

Seeding should follow within 3 days for maximum assurance of a satisfactory stand. Table 1 summarizes the present recommended herbicide application rates. Delays in spraying weeds in the early growth stage will render the treatment less effective. Additional germination of annual weeds can be anticipated on stubble and recently tilled croplands when either Paraquat or Roundup is used. Some perennial weeds will not be destroyed by Paraquat although they will be temporarily set back. Roundup is more effective on some perennial species. Application rates lower than recommended levels may reduce effectiveness of the herbicide, whereas higher rates unnecessarily increase the cost. If Atrazine applications exceed recommended levels, the residual soil activity could be detrimental to bluestems and Indiangrass. Present research shows that 2 lbs. of Atrazine/acre may be close to the tolerance level of bluestems and Indiangrass. Switchgrass, however, has germinated and grown satisfactorily after a 4 lb./acre pre-emergent application. Atrazine was labeled for switchgrass establishment at the recommended rate of 2½ lbs. (80W) per acre in 1978.

Our best overall weed control to date for a no-till seeding has been an application of 2½ lb Atrazine 80-W and 2 quarts of Roundup in late April, 1977, on an overgrazed pasture on a sandy soil. Dominant perennials included bluegrass, bromegrass, quackgrass, dandelions, nodding thistle and hoary alyssum. On stubble fields, where annual weeds are dominant and have germinated, an application of either Paraquat or Roundup will effectively control all seedlings. On a prepared seedbed, apply only Atrazine as a pre-emergent herbicide, either immediately before or after seeding. A pre-planting herbicide treatment is recommended if Roundup or Paraquat is used. Allow at least 3 days after the herbicide application before seeding. Seeding can be delayed up to 6 weeks after the herbicide treatment if weather prohibits planting or equipment is not immediately available. Long delays between application and seeding allows additional weed seed germination, the adversity of which cannot be predicted. A Roundup or Paraquat application after weed growth exceeds 6 inches is apt to be less effective than if it were applied at the optimum growth state of 2-6 inches.

## PLANTING DATES

The optimum planting period for each species of warm season grass, based on the best current date, is from May 15 to July 1. However, some satisfactory grass stands were originally seeded as early as May 1 or July 10 at the latest. One Horicon Marsh stand of switchgrass, which gave excellent first-year growth, was seeded on April 13. Switchgrass has developed into good stands from both early or late seedings, but bluestems and Indiangrass planted between May 24 and June 4 had higher plant densities than seedings made from mid-June to early July. Time of seeding is less important than soil moisture and weed control. However, earlier planting dates would take advantage of better soil moisture conditions. Relatively few fall seedings have been made in Wisconsin (late October or November). Limited data indicate that fresh seed should be used unless seed held over from previous years is tested for germination. Rapid decline in seed viability is believed to be the primary cause of poor establishment of fall grass seedings. Many prairie forb seeds require cold wet stratification for germination and therefore benefit from fall seeding.

## SEEDING

### Rates and Mixtures

Because of annual variation in germination and purity of warm season grass seed, seeding rates are always recommended on the basis of pure live seed (PLS) per square foot (or square meter). Recommendations on seeding rates will vary from 25 to 80 PLS/ft<sup>2</sup>. For Wisconsin conditions, a seeding rate of 50 PLS/ft<sup>2</sup> is suggested for switchgrass or any combination of grasses under most conditions. Seeding rate should be adjusted upward to 65 PLS/ft<sup>2</sup> when seeded with a conventional small grain drill or if hand broadcast. When a Truax drill, Brillion seeder or Zip seeder is used, the seeding rate can be lowered to 40 PLS/ft<sup>2</sup>. Monotypic stands of all 4 species should be seeded at the same rate.

### Nurse Crops

Warm season grasses can also be seeded with an oat nurse crop at 1 to 1½ bushels/acre. Seeding with an oat nurse crop reduces early weed growth but the oats are also competitive. A light oat nurse crop is advisable on sites vulnerable to erosion. On soils where potential erosion is minimal, nurse crops should be considered as an option to seeding without a nurse crop. Currently, there is inadequate data to suggest the better method of seeding.

### Depth of Planting

A rule of thumb in determining planting depth of any seed is that the seed should not be planted deeper than 4 times the diameter of the seed. For most prairie grasses, the planting depth should be ¼ inch or about 6 mm. In seeding large acreages with grass seeders, a uniform planting depth is impossible unless the site is extremely level and the seedbed is very firm. Depth bands on the furrow openers of a Truax drill are fixed at 1 inch and are not adjustable. On a normally cloddy seedbed, the planting depth will range from 1/8 to 1 inch, and on no-till operations in sod or corn stubble, the planting depth varies from surface to about 3/4 inch, depending on the amount of debris or stubble present. Packer wheels on the Truax drill compress the soil over the furrow, which aids in making firmer contact between the seed and soil. The Brillion seeder also distributes seed within ¼ inch of the surface and compacts the soil. Switchgrass seeded with a small grain drill will have the seed distributed between the surface and about 1½ inches in depth. The Zip seeder will only perform satisfactorily on a sod or stubble field which it cannot be used satisfactorily on a prepared seedbed.

On relatively small acreages (less than 2 acres), warm season grasses can also be hand broadcast or, if only switchgrass is planted, a hand-cranked cyclone seeder will suffice. Bluestems and Indiangrass usually do not go through a cyclone seeder very well unless the seed is very clean. Hand-seeded fields should be harrowed after seeding and if the seedbed is especially soft, the use of a culti-packer will aid in compressing the soil. A moderate steady rain will also compact the soil.

Sources of grass-seeding equipment are shown in Appendix A.

## AVAILABLE VARIETIES

Other than Blackwell switchgrass, most available varieties of warm season grasses have not been planted extensively in Wisconsin to compare their performance and longevity. All commercially available strains or ecotypes were selected by professional agronomists in the SCS, University systems or large seed producers through controlled breeding program selection and attendant

evaluation. Clonal improvement is based on disease resistance, productivity or yield, winter hardiness, longevity and ability to recover after mowing or sustained grazing. Each named variety selected has demonstrated superior qualities compared to existing varieties or local ecotypes at the time of introduction or release for commercial purposes. A majority of the available varieties originated in the plains states (North Dakota to Texas). Adaptation to Wisconsin growing conditions is uncertain or unknown for many varieties. Generally, commercial varieties tend to grow taller and flower later than the same species from Wisconsin sources or local ecotypes. Some varieties originating in the southern plains states are suspect in regard to winter hardiness or longevity in Wisconsin.

Except for "Blackwell" switchgrass and "Pawnee" big bluestem, all varietal recommendations should be regarded as tentative. Critical evaluation of each variety seeded at different locations in Wisconsin for at least 5 years is needed for conclusive appraisal. The SCS has not developed grass species or varietal recommendations for Wisconsin similar to those prepared for the plains states.

Sources of seeds, tubers and plants of native vegetation in and near Wisconsin are given in Appendix B.

#### Evaluated in Wisconsin

Big Bluestem. "Pawnee" big bluestem was planted in a mixture of warm and cool season grasses at Waterloo in 1970. It establishes easily and can withstand the competition of "Blackwell" switchgrass which is recognized as the most aggressive of the prairie grasses. This variety was also used in a mixture at Lake Kegonsa and matured at 5½ to 8 ft (1.7-2.4 m). It continues to perform well at both sites. Other recommended varieties: "Kaw" was seeded at Waterloo in 1977, but not evaluated to date and is not recommended by SCS for Minnesota; "Champ PM-SD-27" and "NGD-4" are recommended by the SCS Plant Materials Center at Mandan, North Dakota, for Minnesota.

Little Bluestem. Lake Kegonsa seeding apparently consisted of common or native little bluestem from Nebraska. Some plants persist and appear vigorous. Registered varieties, "Blaze", "Aldous" and "Camper" were seeded in 1977 at Waterloo. SCS recommends "Blaze", "Camper" and "PM-K-129" for portions of Minnesota. Little bluestem from Wilson Nursery has performed well at one site at Waterloo. Little bluestem is often found on low fertility sandy soils in Wisconsin.

Indiangrass. The variety "Holt" was seeded at Lake Kegonsa and Waterloo. Poor establishment was noted in both plantings. In 1977, varieties "Oto", "Holt" and "Osage" were seeded at Waterloo. SCS recommendations for Minnesota were: "Holt", "Nebraska 54", "Oto", "PM-ND-444". The Wisconsin ecotype from Wilson Nursery has performed exceptionally well at Waterloo.

Switchgrass. "Blackwell" is the variety most frequently planted in Wisconsin. It has been relatively easy to establish on wet mesic or dry mesic sites, forming a sod after 4 to 5 years; residual vegetation recovers to an upright stature after months of inundation by a heavy snow blanket. Stands left idle for 7 to 8 years tend to decline in vigor unless periodically burned in late winter or early spring. "Blackwell" shows a slight tendency to spread into adjacent lands with thin cover crops. To date, "Blackwell" has performed equal to or better than other varieties of switchgrass.

Other highly recommended varieties of switchgrass: "Cave-in-Rock" originated in central Illinois. At Waterloo, "Cave-in-Rock" grows about 6 to 12 inches taller than "Blackwell" and develops thicker or heavier fruiting culms. It is completely winter hardy and residual vegetation recovers to an upright stature after snow melt. "Nebraska 28" is an older variety that produces a bluish green foliage and is recommended for Minnesota. It has not been grown extensively in Wisconsin but should be considered as an alternate selection to "Blackwell". "Pathfinder", after preliminary appraisal, is equal to "Blackwell", "Cave-in-Rock" and "Nebraska". It established easily in a no-till trial at Albany and Pine Island. It also develops the typical fall orange-tan color seen in other switchgrasses from mid-October to November. Resiliency of the old vegetation after severe winters has yet to be determined. All above varieties have been seeded at Waterloo for further evaluation. "Kanlow" was planted at one site at Waterloo. It has persisted but does not show the vigor of other varieties. Wisconsin ecotype is a smaller plant, compared to Blackwell, persistent in mixed stands but does not appear to spread naturally.

SCS recommendations for Minnesota: "Cave-in-Rock", "Nebraska 28", "Pathfinder", "Summer", "PM-SD-149" and "NGD-965-98".

Wheatgrasses. The U.S. Fish and Wildlife Service has recommended intermediate wheatgrass (*Agropyron intermeadii*) for nesting cover in the plains states (Duebbert, pers. comm.). This is a

stiff-stemmed cool season grass native to Russia that produces fruiting stems up to about 50 inches on fertile sites. In the northern plains states, intermediate wheatgrass produces more forage than bromegrass and stands have persisted for 8 to 10 years. Alfalfa can also be seeded with intermediate wheatgrass. Under southern Wisconsin conditions it has not developed into a dense stand and plantings 3 or 4 years old appear to be declining in vigor and density. After 3 years invasion of bluegrass (*Poa* sp.) and weedy forbs has also been noted in several intermediate wheatgrass fields. Standability of residual cover over winter is good but generally not comparable to switchgrass. Intermediate wheatgrass has not developed into a dense sod comparable to switchgrass or bromegrass.

Tall wheatgrass (*Agropyron elongatum*) matures at 60-65 inches and is a clump-former similar to the bluestems except that it does not produce the quantity of basal leaves usually seen on bluestem clones. Residual cover is about comparable to intermediate wheatgrass. The first seedings planted at Waterloo in 1970 persisted for 3 years and had completely disappeared after 5 years. If planted, the acreage should be limited to moderately dry sites. Wheatgrass can be planted either spring or late summer (August) with conventional grain drills or a Brillion seeder at the rate of 8-12 lbs/acre. A nurse crop is not required for August seedings and is optional for spring seedings. Based on our trials so far, both intermediate and tall wheatgrasses should be regarded as experimental.

Western wheatgrass (*Agropyron smithii*) is native to the states west of the Mississippi River but is also reported in the Midwest and Ohio river basin. It is a short-growing (24-30 inch) perennial that matures in June. The current season's growth invariably lodges by midsummer. It is winter hardy and longlived but not aggressive. New growth is bluegreen in color. This species will develop a good sod and may contribute to good brood cover if planted with switchgrass or big bluestem. Recommended varieties are: intermediate wheatgrass, Oahe; tall wheatgrass, Jose and western wheatgrass.

#### Potential for Wisconsin

Other warm season grass species that may be considered for trial plantings:

Sand bluestem (*Andropogon hallii*): "Garden" and "Goldstrike" varieties.

Sideoats grama (*Bouteloua curtipendula*): "Butte", "Killdeer", "Pierre" and "Trailway" varieties.

Prairie sandreed (*Calamovilfa longifolia*): "Goshen", "PM-ND-95" varieties.

Sand lovegrass (*Eragrostis trichodes*): "Nebraska 27" and "Bend" varieties.

The above species are native to the northern plains area and are generally adapted to sandy sites. *Bouteloua* and *Calamovilfa* are also native to Wisconsin. Each variety listed is available commercially but its performance in Wisconsin is uncertain. Sand lovegrass has been planted on 2 sites at Waterloo in 1976 and 1977. Sideoats grama was included in one of the mixtures used at Lake Kegonsa but the species has not been noted during field checks.

#### POST-PLANTING MANAGEMENT

##### First Growing Season

Seedings Without a Nurse Crop. All warm season grasses require 8-12 days to germinate under optimum conditions. Annual weed seeds begin germinating about 4 days after the last soil disturbance and rapidly become competitive for light, nutrients and moisture. Foxtails, for example, can germinate and grow 5 ft tall in 6 weeks on fertile soils. Therefore, weed control is absolutely essential to ensure successful establishment. Mowing is often the only alternative. Weed growth should be clipped when it reaches 12-15 inches in height (30-38 cm). Cutting with a rotary mower is preferred to a sickle bar mower. Field chopping and/or removal of the clipped material for livestock feeding is another alternative. Whatever method is used, a 6- to 8-inch stubble should be left to minimize damage to the seeding. A second or third mowing may be required in most fields. Since weed growth can be very rapid on warm days with adequate moisture, new fields should be checked weekly. Unfortunately, most annual broad-leaved weeds will resprout from lateral buds and the grasses will tiller from the base of the plant after mowing.

If broad-leaved weeds predominate, a 2,4-D application may be preferred to mowing. Weed growth should not be taller than 6 inches (15 cm) for optimum results. An application of 1 quart of 2,4-D (Amine) should be applied with 20 gal water/acre on a calm day to limit the drift. Spraying can be done much more rapidly than mowing and, applied at the optimum period of growth (2-6 inches), should completely control most broad-leaved annuals for the season. Grassy annuals are not affected by 2,4-D. There are no herbicides for grassy annual seedlings that will not affect the prairie grass seedlings.

Seedlings With a Nurse Crop. The oat nurse crop can be harvested for green chopping or "haylage" in mid- to late June or allowed to ripen for grain and harvested in early August. Under either method a stubble of 8 to 12 inches should be left depending on the height of the grass seedlings. If the oats are left for grain, the straw should be removed promptly to avoid smothering the seedlings or the combine can be set to leave a high stubble without harvesting the straw. Straw and chaff from the balance of the oats going through the combine should not be enough to cause smothering of the grass seedlings.

### Second Growing Season

Weed control may be advisable the second growing season if field checks indicate a heavy infestation of annuals, winter annuals or biennials. Broad-leaved weeds can be controlled with an application of 2,4-D when the weeds are 2-6 inches tall. Grassy weeds should be treated with atrazine before the warm season grasses start new growth, or about May 15 in an average year. Commercial seed growers report that all established warm season grasses tolerate 2-3 lbs of atrazine/acre. Application should be made by late April or early May as a pre-emergent spray. Quackgrass will be set back, but not eliminated. Annual broad-leaved weeds and some grassy annuals will be controlled. Paraquat only kills annual weeds but will burn back all perennials and, unless applied before the warm season perennials begin growth, it will also damage them. Usually mowing is not recommended the second growing season unless weedy growth is excessive and herbicides have not been applied earlier. If mowing is the only alternative, the stubble should be equal to or higher than the average new growth of the warm season grasses. Mowing should not be permitted after the middle of June.

Generally there is not sufficient residual fuel available after one growing season for a satisfactory burn. Use of atrazine in crop soil as a post emergent herbicide is not recommended any time. Other herbicides may prove valuable in weed control in warm season grasses, but a lack of adequate controlled field experiments at present does not warrant further comment at this time.

### MANAGEMENT OF MATURE STANDS

None of our experimental warm season grass fields have deteriorated to a stage that renovation or plowing under is necessary. Based on the number of fruiting stems produced, grass stands left undisturbed for 8 to 10 years are beginning to show definite decline in vigor. Burning in early spring is the best treatment known to stimulate the production of fruiting stems. Prescribed fire in April will not apparently injure any of the native grasses or dormant forbs. A moderate stand of grasses will have 3 to 4 tons of air-dry fuel per acre. On a high risk day (low relative humidity plus low fine fuel moisture content) a burn will eliminate all residual vegetation including any current growth of cool season grasses. Burning can be safely accomplished until about May 15 without damage to warm season grasses. Early nesting species such as mallards and ring-necked pheasants usually start production in early April and potential destruction of nests and young should be considered before burning after April 1. The frequency of burning is uncertain but most observers tend to suggest a rotational system whereby each site is burned once in 4 years. We expect to determine the effect of fire on the fruiting and general vigor of warm season grasses in future studies, particularly on stands left undisturbed for 8 or more years and showing positive symptoms of decline.

If necessary, burning can also be conducted in late fall or any time in the winter when conditions permit. Primary objection to fall or winter fires is the premature loss of cover. The importance of cover loss to wildlife must be judged for individual parcels in relation to the advantages gained by this rejuvenation practice. We expect quality grasslands can be managed indefinitely by periodic burning. Some evidence exists that fertilization also increases the quantity of cover on normally low fertility sites. To date, there has been little woody plant or perennial weed invasion on well-established warm season plantings.

### SPECIAL CONSIDERATIONS

#### Atrazine Carryover

Carryover atrazine residue should not be a problem to any of the bluestem, indiangrass or switchgrass varieties, but it can be troublesome if oats is used as a nurse crop or a cool season grass or legume is seeded along with warm season grasses. The problem usually arises where either a poor job was done in equipment calibration or in herbicide application the previous year. If an excessive atrazine carryover is suspected, soil samples should be collected in advance of the planting season and placed in flower pots or convenient containers and planted to oats and kept

in a bright room and watered as necessary. Residue problems can be detected if the oats grow normally to about 3 inches and then die back. A more precise test on atrazine carryover includes treating part of the soil sample with charcoal, and then seeding control and treated plots with oats. Details are available to anyone anticipating use of this procedure from local county agricultural agents.

#### Droughty or Wet Soils

While native prairie grasses are found on both dry, low fertility sands and on wet organic soils, they will be difficult to establish on these sites because of growth limitations of and the opportunity to either work or seed these soils. Weed problems are fewer on sands and, if timely precipitation occurs after seeding, the seedlings should become established. However, growth will be slower when compared to seedling growth on mesic sites. While these grasses seldom develop a sod on dry sands, the cover provided exceeds anything else that will grow on these sites.

Cool, wet springs may delay access to floodplains or muck soils until mid-June. If seeding is scheduled on these soils, the seedbed should be worked the previous late summer or fall. Apparently prairie grasses tolerate some spring flooding or high water tables but grow best on organic soils that dry out by mid-spring and remain dry during the growing season. Soils that remain wet because of site and/or poor internal drainage should not be considered for seeding to warm season grasses. These characteristics should be known in advance to aid in decision-making. Because of the soft texture of organic soils, grass drills will not work satisfactorily on these sites.

#### Fertilization

In Iowa, where native grasses are being established for beef cattle pastures, studies show that switchgrass responds to nitrogen fertilization (Schaller 1975). Where established stands have persisted and have not performed well, a soil test and appropriate fertilization may be necessary. If the grasses lack vigor, the weedy species probably have also done poorly.

#### Disease or Insect Problems

We have not observed any significant foliar diseases or heavy insect infestations to date. However, leaf rusts, especially on big bluestem, are a distinct possibility. Occasional "smut" has been observed on the fruiting head. We have not had any reports on the damage done to warm season grasses by such common insects as grasshoppers or armyworms.

High field mouse populations have been noted in undisturbed stands. The entire crowns of some little bluestem clones were clipped off at ground level, but the effect on new growth is unknown. This also occurred in intermediate wheatgrass over winter at Horicon. Cottontails have been observed in switchgrass stands throughout some winters, if only limited snow cover occurred. Fruiting stems of big bluestem are often browsed off.

#### Seed Storage

Seed germination studies conducted several decades ago indicated viability of seed either increased with age or remained stable up to 4 years after harvest. A rapid decline in seed viability after 1 or 2 years storage has not been documented for switchgrass, Indiangrass and the bluestem kept in dry storage under ambient temperatures and humidities. SCS plant materials specialists now recommend fairly uniform cool and dry storage conditions throughout the year. They suggest that temperature (degrees F<sup>0</sup>) plus relative humidity (percent) should not exceed 100 (another rule of thumb). Therefore, any seed left over for the following year should be stored under dry, cool, rodent and insect-free conditions. If a large quantity (50 lb or more) is held over, it is advisable to run germination tests prior to the next planting season to be certain the seed has retained viability. Adjustments should be made in the seeding rate if germination has changed.

TABLE 1. Herbicide recommendations for warm season grasses\*

| Type of Seedbed       | Major Weed Type                         | Herbicide           | Rate/Acre         | Time of Application                  |
|-----------------------|---|---------------------|-------------------|--------------------------------------|
| Plow-disc-drag        | Annuals                                 | Atrazine            | 2½ lb             | Date of seeding + 3                  |
| Old pasture           | Perennials**                            | Atrazine<br>Roundup | 2½ lb<br>2 quarts | Preplant 1 to 6 weeks before seeding |
| Corn stubble          | Annuals                                 | Paraquat            | 1-2 quarts        | Preplant 3 to 7 days before seeding  |
| Corn stubble          | Annuals<br>Biennials<br>Some perennials | Roundup             | 1-2 quarts        | Preplant 3 days before seeding       |
| After emergence       |   |                     |                   |                                      |
| First year            | Broad-leaved annuals                    | 2,4-D               | 1-2 quarts        | Weed growth 2-6 inches in height     |
| First year            | Grassy annuals                          | None                | None              | Mow with rotary mower for field chop |
| Second growing season | Perennials                              | Atrazine            | 2½ lb             | April 25 - May 5 <sup>1</sup>        |

\* None of the herbicides are specifically labeled for use in establishing or maintaining native grass stands. Ceiba-Geigy Co. submitted a request to the EPA for labeling Atrazine in January 1978. Interpretation of non-crop uses where specified is also not clear. However, all of the recommended labeled herbicides have been used successfully for weed control as indicated.

\*\*Except quackgrass.

<sup>1</sup> Average for southern Wisconsin.

#### PRAIRIE REESTABLISHMENT

Concurrent with the increase in use of native grass on state wildlife areas is the interest in establishing a "prairie" or reconstructing a plant community that includes the dominant or prevalent native grasses and forbs. Curtis (1959) classifies prairies into five groups based on soil moisture gradients--from dry to wet.

Prior to European settlement in the early 1800's, approximately 2.5 million acres of prairie flourished in Wisconsin (Curtis 1959). Tall grasses dominated the prairies but numerous species of forbs within the plant community provided color from early summer until late fall. Plant diversity is evident from the 55 prevalent species noted on dry to mesic prairies, and only slightly fewer prevalent species are found on mesic to wet prairies. Bluestems and Indiangrass have exceptional adaptability to dry, mesic and wet sites. Reintroduction of native prairie grasses and forbs on cropland at Waterloo was limited to a one-time seeding in which grass and forb seeds were mixed together and planted simultaneously. For large areas (over 1 acre) this is the only practical and economical approach. Additional and often time-consuming methods of hand planting and hand weeding, however, assure higher levels of success in establishing difficult species. Readers interested in establishing small plots or container-growing should refer to the proceedings of the Midwest Prairie Conferences and related references.

Reconstruction of a native plant community in a single seeding is a relatively new concept. Variable degrees of success have been experienced by the efforts up to the present. Since a majority of plantings are made on mesic sites, the following recommendations apply to seeding a tall grass prairie on a well-drained fertile location.

#### Seed Collection

To secure the best results, seeds of grasses and forbs should be collected at maturity the previous season from local relic stands, and stored under dry, cool conditions until planting the following spring. Improved germination of forbs and grasses can be expected if the seed is slightly moistened and stored in plastic bags at constant temperatures of 34-38°F until ready for planting.

Species composition should include as many of the prevalents (Curtis 1959), that can conveniently be harvested or purchased (Appendix C). At Waterloo the first experimental prairie planting consisted of 7 grass and 25 forb species seeded at an estimated rate of 30 to 7 PLS of grasses and forbs, respectively.

Percentages of each grass and forb species used is arbitrary. In general, each primary grass species (big bluestem, little bluestem, Indiangrass and switchgrass) should be represented by not less than 10% or more than 40% of the total grass seed planted. Forb seed production tends to be quite variable in quantity and viability. Selection of forbs may be limited by the availability of some species, but forbs should comprise at least 10% up to 35% of the total grass seed planted. A minimum of 40 PLS/ft<sup>2</sup> of grass and forb seed should be planted and a preferred seeding rate of 60-70 PLS is recommended.

### Seed Bed Preparation

The planting site should be plowed, disced and harrowed prior to planting and the field should be disced lightly again if seeding isn't promptly completed to provide some control of germinating weeds.

### Seeding

Seeds of all grasses and forbs should be mixed together. All legumes should be inoculated with the proper inoculant on the day of seeding. Wet stratified seeds should be dried carefully for a day or two before seeding to assure thorough mixing and to prevent settling or plugging up if planted with a Truax drill. Needlegrass, Canada rye and pasque flower should either be seeded separately or run through a hammer mill to break off the awns. Failure to do so results in frequent plugging of the drill or difficulty in hand broadcasting the mixture because of clumping of the fluffy seeds between the awns. Relatively clean seed mixtures or mixtures containing leaves or stems or other plant parts not exceeding 1 inch (2.5 cm) will feed through the large seed box on the Truax drill reasonably well. A seed mixture containing longer plant debris (over 1 inch in length) or less than 50% purity should be hand broadcast. Since the Truax drill has packer wheels following the double disc furrow openers, post planting treatment is not required. However, if the seed is broadcast, the field should be harrowed or lightly disced after seeding and culptacked to insure better soil contact with the seed. This operation is especially critical if the seeds have been stratified prior to planting. Stratified seeds often germinate within a week of planting and a dry spell after seeding could result in a high seedling mortality if the upper soil layer dries out.

### Post Planting Treatments

Weed control to insure successful establishment is the most critical but often neglected practice. New plantings should be at least checked bi-monthly to determine the degree of weed competition. Many prairie seedlings are difficult to identify in the early growth stage. Often a hand lens is necessary for identification. Annual weeds grow much faster than prairie species and mowing will be required as soon as the weeds reach 15 inches in height. Herbicides cannot be used in prairie plantings and regrowth of weeds from the mowed stubble will require at least 1 or 2 additional clippings the first season. Stubble height must be judged by the growth of the prairie species so as to provide the best competitive advantage. Clipping at a height of 6-8 inches with a rotary mower is suggested for the first cutting and an 8-10 inch stubble should be left on the second or third cut. Spring burns in late April between the 2nd and 4th growing season are beneficial if sufficient residual cover is present to carry a fire. Fire discriminates against the cool season weedy species such as bluegrass, quackgrass, stinging nettle and giant ragweed, if present.

### Results

The prairie community is slow to mature. Some species, leadplant, shooting star, prairie dropseed and needlegrass, appear to be difficult to establish. Prairie dock, compass plant, rosinweed, yellow coneflower, black-eyed susans, Canada trefoil and wild indigo are common on the Waterloo trails. Prairie dock, compass plant and wild indigo have not flowered after 4 or 5 growing seasons although the plants appear vigorous and healthy. Seventeen forb species and 5 grass species have established and prairie plants have become dominant and are successfully competing with quackgrass. Annual weeds rapidly decline after the third growing season.

Prairie reconstruction is still new in the field of native plant community development. As new plantings are evaluated over 5 to 10 years, additional recommendations will emerge to provide better assurance of successful plantings.

## SUPPLEMENTARY BENEFITS OF WARM SEASON GRASSES

Aside from the direct wildlife benefits of warm season grasses, each species develops a deep fibrous root system which holds soil and prevents erosion. Longevity of established grass stands has not been determined but the condition and vigor of the oldest plantings (1967) suggest they will remain functional indefinitely provided the area is burned once every 4 to 6 years. Curtis Prairie in the University of Wisconsin Arboretum was developed in the 1900's and native prairie grasses and forbs have remained dominant over 30 years. There is also evidence based on observations at Waterloo that good stands of switchgrass or mixed prairie grasses resist invasion of native and exotic woody species compared to old bluegrass pastures and brome-alfalfa mixture.

Blackwell switchgrass retains seeds in the panicle throughout the winter. Martin (pers. comm.) reported a flock of about 125 snow buntings consuming switchgrass seed in January 1979 on a waterfowl production area. Tree sparrows were noted eating big bluestem seed in December 1977 at Waterloo. The extent of winter song bird use of seed is unknown. Only switchgrass retains seed through the winter. Big bluestem seed is present through early January, Indiangrass seed is shed in mid-December, and little bluestem seed is gone by late November.

Another presumed advantage of mature native grasses, primarily the bluestems and Indiangrass, is that lodging is not a problem through early December or prior to the first heavy snowfall. This facilitates hunter and dog mobility. A few monotypic stands of switchgrass have lodged as early as mid-September. Generally the lodging occurs in tall, dense stands on apparently fertile soils in years of normal or above normal summer precipitation. Only a portion of a field lodges and the same section of a stand often remains upright after the following growing season. Switchgrass develops a sod after 4 to 5 years whereas the bluestems and Indiangrass are clump formers or bunch-grasses. Duebbert (1978) and George et al. (1978) have reported higher nest densities and nesting success of waterfowl and pheasants in North Dakota and Iowa, respectively. No comparable data are available for Wisconsin. Wildlife use reported thus far is based on random field observations. Preliminary accounts show waterfowl and pheasant nesting, pheasant brood use, summer deer beds, year-round cottontail and songbird use and an apparent high small mammal population.

For those who appreciate aesthetic values of plants, the prairie grasses change to various hues of yellow, orange and brown-red to purple in the fall. A reliable visual estimate of seedling success can be made in late October by walking through a field of new seeding and noting the distinctive dull copper colored plants. All other exotic species will be dull brown or green if frost tolerant. Native grasses also function as snow barriers and presumably slow spring runoff. These desirable attributes improve the status of these grasses as environmentally preferred vegetation.

## COSTS

Costs per acre were calculated from the Wisconsin Department of Agriculture bulletin on spring (1978) custom rates based on average charges for each tillage or planting operation. To compensate for inflation and variable charges made by custom operators to friends, relatives and neighbors, the 1978 average cost was adjusted 40% higher. Acreage charges for each operation will vary by locality, individual operator, total acreage worked, soils, and distance the operator moves his equipment. Table 2 estimates all costs normally encountered in establishing warm season grasses through contract custom operations. Field operation costs may be substantially reduced if agencies perform their own work or if sharecrop agreements are made with interested private farmers.

Seed and herbicide costs are based on early 1979 quotations or price lists of commercial dealers. First-year establishment costs will also vary according to the type of field operations involved and weed control methods employed. A pre-emergent atrazine application at the recommended rate on prepared seed beds is comparable in cost to mowing twice, and without the possible added loss of seedlings from wheel compaction or smothering from the clipped vegetation. However, mid-summer germination of grassy annuals on atrazine-treated lands may develop into severe competition requiring mowing. This condition is often seen on former corn land.

All tillage operations and herbicide use should be based on past cropping history and individual field characteristics. Poor switchgrass stands or total failures in some fields have been attributed, though not documented, to inadequate weed control in the year of establishment. Because of rapid weed growth under favorable temperatures and soil moisture, fields should be visited weekly to determine what timely and appropriate weed control measures are required.

No estimates of costs were calculated for a prairie establishment because of variables in seed cost and germination. Species selection and interspecific ratios of prairie forbs or the ratios of forbs to grasses is highly subjective and precludes any but purely arbitrary recommendations. Cost reduction can be accomplished by hand collection of seeds from relic stands along public roads and rights-of-way. Supervised youth groups have been responsible for collecting quantities of grass and forb seeds for several public projects in Dane County and this activity is becoming very productive and popular.

TABLE 2. Comparative Estimated Cost per Acre of Establishing Warm Season Grasses\*

| Pre-plant Operations                       | Prepared Seed Bed | No-Till |
|--|-------------------|---------|
| Plowing                                    | \$ 9.00           |         |
| Discing                                    | 5.50              |         |
| Harrowing                                  | 4.80              |         |
| Seeding                                    | 5.15              | \$ 5.50 |
| Applying herbicide                         | 3.00              | 3.00    |
| Sub-totals                                 | \$27.45           | \$ 8.50 |
| <b>Post-planting Costs (First Year)</b>    |                   |         |
| Rotary mowing or field chopping            | \$ 4.50           | \$ 4.50 |
| <b>Herbicide Cost - options</b>            |                   |         |
| Paraquat                                   | 1 pt/acre         | \$ 4.65 |
|  | 2 pt/acre         | 9.25    |
| Atrazine                                   | 2½ lb.            | 5.85    |
| Roundup                                    | 2 qt.             | 26.40   |
| Roundup + Atrazine (2 qt. + 2½ lb.)        | 32.25             | 32.25   |
|  | 33.30             | 40.75   |
| <b>Seed Cost (@ 50 PLS/ft<sup>2</sup>)</b> |                   |         |
|  | <b>Per Acre</b>   |         |
| Big bluestem                               | \$74              |         |
| Little bluestem                            | 55                |         |
| Indiangrass                                | 68                |         |
| Switchgrass                                | 31                |         |

\*Field operation costs based on 1978 Custom Rate Guide average plus 40%.

## APPENDIX A: SOURCE OF GRASS SEEDING EQUIPMENT

### Truax grass drill - 10 ft

Manufactured by Truax Company, 3717 Vera Cruz Ave., Minneapolis, MN 55422, tel. (612)537-6639.

Available through DNR, c/o Jon Bergquist, Area Wildlife Manager, 3911 Fish Hatchery Road, Madison, WI 53711, Tel. (608)266-0208. Rental rates to non-DNR groups or individuals, \$15 per day. (Priority given to DNR projects). The Truax drill has a large seed box for the fluffy bluestems, Indiangrass and most forb seeds. The small seed box is similar to the small seed or legume box on small grain drills. Switchgrass is seeded through the small seed box.

### Zip Seeder and Tye Pasture Pleaser

Three Zip Seeders are available through the Chevron Chemical Corporation located at Baldwin, Antigo and Madison. One Tye seeder is expected in the spring of 1979. Contact R. F. Ludt, Chevron Chemical Co., 3701-A Junction Road, Madison, WI 53711, Tel. (608) 831-7918 to rent equipment. No charge for use of Zip Seeder. It is mounted on a 2 wheel trailer and is easily towed by car. Adapted only for no-till seeding of switchgrass or legumes.

### Small grain drills with legume or grass box

DNR has small grain drills assigned to Burlington, Plymouth, Pine Island and Horicon.

Contact local farmers or implement dealers for rental equipment. Custom operators will also sow switchgrass on prepared seed bed or the complete operation may be offered for contract. Small (grass or legume box) seed boxes on grain drills will not have recommended settings for different seeding rates of switchgrass. To calibrate grain drills for seeding switchgrass, follow these procedures:

1. Tape up all but 3 seed outlets.
2. Dismantle seed tubes from the 3 outlets and attach a small coffee can or plastic bag or container to catch the seed.
3. Put seed in the 3 compartments and drive machine over a marked 25 ft area. Weigh collected seed and multiply by 1000. Convert weight measure to pounds which is the seeding rate per acre. Repeat procedure 3 times and take average.
4. Set rate changer at a new setting and continue calibration as above until range of recommended seeding rates is established.
5. Type or prepare table of the results and glue or permanently attach the guide to the inside cover for future reference.

### Brillion Seeders

Two new (1979) Brillion seeders acquired by Southern District are stationed at Pine Island and Horicon. Rental units are not generally available through implement dealers according to the manufacturer. Switchgrass, clean big bluestem and Indiangrass can be seeded with a Brillion seeder.

### Hand- or Machine-Operated Cyclone Seeders

Hand-cranked cyclone seeders work very satisfactorily for seeding switchgrass. Precise seeding rates are difficult to obtain because the operator must adjust the flow of seeds from the seeder and the width of the seed distribution to cranking speed and walking speed. Calibration is accomplished securely attaching a plastic bag over the outlet, covering a measured distance of 100 ft while cranking uniformly. Quantity of seed collected is multiplied by the fraction of an acre covered to get the seeding rate in pounds per acre. The procedure is repeated with necessary adjustments to get the desired seeding rate. Rental sources of machine-powered cyclone seeders is not known. Hand-operated seeders can be purchased through local grain elevators, coops or agricultural supply houses at approximately \$15-20. Clean big bluestem or Indiangrass can also be seeded with a cyclone seeder but with less reliability on seeding rates.

APPENDIX B: REGIONAL SOURCES OF PRAIRIE, WOODLAND AND WETLAND PLANTS

Following is a list of sources of seeds, tubers and plants of native vegetation in and near Wisconsin.

Roger Alwin  
Freedom Road  
North Freedom, WI 53951

Ferndale Nursery  
Askov, MN 55704

Plants

Game Food Nurseries  
Oshkosh, WI 54901

Aquatic plants, seed roots  
and tubers

High Meadow Farm  
Tom and Molly Murray  
Rt. 3, Box 155  
Mount Horeb, WI 53572

Plants and seed - prairie and  
woodland; some native trees  
and shrubs

Kester's Wild Game Food Nurseries, Inc.  
P. O. Box V  
Omro, WI 54963

Seed and plants

Lafayette Home Nursery  
c/o Jock Ingalls  
Lafayette, IL 63673

Seed and plants - prairie  
species

Little Valley Farm  
Rt. 1, Box 287  
Richland Center, WI 53581

Seed and plants

Lounsberry Gardens  
P. O. Box 135  
Oakford, IL 62673

Plants - prairie and woodland  
species

Midwest Wildflowers  
c/o L. H. Basker  
Box 64  
Rockton, IL 62673

Seed - woodland and prairie  
plants

Natural Habitats Nursery  
4818 Terminal Road  
McFarland, WI 53558

Seed and plants - prairie  
species

Olds Seed Co.  
2901 Packers Avenue  
Madison, WI 53707

Seed and plants

Orchid Gardens  
Route 1  
Grand Rapids, MN 55744

Plants - Northern woodland and  
wetland species

The Potting Shed  
P. O. Box 11638  
Milwaukee, WI 53211

Seed - prairie and woodland  
species

Prairie Associates  
c/o David M. Peterson  
6328 Piping Rock Road  
Madison, WI 53711

Seed and plants - prairie  
species

APPENDIX B (continued)

|  |   |
|--|---|
| Prairie Nursery<br>c/o J. R. Smith<br>P. O. Box 116, Route 1<br>Westfield, WI 53964                            | Seed and plants - prairie species       |
| Prairie Restorations<br>c/o Ron Bowen<br>990 Old Long Lake Road<br>Wayzata, MN 55391                           | Seed and plants - prairie species       |
| Prairie Ridge Nursery<br>c/o Joyce Powers<br>Route 2, Overland Rd.<br>Mount Horeb, WI 53572                    | Seed and plants - prairie species       |
| Strand Nursery Co.<br>Osceola, WI 54020  | Plants - woodland wildflowers and ferns |
| Stoney Brook<br>Prairie Nursery<br>Rt. 2, Box 57<br>Waterloo, WI 53594   | Seed and plants                         |
| Weeping Birch Gardeners<br>John and Cindy Thur<br>Route 1<br>Evansville, WI 53536                              | Perennial flowers                       |
| Wildlife Nurseries<br>P. O. Box 399<br>Oshkosh, WI 54901   | Aquatic plants, seed, roots and tubers  |
| Windrift Prairie Nursery<br>c/o Dorothy and Doug Wade<br>Route 2<br>Oregon, IL 61061                           | Seed and plants - prairie species       |
| Woodland Acres Nursery<br>c/o Marie Sperk<br>Route 2<br>Crivitz, WI 54114                                      | Plants - woodland and prairie species   |
| <u>More Distant Sources</u> - Recommended as a last resort, or as a source for plants not native to Wisconsin. |   |
| Clyde Robin Seed Co., Inc.<br>P. O. Box 2855<br>Castro Valley, CA 94546  | Seed - mostly western, some woodland    |
| Exeter Wildflower Gardens<br>P. O. Box 510<br>Exeter, NH 03833   | Plants - Woodland WHOLESale             |
| Gardens of the Blue Ridge<br>P. O. Box 10<br>Pineola, NC 28662   | Plants - woodland                       |
| Putney Nursery, Inc.<br>Putney, VT 05341   | Plants - woodland                       |
| <u>Other Materials</u>   |   |
| Nitragin Co., Inc.<br>3101 Custer Avenue<br>Milwaukee, WI 53209  |   |
| Rootrainers<br>Spencer-Lemaire Industries, Ltd.<br>10310 - 112th Street<br>Edmonton, Alberta<br>Canada T5K 1N1 |   |

APPENDIX C: PREVALENT MESIC PRAIRIE GRASSES AND FORBS\*

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| Scientific Name                | Common Name           |
|--------------------------------|-----------------------|
| <i>Amorpha canescens</i>       | leadplant             |
| <i>Andropogon gerardi</i>      | big bluestem          |
| <i>A. scoparius</i>            | little bluestem       |
| <i>Asclepias syriaca</i>       | common milkweed       |
| <i>Aster azureus</i>           | sky-blue aster        |
| <i>A. ericoides</i>            | heath aster           |
| <i>A. laevis</i>               | smooth-blue aster     |
| <i>Baptisia leucophaea</i>     | cream wild indigo     |
| <i>Ceanothus americanus</i>    | New Jersey tea        |
| <i>Cirsium discolor</i>        | pasture thistle       |
| <i>Comandra richardsoniana</i> | bastard toadflax      |
| <i>Coreopsis palmata</i>       | tickseed              |
| <i>Desmodium canadense</i>     | tick trefoil          |
| <i>D. illinoense</i>           | Illinois tick trefoil |
| <i>Dodecatheon meadia</i>      | shooting star         |
| <i>Elymus canadensis</i>       | Canada rye            |
| <i>Eryngium yuccifolium</i>    | rattlesnake master    |
| <i>Euphorbia corollata</i>     | flowering spurge      |
| <i>Fragaria virginiana</i>     | wild strawberry       |
| <i>Helianthus laetiflorus</i>  | rigid sunflower       |
| <i>Lathyrus venosus</i>        | veiny pea             |
| <i>Lespedeza capitata</i>      | bush clover           |
| <i>Liatris aspera</i>          | rough blazing star    |
| <i>Monarda fistulosa</i>       | wild bergamot         |
| <i>Panicum virgatum</i>        | switchgrass           |
| <i>Petalostemum purpureum</i>  | purple prairie clover |
| <i>Phlox pilosa</i>            | prairie phlox         |
| <i>Potentilla arguta</i>       | prairie cinquefoil    |
| <i>Ratibida pinnata</i>        | yellow coneflower     |
| <i>Rudbeckia hirta</i>         | black-eyed susan      |
| <i>Silphium integrifolium</i>  | rosinweed             |
| <i>S. laciniatum</i>           | compass plant         |
| <i>S. terebinthinaceum</i>     | prairie dock          |
| <i>Solidago missouriensis</i>  | prairie goldenrod     |
| <i>S. rigida</i>               | stiff goldenrod       |
| <i>S. speciosa</i>             | showy goldenrod       |
| <i>Sorghastrum nutans</i>      | Indiangrass           |
| <i>Sporobolus heterolepis</i>  | prairie dropseed      |
| <i>Stipa spartea</i>           | needlegrass           |
| <i>Tradescantia ohnensis</i>   | spiderwort            |

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\*After Curtis (1959)

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CREDITS

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