EARLY SEASON NATIVE FORBS		May			June			July			August			September		
SCIENTIFIC NAME	COMMON NAME	1-10	10-20	20-30	1-10	10-20	20-30	1-10	10-20	20-30	1-10	10-20	20-30	1-10	10-20	20-30
Caltha palustris	Marsh marigold															
Geum triflorum	Prairie smoke															
Antennaria neglecta	Pussytoes															
Castilleja coccinea	Indian paintbrush															
Krigia biflora	False dandelion															
Saxifraga pensylvanica	Swamp saxifrage															
Senecio aureus	Golden ragwort															
Sisyrinchium campestre	Blue-eyed grass															
Hypoxis hirsuta	Yellow star grass															
Pedicularis canadensis	Lousewort															
Viola pedatifida	Prairie violet															
Cardamine bulbosa	Spring cress															
Allium canadense	Wild garlic															
Lithospermum canescens	Hoary puccoon															
Phlox maculata	Marsh phlox															
Phlox pilosa	Prairie phlox															
Anemone canadensis	Canada anemone															
Prunella vulgaris var. lanceolata	Self heal															
Zigadenus elegans	White camass															
Dodecatheon media	Shooting star															
Campanula aparinoides	Marsh bellflower															
Oxalis violacea	Violet wood sorrel															
Comandra umbellata	Bastard toadflax															
TOTAL EARLY SEASON FORB SPECIES POTENTIALLY RIPE				23		10	12	99		11	34		61	2		

NATIVE GRASSES		June			July			August			September			October			November		
SCIENTIFIC NAME	COMMON NAME	1-10	10-20	20-30	1-10	10-20	20-30	1-10	10-20	20-30	1-10	10-20	20-30	1-10	10-20	20-30	1-10	10-20	20-30
Hierochloe odorata	Sweet grass																		
Heterostipa spartea	Porcupine grass																		
Sphenopholis obtusata	Prairie wedgegrass																		
Calamagrostis canadensis	Blue joint grass																		
Koeleria macrantha	June Grass																		
Glyceria striata	Fowl manna grass																		
Agropyron trachycaulum	Slender wheat grass																		
Bouteloua curtipendula	Sideoats grama																		
Elymus canadensis	Canada wildrye																		
Schizachyrium scoparium	Little bluestem																		
Spartina pectinata	Prairie cord grass																		
Panicum virgatum	Switchgrass																		
Sorghastrum nutans	Indiangrass																		
Sporobolus heterolepis	Prairie dropseed																		
Andropogon gerardii	Big bluestem grass																		
Sporobolus compositus	Tall dropseed																		
Muhlenbergia racemosa	Upland wild timothy																		
Elymus virginicus	Virginia wildrye																		
Cinna arundinacea	Woodland reedgrass																		
TOTAL GRASS SPECIES POTENTIALLY RIPE			1	2	5	3	3				1	8	9	11	8	5	1		

NATIVE LEGUMES		July			August			September			October			November		
SCIENTIFIC NAME	COMMON NAME	1-10	10-20	20-30	1-10	10-20	20-30	1-10	10-20	20-30	1-10	10-20	20-30	1-10	10-20	20-30
Lathyrus venosus	Veiny pea															
Lathyrus palustris	Marsh vetchling															
Astragalus canadensis	Canada milkvetch															
Desmodium illinoense	Illinois tick trefoil															
Desmodium canadense	Showy tick trefoil															
Dalea purpureum	Purple prairie clover															
Lespedeza capitata	Roundhead bushclover															
Dalea candida	White prairie clover															
Baptisia bracteata var. leucophaea	Cream wild indigo															
Baptisia alba var. macrophylla	White wild indigo															
TOTAL LEGUME SPECIES POTENTIALLY RIPE				1	1		2	5	6	8	7	6	3	1		

NATIVE SEDGES		May			June			July		
SCIENTIFIC NAME	COMMON NAME	1-10	10-20	20-30	1-10	10-20	20-30	1-10	10-20	20-30
Carex annectans	Yellow foxsedge									
Carex interior	Prairie star sedge									
Carex stricta	Tussock sedge									
Carex meadii	Mead's sedge									
Carex bicknelli	Prairie sedge									
Carex brevior	Plains oval sedge									
Carex gravida	Heavy sedge									
Carex molesta	Troublesome sedge									
Carex vulpinoidea	Brown fox sedge									
Carex pellita	Woolly sedge									
Carex bebbii	Bebb's sedge									
TOTAL SEDGE SPECIES POTENTIALLY RIPE						3	8	8	7	2

Optimal Collection Period

Seed Ripening Period

LATE SEASON NATIVE FORBS		August			September			October			November		
SCIENTIFIC NAME	COMMON NAME	1-10	10-20	20-30	1-10	10-20	20-30	1-10	10-20	20-30	1-10	10-20	20-30
Stachys palustris	Woundwort												
Vicia americana	Vetch												
Rudbeckia hirta	Black-eyed Susan												
Lobelia spicata	Spiked lobelia												
Iris shrevei	Blue flag												
Rosa carolina	Pasture rose												
Oxypolis rigidior	Cowbane												
Vernonia fasciculata	Ironweed												
Veronicastrum virginicum	Culver's root												
Heliopsis helianthoides	False sunflower												
Lysimachia quadriflora	Narrow-leaved loosestrife												
Lythrum alatum	Winged loosestrife												
Ceanothus americana	New Jersey tea												
Eupatorium maculatum	Spotted Joe Pye												
Thalictrum dasycarpum	Purple meadow rue												
Pycnanthemum pilosum	Hairy mtn. mint												
Lobelia cardinalis	Cardinal flower												
Lilium philadelphicum	Wood lily												
Zizia aurea	Golden alexanders												
Silphium laciniatum	Compass plant												
Eryngium yuccifolium	Rattlesnake master												
Allium cernuum	Prairie onion												
Asclepias tuberosa	Butterfly milkweed												
Lobelia siphilitica	Great blue lobelia												
Silphium integrifolium	Rosinweed												
Pycnanthemum tenuifolium	Slender mtn. mint												
Lysimachia ciliata	Fringed loosestrife												
Asclepias incarnata	Swamp milkweed												
Echinacea pallida	Pale purple coneflower												
Amorpha canescens	Lead plant												
Rudbeckia subtomentosa	Sweet coneflower												
Pycnanthemum virginianum	Common mtn. mint												
Coreopsis palmata	Prairie coreopsis												
Anemone cylindrica	Thimbleweed												
Ratibida pinnata	Gray-headed coneflower												
Pedicularis lanceolata	Swamp lousewort												
Eupatorium perfoliatum	Common boneset												
Potentilla arguta	Prairie cinquefoil												
Oligoneuron rigidum	Rigid goldenrod												
Lilium michiganense	Michigan lily												
Liatris pycnostachya	Prairie blazingstar												
Symphyotrichum sericeum	Silky aster												
Symphyotrichum oolentagniense	Skyblue aster												
Symphyotrichum laeve	Smooth blue aster												
Monarda fistulosa	Wild bergamot												
Verbena stricta	Hoary vervain												
Symphyotrichum novae-angliae	New England aster												
Prenanthes racemosa	Rattlesnake root												
Oligoneuron riddellii	Riddell's goldenrod												
Artemisia ludoviciana	Prairie sage												
Symphyotrichum praealtum	Willowleaf aster												
Parthenium integrifolium	Wild quinine												
Liatris aspera	Rough blazingstar												
Anemone virginiana	Virginia anemone												
Coreopsis tripteris	Tall coreopsis												
Solidago missouriensis	Missouri goldenrod												
Solidago nemoralis	Gray goldenrod												
Solidago speciosa	Showy goldenrod												
Euthamia graminifolia	Grass-leaved goldenrod												
Gentiana andrewsii	Bottle gentian												
TOTAL LATE SEASON FORB SPECIES POTENTIALLY RIPE		4	6	12	32	41	47	45	34	19	4	1	

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Tallgrass Prairie Center Seed Collecting Guide – March 2008, GH

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1 SEED COLLECTING FROM TALLGRASS PRAIRIES

Content by Greg Houseal

PRAIRIE RESTORATION SERIES

Seed of many native species are now commercially available for prairie reconstructions, large or small. Yet many people have an interest in collecting and growing native species for butterfly gardens, backyard and schoolyard wildlife habitat, and prairie restorations. Seed collecting is satisfying and rewarding, a great volunteer activity for introducing people to prairies, and a good way to collect seed for local prairie restorations.

Which species?

Any species can be collected by hand, but hand collecting is particularly useful in collecting seed of native species which:

» occur on specific sites that may be inaccessible to machine harvest.

» are very low- or high-growing species or early- or late-ripening species

» occur as uncommon or patchy species in native prairie.

» have explosive seed dispersal mechanisms (phlox, violets)

Equipment Needed

Leather work gloves

Good quality pruning shears or heavy-duty scissors

Large plastic unbreakable combs

Durable, light weight tubs of various sizes

Clothe or paper bags of various sizes

Backpack for carrying extra bags

Appropriate clothing — sturdy footwear, long pants, hat, extra water

Binoculars for scouting

Willing companions!

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How to Collect?

Seed can be stripped by hand from many species (blazingstars, asters, grasses). Efficiency can be improved by keeping both hands free by fastening collection bags and containers around the waist. In species with seed in 'salt-shaker' pods, try tipping the pod into an open container to collect (shooting star, giant St. John's wort, larkspur, wild columbine). This will minimize the need to clean seed later. If seed is held tightly in the seedhead, simply clip a portion of the seedhead for later cleaning. Prickly seedheads like rattlesnake master (*Eryngium yuccifolium*) or pale purple coneflower (*Echinacea pallida*) will require gloves and shears for efficient collecting. Plastic combs aid efficient stripping of seed from grasses as illustrated in the photo below. Species with explosive pods can be bagged with nylon hosiery just prior to seed dispersal.

Leather gloves and good-quality scissors or shears are a must for effective seed collecting. Unbreakable plastic combs are inexpensive and efficient tools for stripping grass seed. Choose brightly colored tools that will be easy to spot if dropped or misplaced in the prairie while collecting. Use breathable bags (cloth or paper) for collecting that will allow moisture to escape. Even seemingly dry seed/seedheads retain enough moisture when first collected to cause mildew or rot if left unchecked in plastic bags. Use care not to leave collected material in closed vehicles that may heat up in the sun.

Seedhead of pale purple coneflower *(Echinacea pallida)* sliced in half to reveal lighter-colored seeds tucked in between bracts.

Where to Collect?

Obtain permission from the landowner or proper land management agency prior to collecting. Many areas have been planted to native species (reconstructed prairies). Planted prairies provide important wildlife, soil and water quality benefits. They have far fewer species than remnant prairies, and often the original source of seed for the planting has not been recorded or is unknown. If seed source is important for your project, collect from planted prairies only if you know the original source of the seed and it meets your restoration goals.

Be mindful that removal of any plant or plant part from preserves, natural areas, and parks is restricted, so check with the proper agency before collecting in these areas. Harvesting from roadsides may be restricted in some states and counties. Many counties in Iowa, for example, are planting native prairie in roadside rights-of-way. Ask permission from the county roadside managers, engineers, or state department of transportation before collecting from roadsides.

Obtain permission from the landowner or proper land management agency prior to collecting

Collecting from Remnant Prairies

Remnants are small remaining patches of the original prairie landscape that have not been cropped, overgrazed, or otherwise destroyed. Very few remnant prairies exist
in the mid-west today, and most are in need of careful management if they are to be conserved. A commonly expressed rule is "take half, leave half" when harvesting seed from remnants. Be mindful of legal and ethical considerations when collecting. While remnants are important local genetic sources of seed stock for restorations or seed nurseries, they should not be directly exploited for commercial production of seed. Federal and state endangered and threatened species cannot be collected without proper permits (go to *www.iowadnr.com/other/threatened.html* to download a list of Iowa's threatened and endangered species).

Keep in mind two important ideas:

» Attempt to collect roughly equal amounts of seed from several individuals in the population.

» Generally speaking, near neighbors are more closely related genetically than distant individuals, so it is important to collect seed from throughout the population.

Removal of any plant or plant part from preserves, natural areas and parks is restricted; check with the proper agency befor collecting in these areas

Remnant prairies provide genetically adapted seed for restoring prairies for future generations of Iowans!

Are There Negative Impacts to Collecting from Remnants?

Most prairie species are perennial, meaning their roots survive over winter to regrow shoots the next spring, so an annual seed crop is not essential to the perpetuation of the population. Exceptions are annual, biennial, and short-lived perennial species; rare and uncommon species; or common species poorly represented in a remnant. Avoid intense, repeated, annual harvesting of the same remnant area. The negative impacts of over-collecting include trampling of vegetation and introduction of exotic or invasive plants brought in on clothing or equipment. Manipulation of a remnant prairie to maximize seed production – such as whole-site, repeated annual burns; herbicide treatments; or fertilizing – is inappropriate and damaging to remnant biodiversity. Finally, any mechanical harvesting occurring in remnant sites should include a careful inspection and cleaning of equipment prior to use, including vehicles, to avoid introducing exotic/invasive species that may contaminate the equipment and lead to the degradation of the remnant or create long-term management issues.

Federal and state endangered species cannot be collected without proper permits, and should only be done as part of a recovery effort by qualified professionals

Collecting Seed for Genetic Diversity

An important restoration goal should be to capture genetic diversity from remnant populations. Here are some rules of thumb to guide your efforts. First, of course, be reasonably sure the site is a remnant (never plowed, not planted).

Collect seed from at least 20 to 30 well-dispersed individual plants within a population, if possible. Randomize the process, avoid intentionally selecting plants based on size, color, vigor or any other trait. The point is to capture genetic diversity, not novelty. To sample large populations, walk transects and collect seed perhaps every 10 paces. Collect roughly equal amounts of material (seed or seedhead) from each plant you encounter. If collecting from multiple sites, attempt to equalize the contribution of seed from each site, particularly if collecting seed as foundation stock for nursery production to generate seed for other reconstructions.

When to Collect?

Seed ripening and timing of harvest varies by species, environmental conditions, and regional adaptation of plants. Most species ripen gradually, so not all seed will be at the same stage of maturity at any given time. Seed maturity usually progresses from top to bottom of the seed head in grasses and many forbs species. However some ripen from the bottom up, as in the blazingstars. Mature seeds are usually quickly dispersed either by gravity, wind, water, or animals, so it's important not to delay collecting.

The tables illustrate approximate seed maturity times for selected tallgrass prairie species in Iowa. Cold, moist conditions will delay seed maturity; while hot, dry conditions hasten it. Latitude affects ripening since many plants flower and set seed in response to photoperiod. Seed maturity occurs earlier in populations adapted to northern Iowa, and later in populations adapted to southern Iowa. Optimal Collection Periods when more species are likely to be in fruit are indicated.

When to Collect?

Harvest grasses at the hard-dough stage, when firm thumbnail pressure slightly dents the caryopsis.Many grasses do not hold seed long after maturity. Test ripeness by firmly striking the seed head against palm; if some shattering occurs, the seed is ready to harvested.

In forb species, the seedhead or stalk immediately below will appear dry or discolored as seed matures. A notable exception are the spiderworts (*Tradescantia*), members of the day-flower family, which drop mature seed while bracts remain green and other flowers in the same cluster are in bud or blooming. Species with dispersal apparatus, i.e. 'parachutes' (blazingstars, asters, goldenrods, milkweeds) will appear dry and fluffy at maturity and should be picked immediately at this stage. Some species forcefully eject seed at maturity (phlox and violets, for example), and must be checked daily or bagged loosely with a mesh bag so seed is captured upon dispersal.

Keeping Records

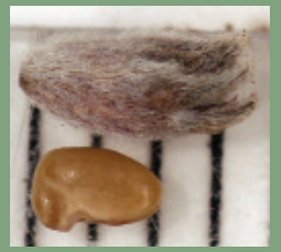
Keeping records of where and when you collect provides important information about a prairie restoration. Basic information to include is location (county, township, section and quarter section), soil type (sandy, clayey, loamy) and moisture (wet, medium, dry), slope and aspect (direction slope faces), approximate size of population, number of plants collected from, and date. It's a good idea to include a sketch of the site to jog your memory about where the species occurred within the prairie.

Data Collected:				
Collector(s):				
Address:				
Contact Information:				
Species Collected:				
County:	**Township:**	**Range:**	**Section:**	**Quarter Section:**
Property Owner/Land Management Organization:				**Sketch of Site:**
Soil Type:				
Slope:				
Aspect (direction slope faces):				
Approximate Size of Population:				
No. of Individual Plants Collected From:				
Associated Species:				

Example of Seed Collecting Label

What is Debearding?

Many grass species have seeds with "beards" (hair-like awns), and many forb species have "parachutes" (pappus) attached to seeds (e.g. fluffy seed of asters and goldenrods). These awns and pappus are adaptive and aid seed dispersal in nature. Debearding is the process of removing these hair-like appendages. The terms debearding and deawning are sometimes used interchangeably and applied to both grass and forb seed.



Purple prairie clover with hull, top; dehulled below.

Big bluestem with beard, top; caryopis below

What is Dehulling?

Seeds of native legumes (bean family) are tightly held in small pods or hulls (e.g. prairie clover, showy tick trefoil, leadplant, round-head bushclover). Dehulling removes seeds from these pods.

Are Debearding and Dehulling Necessary?

Debearding fluffy grass and forb seed and dehulling legume seed isn't absolutely necessary for seed to germinate and grow, at least eventually, and are impractical to do by hand except on a small scale. These techniques do provide important benefits, however, and are used routinely by commercial native seed producers. Both of these techniques improve flowability of the seed allowing it to be cleaned to greater purity and germination. Seed will flow through a seed drill more efficiently when planted, and removing awns or hulls improves seed-to-soil contact important for timely germination.

In addition, mechanical dehulling provides scarification, a process that prepares the hard seed coat of legumes to more readily absorb water for germination. Removing the hull also allows for more accurate laboratory seed testing, since hulls can mask seed quality.

Deawning or dehulling small lots of seed by hand is time consuming and dusty, but can be done. It can be accomplished by rubbing fluffy seed over a small mesh screen with openings just large enough for the seed to pass through, then using air-flow to separate seed from chaff. A small gallon-sized Forsberg huller/scarifier machine is useful for de-awning small quantities of seed. This type of machine is very aggressive and only a few seconds of treatment are typically needed. Another inexpensive device is the Hoffman Mfg. hand deawner/debearder.

Storage

Proper storage of seed is essential to maintain viability (ability to germinate) and vigor (ability to successfully establish in the field). Seed can be kept in a cool, dry, rodent-proof place for up to a year. Longer-term storage requires a stable temperature- and humidity-controlled environment. Seed stored at 60°F stays viable twice as long as seed stored at 70°F. A good rule of thumb is that the sum of the temperature (degrees Fahrenheit) and relative humidity (RH) should not exceed 100. Examples would be storing seed at 50°F and 40% RH or 40°F and 50% RH, the addition of the two is less than 100. Relative humidity above 40% is especially detrimental to legume (oil based) seeds. Once seed has been dried properly, moisture resistant containers, such as glass or plastic jars, or 4-mil plastic bags (Ziplocs), will help protect it from collecting moisture.

Other Important Factors Affecting 'Shelf-life'

Important factors besides temperature and humidity can affect longevity of stored seed. Non-seed (inert) matter can harbor fungal and insect pathogens, which might damage seed during storage. Cleaning seed properly and thoroughly will extend viability. Overly aggressive cleaning, however, can damage seed and shorten longevity of stored seed. Care should be taken with debearding or de-hulling processes not to damage or break seed.

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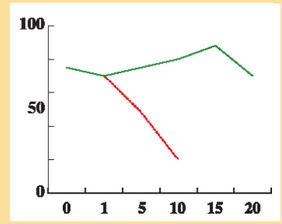
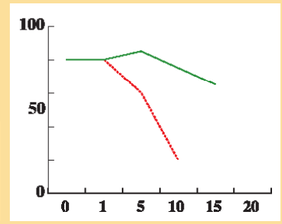
Indian Grass (Sorghastrum natans)

Storage Affects Germination

Generally, germination tends to increase slightly in some species stored up to a year after harvest as dormancy mechanisms break down. Germination then declines over the long term due to seed mortality during storage. Proper storage conditions will slow this decline.



Purple Prairie Clover (Dalea Purpurea)



% of germination with refridgeration

% of germination with out refridgeration

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DRYING, CLEANING AND STORING PRAIRIE SEED

Content by Greg Houseal

PRAIRIE RESTORATION SERIES

Collecting native seed requires a considerable investment of time, patience, and diligence. If the seed is to be stored for any length of time, the next step is to properly care for the harvest! Drying, cleaning and storage requirements for prairie seed after collecting will depend on how and which species are collected, the length of time stored, and the intended seeding method. If seed is collected in bulk and immediately spread on a restoration site, little processing is necessary. Also, seed quality varies greatly from each year and from one site to another, so extensive cleaning may be fruitless if seed quality is poor. Provisions should be made to begin drying any material stored more than a day.

Consider keeping seed collections separate for individual species to facilitate thorough cleaning and assessment of seed quality. This is especially important if seed is collected for long-term storage, seedling propagation, seed testing, or for special restoration efforts.

Equipment Needed

This is a basic list of equipment needed for drying, cleaning and storing native seed on a modest scale:

Drying	Cleaning	Storing
Clean, dry work space protected from the elements	Plastic tubs and other containers of various sizes	Cool, dry, rodent proof storage area
Newsprint (or tarps for spreading out larger quantities of seed)	Screens of various mesh-sizes and dimensions	Refrigeration for long term storage (more than a year)
Low humidity and good air circulation	Leather gloves	Air-tight bags or containers for dried seed
Box-type fans	Good quality dust masks	
	Good ventilation	
	Heavy work boots for stomping	

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Much of the bulk material in native seed collecting is non-seed (inert) floral parts, leaves, and stems. The quantity of material collected will dictate the scale of time, tools, and equipment needed for efficient drying and processing of the seed. Some species are more challenging to process than others.

Important Tips on Seed Drying

Drying bulk material immediately after harvest is critical for preventing mold and mildew. Drying will also allow some immature seeds to ripen and aid threshing of the seed out of seed heads or pods, and thus help maximize seed yield. Small amounts can be placed loosely in cloth or paper bags or spread out on screening or newspaper in a cool, dry place with good air circulation. If using paper bags, leave tops open and turn the contents once or twice daily. Take care not to pack collected bulk material into bags too tightly; keep it loose so air can circulate.

Breathable cotton bags full of seedheads in forced-air-drying bins.

Spiderwort spread on tarp with box fan.

Larger quantities can be spread on tarps and turned once or twice daily with pitchforks. Place box fans strategically to keep air circulating over and around bulk material. Do NOT use any form of direct heat! It can damage and kill seeds. Drying may take several days to two weeks, depending on quantity and drying conditions.

Some Simple and Effective Cleaning Techniques

Simple techniques are available to effectively clean modest amounts of seed. Proper cleaning will remove much of the inert material and dust, and also remove empty, non-viable seed. These cleaning techniques involve various ways of threshing (knocking seed free of seedheads) and sorting seed using screens and airflow. Material should be properly dried before further cleaning.

Threshing — Stomp method

Species with large, coarse seed heads that tend to hold the seed tightly can be threshed by stomping on seed heads. This method is very effective on species of wild indigo (Baptisia), rattlesnake master (Eryngium), compassplant and rosinweed (Silphium), sunflowers (Helianthus), black-eyed susan and sweet coneflower (Rudbeckia), golden Alexander (Zizia). Using large plastic tubs, place about a 2-in. layer of bulk material in the bottom and stomp on it with waffle-type boots. Toe kicks to the corners of the tub help break up any stubborn seed heads. Stomped material is then screened through a coarse 1/2-in. or 1/4-in. screen into a second tub. Continue in batches, returning any intact seed heads remaining to the stomping tub. Pale purple coneflower (Echinacea) tends to be stubborn and may require machine threshing, unless it's collected late in the season after seed heads naturally begin to break apart.

Threshing — Shake Method

Many species have seeds that shake free of a capsule or open pod. This method can be effective for dried seedheads of Culver's root (Veronicastrum), cardinal flower and great blue lobelia (Lobelia), shootingstars (Dodecatheon), mints (Pycnanthemum, Monarda), and gentians (Gentiana). Either hold dry seedheads upside down against the inside of a tub or place in a bag and shake or beat gently to free seed. This method has the advantage of minimizing the amount of chaff and inert material in the seed.

Threshing — Screen Method

Hand clipped and dried seedheads of blazingstars (Liatris), asters (Symphyotrichum), and goldenrods (Solidago, Oligoneuron), and spiderworts (Tradescantia), for example, can be threshed by rubbing the seed heads over a large screen made of 1/2-in. or 1/4-in. hardware cloth using gloved hands or aluminum scoop shovels. Elevate the screen on sawhorses over a tarp; fluffy seed will float down onto the tarp and can easily be scooped up for further processing.

Screens

Screens are used for sorting by shape and size and are essential for cleaning. Any kind of mesh can be made into a ready-made screen including kitchen sieves, colanders, window screens, hardware cloth, decorative grating are just a few ideas. Commercially available screens are made in a wide range of pore sizes and shapes for specific purposes. Handheld pan-type screens are handy for small batches. Homemade screens of hardware cloth, available in 1/8, 1/4 and 1/2 inch mesh attached to wood frames are effective for rough cleaning. Depending on the application, screens are classified as scalping, grading or sizing, and sifting, as described below.

Scalping

Scalping removes objects larger, longer, and wider than the desired crop seed. Screens used for scalping have pores larger than the seed. Most compassplant seeds will fall through a 1/2 inch mesh, for example, which scalps off larger bits of leaves, stems, and bracts. Scalping material through a much larger screen first, and then one closer to seed size is often more efficient, allowing material to flow more freely through each screen.

Grading or Sizing

Grading sorts desired seed, or "crop" seed by size. Any given species' seed will contain a range of seed sizes. Avoid intentionally grading seed intended for restoration plantings, since selection for seed size can happen in one generation, (i.e., large seeds will give rise to plants with large seeds), and may reduce genetic variability. Large rosinweed seeds, for example, may not go through a 1/4 inch screen, but smaller rosinweed seeds will. Using a 1/4 inch screen in this case would not be advisable.

Sifting

'Sifting is the final screening step. Use a screen with pores just smaller than the seed to allow dust, broken seeds, etc. to fall through and yet retain desired seed on screen. For example, most compassplant seeds won't fall through a 1/4 inch screen, but smaller bits of plant material will, especially the 'straw'.

This series of screening processes is effective in concentrating desired seed and removing most inert material. Not all seeds will be viable, however, even if they otherwise look normal. Some seeds will be 'light' in weight due to immaturity, underdevelopment or from being eaten from the inside by seed predators. These seeds will not be removed by simple screening. This "light" seed is removed with airflow, either by winnowing or aspiration.

Airflow — Winnowing

Winnowing uses horizontally moving air to separate heavy from light particles. Winnowing seed in a gentle breeze can be very effective in removing chaff and light seed. To achieve more control, place a tarp on the floor and an ordinary box fan at one end of the tarp. Pour seed gently in front of the fan. Heavier seed falls closer to the fan than light seed or empty seed. Fine-tune the process by experimenting with fan speed and distance from fan. Once you find the most effective combination, continue to pour the seed in front of the fan in a consistent manner. The seed should now be laying somewhat fanned out on the tarp, with the heavier seed nearer to the fan and light or empty seed further away. Using a thumbnail, push down on the seed coats closest to the fan at first, repeating this test as you gradually move away from the fan. Heavy seed will feel firm and resist being crushed with gentle, downward pressure; empty seeds, on the other hand, will offer little resistance and crush easily. Make a determination where the heavy seed ends and the light or empty seed begins, and draw a line through the pile of seed at this point. Clean, heavy seed can then be swept up and stored for planting, while the rest is discarded.

Airflow — Aspirating

Aspirating uses vertically moving air to suspend particles in a column. Lighter seeds are either captured in a pocket of the column, as in a South Dakota seed blower, or blown completely out of the column. Heavier seeds drop out of the column. Desired separation is achieved by adjusting airflow in the column.

Fanning mills and air/screen cleaners are machines designed to combine the screening and aspiration process and are very efficient once the proper screens and settings have been made. Old fanning mills, which both screen and aspirate seed, can sometimes be purchase at farm sales for a modest price, but may require modest repairs.

NATIVE PLANT PROPAGATION			OUTDOOR PROPAGATION			GREENHOUSE SEEDLING PROPAGATION					
FAMILY	SPECIES		Propagation	Sowing Time	Division/	SCARIFICATION	STRATIFICATION		SOWING	OUT-PLANTING
	Common Name	Scientific Name	Methods	Outdoor/Flats	Transplant		COLD	# Weeks	DEPTH	TIME
	WILDFLOWERS									
APIACEAE	Rattlesnake master	*Eryngium yuccifolium*	SEED	Dormant	Spring	-	Moist	8-12	1/4"	Spring
(Parsley)	Golden Alexander	*Zizia aurea*	SEED, DIV	Dormant	Spring/Fall	Scarify?	Moist	12-16	1/4"	Spring
ASCLEPIADACEAE (Milkweed)	Butterfly milkweed	*Asclepias tuberosa*	SEED	Dormant	-	-	Moist	4-8	1/4"	Spring
ASTERACEAE	Prairie sage	*Artemisia ludoviciana*	SEED, DIV	Dormant	Spring/Fall	-	Dry	12	SURFACE	Spring
(Composite)	Sky blue aster	*Aster azureus*	SEED	Dormant	-	-	Moist	8	1/4"	Spring
	Smooth blue aster	*Aster laevis*	SEED	Dormant	-	-	Moist	8	1/4"	Spring
	New England aster	*Aster novae-angliae*	SEED, DIV	Dormant	Spring/Fall	-	Moist	8	1/4"	Spring
	Prairie coreopsis	*Coreopsis palmata*	SEED, DIV	Dormant	Spring/Fall	-	Moist	12	1/4"	Spring
	Pale purple coneflower	*Echinacea pallida*	SEED	Dormant	-	-	Moist	12	1/4"	Spring
	Oxeye false-sunflower	*Heliopsis helianthoides*	SEED	Dormant	-	-	Moist	12	1/4"	Spring
	Rough blazing-star	*Liatris aspera*	SEED, CORM	Dormant	Fall	-	Moist	8-12	1/4"	Spring
	Prairie blazing-star	*Liatris pychnostachya*	SEED, CORM	Dormant	Fall	-	Moist	8-12	1/4"	Spring
	Wild quinine	*Parthenium integrifolium*	SEED	Dormant	-	-	Moist	8-12	1/4"	Spring
	Greyhead coneflower	*Ratibida pinnata*	SEED	Dormant	-	-	Moist	8-12	1/4"	Spring
	Sweet coneflower	*Rudbeckia subtomentosa*	SEED	Dormant	-	-	Moist	8-12	1/4"	Spring
	Rosinweed	*Silphium integrifolium*	SEED, DIV	Dormant	Spring/Fall	-	Moist	8-12	1/4-1/2"	Spring
	Compass plant	*Silphium laciniatum*	SEED	Dormant	-	-	Moist	8-12	1/4-1/2"	Spring
	Stiff goldenrod	*Solidago rigida*	SEED, DIV	Dormant	Spring/Fall	-	Moist	8-12	1/4"	Spring
	Showy goldenrod	*Solidago speciosa*	SEED, DIV	Dormant	Spring/Fall	-	Moist	8-12	1/4"	Spring
CAMPANULACEAE (Bell Flower)	Great blue lobelia	*Lobelia siphilitica*	SEED	Dormant	-	-	Dry	12	SURFACE	Spring
COMMELINACEAE	Prairie spiderwort	*Tradescantia bracteata*	SEED, DIV	Dormant	Spring/Fall	Scarify	Moist	12	1/4"	Spring
(Day Flower)	Ohio spiderwort	*Tradescantia ohioensis*	SEED, DIV	Dormant	Spring/Fall	Scarify	Moist	12	1/4"	Spring
GENTIANACEAE	Bottle gentian	*Gentiana andrewsii*	SEED	Dormant	-	-	Moist	12	SURFACE	Spring
IRIDACEAE	Blueflag iris	*Iris shrevei*	SEED, DIV	Dormant	Spring/Fall	-	Moist	12	1/2"	Spring
(Iris)	Blue-eyed grass	*Sisyrinchium campestre*	SEED, DIV	Dormant	Spring/Fall	-	Moist	16	SURFACE	Spring
LAMIACEAE	Wild bergamot	*Monarda fistulosa*	SEED, DIV	Dormant	Spring/Fall	-	Dry	8-12	SURFACE	Spring
(Mint)	Hairy Mt. mint	*Pycnanthemum pilosum*	SEED, DIV	Dormant	Spring/Fall	-	Dry	12	SURFACE	Spring
	Narrowleaved Mt. mint	*Pycnanthemum tenuifolium*	SEED, DIV	Dormant	Spring/Fall	-	Dry	12	SURFACE	Spring
	Virginia Mt. mint	*Pycnanthemum virginianum*	SEED, DIV	Dormant	Spring/Fall	-	Dry	12	SURFACE	Spring
LILIACEAE	Wild garlic	*Allium canadense*	BULBLETS	Fresh	Fall	-	-	-	-	Spring
(Lily)	Turk's cap lily	*Lilium michiganense*	SEED,BULB	Dormant	Late Fall	-	4wk wam/4wk cold		1/4"	Spring
RANUNCULACEAE	Canada anemone*	*Anemone canadensis*	SEED,DIV	Dormant	Spring/Fall	Scarify	Moist	16	1/4"	Spring
(Buttercup)	Thimbleweed	*Anemone cylindrica*	SEED	Dormant	-	Scarify	Moist	12	1/4"	Spring
RHAMNACEAE (Buckthorn)	New Jersey tea	Ceanothus americana	SEED	Dormant	-	WetHeat	Moist	12	1/4"	After last frost
SCROPHULARIACEAE	Culver's root	*Veronicastrum virginicum*	SEED, DIV	Dormant	Spring/Fall	-	Dry	12	SURFACE	Spring
POACEAE	**GRASSES-WARM**									
(Grass)	Big bluestem	*Andropogon gerardii*	SEED, DIV	Late Spring	Spring	-	Dry	-	1/4"-1/2"	Late Spring
	Side-oats grama	*Bouteloua curtipendula*	SEED, DIV	Late Spring	Spring	-	Dry	-	1/4"-1/2"	Late Spring
	Switchgrass	*Panicum virgatum*	SEED, DIV	Late Spring	Spring	-	Moist	4	1/4"	Late Spring
	Little bluestem	*Schizachyrium scoparium*	SEED, DIV	Late Spring	Spring	-	Dry	-	1/4"	Late Spring
	Indian grass	*Sorghastrum nutans*	SEED, DIV	Late Spring	Spring	-	Dry	-	1/4"	Late Spring
	Prairie cordgrass	*Spartina pectinata*	SEED, DIV	Late Spring	Spring	-	Moist	4	1/4"	Late Spring
	Tall dropseed	*Sporobolus asper*	SEED, DIV	Late Spring	Spring	-	Dry	-	1/4"	Late Spring
	Prairie dropseed	*Sporobolus heterolepis*	SEED, DIV	Late Spring	Spring	-	Moist	4	1/4"	Late Spring
	GRASSES-COOL									
	Bluejoint grass	*Calamagrostis canadensis*	SEED, DIV	Early Spring	Spring/Fall	-	Dry	-	1/4"	Spring
	Woodland reedgrass	*Cinna arundinacea*	SEED	Early Spring	-	-	Dry	-	1/8"	Spring
	Canada wildrye	*Elymus canadensis*	SEED	Fall	-	-	Dry	-	1/4"	Spring
	Virginia wildrye	*Elymus virginicus*	SEED	Fall	-	-	Dry	-	1/4"	Spring
	Junegrass	*Koeleria macanthra*	SEED	Early Spring	-	-	Dry	-	1/8"	Spring
	Upland wild timothy	*Muhlenbergia racemosa*	SEED	Early Spring	-	-	Dry	-	1/8"	Spring
	Porcupine grass*	*Stipa spartea*	SEED	Fall	-	-	Moist	16	1/4"	Spring
CYPERACEAE	**SEDGES**									
(Sedge)	Prairie sedge	*Carex bicknellii*	SEED, DIV	Fall	Early Spring	-	Moist	8	SURFACE	Spring
	Plains Oval Sedge	*Carex brevior*	SEED, DIV	Fall	Early Spring	-	Moist	8	SURFACE	Spring
	Heavy sedge	*Carex gravida*	SEED, DIV	Fall	Early Spring	-	Moist	8	SURFACE	Spring
FABACEAE	**LEGUMES**									
(Legume)	Leadplant	*Amorpha canescens*	SEED	Dormant	-	Scarify	Moist	12	1/4"	After last frost
	Canada milkvetch	*Astragalus canadensis*	SEED	Dormant	-	Scarify	Moist	2	1/4"	After last frost
	White wild indigo	*Baptisia alba*	SEED	Dormant	-	Scarify	Moist	2	1/4"	After last frost
	Cream Wild Indigo	*Baptisia bracteata*	SEED	Dormant	-	Scarify	Moist	2	1/4"	After last frost
	White prairie clover	*Dalea camdida*	SEED	Dormant	-	Scarify	Dry	-	1/4"	After last frost
	Purple prairie clover	*Dalea purpurea*	SEED	Dormant	-	Scarify	Dry	-	1/4"	After last frost
	Showy tick-trefoil	*Desmodium canadense*	SEED	Dormant	-	-	Dry	-	1/4"	After last frost
	Roundhead bush clover	*Lespedeza capitata*	SEED	Dormant	-	Scarify	Moist	2	1/4"	After last frost

* Species with an asterix have double dormancy, requiring 2 yrs, or two stratification cycles, to break dormancy.

Preventing 'Damping Off'

If otherwise healthy seedlings suddenly fall over, appearing to be cut off at soil level, then "damping off" fungus is present. Legumes are particularly susceptible, but other species can be affected if planted too densely. Maintain good air circulation to evaporate excess water from stems and soil surface. A box-fan set on low facing seedlings will help. Thinning may be necessary. Sprinkling a layer of perlite over the top of the soil surface after seeding or on infected seedlings will prevent or stop infection from spreading. Washing and sterilizing containers, benches, and equipment and using sterile potting medium will also help reduce the risk of damping off.

Native Plant Prop. Protocol:www.nativeplantnetwork.org/network/

Ontario Rock Garden Society:www.onrockgarden.com/

Prairie Moon Nursery Cultural Guide: www.prairiemoon.com/

Missouri Botanical Garden, www.mobot.org/gardeninghelp/plantfinder/Alpha.asp.

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Roots

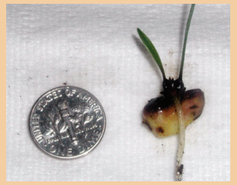
Almost any plant with fibrous roots and multiple stems can be propagated by division. Dig up or un-pot plant and use a sharp knife or trowel to cut down into root mass. Some damage will occur, but be sure to include intact root and shoot portions for re-potting/transplanting. Divide in half for two large plants, or multiple times for maximum number of smaller plants. Fall or early spring are the best times for division, depending on the species (see Table).

Corms

Rough blazing star corms dug in fall for transplant. Large corms can be cut in half.

A corm is a short, fleshy, vertical underground stem. The blazingstars (*Liatris spp.*) grow from corms. In the fall these can be dug up and divided in a way similar to potatoes, and transplanted for mature flowering plants the next growing season. Small corms (cormels) can be broken off the main corm, or cut larger corms (2 inch diameter or more) in half.

Bulbs



Michigan lily scaly bulbs (left), dug in fall, all from a single plant. Side bulbs or individual scales can be broken off and transplanted. Bulb scale (right) growing new leaves and rootlet.

A bulb is a thickened, underground bud with fleshy scales. Species like prairie onion and wild garlic (*Allium spp*) and Michigan and Wood lily (*Lilium spp*) have bulbs. In vigorous plants smaller side bulbs (bulbels) may develop that can be removed and re-planted. Lilies have scaley bulbs, and each scale can grow into a separate plant. Under good growing conditions, lilies will send out one or two short rhizomes a short distance (2-3") and a new bulb will form which can be carefully dug up and transplanted for mature flowering plants the next season.

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3 PROPAGATING NATIVE PLANTS

Content by Greg Houseal

PRAIRIE RESTORATION SERIES

Propagating native plants is hands-on learning at it's best.`Gain experience with individual species life-cycle, growth-habits, and natural history...and bring important biodiversity to your out-door living space at the same time!

Equipment Needed

This is a basic list of equipment needed for propagating native plants:

Native plant materials (seeds and/or plants)	**Clean sand/ vermiculite**	**Containers/Labels**
		Pruning shears, knife
Ziploc bags/ permanent marker	**Refrigerator**	
	Sterile potting soil	**Trowels and shovel**

Starting from Seed

Propagating native plants from seed is a great learning experience, and a great way to grow a large number of plants from a diverse genetic source(s). It is the best way to develop seedling identification skills for assessing new restoration plantings. Be sure the seed your planting is viable, either from seed test results or from an experienced collector. It's important to know a bit about seed dormancy and how to overcome it to successfully germinate native seed.

Seed Dormancy and Germination

Dormancy is an important trait of native species, especially forbs, allowing germination to occur over time and in proper season in nature. If starting seedlings in the greenhouse, it's best to break dormancy artificially using various techniques as described below.

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Adding wet sand to an equal amount of seed in preparation for stratification.

Stratification

Most prairie species require a winter treatment, i.e. cold, moist conditions known as stratification to break dormancy. Mix seed with an equal amount of moist sterile sand, sawdust, or vermiculite and place in a Ziploc bag. Avoid excessive moisture; water should not be pooled anywhere in the bag. Use vermiculite if working with species adapted to drier conditions to minimize the risk of rot. Place seeds in refrigerator (32 to 45 °F or 0 to 10 °C) for the recommended period of time (see Table on back). Check bags weekly for mildew or dryness. A few species, among them American vetch (*Vicia americana*) and butterfly milkweed (*Aesclepias tuberosa*), will germinate at these temperatures, so plant immediately if this occurs.

Some species may germinate best when stratified under natural winter temperature fluctuations. If sowing seeds in flats for outdoor stratification, cover with screen mesh to protect seeds from being displaced by animals or heavy rains. Sow seeds in early March in cold frames for stratification and extending the growing season in the spring. A few species may require warm (68 to 94°F or 20 to 35°C), moist conditions, or warm-moist followed by cold –moist stratification, such as Michigan lily (*Lilium michiganense*). Other species requiring this treatment are found in the Parsley, Buttercup, Arum, Lily, and Iris families (Baskin and Baskin 1998).

Scarification

Species with a hard or waxy seed coat require scarification. Scarification is a technique that simulates the natural disintegration (such as weathering, abrasion, or partial digestion) of the seed coat to allow water uptake for timely germination. Species in the Sumac, Legume, Geranium, and Buckthorn families may require scarification (Baskin and Baskin 1998). A simple scarification technique is to rub a single layer of seed between two sandpaper-covered boards for a minute or so until seed coat begins to appear dull. Percussion scarification involves shaking seeds vigorously inside a heavy glass bottle for a few minutes. Commercial scarifiers are also available from seed equipment manufacturers, such as a Forsberg scarifier. In all cases, care is necessary to avoid breaking or damaging seeds.

Special Case: *Wet-Heat Scarification*

New Jersey tea (*Ceanothus americana*) and false gromwell (*Onosmodium molle*) require wet-heat treatment. Pour boiling water (212 °F, 100 °C) over the seeds just enough to cover them all and allow to cool to room temperature, or immerse seeds in boiling hot water for five to twenty seconds and remove to rinse and cool. Be sure not to boil the seed! Germination of these species will improve with stratification after wet-heat treatment.

Ready, Get Set, Sow...

Seeds are primed and ready to grow! Critical to successful propagation of native seedlings are using suitable containers and potting medium, and proper watering, soil temperature, light, and air.

Containers

Containers should provide good drainage, space for strong root development, and yet be small enough to provide efficient use of potting medium and bench space. Deeper containers aren't necessarily better, but they will help accommodate tap-rooted species. It's important to allow roots to 'air-prune' (can't grow any further) as they reach the bottom of the soil column so lateral root development will occur within the container. This is accomplished with good drainage around and away from the container (no water puddling under pots). Good lateral root development will aid later in transplanting (and survival!) of seedlings.

Potting Medium

A good potting medium should be light enough to allow for good root development, provide adequate drainage, and have enough fertility for seedlings to grow quickly for timely transplanting. It should also be sterile, meaning weed seed- and disease-free. A soil-less mix (less than 20% soil) is a good choice, and pre-mixed and packaged sterile potting soil is available commercially. Just be sure it's well moistened before filling containers and sowing seed.

Soil-less Mix Recipe

This recipe makes about 1 cubic yard of potting medium:

Peat moss (4 cu. ft/bag)	*2 bags (8 cu. ft)*
Vermiculite (medium 4 cu. ft/bag)	*1/2 bag (2 cu. ft)*
Perlite (4 cu. ft/bag)	*1/2 bag (2 cu. ft)*
Sterile soil	*two 5-gal buckets*
Composted (sterile) manure	*40-lb bag*
Osmocote® Plus fertilizer 15-9-12 (180 days)	*8 lb*

For best consistency, screen peat moss, soil, and composted cow manure through a½/2-in. mesh hardware cloth. Add remaining ingredients, mix with shovels on clean floor. Caution: All of these materials are extremely dusty in their dry form. Wear high quality dust mask and moisten materials thoroughly with water as they are mixed to reduce dust and aid water uptake of finished medium. Store unused medium in plastic tubs with tight fitting lids to prevent drying out.

Sowing

Sow several seeds in each container. Thin later if necessary. Cover with no more than ¼ inch of soil for most species. Caution: Very tiny seeds should not be covered! Species such as Culver's root (*Veronicastrum virginicum*), mountain mints (*Pycnanthemum spp.*), grass-leaved goldenrod (*Euthamia graminifolia*), Joe-pye weed (*Eupatorium spp.*), great blue lobelia (*Lobelia siphilitica*), and prairie sage (*Artemisia ludoviciana*) do best if sprinkled on top of the soil surface and kept continually moist until the seed leaves (cotyledons) are evident.

Growing

Prairie seedlings need full sunlight for normal development. Sow seeds in early February in a greenhouse environment (mid-March in cold frames). Keep the soil surface moist until germination has occurred. Use a gentle spray wand so seed isn't dislodged, forced deeper into the soil, or splattered out of the containers. Expect germination and emergence to occur over a 2-6 week period. Warm season grasses and legumes germinate best in warm soils greater than 70 °F (21 °C). Cool season grasses and many forbs germinate more readily in cool soil temperatures 40 to 50 °F (5 to 10 °C) and may cease germination at temperatures above 77 °F (25 °C). If sowing seed in flats, precise regulation of soil temperature can be achieved with propagation mats. These are commercially available at reasonable cost from nursery or greenhouse supply companies. Water established seedlings thoroughly at least once a day, moistening the entire soil column. Allow the soil to drain and surface soil to begin to dry somewhat between waterings.

Transplanting Seedlings

Strong root development is the key to successful transplants. Roots should fully occupy the entire soil column forming an intact root "plug" (retains the shape of the container when removed for transplanting). The ideal time for transplanting is in the spring after the last frost-free date for your region. Acclimate seedlings gradually to outdoor conditions of sun and wind through a process call "hardening off." Set flats or trays outside (sheltered from strong winds and full sun) for a few hours each day from mid-morning to mid-afternoon about a week before transplanting. If transplanting in summer, be prepared to water regularly and deeply until plants are established. Transplanting in the fall (early to mid-September) is an option if strong root development is present to survive the winter months.

Common weedy species of tallgrass prairie

Invasive		Persistent		Opportunistic	
Common Name	***Scientific Name***	**Common Name**	***Scientific Name***	**Common Name**	***Scientific Name***
Canada thistle	*Cirsium arvense*	Smooth brome	*Bromus inermis*	Chicory	*Cichorium intybus*
Crown vetch	*Cronilla varia*	Musk thistle	*Carduus nutans*	Bull thistle	*Cirsium vulgare*
Queen Anne's Lace	*Daucus carota*	Oxeye daisy	*Chrysanthemum leucanthemum*	Smooth sumac	*Rhus glabra*
Cut-leaved teasel	*Dipsacus laciniatus*	Tall fescue	*Festuca arundinacea*	Common mullein	*Verbascum thapsus*
Common teasel	*Dipsacus sylvestris*	White sweet clover	*Melilotus alba*	Conmmon ragweed	*Ambrosia artemisiifolia*
Leafy spurge	*Euphorbia esula*	Yellow sweet clover	*Melilotus officinalis*	Giant Ragweed	*Ambrosia trifida*
Sericia lespedeza	*Lespedez cuneata*	Wild parsnip	*Pastinaca sativa*		
Purple loosestrife	*Lythum salicaria*	Kentucky bluegrass	*Poa pratensis*		
Pampasgrass	*Miscanthus sacchariflorus*	Multiflora rose	*Rosa multiflora*		
Reed canary grass	*Phalaris arundinaceae*	Poison Ivy	*Toxicodendron radicans*		
Buckthorn	*Rhamnus cathartica*	Red clover	*Trifolium pratense*		

Exotic and Invasive Species

The presence of exotic (non-native) or invasive species will influence longterm management cost and strategies. Weed species in the first category are considered invasive. Invasive species will lower the remnant's quality over time and can present significant challenges to long-term restoration and management of the site. Applying no management to the site means losing the remnant plant community to the invasive species, yet control methods used on invasive species may in themselves be detrimental to the remnant.

Invasive:
weed species that out compete native species and threaten to destroy native plant communities

Persistent:
weed species that occur regularly in prairie but are not likely to significantly change native species composition

Opportunistic:
weed species that would probably be eliminated with proper management practices

High-quality remnant areas most susceptible to invasion should be given higher priority for management.

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Assessing Remnant Quality

Assessment gives a measure of the quality of a remnant, which guides and prioritizes long term management objectives. Major influences of quality are native species diversity, (particularly the presence of conservative species, i.e., those most sensitive to disturbance); prior management history of the site (grazing, overseeding, tiling, grading, etc.); and the presence of exotic or invasive species that pose an immediate threat to the remnant (see Remnant Quality Indicators). There are three main objectives of remnant assessment: 1) to determine appropriate management strategies for the site (i.e., Do No Harm), 2) to monitor the recovery of the remnant in response to management activities, and 3) to prioritize resources for acquisition, preservation, rehabilitation and management of remnant sites. If natural areas are to be compared, inventories of consistent scope and precision must be conducted. A thorough plant inventory requires at least monthly surveys throughout the growing season. Factors that will affect the total number of species identified include the skills of the observer(s), the number of observers, and the amount of time spent surveying the site. It is important to apply equal effort toward each inventory so that meaningful comparisons can be made between sites.

Remnant Prairie Quality Indicators

Factor	Low Quality	High Quality
native species diversity	low	high
presence of conservative species	absent	present
soil profile	disturbed	undisturbed
past site history	high impact	low impact
invasive species	abundant	few/absent
exotic species	abundant	few/absent
aggressive woody species	dominant	minimal

Callicott, J.B. and E.T. Freyfogle. For the Health of the Land: Previously Unpublished Essays and Other Writings. Island Press, 1999.

Gilpin, M. E., and M. E. Soule. 1986. Minimum viable populations: process of species extinctions. Pages 19-34 in M. E. Soule, editor. Conservation biology: the science of scarcity and diversity. Sinauer, Sunderland, Massachusetts, USA.

Menges. 1991. Seed germination percentage increases with population size in a fragmented prairie species. Conservation Biology 5:185-164.

Other Factors Affecting Remnant Quality/Management

Other factors that may affect the remnant's quality and management include the size and shape of the remnant, distance and connectivity to other remnants, and land-use surrounding the remnant (Saunders et al. 1991). The smaller the remnant, the greater the impact external forces (invasive species, herbicide drift, nutrient and water influx) will have on the quality and long-term survival of the remnant. Larger remnants are likely to have greater diversity because they are more likely to encompass different types of habitat, yet high-quality remnants as small as 10 acres (4 ha) may possess most of the local diversity present in a much larger prairie (Robertson et al. 1997). The size of a remnant also determines the potential population size of a species. Larger populations tend to have greater levels of genetic diversity, and thus may be more resilient (adaptive) to environmental stressors and more resistant to extinction (Gilpin and Soule 1986). There is also evidence that seed viability increases with larger populations, possibly because they attract more pollinators and/or are more genetically diverse (Menges 1991). Mitigating these negative impacts to small isolated remnants by modifying surrounding land use will enhance the quality of the remnant areas being preserved.

Native Plant ID Resources

The Tallgrass Prairie Center Guide to Prairie Restoration in the Upper Midwest. 2010. Smith, D., Williams, Houseal, G., Henderson, K. U. of Iowa Press. 293 pages

A Practice Guide to Prairie Restoration. 2001. Kurtz, C. U. of Iowa Press. 56 pages.

The Tallgrass Restoration Handbook. 1997. Packard and Mutel, Eds. Society of Ecological Restoration. Island Press. 463 pages.

Plant Iowa Natives. www.plantiowanatives.com

Grasses of Iowa. www.eeob.iastate.edu/research/iowagrasses

Illinois Wildflowers. www.illinoiswildflowers.info. © 2002 – 2006 John Hilty

Kansas Wildflowers and Grasses. www.lib.ksu.edu/wildflower.

USDA Plants National Database. www.plants.usda.gov

An Illustrated Guide to Iowa Prairie Plants. 1999. Christiansen P., and M. Muller. U Iowa Press. Iowa City, Iowa. 237 pages.

Wildflowers of the Tallgrass Prairie, the Upper Midwest. 1989 Runkel, S. and D. Roosa. Iowa State University Press. Ames, Iowa.

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4 Recognizing AND Appreciating Tallgrass Prairie Remnants

Content by Greg Houseal

PRAIRIE RESTORATION SERIES

What is a Prairie Remnant?

Prairie remnants are fragments of the original prairie landscape with their native plant communities still intact. Typically, this means soils were never plowed, graded, or buried by fill. Original prairie is meant to imply that populations of species have persisted or regenerated themselves on site through time (i.e., not planted by people as in prairie reconstruction). Some sites may have had brief soil disturbance in the past, for example, grading to create railroad beds in the 1800s, or fields that were cultivated for brief periods then abandoned. The key point regarding remnants is that some component of the original native vegetation remains, either having persisted on site or naturally re-colonized from surrounding original prairie still present after the disturbance.

Think you have a remnant and wondering who to call? Contact your County Conservation Board, Iowa Department of Natural Resources field office or Natural Resources Conservation Service field office. They can direct you to resources to help properly manage, restore and maintain these priceless fragments of Iowa's biological and cultural heritage.

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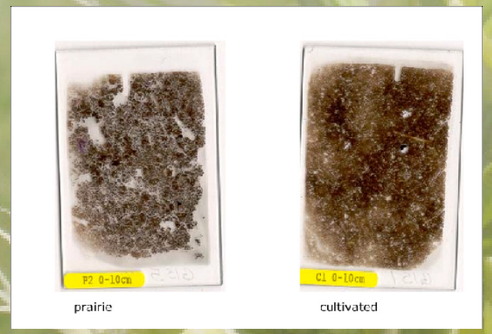
Some species, whether animal or plant, like this federally endangered prairie fringed-orchid (background), exist only in remnant pairie, which cannot be replaced.

Why are Prairie Remnants Important?

Remnants really are islands of biodiversity remaining after large-scale conversion of the prairie ecosystem. Remnants are repositories of biological, ecological, and cultural values, and deserve preservation and management. They may contain once common animal and plant species now threatened with extinction, or harbor rare populations of species with unique genetic traits and adaptations. Remnants are benchmarks against which to measure the success of modern day prairie restorations, providing a reference point for species composition, ecosystem functions, and soil health. The untilled soils of remnants are the "gold" standards of fertility, soil structure, and soil. Ultimately, prairie reconstruction would not be possible without the seed sources and ecological information that remnant prairies offer. The greatest threat to small remnants is continued isolation from gene flow and their vulnerability to disturbance from surrounding land use activities or misguided management within the remnant. Buffering, reconnecting, and restoring prairie on the scale of landscape is critical if native remnant tallgrass prairie is to be preserved as a viable ecosystem well into the future.



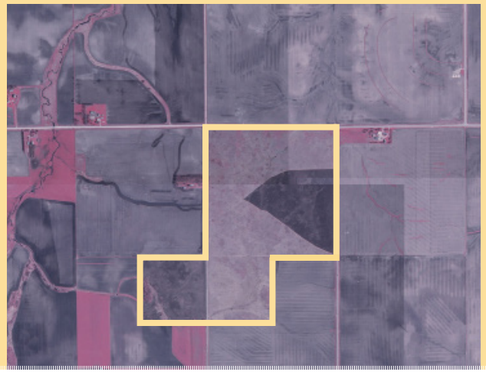
Porosity comparison of healthy native prairie soil (left), and compacted farmed soil (right). Image Courtesy of Dr. Lee Burrass, ISU.

Where Do Remnants Persist?

Surprisingly, remnants do persist in the highly fragmented and intensely farmed landscape of the modern Midwest. Leopold, in first half of the 1900's, observed that prairie plants were "content with any roadside, rocky knoll, or sandy hillside not needed for cow and plow" (Callicott and Freyfogle 1999). These remain likely places to look for remnant prairie, today. Prairie also persist in early transportation corridors (i.e., rights-of-way) for roads and railroads, and recovering pastures if not too heavily grazed. Prairie may persist in out-of-the-way corners of farm fields cut off by creeks or otherwise inaccessible to tillage equipment and protected from herbicide drift. Historic old-settler cemeteries, established on prominent hilltops and fenced from grazing may harbor remnant prairie. Many of these sites have been mowed at times in the past but recovered when mowing ceased, or the prairie plants survived in the surrounding fence line. A few are preserved as prairie and maintained by volunteers and county or state resource managers.

Until the mid-1900s, prairie hay was prized as high-quality forage for workhorses, and typically harvested once in mid-summer each year. Most prairie hay meadows were lost with the widespread mechanization of farming after World War II. A few hayed prairies remain in areas that were too wet, rocky, or small to row-crop, or where the landowner preserved the practice as a cultural tradition.

Awareness of where remnants are likely to persist on the landscape, experience recognizing native plants, and aerial photo interpretation skills are all useful tools in locating remnants. Perhaps the most effective method, however, is to seek out local knowledge from landowners, hunters, and native plant enthusiasts familiar with the area of interest.



Infrared aerial photo of Hayden Prairie State Preserve outlined in yellow. Note darker burned area (SW 40 acres square portion and triangular portion center east side).

Aerial photographs, particularly infrared, can help pinpoint likely areas to field check for prairie remnants. Knowledge of the vigor and density of vegetation and time of year of the photo is key to interpreting the red colors of infrared aerial photography. The red tone of color infrared aerial photographs is usually associated with live vegetation. Very intense reds indicate dense vegetation growing vigorously at the time the photograph was taken. In any case, it's critical to field check potential sites. In Iowa, aerial photographs, including historical, black and white, and infrared, are available from the Iowa Geographic Map Server at cairo.gis.iastate.edu. Aerial photographs are also available at local natural resources conservation service (NRCS) offices.

Formerly grazed, prairie persist on steep slopes and thin soils at Blackmun Prairie

A patch of prairie in a pioneer cemetery in Ida county

Are all remnants the same?

No two remnants are alike. Some may be wet prairie, while others may be dry prairie, or anywhere in between. Likewise, many other types of remnant native plant communities exist, including wetlands (fens, bogs, seeps, sedge meadows, etc.) and woodlands (forest, open woodlands, savannas).

Native Species Diversity

The more native species present, the greater the quality of the remnant. Ecologists refer to the number of species present on a site as species richness. A site with 80 plant species has greater species richness than a site with 20 plant species. The types of species present and their abundance and distribution are also important considerations of quality. Species diversity, defined as the relative abundance of species throughout the site combined with the number of species present, gives a more complete description of remnant quality. Two prairies of the same native species richness (number of species) may differ considerably in diversity if one site has only a few individuals of many species while the other has many, well-represented individuals of each species.

Federally listed species are protected by law, and their presence may help secure funding for acquisition or management of the site. Federal- and individual state-listed threatened and endangered species are available from the U.S. Fish and Wildlife Service at www.fws.gov/Endangered/wildlife.html.

Prior Land Use History

Information about prior land use at a site may be gleaned from the current or past landowner, local residents, or state or federal agencies. Historic aerial or landscape photographs can add valuable insight into land use history. Original land survey records from the 1800s may indicate whether an area was considered prairie, savanna (categorized variably as 'woodland', 'open/oak woods', 'timber'), or wetland at the time of the survey. This information can be used to guide restoration efforts. (Iowa land records are available at www.public.iastate.edu/~fridolph/dnrglo.html).

The Importance of Seed Quality (Pure Live Seed)

Seed quality is critically important to the success of a restoration! Seed quality is measured as pure-live seed (PLS), which can only be obtained from a seed test by a certified seed testing lab. This is essential for calculating seeding rates for each species, allowing for a balanced mix of grasses, forbs, shrubs, and sedges. Fortunately, seed quality has improved dramatically as growers gain experience and acquire better equipment for producing, harvesting, and cleaning native species. Seed dispersal apparatus like awns on grass seed and hairy parachutes on forb seed are routinely removed. This means the seed lot can be cleaned to greater purity and viability and will flow more efficiently through the seeding equipment.

Pure Live Seed

Quality native seed is sold on a pure live seed, or PLS basis. Three factors are used to calculate the percentage of pure live seed: purity, germination, and dormancy. Purity is a measure of pure, unbroken crop seed units as a percent by weight of the seed lot. Percent germination is determined by placing seed in a germination chamber for an approved time period. Many species, particularly forbs, have dormancy mechanisms that require several weeks of cold-moist stratification to break dormancy, allowing germination to occur. For most native species, no standard protocol exists for breaking dormancy for germination testing purposes. Therefore, any remaining non-germinated seed is tested biochemically with tetrazolium chloride (TZ), a clear compound that stains living tissue cherry red. The analyst determines the potential viability of stained seed – non-germinated seed considered viable by a TZ test is counted as dormant. A seed test showing a high percentage of dormancy is common in many native forb species and some grasses (Figure 2). This should be expected of natives, particularly in seed lots harvested within the past year. A high percentage of dormancy means much of that seed won't germinate until dormancy is broken, either artificially or by natural environmental conditions.

To request copies, or for more information, contact Greg Houseal at 319.273.3005 or email gregory.houseal@uni.edu

Tallgrass Prairie Center, University of Northern Iowa
Cedar Falls, IA 50614-0294
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Lab. Number			12-16-41	
Date			1/16/08	
Kind and Variety			Butterfly milkweed	
			(Asclepias tuberosa)	
Purity and Germination analysis of seed sample				
Pure seed			98.00	%
Inert matter			2.00	%
Other crop			0.00	%
Weed seeds			0.00	%
Germination			53.00	%
Hard seed				%
Total germ and hard seed				%
Dormant seed			27.00	%
Tetrazolium				%
Name and no. of noxious weed seeds per lb. (All state noxious count unless otherwise indicated.)			None	

(Figure 2 Sample seed test of butterfly milkweed (Asclepias tuberosa) results noting purity, germination, and dormancy.

ICIA 2010. Native Seed Directory. Iowa Crop Improvement Association, 4611 Mortensen Road, Suite 101, Ames, IA, 50014.

Reinartz JR. 1997. Restoring populations of rare plants. Chapter 6. In: Packard S and Mutel CF, editors. The Tallgrass Restoration Handbook. Washington D.C.: Island Press. Pp 89-95.

USDA-NRCS 1997. BADLANDS Ecotype Little bluestem, May 1997. http://www.plant-materials.nrcs.usda.gov/pubs/ndpmcrb7356.pdf Accessed April 7, 2008.

Young SA. 1995. Verification of germplasm origin and genetic status by seed certification agencies. In: Roundy BA, McArthur ED, Haley JS, Mann DK, composers. Proceedings of the Wildland Shrub and Arid Land Restoration Symposium; 1993 Oct 19-21; Las Vegas, NV. Ogden (UT): U.S. Department of Agriculture, Forest Service, Intermountain Research Station.

Calculating Pure Live Seed Amounts

PLS is a measure of the proportion of the viable seed of a species or variety per unit weight for a given lot of seed. PLS for forage crops and turf grass is normally calculated using percent purity and percent germination only, as dormancy is not a significant issue for these types of species. Native species, however, may have a significant proportion of dormant, yet viable seed, particularly among forb species. The native seed trade recognizes this fact and uses all three factors – purity, germination, and dormancy – to calculate the PLS of any given native seed lot per below:

Pounds (#) PLS is calculated as:

#PLS= (#Bulk) x (%purity) x (%germination + % dormant)

Where % is expressed as a proportion, i.e. 98% = 0.98

For example, a 50-pound bulk bag of seed that is 98% pure seed, with 53% germination and 27% dormant seed, really contains only 38-pounds of pure viable seed (seed that potentially will germinate):

#PLS = 50#bulk x 0.98 x (0.52 + 0.27) = 38# PLS or 50-pounds bulk x 0.7742

If however, you request 50-pound PLS bag of that same seed, you would receive a bag weighing 64.58-pound bulk.

Bulk pounds = #PLS/[(%purity) x (%germination + % dormant)] or 50# PLS/0.7742= 64.58 bulk pounds

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Native Seed Source AND Quality

Content by Greg Houseal

PRAIRIE RESTORATION SERIES

Restoring a lost landscape such as tallgrass prairie requires plant material; either seeds, plugs, or rootstock. Emphasizing ecological restoration, resource managers seek to use an appropriate genetic source for restoring prairie vegetation to the landscape. Source should not be confused simply with where the plant material is produced or sold (that is the geographic location of a production field, nursery, or seed dealer). Source refers to the original remnant or genetic source(s), sometimes referred to as the provenance, of the plant material. This source material may be used directly on a restoration site, or propagated to establish a commercial nursery or production field to produce larger quantities of the 'source' material.

Importance of Seed Source

It is important to select a seed source appropriate for the goals and objectives of the prairie restoration (summarized in Table

Considerations for selecting an appropriate seed source that balance ecological and economic realities may include the following:

proximity to remnant prairies that might be negatively impacted by introduced genotypes or species

objective of the planting, i.e., ecological restoration for habitat, biodiversity, aesthetics vs economic use as forage, biomass

budget and time constraints of the project (cost)

Options for obtaining seed range from harvesting your own, to purchasing either bulk-harvested material or commercially produced seed from native seed producers. These types of seed sources are described below.

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Hundreds of species can now be purchased commercially, either as individual species or custom-mixed for specific site conditions, from moist to dry sites, and from full to partial sun. It is a good idea to review the list of included species to be sure they are native to your area and are of acceptable source for your restoration goals. Expect your seed to be delivered with seed test results attached.

Local Ecotype

The term 'local ecotype' implies that unique, possibly adaptive, genetic traits (more properly, genotypes) may exist in a remnant population. The assumption that local seed is always better adapted to a proposed restoration site than non-local seed should be qualified. A single local seed source may be adequate if a large, genetically diverse population is available and seed is collected from throughout the population. Very small or degraded remnants may lack species or genetic diversity appropriate to the site. Seeds/genetics from other remnants of similar soils and hydrology in the area may be desirable additions for severely degraded remnants. Seed harvested locally from the remnant, or from nearby remnants, is a desirable seed source for plantings intended as genetic buffers (e.g. to conserve local gene pool) of existing remnants. The challenge of this approach is harvesting enough quality seed from a remnant in a single year to seed the new planting; therefore, the seeding may need to be done in phases over successive years (but see section on bulk harvesting).

Restoring Gene Flow in a Fragmented Ecosystem

Developing foundation stock for generating commercial quantities of seed appropriate for restoration, Reinartz (1997) advocates using seed from multiple-source populations as foundation seed:

> The new genetic population created by combining genotypes of several relict [remnant] populations will form novel genetic combinations, having the potential to evolve entirely new genotypes in a novel habitat. The multiple sources used for establishing the nursery must all be found in the same local area (at least state or region) as the site where the new population will be created.

An equal amount of seed – or seedling grown transplants – from each population should be planted in the nursery so that all populations contribute roughly equal amounts to the next generation of seed.

Regional Seed Sources

In the Midwest, remnant prairies are scattered, small, and isolated and there may be no local remnant sources of seed over large areas of the landscape. Regional seed sources, pooled from several remnant populations, have a broad genetic base that favor the odds that the right genotypes are present to best establish and persist in reconstructed (planted) prairie. Seed-source regions (or provenance zones) based on geography, landforms, water sheds, species range distribution, and political boundaries have been variously defined and applied to restoration efforts around the Midwest.

Bulk Harvest

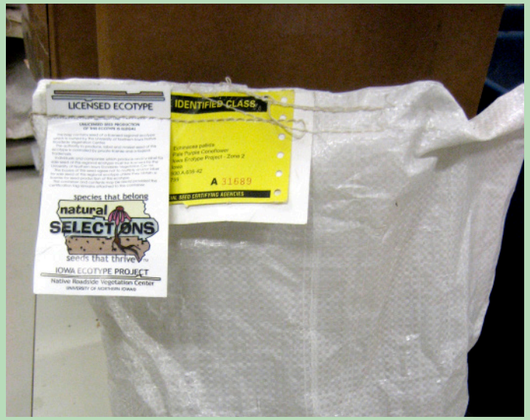
Seed can be bulk harvested from prairie with a combine, seed stripper, or flail vac. Diversity will be limited to species in seed at time of harvest and within the cutting height of the combine/stripper. Bulk harvested material is a mixture of seed, chaff, leaves, and stems. A certified seed test for purity, species composition, and weed content is possible, but tests are costly because of the time required to sort material for analysis. Bulk material harvested from a well-managed stand may contain 10% to 15% seed by weight, so a seeding rate of 10 lbs seed/acre will require 100 to 150 lbs bulk material to be broadcast per acre. Supplementing bulk-harvested material with seed from very low or high growing species, or those that ripen very early or late, is an important consideration since these species may otherwise be unrepresented in the machine harvest. If purchasing bulk material, request a copy of the seed test analysis to be sure of species composition and lack of noxious weeds.

Commercial Seed Sources

We are fortunate in the Midwest to have many native species commercially available, even for large-scale prairie restorations. Providing enough seed for commercial production usually requires growing out source material in nursery or production fields to increase seed quantity. Larger quantity's usually translates into lower cost, depending on market demand, which can fluctuate widely from year to year. Source material (foundation seed) for commercial production may be from one or more original sources, or more commonly, regional source material.

Caring for Remnants When Harvesting Seed

Producers of bulk harvest seed must take great care to control exotic and invasive species in the stand since they cannot be cleaned out of the material after harvest. Care should be used in cleaning any kind of machinery used in harvesting remnants to avoid contaminating these sites with invasive or non-native species and outside sources of native species. If harvesting from a native prairie remnant, avoid the use of whole-site annual burns, herbicides, fertilizers, or other questionable practices that are detrimental to the long-term ecology of remnant prairie.



Source-Identified Seed

Standards for source-identified, or "Yellow Tag" seed, were developed by the Association of Official Seed Certifying Agencies (AOSCA) in the mid 1990's. Source-identified standards provide a "fast-track" plant material release procedure for commercial production of native species for restoring specific plant communities (Young 1995). AOSCA's affiliate state crop improvement associations administer the program for participating commercial native seed producers. Source-identified seed may originate from a single source or from several sources pooled together as a regional source. No intentional selection or testing of traits occurs. Original collection sites are documented, and nursery and production fields are inspected and certified annually. Commercially produced seed is marketed with an official AOSCA yellow certification tag, identifying the source and the producer of the material. Hundreds of native species are now available as source identified seed (ICIA 2010).

As the commercial native seed industry has developed, several Midwest states have adopted source-identified seed programs. Individual states differ in their application of source-identified program guidelines regarding native species, so it's important to check specific policies for the particular state in question.

Cultivated Varieties of Native Species

The USDA Plant Materials Center's (USDA-PMC) develops cultivated varieties, commonly known as cultivars, of several native grass and forb species. Traditionally, an entire plant or seeds from a plant that exhibited a desired characteristic, such as vigor, were collected for further testing. These collections are evaluated for desired traits in common gardens. A selection of individuals or populations is then made for further breeding and increase. Desired traits include good germination, establishment, high forage yield, height, vigor, and winter hardiness. Cultivars may be desirable for pasture, forage or biomass production, but generally are not recommended for prairie restoration either because they have been derived from distant, out-of-state sources; or have been selectively bred for specific traits, often competitiveness and vigor, possibly narrowing their genetic diversity. If cultivars must be used for reconstructions, two or three different varieties should be used to increase the genetic diversity of the planting.

More recently, USDA-PMC plant selections have reflected the trend toward broad genetic based regional seed sources. Badlands "ecotype" little bluestem (Schizachyrium scoparium) for example, is a composite of 68 accessions (collections) selected for disease resistance from an initial evaluation of 588 vegetative accessions collected from throughout North and South Dakota and Minnesota (USDA-NRCS 1997). This broad selection of a diverse assemblage of little bluestem populations may be a desirable and appropriate seed source for restorations in those states from which it was derived.

Cultivar material has been developed for a limited number of native species. Many native species that are in demand for restoration can only be obtained through direct harvest from native stands or through the source-identified seed program described above.

	Source Identified		Cultivar
Planting Goal	Local Genotype	Regional Source	
Remnant Restoration	X		
Prairie Reconstruction	X	X	
Forage/Biomass		X	X

Species Life Span

Most species in a prairie seed mix are perennials. The seed mix should also include species like: partridge pea, Chamaecrista fasiculata (annual) and black-eyed susan, Rudbeckia hirta (biennial). These species readily germinate and grow large in the first growing season, covering more bare soil, thereby reducing the potential soil erosion. Their rapid growth may reduce weed abundance in early establishment too. Perennials will provide long-term diversity and stability in the planting.

Appropriate Seed Sources

Seed derived from multiple remnant sources within the region of the planting site may be better adapted to the climate and soils of a site than seed from distant sources (Williams et al. 2006). Seed used for a native planting in Iowa should be certified as to origin and be derived from Iowa prairie remnants when ever possible.

Seed Cost

Deciding how many of the more expensive forbs to include depends upon the seed budget and the preference of the person paying for the seed. Consider including some expensive forbs in seed mixes; costs can be controlled by lowering seeding rates of the expensive species. We advocate planting for maximum diversity. It is better to include more species in the seed mix and lower seed rates than to plant fewer species with higher seed rates.

Nurse Crops

Nurse crops are usually cereal grains crops that are planted with the natives. The readily germinating seed and quickly maturing plants make nurse crops good competitors against weeds and are effective at holding the soil in place on erodible sites while native seedlings are getting established. Due to their life history characteristics, nurse crops tend to diminish from the prairie planting by the second or third year (see Table 2 for a list of nurse crops).

To request copies, or for more information, contact Greg Houseal at 319.273.3005 or email gregory.houseal@uni.edu

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A roadside right-of-way planted in fall with winter wheat (nurse crop) and prairie seed. This photograph was taken the following spring – taller plants are winter wheat and shorter plants are natives.

A CRP field planted to oats (right) and prairie seed in late spring to stabilize the soil and reduce weeds. Oats were planted at 1 bushel/acre and seeded with a no-till grass drill. Photograph was taken in late June.

Table 2 – Nurse Crop Recommendation

Planting Scenario	Nurse Crop	Seeding Rate
Spring planting on a level site	Oats	16 pounds/acre
Spring planting on a sloped site	Oats	32 pounds/acre
Fall planting on a level site	Winter Wheat	15 pounds/acre
Fall planting on a sloped site	Winter Wheat	30 pounds/acre

Christiansen, P., and M. Muller. 1999. An illustrated guide to Iowa prairie plants. Iowa City, Iowa. University of Iowa Press.

Henderson K and Kern C. 1999. Integrated roadside vegetation management technical manual. Cedar Falls (IA): Roadside Management Program, University of Northern Iowa.

Meyer MH, Gaynor VA. 2002. Effect of seeding dates on establishment of native grasses. Native Plants Journal 3(2): 132-138.

Williams D, Houseal G, Smith D. 2006. Growth and reproduction of local ecotype and cultivated varieties of Panicum virgatum and Coreopsis palmata grown in common gardens. Pages 55-60. in D. Egan and J Harrington. (eds.), Proceedings of the nineteenth North American Prairie Conference. Madison: University of Wisconsin-Madison.

Developing a Seed Mix (using the seed calculator)

High-quality seed of hundreds of native prairie species is commercially available today. The cost of seed varies greatly by species, but forb seed can be costly. The Tallgrass Prairie Center has developed a seed calculator program to design seed mixes based upon the number of seeds per square foot for each species. The seed calculator will automatically calculate the cost of seeds based upon species selected and their cost. Seed cost can be rapidly recalculated with changes in species selection and seed quantities using the seed calculator. Seeding rate is the total number of live seeds sowed per unit area (seeds per square foot). Go to www.tallgrassprairiecenter.org for a free copy of the seed calculator. When using the seed calculator, consider the following recommendations.

1. All prairie reconstructions should be planted with a minimum of 40 seeds per square foot. Planting fewer than 40 seeds per square foot may result in a weedy plant community. For slopes 3:1 or greater, we recommend 60 to 80 seeds per square foot because of potential loss due to erosion.
2. Always use a nurse crop on erodible sites (Table 2).
3. Develop a species-diverse seed mix. Include a minimum of 6 grasses (cool- and warm-season), 3 sedges, and 25 forbs (5 legume and 20 nonlegume species).
4. A 50:50 mix of grass and sedge to forb seed will produce a prairie planting rich in forbs. Therefore, if the seeding rate is 40 seeds per square foot, 20 seeds per square foot are grass and sedge seed, and 20 seeds per square foot are forb seed.
5. Choose grass, sedge, and forb seed native to your region and most appropriate for the soil moisture conditions of the site.
6. Include annual, biennial, and perennial forb species in the seed mix. Generally, 1 seed per square foot of native annuals and biennials will result in many adult plants. Annuals and biennials should not exceed 10% of the total forb seed. Try to equalize the number of seed per square foot of the perennial forbs as much as your budget will allow.
7. Consider including some expensive species that are appropriate for the site at a seeding rate that you can afford. If the site conditions are appropriate, add a little cream false indigo, prairie phlox, or flowering spurge. A small amount of seed is better than no seed.
8. For a dormant planting, increase the seeds per square foot of warm-season grass species by 50% due to increased seed mortality (Henderson and Kern 1999; Meyer and Gaynor 2002). For example, if the seed mix contains 20 grass and sedge seeds per square foot for a nondormant seeding, 30 seeds per square foot should be used for a dormant seeding. A possible exception to this may be switchgrass, which has a hard seed coat that can overwinter. Seeding rate of switch grass need not be changed for a dormant seeding.
9. Planting seed at the proper depth ($^1/_8$ to $^1/_4$ inch) and insuring good seed-to-soil contact are essential for any seed to germinate and establish. Proper seed placement is less certain when broadcast-seeding (hydroseeding, hand-seeding, and broadcast/drop seeders). If broadcast-seeding methods re used, seeding rates for grasses, sedges, and forbs should be increased up to 30% (Henderson and Kern 1999).

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6 Designing Seed Mixes

Content by Dave Williams

PRAIRIE RESTORATION SERIES

A well-planned seed mix is essential to reconstructing a diverse and stable plant community. Selecting species for any native planting involves knowing the physical characteristics of the site (soil type, hydrology, slope, aspect, and sunlight exposure) then choosing the most appropriate native plants for that site. All native plantings should include grasses, sedges, and forbs (both legume and non-legume species). The seed mix should also include annual, biennial, and perennial species to foster both early establishment and maintain long-term diversity.

The cost and availability of the seed is often the primary factor in determining which species and how much seed of a species gets included in a seed mix. Seeding calculators are valuable tools to enable practitioners to develop diverse seed mixes within a seed budget. It is also important to consider the source of seed and the ratio of forb to grass species in the mix. A well-planned seed mix will result in a diverse, weed-resistant prairie plant community that will last a lifetime.

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Criteria for Species Selection

Selecting the appropriate species of native plants is one of the first steps in planning a reconstruction project. Each soil type is a unique blend of sand, silt, clay, and organic matter that affects how the soil drains and retains water. Every plant species has evolved to grow within a certain range of soil moisture conditions. Planting species that are best adapted to the soil moisture(s) of the site will ensure their persistence in the planting. To determine the soil type and drainage class of your site, visit with your local Natural Resources Conservation Service (NRCS) office to obtain a soils map or look online at www.nrcs.usda.gov.

Soil Types/Moisture

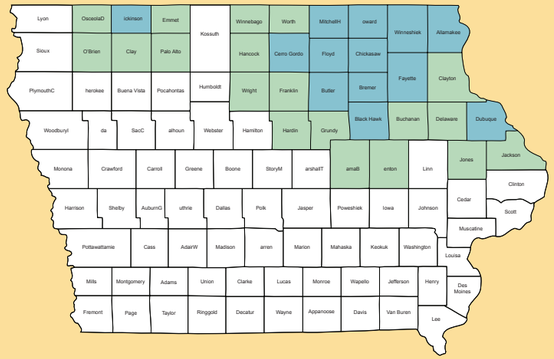
There are five general soil moisture categories: wet (hydric), wet-mesic, mesic (moderate), dry-mesic, and dry (xeric). Hydric soils include poorly drained, and very poorly-drained soils that typically have standing water for part or most of the growing season. These areas may harbor prairie remnants because they were typically too wet to farm. Wet-mesic soils include somewhat poorly drained lighter colored clay soils. Mesic soils include well drained and moderately well drained, dark loamy soils. Dry-mesic soils include somewhat excessively drained glaciofluvial, eolian, and thick loess soils. Xeric soils include excessively drained sandy or gravelly soils and shallow loam soils often found on steep slopes and ridges. See Table 1 for a recommended native seed mix for 1-acre mesic soil sites in Iowa (Except Loess Hills).

Table 1 – Mesic Soil Seed Mix

		Seeding Rate	Quantity Needed
Grass/Sedge	Scientific Name	(seeds per square foot)	(Ounces PLS*)
Slender Wheatgrass	Agropyron trachycaulum	1.00	6.3
Big Bluestem	Andropogon gerardii	3.00	13.1
Side-oats Grama	Bouteloua curtipendula	3.00	15.1
Yellow Fox Sedge	Carex annectens	1.00	0.5
Copper-shoulder oval sedge	Carex bicknellii	0.25	0.6
Plains oval sedge	Carex brevior	0.25	0.4
Long-awned bracted sedge	Carex gravida	0.02	0.1
Field oval sedge	Carex molesta	0.25	0.4
Canada Wildrye	Elymus canadensis	1.00	7.0
Switchgrass	Panicum virgatum	2.00	5.5
Little Bluestem	Schizachyrium scoparius	3.00	8.5
Indian Grass	Sorghastrum nutans	3.00	11.4
Tall Dropseed	Sporobolus compositus	5.00	7.3
Prairie Dropseed	Sporobolus heterolepis	0.75	2.2
	TOTAL	23.5	78.3
Forbs (Legumes)	Scientific Name		
Leadplant	Amorpha canescens	0.25	0.6
Milk Vetch	Astragalus canadensis	1.00	2.6
White Wild Indigo	Baptisia alba	0.03	0.8
Cream False Indigo	Baptisia bracteata	0.01	0.3
Partridge Pea	Chamaecrista fasiculata	0.30	4.8
Purple Prairie Clover	Dalea purpurea	2.00	5.8
Showy Tick Trefoil	Desmodium canadense	0.25	2.0
Illinois Tick Trefoil	Desmodium illinoense	0.25	2.5
Licorice Root	Glycyrrhiza lepidota	0.05	0.6
Round-Headed Bush Clover	Lespedeza capitata	0.10	0.5
	TOTAL	4.2	20.5
Forbs (Non-Legumes)	Scientific Name		
Wild Garlic	Allium canadense	0.10	0.5
Canada Anemone	Anemone canadensis	0.05	0.3
Thimbleweed	Anemone cylindrica	0.05	0.1
Prairie Sage	Artemisia ludoviciana	1.00	0.2
Swamp Milkweed	Asclepias incarnata	0.15	1.4
Butterfly Milkweed	Asclepias tuberosa	0.08	0.8
Whorled Milkweed	Asclepias verticillata	0.05	0.2
Prairie Indian Plantain	Cacalia plantaginea	0.01	0.1
New Jersey Tea	Ceanothus americanus	0.05	0.3
Prairie Coreopsis	Coreopsis palmata	0.10	0.4
Pale Purple Coneflower	Echinacea pallida	0.25	2.1
Rattlesnake Master	Erynigium yuccifolium	0.20	1.2
Flowering Spurge	Euphorbia corollata	0.15	0.8
Grass-leaved Goldenrod	Euthamia graminifolia	1.00	0.1
Bottle Gentian	Gentiana andrewsii	0.50	0.1
Bigtooth Sunflower	Helianthus grosseserratus	0.20	0.6
Prairie Sunflower	Helianthus laetiflorus	0.03	0.3
Ox-eye Sunflower	Heliopsis helianthoides	0.75	5.2
Prairie Blazingstar	Liatris pycnostachya	0.20	0.8
Wild Bergamot	Monarda fistulosa	1.00	0.6
Stiff Goldenrod	Oligoneuron rigidum	1.00	1.1
Prairie Phlox	Phlox pilosa	0.03	0.1
Prairiie Cinquefoil	Potentilla arguta	1.00	0.2
Common Mt. Mint	Pycnanthemum virginianum	1.00	0.2
Yellow Coneflower	Ratibida pinnata	1.00	1.5
Black-eyed Susan	Rudbeckia hirta	1.00	0.5
Compass Plant	Silphium laciniatum	0.02	1.3
Showy Goldenrod	Solidago speciosa	1.00	0.5
Smooth Blue Aster	Symphyotrichum laeve	1.50	1.2
New England Aster	Symphyotrichum novae-angliae	0.75	0.5
Purple Meadow Rue	Thalictrum dasycarpum	0.10	0.4
Prairie Spiderwort	Tradescantia bracteata	0.10	0.4
Ironweed	Vernonia fasciculata	0.50	0.9
Culver's Root	Veronicastrum virginicum	2.00	0.1
Golden Alexanders	Zizia aurea	0.50	2.0
	TOTAL	18.4	26.8

Slope and Aspect

The site conditions on a slope and the direction it faces (aspect) affect the establishment of native plants. The upper portion of a slope is usually drier than the lower portion; south and west aspects are relatively more xeric than the north and east aspects at the same elevation. Thus, there is a difference in species along the moisture gradient from top to bottom of a slope and around it as the aspect changes. Roadside rights-of-ways in particular often transition from dry to mesic to wet soils in a small area, and the changes in species composition associated with those soils' moistures can be dramatic. If the slope is gradual and the changes in moisture conditions can be easily seen, seeding species that match the moisture condition of the soil will improve establishment of those species. If the soil moisture gradient isn't as apparent, slopes can be "shotgun" seeded with all species; including species in the seed mix that match each moisture condition.



Potential Range Expansion Historic Distribution

Historic Iowa distribution of prairie smoke (Geum triflorum) and additional Iowa counties that planting this species is recommended (Adapted from Christiansen and Müller 1999)

Species Geographic Distribution

Select species that are native to the region of the planting site. A "region" can be defined as the home county and the contiguous counties around it. If a species is not present in the region of the planting site, it should be left out of the seed mix. To obtain a list of tallgrass prairie species (grasses, forbs, and sedges) native to your county, visit the USDA-NRCS Plants Web site at plants.nrcs.usda.gov.

Species Light Requirements

Tallgrass prairie does best in full sunlight but will tolerate some shade (up to 20%). If the planting site is adjacent to a woodland and is subjected to reduced sunlight, choose species that are adapted to partial shading. Most seed catalogs group prairie species into three light categories (full sun, partial shade or savanah, and shade or woodland).

Species Diversity

Pheasant in forb rich planting. A forb rich prairie reconstruction provides nectar sources for insects — food for young pheasant chicks.

A prairie seed mix that includes species from each plant group (warm- and cool-season grasses, legume and non-legume forbs, and sedges) will result in a stable, weed-resistant plant community and it will attract and sustain wildlife. A species-rich prairie planting will eliminate germinating weed seed by being a better competitor for resources. It may be inexpensive on the front end of the project to plant only a few grass and forb species, but eliminating weeds that have invaded a native planting can be difficult and costly down the road. Species-diverse seed mixes should be strongly considered for all native plantings.

Invasion of Canada thistles into a species-poor native grass planting in Black Hawk County, Iowa.

Big Woods planting in Cedar Falls, Iowa. A species diverse prairie reconstruction planted in 2001 at Big Woods Lake in Cedar Falls, Iowa. The seed mix included 79 species of grasses, sedges and forbs – 61 species were detected in 2007.

Species Phenology

Tallgrass prairie plants have evolved to take advantage of available resources throughout the growing season. Some grasses and all sedges germinate, grow, and flower in spring or fall (cool-season plants), while others germinate in late spring, and grow and flower in the summer (warm-season grasses). For a prairie planting to resist non-native weed invasion, the planting must include native species from both cool- and warm-season grasses, forbs, and sedges. Leaving out cool-season grasses and sedges will expose the planting to weed invasion from plants like smooth brome, Bromus inermis and Kentucky bluegrass, Poa pratensis.

2. Stand Enhancement (Interseeding)

Stand enhancement techniques are often applied to sites that are dominated by grasses with few to no prairie forbs. Stand enhancement adds native grasses and forbs without eliminating the established vegetation.

Direct Interseeding (Option 1)

Seed is sown into the established vegetation without disrupting the established vegetation. Prairie plant establishment can be low in stands of persistent perennial plants and non-native vegetation can persist for many years after seeding. Any seeding method can be used. This site preparation option is quick and can be done without any specialized equipment, but will require patience.

Repeated Mowing and Interseeding (Option 2)

» Remove standing dead material and thatch by prescribed burning in fall or by late summer haying.

» Seed in fall or in early- spring with a no-till drill.

» Mow from late-April to early-September, four inches high every two or three weeks the first growing season.

Spray, Mow and Interseed (Option 3).

» Remove standing dead material and thatch in spring by prescribed burning, haying or mowing.

» Spray 50 percent of the stand with a grass herbicide when there is four to six inches of new growth.

» Seed in fall or in early-spring with a no-till drill.

» Mow once in early-summer in the first growing season.

Disk and Interseed (Option 4).

» Removed thatch and standing dead material in late-summer by grazing, haying or mowing.

» Lightly disk (to the four inch depth) 50 percent of the site in early-fall.

» Seed in late-fall or in early-spring. Any seeding method can be used.

» Mow in late-spring and in mid-summer in the first growing season.

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The "Screwdriver Method" For Compacted Soil

Soil compaction is a condition when there is a decrease in air space between soil particles. Heavy machinery operation, human or livestock trampling can cause soil compaction. Compacted soil can severely reduce establishment of natives by preventing seeds from being planted at a proper depth and by inhibiting root penetration of newly germinated seedlings. To check for soil compaction near the soil surface, stick a large flat screwdriver into the soil at multiple spots in the compacted region. If the screwdriver cannot be pushed more than 2 inches into the soil in at least half of the spots, there is a good chance that the soil surface is too compacted. To eliminate surface compaction, rototill the site to loosen the upper 4 inches of soil. Any large (greater than 1/2 inch) dirt clods need to be broken into smaller pieces. To reduce clod size, harrow the site using a drag harrow or a piece of chain link fence with some weight added.

Removing Trees and Shrubs

The species composition of a planted prairie will change over time if volunteer trees and shrubs are not eliminated. Shade from trees and shrubs will create cooler and moister conditions under the canopy favoring shade tolerant plant species and displacing full-sunlight prairie species. In addition, woody plants that are left on the site will spread, by suckering and seed, further displacing prairie plants. Woody plants can also interfere with no-till drilling and broadcast seeding of the natives.

Some practitioners leave a few clone groups of native trees like wild plum and choke cherry on the site for habitat. However, native trees and shrubs like boxelder, (Acer negundo), red cedar (Juniperus virginiana) and gray dogwood (Cornus foemina) should be removed because they can aggressively spread in a planted prairie (Table 1). We recommend the removal of all non-native trees and shrubs.

Herbicides are very effective at killing woody plants. Smaller trees and shrubs can be foliar-sprayed. Trees greater than 1/2 inch diameter need to be cut and the stump chemically treated to prevent resprouting (Table 1). Herbicide should only be applied to the inner bark (cambium layer) of the cut surface. The inner bark region of the cut stump is a thin layer adjacent to the outer bark of the tree. Because of the high concentration of chemical in stump-treatment herbicides, it is important to be careful not to dribble herbicide off the cut surface onto the ground. Coniferous trees (pines and cedars) do not need to be treated after being cut because they will not re-sprout, but all deciduous trees will need to be treated. Stumps need to be cut flat and as close to the ground as possible to prevent interference with seeding equipment.

Persistent perennial plants that should be killed prior to planting prairie vegetation.

Table 1 — Persistent Perennial Plants

Common Name	Genus-species	Phenology	Herbicide Class*	Application Method*	Application Time*
Kentucky bluegrass	Poa pratensis	grass	glyphosate	foliar applied	in spring at boot-to-early seedhead stage
quackgrass	Agropyron repens	grass	glyphosate	foliar applied	6" - 8" tall
reed canarygrass	Phalaris arundinacea	grass	glyphosate	foliar applied	in spring at boot-to-early seedhead stage
smooth brome	Bromus inermis	grass	glyphosate	foliar applied	in spring at boot-to-early seedhead stage
tall fescue	Festuca arundinacea	grass	glyphosate	foliar applied	in fall with 6" - 12" new growth
bird's-foot trefoil	Lotus corniculatus	herbaceous	clopyralid, triclopyr	foliar applied	up to 5 leaf
Canada thistle	Cirsium arvense	herbaceous	clopyralid	foliar applied	in spring, rosette to bud
crown vetch	Coronilla varia	herbaceous	triclopyr	foliar applied	up to 5 leaf
leafy spurge	Euphorbia esula	herbaceous	picloram	foliar applied	in spring at true flower stage, or fall regrowth
black locust	Robinia pseudoacacia	woody	triclopyr	cut stump or basal bark	anytime (except with snow or running water)
box elder	Acer negundo	woody	picloram, triclopyr	cut stump or basal bark	anytime (except with snow or running water)
common buckthorn	Rhamnus cathartica	woody	picloram, triclopyr	cut stump or basal bark	anytime (except with snow or running water)
gray dogwood	Cornus racemosa	woody	picloram, triclopyr	cut stump or basal bark	anytime (except with snow or running water)
green ash	Fraxinus pennsylvanica	woody	picloram, triclopyr	cut stump or basal bark	anytime (except with snow or running water)
honey locust	Gleditsia triacanthos	woody	triclopyr	cut stump or basal bark	anytime (except with snow or running water)
multiflora rose	Rosa multiflora	woody	picloram, 2,4-D	cut stump or basal bark	anytime (except with snow or running water)
red cedar	Juniperus virginiana	woody	none needed		
siberian elm	Ulmus pumila	woody	picloram, triclopyr	cut stump or basal bark	anytime (except with snow or running water)
silver maple	Acer saccharum	woody	picloram, triclopyr	cut stump or basal bark	anytime (except with snow or running water)
smooth sumac	Rhus glabra	woody	triclopyr	cut stump or basal bark	anytime (except with snow or running water)
tartarian honeysuckle	Lonicera tatarica	woody	picloram, triclopyr	cut stump or basal bark	anytime (except with snow or running water)

* Always read and follow label directions.

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7 Site Preparation

Content by Dave Williams

PRAIRIE RESTORATION SERIES

Site preparation alters the existing vegetation and soil structure in advance of seeding, increasing emergence, growth and survivorship of the seeded natives by removing thatch, improving seed to soil contact, and reducing weeds. From construction sites to cornfields, site conditions can be drastically different and require specific site preparation techniques. There are two broad categories of site preparation: one associated with bare soil sites, and one with vegetated sites.

Caution - Most of the site preparation methods described in this publication involve killing the existing vegetation and should NOT be used if remnant prairie vegetation (prairie plants that were not planted) are present at the site. Restoration techniques should be applied if remnant prairie plants are present.

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Site Preparation For "Bare Soil" Sites

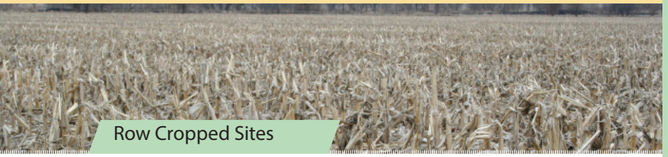
Construction Sites

In many construction sites, the original soil profile has been altered during the construction process. Some areas within the site may have compacted soil from construction equipment (see Assessing for Soil Compaction). Many construction sites have large clods and compacted soil. An ideal seedbed for a native seeding should consist of friable soil particles (1/2 inch or smaller) in the top 1 inch of the soil.

Dirt clods too large to plant into

Cultipacking to reduce clod size

» Rototill or shallow disk (4 inch depth) prior to seeding for compacted soil or if clods are greater than 1/2 inch.
» Seed in fall or in early spring
» Cultipack the site before seeding if a no-till seed drill is used. Cultipack the site after
seeding if the site is seeded with a drop seeder



Row Cropped Sites

Photo of corn field too trashy to use a no-till grass drill

Sites that have been row cropped may require different kinds of site preparation. The amount of site preparation needed depends upon the quantity of crop residue (see Assessing Crop Residue Section) left on the field and the type of seeding equipment used.

Light bean residue

Corn stover round baled after harvest

Corn field cut for silage

Field examples of light crop residue not needing any tillage prior to seeding natives with a no-till grass drill.

Light Crop Residue

Bean field being harrowed

» No other site preparation needed if seeded with a no-till drill.

» If broadcast or drop seeding, first cultivate with a spiked toothed harrow to roughen the soil surface.

» Seed in fall or in early spring

» Cultipack after seeding improves seed-to-soil contact.

Heavy Crop Residue

Disking corn field

» Mow (chop) stalks if standing.

» Remove crop residue by baling or by discing/cultivating the planting site to mimic a seedbed needed for a corn or soybean planting.

» Seeding can be done in fall or in spring after removing crop residue.

» Cultipack after seeding improves seed-to-soil contact.

One disking pass

Second disking pass

Third disking pass

Feedlots, Overgrazed Pastures

Bare soil can result from severe overgrazing and livestock trampling. By removing livestock from the site, vegetation can re-emerge from underground rootstock. Livestock should be removed for at least one entire growing season to allow the vegetation to recover and be identified. If remnant (not planted) prairie plants are detected, the site should be considered a prairie remnant and site preparation techniques for prairie remnants should be used. Typically, feedlots and overgrazed pastures will contain persistent perennial plants and high levels of weed seed in the soil. Manure can also contribute to high levels of nitrogen in the soil, which will stimulate weed germination and weed growth. If no remnant prairie plants are detected, use site preparation techniques from the Stand Replacement subsection of this publication.

Site Preparation For "Vegetated" Sites

Types of vegetated sites include: turf grass lawns, pastures, hayfields, and conservation plantings. Vegetation on these sites can vary from smooth brome/alfalfa hayfields and Kentucky bluegrass lawns to a dense stand of prairie grasses on a site enrolled in a federal government Conservation Reserve Program (CRP). Caution - If a site contains remnant (not planted) prairie plants, the site should be considered a prairie remnant and site preparation techniques for prairie remnants should be used.

There are two site preparation options- stand replacement (starting over) and stand enhancement (interseeding). Stand replacement site preparation techniques should be used to replace a current stand of non-native grasses and legumes with prairie grasses and wildflowers. Stand enhancement site preparation techniques are typically used when the goal is to add additional prairie species to sites that currently have some native plants or are dense stands of prairie and pasture grasses with few to no wildflowers.

1. Stand Replacement (Starting Over)

Stand replacement has three primary methods of site preparation. Select a site preparation technique based upon the speed in which you want to complete the project, the budget for the project, and the kind of equipment available to conduct site preparation activities.

Spray and Plant (Option 1)

» Mow (4 inches high or less) in spring or in late summer or burn when the vegetation is dormant.

» Apply an appropriate herbicide(s) to actively growing vegetation when there is 4 to 6 inches of new growth. For legume/grass stands, a mixture of a broadleaf and grass herbicide, such as glyphosate and 2,4-D should be used. It can take 2 to 4 weeks after mowing or burning for the vegetation to have enough new growth for a herbicide treatment. Re-spray any green plants after 14 days from the first herbicide treatment. Wait another 14 days after the last herbicide treatment to seed. Seed can then be broadcasted or drilled.

Small boom sprayer

Large boom spraying

Backpack spraying

Repeated Spray and Plant (Option 2)

This site preparation technique requires an entire growing season and is more expensive than option 1, but control of persistent perennial plants is greatly improved.

» Mow (4 inches high or less) or prescribe burn in early-spring.

» Apply glyphosate to vegetation when there is 4 to 6 inches of new growth. Respray or spot treat each time it 'greens up' throughout the summer and into early fall.

» No further site preparation is needed if the site is seeded with a no-till seed drill. If seeding with a broadcast seeder or drop seeder, the area should be roughed up with a spiked toothed harrow before seeding, breaking apart thatch and loosening the surface soil. After seeding, the site should be cultipacked (rolled).

Spray, Till and Plant (Option 3)

This method controls established persistent perennial plants and germinating weed seed in the soil. Caution - This option is not recommended for erosive sites as repeated discing will create bare soil.

» Mow (4 inches high or less) or prescribe burn in early-spring.

» Apply glyphosate to actively growing vegetation when there is 4 to 6 inches of new growth.

» Wait 10 days after the herbicide application and Disk the site at 3-4 week intervals for the entire growing season.

» Seed in fall or in early-spring.

» Cultipack after seeding improves seed-to-soil contact.

Assessing Crop Residue

Crop residue can be grouped into two categories- light or heavy. Light crop residue is defined as crop stubble no more than 4 inches high with residue on the surface not intertwined and some bare soil that can be seen through the residue. Light crop residues can include: soybean residue, corn residue after a silage harvest, corn residue after baling the residue, or cereal grain residue. Heavy crop residue is defined as crop stubble taller that 6 inches, intertwined and layered on the surface, with no bare soil visible. Heavy crop residues can include: corn or sorghum residue after a typical harvest and some cereal grains, such as winter wheat.

Assessing crop residue in the field must be done onsite. Walk in a line across the field and stop in ten spots of equal distance from end to end. Look down near your feet to see if bare soil is visible. Reach down and grab some residue; it is intertwined if a layer of residue larger than your hand comes off the ground. If intertwined residue is found and bare soil cannot be seen in more than five spots, consider the crop residue to be heavy.

Grass Drills

Photo of notill seed drilling. Seeding natives with a Truax FLXII grass and grain drill. No tillage is necessary prior to seeding because this drill is designed to plant the seed into existing sod.

A grass drill is the best way to plant seed into existing sod or firmly packed bare dirt. Grass drills with no-till attachments can plant seed into grass sod without any pre-tillage. Reduced soil erosion and fewer weeds are advantages of no-till drilling into sod. Grass drills work best if the soil and the vegetation are dry and most of the thatch and standing dead material is removed by burning or haying. When operating properly, a no-till drill moves the thatch with trash plows, cuts a shallow furrow, meters the seed at the selected rate, plants the seed 1/8 inch – 1/4 inch deep, and presses the seed into the soil. In some areas, grass drills can be rented from governmental agencies. Check with your local Natural Resources Conservation Service for information on renting a grass drill. Note – A grass drill is a very specialized piece of equipment and should be operated by a person experienced in their operation.

To achieve the best performance and outcome with a grass drill, the seed must be properly mixed and calibrated and the drill must be operated correctly. The following are some best practices to optimize the use of a grass drill in planting prairie seed.

» Assign each species to the appropriate box based upon seed size and the extent to which the seed has been cleaned (Figure 1; Table 1). Note: Most species can be mixed together if seed is debearded/deawned and dehulled and can be seeded through the rear cool-season/grain box.

» Consider broadcast seeding (by hand or seeder) the very small seed. Some practitioners will hand broadcast very small seed (100,000 seeds or more per ounce) instead of using the grass drill. It is thought that a grass drill plants very small seed too deep. This may work well for smaller sites. However, hand seeding and getting an even coverage of seed in a large planting may not be possible or practical. In this case we recommend mixing all the very small seeded species (Table 2) together and mix in an equal amount of scoopable kitty litter. Remove one or two discharge tubes from the front small seed box on the grass drill and add the very small seed mix in the well(s) where the tubes were removed. Seed will randomly fall to the soil surface and will likely to get pressed into the soil by the drill and tractor tires as the units pass over.

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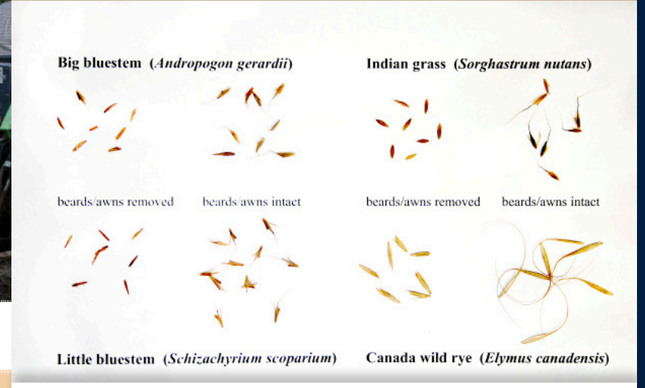
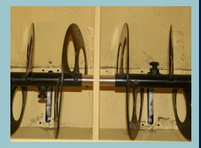


Figure 1 – Prairie grass seed that are de-bearded and de-awned and seed of the same species with beards and awns intact.

Tips on No-Till Seeding — Drill Seeding

» Add inert material to the seed to increase the volume. Filler should be similar in size to the seed in the mixture. Add scoopable cat litter to the seed that is to go in the front small seed box. For seed in the fluffy seed box, add an equal part of vermiculite. For seed in the cool season/grain box add an equal part of cracked corn.



Closeup of inside of the middle "fluffy" seed box on a no-till drill. The augers and picker wheels are designed to pull apart prairie seed that have their beards and awns intact.

» Calibrate each box separately

» Always operate a grass drill at the recommended ground speed. Excessive ground speed will cause the drill to improperly plant the seed.

» Adjust the drill when operating. Look for seed not planted in the rows and adjust the drill accordingly.

» Inspect the drill while operating. Avoid drilling in wet conditions. Mud buildup on the depth bands can change the seeding depth. A stiff putty knife works well to remove mud on the depth bands.

» Periodically squeeze and shake the feeder tubes connected to the fluffy and cool-season boxes. Individual compartments within the small seed box should have similar quantities of seed remaining while drilling. A compartment with more seed than the other compartments may indicate a plugged feeder tube.

Different types of filler material that can be mixed with prairie seed to increase its bulk and improve flow through a grass drill.

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Table 1 – Seed Drill Box Designations of Selected Prairie Species

	Awns, Beards, Hulls		
Grasses	Genus-Species	Removed	Intact
Big bluestem	Andropogon gerardii	Rear Box	Middle or Rear Box
Side-oats grama	Bouteloua curtipendula	NA*	Middle or Rear Box
Prairie brome	Bromus kalmii	NA	Middle or Rear Box
Copper-shoulder oval sedge	Carex bicknellii	Front or Rear Box	Front or Rear Box
Plains oval sedge	Carex brevior	Front or Rear Box	Front or Rear Box
long-awned bracted sedge	Carex gravida	Front or Rear Box	Front or Rear Box
Field oval sedge	Carex molesta	Front or Rear Box	Front or Rear Box
Lance-fruited oval sedge	Carex scoparia	Front or Rear Box	Front or Rear Box
Common fox sedge	Carex stipata	Front or Rear Box	Front or Rear Box
Brown fox sedge	Carex vulpinoidea	Front or Rear Box	Front or Rear Box
Canada wildrye	Elymus canadensis	Middle or Rear Box	Middle Box
Virginia wild rye	Elymus virginicus	Middle or Rear Box	Middle Box
Switchgrass	Panicum virgatum	Front or Rear Box	NA
Little bluestem	Schizachyrium scoparium	Rear Box	Middle Box
Indian grass	Sorghastrum nutans	Middle or Rear Box	Middle or Rear Box
Prairie cordgrass	Spartina pectinata	Middle or Rear Box	Middle or Rear Box
Tall dropseed	Sporobolus compositus	Front or Rear Box	Front or Rear Box
Prairie dropseed	Sporobolus heterolepis	Front or Rear Box	Front or Rear Box
Porcupine grass	Hesperostipa spartea	Rear Box	Middle Box
Forbs			
Wild garlic	Allium canadense	Middle or Rear Box	NA
Leadplant	Amorpha canescens	Front or Rear Box	Middle or Rear Box
Thimbleweed	Anemone cylindrica	Front or Rear Box	Middle or Rear Box
Tall thimbleweed	Anemone virginiana	Front or Rear Box	Middle or Rear Box
Swamp milkweed	Asclepias incarnata	Front or Rear Box	Front or Rear Box
Butterfly milkweed	Asclepias tuberosa	Front or Rear Box	Front or Rear Box
Whorled milkweed	Asclepias verticillata	Front or Rear Box	Front or Rear Box
Upland white aster	Aster ptarmicoides	Front or Rear Box	Middle or Rear Box
Milk vetch	Astragalus canadensis	Front or Rear Box	NA
Partridge pea	Cassia fasiculata	Front or Rear Box	NA
Prairie coreopsis	Coreopsis palmata	Front or Rear Box	NA
White prairie clover	Dalea candida	Front or Rear Box	NA
White wild indigo	Baptisia alba	Front or Rear Box	NA
Purple prairie clover	Dalea purpurea	Front or Rear Box	Front or Rear Box
Showy tick trefoil	Desmodium canadense	Front or Rear Box	Front or Rear Box
Pale purple coneflower	Echinacea pallida	NA	Rear Box
Rattlesnake master	Erynigium yuccifolium	NA	Rear Box
Joe pye weed	Eupatorium maculatum	Front or Rear Box	Middle or Rear Box
Tall boneset	Eupatorium altissimum	Front or Rear Box	Middle or Rear Box
Bigtooth sunflower	Helianthus grosseserratus	NA	Front or Rear Box
Western sunflower	Helianthus occidentalis	NA	Front or Rear Box
Prairie sunflower	Helianthus pauciflorus	NA	Front or Rear Box
Ox-eye sunflower	Heliopsis helianthoides	NA	Front or Rear Box
Round-headed bush clover	Lespedeza capitata	Front or Rear Box	Front or Rear Box
Rough blazingstar	Liatris aspera	Front or Rear Box	Middle or Rear Box
Meadow blazingstar	Liatris ligulistylis	Front or Rear Box	Middle or Rear Box
Prairie blazingstar	Liatris pycnostachya	Front or Rear Box	Middle or Rear Box
Michigan lily	Lilium michiganense	NA	Rear Box
Wild lupine	Lupinus perennis	NA	Front or Rear Box
Wild bergamot	Monarda fistulosa	NA	Front or Rear Box
Dotted mint	Monarda punctata	NA	Front or Rear Box
Stiff goldenrod	Oligonueron rigidum	Front or Rear Box	Middle or Rear Box
Wild quinine	Parthenium integrifolium	Front or Rear Box	Middle or Rear Box
Large Fl. beardtongue	Penstemon grandiflorus	NA	Front or Rear Box
Prairie phlox	Phlox pilosa	NA	Front or Rear Box
Prairie buttercup	Ranunculus rhomboideus	NA	Front or Rear Box
Yellow coneflower	Ratibida pinnata	NA	Front or Rear Box
Wild rose	Rosa spp.	NA	Middle or Rear Box
Black-eyed Susan	Rudbeckia hirta	NA	Front or Rear Box
Sweet coneflower	Rudbeckia subtomentosa	NA	Front or Rear Box
Wild petunia	Ruellia humilis	NA	Front or Rear Box
Rosinweed	Silphium integrifolium	NA	Middle or Rear Box
Compass plant	Silphium laciniatum	NA	Middle or Rear Box
Smooth blue aster	Symphyotrichum laevis	Front or Rear Box	Middle or Rear Box
New england aster	Symphyotrichum novae-angliae	Front or Rear Box	Middle or Rear Box
Purple meadow rue	Thalictrum dasycarpum	NA	Front or Rear Box
Prairie spiderwort	Tradescantia bracteata	NA	Front or Rear Box
Ohio spiderwort	Tradescantia ohiensis	NA	Front or Rear Box
Blue vervain	Verbena hastata	NA	Front or Rear Box
Hoary vervain	Verbina stricta	NA	Front or Rear Box
Ironweed	Vernonia fasciculata	Front or Rear Box	Middle or Rear Box
Heartleaf alexanders	Zizia aptera	NA	Front or Rear Box
Golden alexanders	Zizia aurea	NA	Front or Rear Box

* NA – Not Applicable

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8 Seeding

Content by Dave Williams

PRAIRIE RESTORATION SERIES

Deciding when to plant a prairie is a challenge. Some species establish better when spring planted, other species establish better when fall planted and some species are hard to establish whenever they are planted. Seeding rates of some species may need to be increased depending on when and how they are planted.

Prairie seed can be planted by broadcast seeding, hydroseeding and drill seeding. Regardless of the seeding method used, it is essential that seed be planted at the proper depth and with good seed-to-soil contact.

Seeding Time

Tallgrass prairie plants exhibit a wide range of growth characteristics. With adequate soil moisture, cool-season grasses and many forbs germinate in early spring when minimum soil temperatures are between 39° to 45° F (3° to 7° C), while warm-season grasses germinate in late spring when soil temperatures reach 50° to 56° F (10° to 13° C) (Smith et al. 1998). Real time soil temperatures for the tallgrass prairie region can be found at www.greencastonline.com/SoilTempMaps.aspx. Native seed mixes often contain both cool and warm-season species, and there is no single best time to plant. However, choosing a planting time to maximize germination and establishment depends upon the species selected and their contribution to the seed mix. A seed mix with a strong forb component (50 percent or greater forb seed) should be dormant seeded. By contrast, a seed mix of mostly warm-season grasses (70 percent or greater grass seed) should be seeded in mid-spring.

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Dormant Seeding
(Soil temperatures between 38° to 32° F)

A dormant seeding is defined as planting seed during a time when there is the least chance of germination and seed will lie dormant for several months. For most of the tallgrass prairie region dormant seeding can begin in early November. Early onset of very cold weather in the fall, or cold weather into late winter can extend the calendar times for dormant seeding. The benefits of dormant seeding are twofold. First, seeding when soil temperatures are below 39° F ensures that there is no germination of the natives until the following spring when environmental conditions are suitable for germination and growth. Second, dormant seeding benefits forbs by permitting stratification which improves germination . We recommend that dormant seeding be done only if the seed can be planted into the soil (1/8 to 1/4 inch deep) and packed. Seed broadcasted onto ice or frozen ground is not recommended as it will expose the seed to wind erosion and predation. Dormant planting mimics the natural process of seed ripening and autumn/winter dispersal of many prairie species. However, dormant seeding of most native grasses, except switchgrass, (Panicum virgatum)and Canada wild rye (Elymus canadensis)) increases seed mortality (Meyer and Gaynor 2002). If the seed mix contains 50:50 forb seed to grass seed or greater, dormant seeding should be considered. Grass seed should be increased by 25 percent if dormant seeded to compensate for seed loss (Henderson and Kern 1999).

Spring Seeding (Late March to Mid-June)

There is a wide range of soil temperatures in spring. Spring soil temperatures (1 inch deep) in Iowa range from 35° F (2° C) in late March to over 70° F (21° C) in mid June (Riley 1957). The specific time of year the site is seeded will determine which species are favored in the seed mix. Early spring seeding favors cool-season grasses , sedges and some forbs. The window for germination of cool-season plants diminishes as soil temperatures increase throughout spring. A late spring seeding favors warm-season grasses and some forbs. Spring seeding may not permit adequate stratification for some forbs to break dormancy. Non-germinated seed will remain in the soil until conditions are appropriate for germination.

Summer Seeding (July to September)

Planting mid and late-summer is risky business. New germinates exposed to excessive heat and drought will perish. In addition, many prairie species require 2–6 weeks to germinate. By the end of the growing season, it is likely that seedlings may be too small to survive the winter. Seeding natives during this time is not recommended.

Frost Seeding (February to March)

Seeds on cracked soil
Prairie seeds can become incorporated into the soil by the cracks that are created by freeze-thaw cycles in late winter.

Frost seeding is a special form of dormant seeding done at the tail end of winter when temperatures are below freezing at night and above freezing during the daytime. If the soil surface is free of snow or ice, seed can either be drilled or broadcast. The freeze-thaw action creates small cracks in the soil and allows seeds to settle into it. The effect on germination of prairie grass and forb seed by a frost seeding as compared to other seeding times is unknown. However, research on non-native legumes has shown that frost seeding can improve seed germination, but an unusually dry and warm spring can result in poor establishment (Barnhart 2002). In addition, the effect on germination of non-native cool–season grasses that are frost seeded can vary and is not recommended for some species (West et al. 1997). The benefit of frost seeding prairie seed may be related to the length of time the seed remains in the soil before germinating. As compared to a dormant seeding in November, frost seeding reduces the time seed remains in the soil before germination and may reduce seed mortality from pathogens and/or granivory (Hemsath 2007). We believe that frost seeding can be a good time to seed for most native seed mixes. We recommend seeding with a no-till grass drill to maximize seed-to-soil contact. If broadcast seeding is used, the seeding rate should be increased by 25% to compensate for seed loss due to wind erosion and predation (Henderson and Kern 1999). Frost seeding is not recommended on eroded sites with rills and gullies. If the site is prone to erosion, sow oats (up to 1 bushel per acre) with the prairie seed and/or a mulch should be applied and crimped into the soil to keep the seed in place.

Seeding Methods

Planting seed at the proper depth with good seed-to-soil contact is essential. Seed planted too deep will not emerge resulting in poor stand establishment. Likewise, seed not covered by soil can germinate, desiccate and die. It's the responsibility of the person(s) actually doing the seeding to ensure that seed is planted correctly. This requires periodic checking of the planted seed and the equipment during seeding.

Broadcast Seeding

Broadcast seeders range from tractor and ATV mounted implements to hand-held seeders or simple hand broadcast seeding. This method can be a low cost way to seed your prairie. An inexpensive hand held fertilizer spreader, available at your local hardware store can be used for seeding.

To assure that the seed is evenly distributed and dispersed over the planting site the seed must be properly mixed and the seeding rate carefully calculated. The seed should be mixed in equal parts with inert material such as vermiculite, cracked corn or kitty litter. This will increase the volume of the seed. Because of improvements in seed cleaning, the volume of prairie seed needed to plant a smaller site (1 acre or less) may not fill a 5-gallon bucket. Mixing any of these materials with the prairie seed will improve the seed flow through the seeder, and will make calculating the seeding rate much easier. Seed can be mixed in a plastic tub by hand or on a concrete slab using a flat shovel. If you use a mechanical seeder, calibrate the equipment before sowing seed and follow the calibration procedure as listed in the owner's manual. If seed is hand broadcasted, divide seed by half and sow each half over the entire site so the site is seeded twice. This will ensure even seed dispersal and distribution over the site. After seeding, seed should be incorporated into the soil to improve seed-to-soil contact. Incorporating seed into the soil can be done by dragging a piece of heavy chain, or a piece of chain link fencing, or using a drag harrow, or raking seed in with a garden rake. Drag, harrow, or rake until the seed disappears. Finally, pack the soil with a cultipacker or lawn roller.

Broadcast seeding with a Viacon fertilizer spreader and dragging a piece of fencing to incorporate the seed into the soil.

Seeding natives with a Brillion grass seeder. Seed is dropped in between two steel wheel gangs-one conditions the soil and the other cultipacks the seed.

Table 2 — Seed that Should be Broadcasted

Small seeded prairie species that can be broadcasted onto the surface without incorporating into the soil.

Grasses/Sedges	Scientific Name	Moisture Class*	Seeds/Oz.
Blue Joint Grass	Calamagrostis canadensis	W-M	248,880
Brown Fox sedge	Carex vulpinoidea	W-M	100,000
Fowl Manna Grass	Glyceria striata	W-M	160,000
June Grass	Koeleria macrantha	D	400,000
Forbs			
Prairie Sage	Artemisia ludoviciana	M-D	250,000
Heath Aster	Symphyotrichum ericoides	M-D	200,000
Silky Aster	Symphyotrichum sericeus	D	476,000
Harebell	Campanula rotundifolia	D	900,000
Bottle Gentian	Gentiana andrewsii	W-M	280,000
Sneezeweed	Helenium autumnale	W-M	130,000
Great St. Johns Wort	Hypericum ascyron	W-M	190,000
Great Blue Lobelia	Lobelia siphilitica	W-M	500,000
Foxglove Beardtongue	Penstemon digitalis	M	130,000
Common Mt. Mint	Pycnanthemum virginianum	W-M	220,000
Grass Leaved Goldenrod	Euthamia graminifolia	W-M	200,000
Old Field Goldenrod	Solidago nemoralis	D	300,000
Showy Goldenrod	Solidago speciosa	M-D	103,600
Culver's Root	Veronicastrum virginicum	W-M	800,000

W
Wet soils- Water drains very slowly resulting in standing water at or near the surface for most of the year.

M
Mesic soils - Water drains readily from the soil but soil remains moist for most of the year.

D
Dry soils - Water drains rapidly resulting in dry soil for most of the year.

Hydroseeding

Hydroseeding is a unique seeding method where seed is mixed with water, mulch and tackifier to form a slurry that is sprayed directly on the ground. Many county road departments and some landscaping companies use hydroseeding to seed prairie. While this method of seeding is restricted to professionals, you may decide to hire a local company to hydroseed your prairie. We recommend that your seeding contractor hydroseed with a two step process. The first step is to broadcast the seed (see the Broadcast Seeding subsection). The second step is to spray the hydromulch slurry (without seed) over the seeded area. This two-step process will help insure that the seed is not suspended in the mulch where it can desiccate. Additives can be included in the slurry to reduce soil erosion (Meyermann 2008).

Manual Maintenance

There are non-herbicide methods to control weeds and woody plants in a native planting. These methods require extra physical exertion and time, but can be the least damaging to the surrounding native plants. The severity of the infestation and the stamina of the land manager will dictate whether these methods are practical.

Hand weeding

The best time to hand weed is immediately after a rainstorm when the ground is soft and a large portion of the root can be extracted. Perennial rhizomatous weeds like Canada thistle and leafy spurge will require several pullings in the same year and may require weeding two or more years. Wear thick gloves- Canada thistle plants are prickly and leafy spurge sap can cause dermal reactions.

Hoeing, spade shovel, hedge/pruning shears

Chopping works very well on biennial plants. Cutting the plant under the soil surface or near its base as it begins to flower will greatly reduce its ability to re-grow and produce seed.

Heavy duty string trimmer (fitted with a steel brush blade or plastic knives) — A gas powered string trimmer can selectively cut small weed patches and smaller diameter woody plants scattered throughout a planting. This piece of equipment can be dangerous to operate. Always wear proper safety equipment that should include gloves, long-sleeved shirt, safety glasses, hearing protection, hard hat, chaps, and steel-toed shoes. Read and follow recommendations in the owner's manual for safe operation.

Girdling

Girdling (like rabbits do to young trees and shrubs in the winter) can kill woody plants. Girdling is accomplished by scraping a thin layer of bark off the stem all the way around the plant near its base. Immediately inside the outer layer of bark is a very thin green layer (phloem) that must be removed. On young woody plants, the tissue can be scraped off fairly easily with a sharp pocked knife. Be careful not to girdle too deeply. Cutting too deep will stimulate the plant to produce new sucker shoots, which is the same plant response as when the stem is completely severed. Girdling stops nutrients generated in the leaves from moving into the roots. The result is that the roots starve and die. Be sure to girdle any new sucker shoots. Any shoots not girdled will allow the plant to survive.

To request copies, or for more information, contact Greg Houseal at 319.273.3005 or email gregory.houseal@uni.edu.

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Note:
Always wear protective clothing and gloves to guard against thorns and plant compounds that can cause severe skin reactions.

Prescribed Burning

A prairie planting should be burned as soon as the site can carry a continuous fire. Proper use of prescribed fire will accelerate growth of most prairie plants and deter cool-season weeds and small woody plants. Typically, there is not enough fine fuel (grass leaves) to carry a fire in a one or two year old planted prairie due to frequent mowing. By the end of third growing season however, there should be enough grass growth to carry a fire. The first prescribed fire on a newly reconstructed prairie often is done in the spring to stimulate the warm-season prairie grasses. The management objectives should determine frequency and timing of prescribed fires for subsequent prescribed burning. Caution - Prescribed burning should only be done by trained and experienced personnel. To learn more on prescribed burning visit the Iowa Natural Resources and Conservation Service (NRCS) website at ia.nrcs.usda.gov/news/brochures/publications.html to download a free copy of Prescribed Burning.

Irrigation

Irrigation can be an important management tool. Once a seed germinates, there is a critical phase of development between emergence and the time the seedling develops its first true leaf. While the plant is still in this cotyledon stage, it cannot survive an extended period of drought. If rainfall is not adequate, seedlings will benefit from being watered 1 to 2 inches every three days during the first growing season (Morgan 1995). Irrigation increases the probability that the plants will survive into the second growing season and beyond.

Fertilizers

Fertilizers are not recommended for native plantings. Most plants including natives benefit from fertilizers, but weeds benefit more, making fertilizers a poor management strategy. Fertilizing a newly planted prairie will disproportionately favor opportunistic weedy species. Most native species are well adapted for nutrient poor soil. In some cases, fertilization may also damage or kill native seedlings.

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Table 1 — Persistent Perennial Plants

Common Name	Genus-species	Phenology	Herbicide Class*	Application Method*	Application Time*
Kentucky bluegrass	Poa pratensis	grass	glyphosate	foliar applied	in spring at boot-to-early seedhead stage
Quackgrass	Agropyron repens	grass	glyphosate	foliar applied	6" - 8" tall
Reed canarygrass	Phalaris arundinacea	grass	glyphosate	foliar applied	in spring at boot-to-early seedhead stage
Smooth brome	Bromus inermis	grass	glyphosate	foliar applied	in spring at boot-to-early seedhead stage
Tall fescue	Festuca arundinacea	grass	glyphosate	foliar applied	in fall with 6" - 12" new growth
Bird's-foot trefoil	Lotus corniculatus	herbaceous	clopyralid, triclopyr	foliar applied	up to 5 leaf
Canada thistle	Cirsium arvense	herbaceous	clopyralid	foliar applied	in spring, rosette to bud
Crown vetch	Coronilla varia	herbaceous	triclopyr	foliar applied	up to 5 leaf
Leafy spurge	Euphorbia esula	herbaceous	picloram	foliar applied	in spring at true flower stage, or fall regrowth
Black locust	Robinia pseudoacacia	woody	triclopyr	cut stump or basal bark	anytime (except with snow or running water)
Box elder	Acer negundo	woody	picloram, triclopyr	cut stump or basal bark	anytime (except with snow or running water)
Common buckthorn	Rhamnus cathartica	woody	picloram, triclopyr	cut stump or basal bark	anytime (except with snow or running water)
Gray dogwood	Cornus racemosa	woody	picloram, triclopyr	cut stump or basal bark	anytime (except with snow or running water)
Green ash	Fraxinus pennsylvanica	woody	picloram, triclopyr	cut stump or basal bark	anytime (except with snow or running water)
Honey locust	Gleditsia triacanthos	woody	triclopyr	cut stump or basal bark	anytime (except with snow or running water)
Multiflora rose	Rosa multiflora	woody	picloram, 2,4-D	cut stump or basal bark	anytime (except with snow or running water)
Red cedar	Juniperus virginiana	woody	none needed		
Siberian elm	Ulmus pumila	woody	picloram, triclopyr	cut stump or basal bark	anytime (except with snow or running water)
Silver maple	Acer saccharum	woody	picloram, triclopyr	cut stump or basal bark	anytime (except with snow or running water)
Smooth sumac	Rhus glabra	woody	triclopyr	cut stump or basal bark	anytime (except with snow or running water)
Tartarian honeysuckle	Lonicera tatarica	woody	picloram, triclopyr	cut stump or basal bark	anytime (except with snow or running water)

* Always read and follow label directions.

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9 Initial Post Seeding AND EARLY RECONSTRUCTION MANAGEMENT

Content by Dave Williams

PRAIRIE RESTORATION SERIES

The establishment of a prairie plant community takes 3 to 5 years. Without early management of the vegetation during this critical time, weeds and woody plants will displace the emerging and newly established native plants resulting in a weedy plant community that will persist for many years. The goal after seeding is to reduce unwanted plants (weeds) and stimulate establishment and growth of the native plants until the prairie plant community is established.

A variety of early management techniques includes frequent mowing, herbicide use, manual maintenance (hand pulling, hoeing, and girdling), prescribed burning, and irrigation to control unwanted plants and enhance the natives.

Prairie Plant Establishment And Weeds

Weed control in a newly seeded native planting should be a high priority in early reconstruction management. Fast growing annual weeds can form a closed canopy over native perennial seedlings in less than 30 days, reducing light to a fraction of full sunlight. Low light intensity stunts native seedlings' development, making them susceptible to winter mortality (Williams et al. 2007).

Perennial weeds can also negatively impact native plant establishment (Table 1). Of most concern to resource managers are the perennial weeds that displace native plants and invade established prairie plantings. Perennial weeds and perennial prairie plants share many similar traits. Both produce seed, spread vegetatively and occupy the same root zone and above ground space. Some perennial weeds such as Canada thistle (Cirsium arvense) and leafy spurge (Euphorbia esula) form dense colonies that eliminate native plants (Butler et al. 2004). Methods to control perennial weeds must be used carefully because they will also have the same effect on the native perennials.

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Establishment Mowing

Selective mowing of weeds in a first year prairie planting

Plants that are allowed to grow high enough to create a closed canopy during the first few years of a prairie planting will reduce germination, growth, and survival of the perennial prairie plants (Williams et. al. 2007). This can create long-term maintenance problems. Frequent mowing is an effective technique to prevent a weed canopy from forming in a new prairie planting. Mowing can be done with any type of mower as long as the mower deck can be raised at least 4 inches. Some practitioners prefer using a flail type mower because the biomass is cut into smaller pieces and does not leave a windrow (thick layer of thatch) on the surface. As a general rule of thumb, do not let the weeds and other vegetation get taller than knee high in the first growing season. Mow to a height of 4 to 6 inches whenever the vegetation grows 12 to 18 inches high in the first growing season. Don't be concerned about damaging the natives by mowing. Most prairie seedlings will grow below the 4 to 6 inch mow height in the first growing season. The frequency and duration of mowing depends upon the weed density and climate conditions during the growing season. Typically in Iowa, with average precipitation, mowing may be needed every three weeks from early-May to early-September in the first growing season. This frequent mowing regime will curtail the growth and seed set of weeds while preventing thatch build-up that can smother native seedlings.

Mowing in the second growing season depends upon the density of persistent perennial and biennial weeds. To avoid damaging the native plants, mowing height should never go below 12 inches in the second growing season. Time between mowing treatments can be monthly or longer depending upon the weed pressure. For scattered weed patches, consider spot mowing or hand pulling to minimize the impact upon developing prairie plants. If there is a flush of tall rank biennial weeds like Queen Anne's lace (Daucus carota), sweet clovers (Melilotus spp.) or wild parsnip (Pastinaca sativa), it is important to mow or pull just prior to flowering to severely curtail or eliminate the plants ability to flower and go to seed (Sheley 2001).

By the third growing season, most of the vegetative growth throughout the site should be prairie plants and mowing should not be needed. If there is a threat of a weed canopy in Year 3, a stand evaluation should be conducted to determine if there are adequate numbers of prairie plants remaining in the site (see Evaluating Stand Establishment in this series). If native plant establishment is less than 1 plant per square foot, we recommend using a stand enhancement technique to add more prairie grasses and forbs to the stand (see Site Preparation in this series).

Note:
Mowing is only partially effective at controlling persistent perennial weeds and woody plants. It will eliminate seed production and reduce weed canopy if implemented at the right time during the growing season but will have little effect or in some cases increase rhizomal spread (Lalonde et al. 1994). In those circumstances, herbicides may be needed to control persistent perennial weeds.

Herbicides

Figure 1 — Crown vetch (green) can be sprayed in fall when adjacent prairie vegetation is dormant.

Herbicides, when used carefully at rates listed on the label, can be very effective at controlling persistent perennial weeds and woody plants (Table 1). Careless application will result in killing native species. Just how many weeds are considered 'weedy' in a native planting is a matter of personal preference, but addressing weed issues early can save heartache later on. There will be less damage to native plants if chemical control is used within the first few years of a seeding, when weeds are less abundant and can be spot sprayed. Waiting until the weeds are abundant in the planting can turn spot spraying into blanket spraying which is extremely damaging to natives. States require certification testing and licensing to purchase and apply certain pesticides. Contact your State Department of Agriculture to obtain more information on pesticide certification. Always read and follow label directions. The following are some strategies to minimize damage to native plants when using herbicides to control unwanted plants.

1. Spray only the persistent perennial weeds and woody plants (Table 1). Over time prairie plants will exclude most other weeds from the planting.

2. Spray when the natives are dormant. Crown vetch (Coronilla varia) and leafy spurge remain green into fall and can be sprayed after most native plants are dormant (Figure 1).

3. Use herbicides that are species specific. Some herbicides work better than others on individual weed and woody species. Cyclopyralid or chlorsulfuron is more effective at controlling Canada thistle than glyphosate. Fosamine can be foliar sprayed on woody plants without affecting native forbs (non-woody) and grasses. The Nature Conservancy has an extensive list of weeds and methods of controlling them on the web at tncinvasives.ucdavis.edu

4. Spray the weeds at the proper stage of plant development. The label will indicate at what stage of development the weed species is most susceptible to the effects of the chemical. 'Rosette to bud', 'Up to 5 leaf stage', '1 to 3 leaf stage before vining', and 'boot to early seedhead stage' are some examples of specific label recommendations for optimum spraying times.

5. Apply the herbicide at the rate specified by the label. The herbicide application rate will vary according to the weed species and severity of infestation.

6. Use spot spraying. To minimize over-spraying onto non-target plants, use a hand wand instead of boom sprayer. A backpack sprayer with a spray wand extension allows the operator to place the nozzle tip very close to the weed and minimizes over-spraying.

Backpack sprayer with wand extension spraying Canada thistle

Closeup of backpack sprayer with wand extension spraying Canada thistle

7. Use boom spraying only on large dense weed patches.

8. Avoid creating drift when spraying. Lower the spray pressure and increase the nozzle orifice size to reduce spray drift. Don't spray on windy days. Consider spraying in the early morning or early evening when the winds tend to be calm.

9. Cut rather than foliar spray woody plants. Many brush herbicides require complete coverage when foliar sprayed. There is the potential for excessive over-spraying onto non-target plants. A cut stump herbicide to prevent the stump from resprouting can be applied precisely to where it is needed without damaging surrounding vegetation (Table 1).

Stump treatment of cambium with Tordon

10. Do not apply a herbicide to a cut stump that is actively flowing with sap. Sap flow will cause the herbicide to run off the cut stump into the soil and kill nearby vegetation. This is often referred to as 'the ring of death'.

Stump Stick

Volunteer trees are a pesky nuisance in prairie plantings. It Doesn't matter whether a planting is a multiple acre field or a backyard prairie, trees will find their way in. One method to remove volunteer trees is by hand cutting and treating the cut stump with an appropriate herbicide listed for that use on the label. Tree size will determine what piece of equipment to use. Loppers and hand pruners can be used for trees less than 0.5 inches in diameter, a gas weed whip with a brush blade can handle trees up to 2 inches in diameter and a chain saw should be used for anything larger than 2 inches diameter. It's a labor-intensive activity but it is highly effective and minimizes negative impacts to surrounding flora and fauna. To precisely apply herbicide to the cut stump and minimize off target movement of herbicide, the Tallgrass Prairie Center has developed the "stump stick". The stump stick has many advantages: it is made entirely of PVC so it's resistant to herbicides that are acid and salt formulations, it is simple to construct and materials to make it cost less than $15.00. The stump stick is easy to handle and applies herbicide on the cut surface of a plant without over-application to non-target plants. The best part is that you don't have to bend over to apply the herbicide — saving a backache after a full day of cutting trees! For more information on the stump stick visit our website at www.tallgrassprairiecenter.org.

Scouting For Weeds

An additional tool for monitoring a new planting is to scout for weeds in the field. A good scouting effort will reveal weed patches not detected by the quadrat samples. It is critical to find weed problems early because they could increase in abundance and displace prairie plants over time. When scouting in the field, weed patches consisting of 20 or more individual plants should be flagged. Mark their location and population size on the site map. This information is essential for the landowner to take the appropriate weed control measures.

Method 2: Assessing Stand Establishment Using Species Frequency

Prairie plant establishment can also be assessed in a newly reconstructed prairie by calculating species frequency (Siefert and Rosburg 2004). This method uses the same randomized quadrat sampling techniques as described in the previous section. Prairie species are identified within the quadrat and recorded on the data sheet as present or absent (see Table 2). Counting of individual plants is not needed. An advantage of this method is that it doesn't require determining individual plants, which can be difficult in a more mature prairie reconstruction (two or more years old) when many prairie species produce multiple tillers, stems, and spread by rhizomes. A reconstructed prairie should have a prairie plant frequency of 50% or higher (Rosburg 2006). Any persistent perennial weeds detected during quadrat sampling should trigger a scouting of the field to locate and map these plants for weed control (see Scouting section).

Table 2 – Plant Frequency Example

	Quadrat Samples (1 square foot area)																			
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	FRQ
Big bluestem	p		p	p			p	p										p			.30
Indian grass	p				p	p										p					.20
Switchgrass	p	p	p	p	p	p	p	p													.40
Side-oats grama					p	p														p	.15
Black-eyed Susan	p	p		p	p	p	p					p	p								.40
Wild bergamot					p			p													.10
Stiff goldenrod			p			p	p				p										.20
Showy tick trefoil				p					p					p							.15
Compass plant				p																	.05
PRESENT/ABSENT	p	p	p	p	p	p	p	p	p	a	p	p	p	p	a	p	a	p	a	p	.80
Canada thistle	p		p	p	p						p	p						p			.35
Smooth Brome	p	p	p	p	p			p	p		p	p	p		p		p	p	p		.70

a - absent p - present

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To calculate prairie plant establishment (by frequency) follow the three steps listed below.

Step 1 – Sum the number of quadrats where there was a prairie plant present -
Prairie plants occurred in quadrats # 1,2,3,4,5,6,7,8,9,11,12,13,14,16,18,20 = 16
quadrats had at least one prairie plant

Step 2 – Divide the total number of quadrats with prairie plants present by the total number of quadrats sampled
Plant frequency = 16 quadrats with prairie plants/20 quadrats sampled = 0.80

Step 3 – Multiply plant frequency by 100
Prairie plant frequency (%) = 0.80 x 100 = 80.0 %

In this example, prairie plant establishment exceeds the minimum of 50% and the planting is well on its way to being successful. However, the presence of Canada thistle, a persistent perennial plant, should trigger the need to control this weed (see Brochure 9).

Sampling Terminology

Investigator - The person conducting the vegetation sampling and evaluation of data.

Plant Density – The number of plants per unit area as measured by actual counts.

Plant Frequency – The percentage of samples in which a species or target group appears.

Quadrat - A frame of known area (usually 1 square foot) that the investigator places on the ground and samples only rooted plants inside of the frame.

Randomized Sampling - A technique to ensure that all locations of the planting and all individuals of the population have an equal chance of being sampled.

Sample Bias - Something that was done in sampling to produce results that do not represent the actual condition.

Seedling Average (plants per square foot) - The sum of all prairie seedlings counted in quadrats divided by the total quadrat area sampled.

Site - The area that has been seeded with prairie plants.

Stratified Random Sampling - A technique to ensure that all habitat types within the site are represented by samples.

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Photographic Monitoring

A picture is worth a thousand words. In 1994, at the 14th North American Prairie Conference in Manhattan, Kansas, Dr. Paul Christiansen presented his research project of establishing prairie species in a roadside by overseeding them into non-native smooth brome (Bromus inermis) after a burn. He had established a permanent photo point on his research site and took images of the site before seeding and at 2, 5, 10, and 13 years after seeding. Watching the plant community transform from a mono-culture stand of non-native grass to a diverse prairie plant community (that resembled a prairie remnant) was fascinating. Photographic monitoring can be extremely useful in reconstructed prairies to document the long-term vegetation changes.

Seasonal Changes in a 5 year-old prairie planting. Photos were taken the same year in (A) late spring, (B) mid-summer and in (C) early fall

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10 Evaluating Stand Establishment

Content by Dave Williams

PRAIRIE RESTORATION SERIES

This brochure is intended to assist the practitioner/landowner in the sampling and evaluation of prairie plant establishment in a new seeding. Deciding where to sample, how many samples to take, what to measure, and how to analyze the data for an assessment of prairie plant establishment are discussed.

Equipment Needed

Seeding Plan
The seeding plan should include the following: a species list, noting the quantities that were seeded; a description of the site preparation, seeding method, and sowing time; and an aerial photograph and soil map of the site.

Prairie Seedling Photographs and Seedling Key

Missouri Department of Conservation Pocket Seedling Guide mdc.mo.gov/grownative/plantID/

A field guide to identify prairie grasses and forbs for your region.

Knee pads
Hard ground is tough on the knees.

Clipboard
For a hard surface to record data.

Quadrat Frame

Weed Identification Guide
Weeds of Nebraska and the Great Plains, published by Nebraska Department of Agriculture, is an excellent reference book for weeds found in the tallgrass prairie region.

Hand Lens
Hairs, ligules, and auricles on seedling plants need magnification to be detected. A 5x, 10x, 15x triple lens can be bought for less than $5.00 from Forestry Suppliers, Inc. (www.forestry-suppliers.com).

Digital camera and spare batteries

Mechanical Pencils
Mechanical pencils maintain sharp lead, which makes data recording easier.

Blank data entry sheets

Lunch bags (paper) To hold plant specimens.

Vinyl flagging (roll and wire flags)
For marking areas on the site that need reseeding, weed/brush control ect.

Scissors
To clip plant specimens. Fiskars are very durable.

Fine tipped Sharpie
To mark on lunch bags for plant specimens

Calculator

Gloves
To prevent skin contact with plants that cause blistering like poison ivy (Toxicodendron radicans) and wild parsnip (Pastinaca sativa).

Insect Repellent
Works well for mosquitoes and chiggers but not so well for biting flies.

Sunglasses
The glare from the data sheets on a clear sunny day is intense.

Tallgrass Prairie CENTER
Restoring a National Treasure
University of Northern Iowa

Why Assess Prairie Plant Establishment?

Assessing establishment of prairie plants in the first or second growing season can eliminate the unnecessarily reseeding of a successful planting or prolonging the maintenance of a failed planting. Establishment often varies throughout a planting. Variations in topography and soil types expose the seed to different growing conditions, sometimes resulting in poor emergence. One purpose of vegetative sampling is to find areas within the planting that have too few seedlings so they can be reseeded. Sampling can also detect areas where there are persistent perennial weeds, which will reduce prairie plant establishment. Controlling these weeds early in the reconstruction can save the landowner time and money.

What Is Sampling?

Sampling is a systematic process used to gather a small part (or sample) of something and analyze it to answer a basic question. A basic question asked by managers and landowners about a new prairie planting might be, Are there enough prairie plants in the planting? To answer this question you can proceed in one of two methods. The first method would be to identify and count every prairie plant in the planting. Then take that number and divide it by the total square feet in the planting which will result in the number of seedlings per square foot. This number can be compared with the recommended number of seedlings per square foot that are needed for adequate native plant establishment. The first method would be extremely time consuming but one could accurately calculate prairie plant establishment for the planting. The second method would be to choose many different locations throughout the planting, and identify and count only the prairie plants that occur in a very small area (1 square feet) at each location. Prairie plant establishment could then be calculated by adding up all prairie plants found then dividing them by the total square feet that was sampled. This number, as with the number in the first method, can be compared with the recommended number of seedlings that are needed for adequate native plant establishment. Clearly, the second method is easier and saves time. If the second method is correctly done, the number of plants per square foot should be very similar to the first method. Sampling is an excellent assessment tool in prairie management.

How Much And Where To Sample

Determining how much vegetative sampling is needed depends upon the complexity of the landscape. For planting sites, regardless of size, that don't have much variation in topography and soil type, a minimum of 20 to 30 samples are needed to assess prairie plant establishment (Witmer 1999). In plantings that have varying habitats (such as varying slopes and aspects, rock outcrops, swales, or waterways), additional vegetative sampling is required. To accurately assess seedling establishment in plantings with a variety of habitats, areas of the site with similar environments should be sampled and analyzed separately. This is called stratified sampling. Stratified sampling requires dividing the site into habitat types based on environment and calculating prairie plant establishment for each habitat. We recommend a minimum of 20 to 30 samples be taken for each habitat type. An advantage of stratified sampling is that areas in the planting that have poor seedling establishment can be identified that may otherwise go undetected.

It is human nature to choose sampling locations with only a few plants present because it makes identification/counts much easier, but the results will not provide the accurate information needed to successfully manage the planting. Instead, vegetation should be sampled at random locations within habitats to obtain the most representative information of the plant species composition. The process is called randomized sampling. The following steps will help ensure that sampling is randomized before going into the field.

1. Review the site map and mark each distinct habitat type that should be sampled and analyzed separately.

2. On the map, select a starting point anywhere along the boundary of each habitat type to be sampled. Choose an end point on the opposite side of the habitat type that is furthest away from the starting point. With a pencil, connect the points. This line is called a transect. Measure the transect length using the map scale. Divide the number of samples (20 to 30) by the transect length. This will give you the distance between each sample to be taken along the transect in the field.

3. Measure your pacing distance using a normal walking speed.

4. Divide the distance between samples by your pace distance to determine how many paces are needed between samples.

Lower Right Photo: Rectangular open ended quadrats can be easily inserted into dense vegetation. Sample area inside each quadrat frame is $^1/_{10}$ m^2.

Collecting Vegetation Samples

Upper Left Photo: Circular quadrats made from PVC tubing – sampling area in the large quadrat is $^1/_4$ m^2 and $^1/_{10}$ m^2 for the small quadrat.

Vegetation sampling in grasslands is often done using a quadrat. A quadrat is a small frame with a known area measurement inside the frame. Seedling density and frequency can be accurately measured using a 1 square foot quadrat frame (Dayton 1988). Quadrats can be built from flexible PVC tubing, wood or wire.

Most grassland quadrats are three-sided, with one side left open for easy insertion into the sample area. The frame is inserted near the base of the plants at pre-selected locations along the transect and the vegetation inside the frame is identified and counted. One sample equals one quadrat of vegetation. The following steps should be used when entering the field to sample.

1. Using the site map as a guide, locate the transect line's starting and end points and mark with field flags.

2. Starting at one of the field flags walk a straight line towards the other flag the number of paces needed between samples (see above).

3. Place the quadrat at your feet and sample the vegetation.

4. Continue along the transect, walking the calculated number of paces and taking a quadrat sample until all the samples are taken.

For ease of seedling identification, the best time to sample a new planting is in late August to early September. By the end of summer, most prairie seedlings will have grown enough to be accurately identified.

Method 1: Assessing Stand Establishment Using Plant Density

There are several ways of sampling vegetation within the quadrat frame. A good way to assess prairie plant establishment in a newly reconstructed prairie is by measuring plant density. This involves identifying and counting each prairie plant within the quadrat frame. Plant density is an excellent sampling method in early reconstructions (Year 1) because prairie seedlings have not yet spread by rhizomes and/or produced multiple tillers and stems. Counting individual plants/stems is feasible. A native planting should have a minimum of 1 prairie plant/ square feet (Morgan 1995). A planting that has less than 1 prairie plant/ square foot by the end of Year 2 is susceptible to weed invasion and may require additional management to control weeds (see Initial Post Seeding in this series).

Table 1 – Plant Density Example

P - Present	Quadrat Samples (1 square foot area)																			
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
Big bluestem	I		I	II			I	I										I		
Indian grass	II				I	I										I				
Switchgrass	I	I	I	II	I	I	I	I												
Side-oats grama					I	I														I
Black-eyed Susan	I	II		I	I	I	I					I	I							
Wild bergamot				I				I												
Stiff goldenrod			I			I	I				I									
Showy tick trefoil				I				I					III							
Compass plant				I																
TOTAL SEEDLINGS	5	3	3	7	5	5	4	3	1	0	1	1	1	3	0	1	0	1	0	1
Canada thistle	P		P	P	P						P	P						P		
Smooth Brome	P	F	P	P	P			P	P		P	P	P		P		P	P	P	

Developing a good data sheet is critical to any sampling method. Use a spreadsheet format to create a data sheet for the field. The data sheet should be identical to the spreadsheet on the computer. This will reduce mistakes when entering data from the field into the computer. Organize the data sheet by rows and columns. Each column represents a quadrat sample and each row represents a plant species. Arrange the species first by grasses, then forbs and weeds. List all the native species seeded on the data sheet. They should be listed by number of seeds per square feet planted (highest to lowest). When data are entered in the computer spreadsheet, enter the number of hash marks. Recording the data is easier when the highest seeded species are clustered together on the data sheet. Record only the presence of persistent perennial weed species (Table 1) on the data sheet; it is not necessary to count their seedling numbers. Any persistent perennial weeds detected during quadrat sampling should trigger a scouting of the field to locate and map these plants for weed control (see Scouting section).

Place the quadrat at each random sample location (as previously described above) and record every prairie plant inside the frame. When identifying seedlings, follow the order listed on the data sheet; identify the native grasses first, followed by the native forbs, saving the weeds for last. Quadrat sampling with another person can be efficient. With a two-person sampling team, one person records the data while the other person identifies the plants. Plants that are difficult to identify should be collected and bagged for later identification or flagged (label the flags A, B, C, etc.) and returned to in a couple of weeks. When collecting unknown species in bags, assign each plant a letter on its bag and record it on the data sheet so it can be changed on the sheet when identification is made. Periodically check the data sheet to make sure that the quadrat column that is recorded is the one that seedlings are sampled from.

To calculate prairie plant establishment (by density) for this example reconstruction, follow the three steps listed below.

Step 1 – Sum the total prairie seedlings recorded in all quadrats -
Total prairie seedlings = 5+3+3+7+5+5+4+3+1+0+1+1+1+3+0+1+0+1+0+1=45

Step 2 – Sum the total quadrat area sampled -
Total sampling area = 20 (quadrat samples) x 1 square foot (quadrat area) = 20 square feet (See Table 1)

Step 3 – Divide Total prairie seedlings by the Total sampling area -
Prairie seedling establishment = 45 seedlings/20 square feet = 2.3 seedlings per square foot

In this example, prairie plant establishment exceeds the minimum of 1 prairie plant per square foot, which is an adequate stand. Note: In this example, the presence of Canada thistle should trigger the need for control of this weed (See Initial Post Seeding in this series).