A Guide to Prairie and Wetland Restoration in Eastern Nebraska

A Joint Publication of

Prairie Plains Resource Institute and Nebraska Game and Parks Commission

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PPRI Mission

Maintaining and restoring Nebraska ecosystems: creating opportunities for education, research, stewardship, and community development.

Prairie Plains Resource Institute (PPRI), is an educational land trust incorporated in 1980 as a nonprofit, 501(c)(3) tax-exempt membership organization. The mission of PPRI is being carried out through four major efforts: **Ecological Restoration**, **Prairie Preserves**, **Education** and the **Platte River Corridor Initiative**.

Nebraska Game and Parks Commission

The mission of the Nebraska Game and Parks Commission is stewardship of the state's fish, wildlife, park, and outdoor recreation resources in the best long-term interests of the people and those resources.

A Guide to Prairie and Wetland Restoration in Eastern Nebraska

by

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Cover Photo: Krista Adams collecting porcupine grass (*Hesperostipa spartea*) seeds in a Sandhills prairie near Pierce, Nebraska.

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Acknowledgements

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There are several excellent publications on prairie and wetland restoration (Appendix A). These provided valuable information for this publication, particularly *Going native – a prairie restoration handbook for Minnesota landowners*, *The tallgrass restoration handbook* and *A practical guide to prairie reconstruction*.

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Chapter 1 - Introduction

History of Prairie Restoration in Eastern Nebraska

Inspired by a trip to restored prairies in Illinois and Wisconsin in 1978, Bill Whitney of Aurora, Nebraska began harvesting prairie seed and studying the prairies of central Nebraska. In the spring of 1979, he conducted his first prairie restoration, a garden-sized plot on a friend's farm. The mixed seed, a big coffee can full, included about 35 native grasses and wildflowers collected from local prairies and roadsides.

Bill Whitney, in 1978, standing amidst the Morton Arboretum prairie restoration in Lisle, Illinois.

In 1980 Bill and his wife, Jan, founded Prairie Plains Resource Institute (PPRI), a nonprofit organization based in Aurora and dedicated to prairie restoration, preservation

Young seed collector on the Platte River bluffs of Hamilton County, Nebraska in 1980.

and environmental education. During the 1980s Whitney conducted several additional small restorations around Aurora and managed three remnant prairies owned by PPRI. At that time, few people in the Midwest were restoring prairies containing large numbers of species, and restoration methods were not well documented. Much of Bill's knowledge of prairie restoration was gained through practical experience.

Beginning in 1991, PPRI was contracted to restore wet meadows on cropland in the central Platte River valley owned by the Platte River Whooping Crane Habitat Maintenance Trust (PRCT) and The Nature Conservancy (TNC). Between 1991 and 1996, Whitney and a host of volunteers hand planted nearly 400 acres of wet meadow in the valley. Using methods Whitney developed, the Crane Trust

PPRI's custom fabricated seed harvester used during the early 1990s.

and Conservancy continue to do prairie restorations in the Platte River valley.

With a grant from the Nebraska Environmental Trust in 2000, PPRI established the Prairie Restoration Cooperative in partnership with the Nebraska Game and Parks Commission (NGPC), TNC, U.S. Fish and Wildlife Service (USFWS), Pheasants Forever (PF) and Natural Resource Conservation Service (NRCS). Together they are working to expand high-diversity prairie restoration to new areas and habitats within the state, to increase their capability to do restorations, and to increase the availability of local-ecotype native seed for restorations, wildlife plantings and horticultural use. Since 2000 the Cooperative has planted more than 1,500 acres of prairie and wetland in the eastern half of Nebraska, mostly on lands owned by conservation agencies or protected through conservation easements.

A seed sower lineup on a Platte River valley restoration.

About This Publication

This publication documents the restoration methods originally developed by Bill Whitney and later refined by himself and other ecologists from TNC, PRCT, NGPC and USFWS working in eastern Nebraska. Restoration of the following plant community types is covered in this document: tallgrass prairie, mixed-grass prairie, sand prairie, freshwater wet meadow and marsh, Rainwater Basin wet meadow and marsh, and saline wet meadow and marsh.

The methods we use are generally affordable and not complicated. To quickly summarize, we handpick and machine harvest seed, do little seed cleaning and broadcast plant with a fertilizer spreader. We do not mow annual weeds during the initial years after planting and manage established restorations with prescribed fire and grazing. Many Midwestern restorationists use other methods. For example, some plant highly-cleaned seed with a seed drill, pack the soil after planting and mow annual weeds in the first year after planting. We will touch on these methods within this publication.

Our methods have proven successful and practical for restorations in eastern Nebraska. We do not wish to imply that our restoration methods work better or are more successful than the methods of others. Other restoration methods might be more appropriate for areas with different climates, soils and vegetation. Innovations in our restoration methodology over the years have resulted from our experimentation

Sowers taking a break after a 1993 planting.

and by learning from the restoration efforts of others. Our methods will likely be refined in coming years as we gain more experience and knowledge about prairie and wetland restoration and ecology.

The Plant Communities of Eastern Nebraska

Early French explorers traversing central North America had no term for the vast grasslands they encountered, so they called it prairie – literally, meadow. Then, prairie covered more than 95 percent of the Nebraska landscape. The prairies were of three basic types: tallgrass, mixed-grass and Sandhills prairie – each of which developed in response to variations in climate and soils. Trees in eastern Nebraska were restricted to well-watered and somewhat fire-protected stream valleys by wildfire, drought and competition with prairie grasses. Woodlands occupied only about 2 percent of eastern Nebraska's presettlement landscape.

Tallgrass prairie covered the rolling hills of the eastern third of Nebraska where annual precipitation averaged more than 25 inches. It also extended westward into the drier plains in stream valleys, such as those of the Platte, Republican, Elkhorn, Niobrara and Loup rivers. Tall grasses – big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*) and switchgrass (*Panicum virgatum*) – were the dominant plants of the tallgrass prairie. In the rich soils of wet valleys these grasses often grew 6 feet or taller.

Tallgrass prairie soils, which developed over thousands of years, commonly had topsoils over 18 inches thick and rich in organic matter and nutrients. Hundreds of species of wildflowers, grasses and sedges added color and diversity to the tallgrass landscape. The large majority of prairie plants are perennials, which resprout each spring from roots, bulbs or corms. Annuals and biennials are a minor component of the prairie flora.

The tallgrass prairie region was the first in Nebraska to be settled by Europeans. Immigrants, who first arrived in large numbers after the passage of the Homestead Act in 1862, found the fertile soils and ample rainfall in the tallgrass region well suited for growing corn and other crops. By 1900, most of the tallgrass prairie had been plowed. Today less than two

Tallgrass prairie.

Mixed-grass prairie on the loess bluffs of the Platte River east of Grand Island, Nebraska.

West of the tallgrass prairie region, but excluding the Sandhills, mixed-grass prairie cloaked the drier loess covered plains and hills. The word "mixed" represents the combination of short, mid and tall grasses that dominated this prairie type. Mid and short grasses, primarily little bluestem (*Schizachrium scoparium*), needle-and-thread (*Hesperostipa comata*), side-oats grama (*Bouteloua curtipendula*), blue grama (*B. gracilis*) and buffalograss (*Buchloe dactyloides*) grew on the upper slopes and hilltops. Tall grasses grew on lower slopes and bottoms.

Roughly a third of eastern Nebraska's mixed-grass prairie has survived, primarily in areas too steep, rocky, dry or infertile to farm. The largest expanses remain on the steep loess hills of central Nebraska and on the breaks and bluffs of the Platte, Republican and Niobrara rivers.

percent of Nebraska's original tallgrass prairie remains.

The majority of remnant tallgrass prairies are usually less than 80 acres and have survived as hay meadows and grazed pastures. They are literally islands of prairie in a sea of cropland. A few larger tracts exceeding a square mile are found on land too steep, rocky or infertile to plow. Hayed prairies are generally in better condition and have a higher diversity of native plants than pastured prairies. Many pastures have been overgrazed and sprayed with herbicides leading to loss of native plant diversity. Encroachment of shrubs, trees and exotic plants has reduced the value of most remnant prairies as native plant and wildlife habitats.

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An eastern extension of mixed-grass prairie occurs on Pierre Shale-derived soils near the Missouri River in northeast Nebraska.

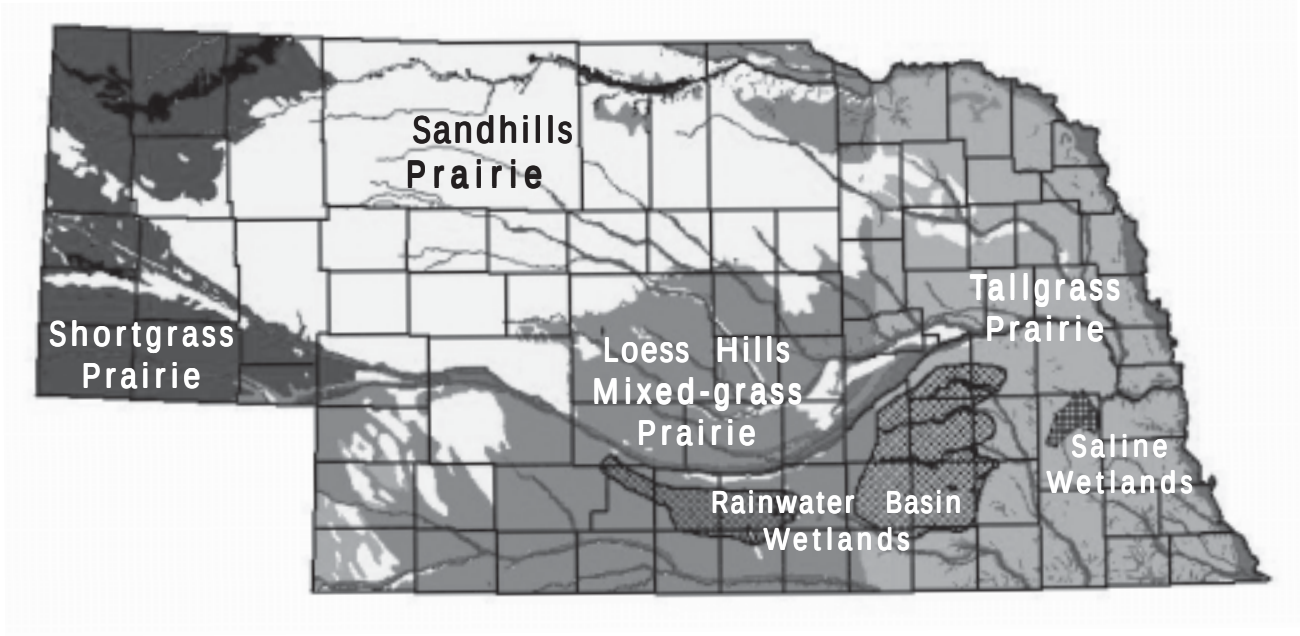

Figure 1. Presettlement distribution of the major plant community types of Nebraska (modified from Native vegetation map of Nebraska., Kaul and Rolfsmeier 1993).

Settlement and farming in the mixed-grass prairie region started slightly later and proceeded at a slower pace than in the tallgrass prairie region. Initial plowing of the mixed-grass prairie continued until the 1920s, when nearly all land capable of supporting dryland farming was under cultivation. Some mixed-grass prairie not suitable for dryland farming went under the plow when well irrigation was developed in the 1950s. This conversion was further spurred with the advent of center-pivot irrigation in the early 1970s. Since the early 1980s, the conversion of prairie to irrigated cropland has slowed.

The Nebraska Sandhills, North America's largest dune field, covers much of north-central Nebraska. The dune soils support Sandhills prairie dominated by a variety of tall, mid and short grasses including sand bluestem (*Andropogon hallii*), prairie sandreed (*Calamovilfa longifolia*), sand dropseed (*Sporobolus cryptandrus*), little bluestem, needle-and-thread and hairy grama (*Bouteloua hirsuta*). Valleys between dunes support a more lush growth of vegetation and many scattered wetlands.

Attracted by the free and open range, cattlemen in the 1870s were the first to settle in the Sandhills. Passage of the Kincaid Act in 1904 attracted farmers to the region. However, a succession of dry years and crop failures soon forced most to sell out to ranchers. Ranching has remained the predominant land use in the Sandhills. Today only about 5 percent of the Sandhills is cultivated.

Sandhills prairie, like all of Nebraska's prairie types, developed under the influence of wildfire and grazing by large ungulates, such as

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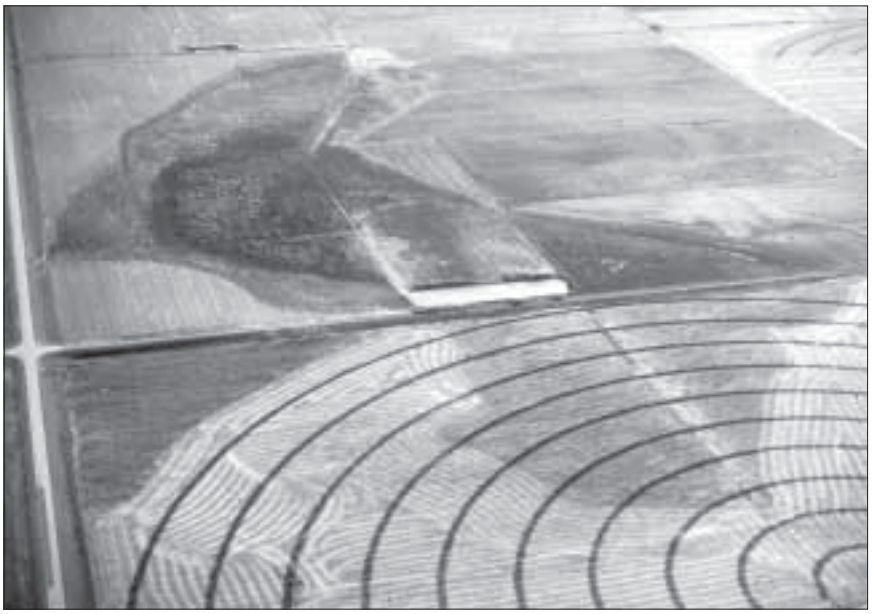
The Sandhills contain Nebraska's largest concentration and diversity of wetland types.

bison, pronghorns, elk and deer. Fires kept trees and shrubs from encroaching upon the prairies, reduced litter buildup, enhanced nutrient availability and, in general, stimulated the growth of prairie plants. Like fire, grazing reduced litter buildup and recycled nutrients. Random grazing patterns also produced areas of varying vegetation height and density, which in turn, provided habitat for a diversity of prairie animals.

With settlement the natural disturbance patterns of Nebraska's prairies changed. Wildfires were suppressed and grazing patterns changed as the free-roaming ungulates were replaced by fenced herds of cattle. Since settlement many native prairies have been overgrazed, which has reduced native plant diversity and promoted invasion by aggressive exotic plants, such as Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), cheatgrass (*Bromus* spp.) and thistles.

Many of Nebraska's prairie remnants have lost ecological value because of their small size and fragmented distribution within a cropland-dominated landscape. Small prairies provide few nesting opportunities for grassland nesting birds, such as bobolinks and prairie chickens, which require larger blocks of nesting habitat. These small prairies surrounded by croplands and roads are also susceptible to invasion by exotic plants, herbicide drift, erosion and loss of native species. Though small and highly vulnerable, small prairies are important seed collecting sites and habitat for many species of plants, wildlife and insects.

Before settlement, wetlands were commonly interspersed among Nebraska's prairies, primarily in the Rainwater Basin region



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A drained and partially farmed Rainwater Basin wetland in south-central Nebraska.

of south-central Nebraska, in the Sandhills and in stream and river valleys. Wetlands, shallow bodies of water or areas with water-saturated soils, are among Nebraska's most productive habitats and home to a diversity of aquatic plants and animals.

Rainwater Basin wetlands formed over thousands of years as wind-excavated depressions in the south-central Nebraska loess plain. The rainwater- and snowmelt-filled basins are a key spring staging area for millions of ducks, geese and shorebirds, which feed and rest there before continuing their northward migration.

By the early 1900s, most good soils in the loess plains of south-central Nebraska were already farmed. Farmers then began draining the basins, which were considered wastelands, to increase their acres of cropland. By 1920, 20 to 35 percent of the basins in Fillmore County had been drained and converted to cropland. Today less than 10 percent of the original basins remain.

Valuable bird habitat, as well as habitat for other aquatic species, was lost when the basins were filled or drained. Migrating waterfowl have been forced to concentrate in large numbers on the remaining basins. Numbers sometimes approach a million ducks and geese per basin. Crowding has made birds susceptible to outbreaks of fowl cholera, a disease that claims thousands of birds some years.

The Sandhills contain Nebraska's largest concentration and diversity of wetland types. They include wet meadows (lowlands with water-saturated soils dominated by sedges and grasses), marshes (deeper water areas with emergent vegetation such as rushes and spikerushes), lakes and fens (spring-fed wetlands with peat or muck soils). Sandhills wetlands have not undergone the intense conversion to cropland that occurred in other regions of Nebraska, but many have been ditched and drained to facilitate haying.

Before Euroamerican settlement, Nebraska's river floodplains were a mosaic of oxbow lakes, backwater marshes, wet meadows and woodlands. Annual spring and early summer floods were vital to the ecological health of these floodplain ecosystems. The floods cut new channels, leaving the old channels to form backwater wetlands, and saturated the floodplain soils. The majority of Nebraska's floodplain wetlands have been ditched, drained and converted to cropland. In addition, stream channelization, dam construction and reduced stream flows have greatly altered the hydrology of remaining floodplain wetlands beyond the Sandhills.

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A natural floodplain in the Nebraska's Sandhills with an unchannelized meandering stream. In some highly disturbed floodplains in eastern Nebraska restoration practices could include modification of channels and wetlands and reseeding of native vegetation.

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Salt-adapted vegetation of a saline wetland near Lincoln, Nebraska.

Saline wetlands occur in the floodplain of Salt Creek and its tributaries in Lancaster and southern Saunders counties. Groundwater seepage over thousands of years from deeply buried saline aquifers has accumulated salts in the floodplain soils, allowing this unique wetland type to form. The wetlands' vegetation is composed of salt-adapted plants such as saltgrass (*Distichlis spicata*) and seablite (*Suaeda calceoliformis*). Salt-encrusted mudflats are a common feature of saline wetlands. These mudflats are rich in invertebrate life and are heavily used by migrating shorebirds.

The channelization of Salt Creek, initiated in 1917 as a flood-protection measure for the city of Lincoln, greatly affected the saline wetlands. Completed in 1942, the channelization encouraged tributary streams to head-cut, carving deeper into their beds to adjust to the gradients. The lowered streambeds eventually cut into saline wetlands, draining them and diluting their salt concentrations. Many saline wetlands were filled and developed as Lincoln expanded over the years. Others were drained, filled and farmed.

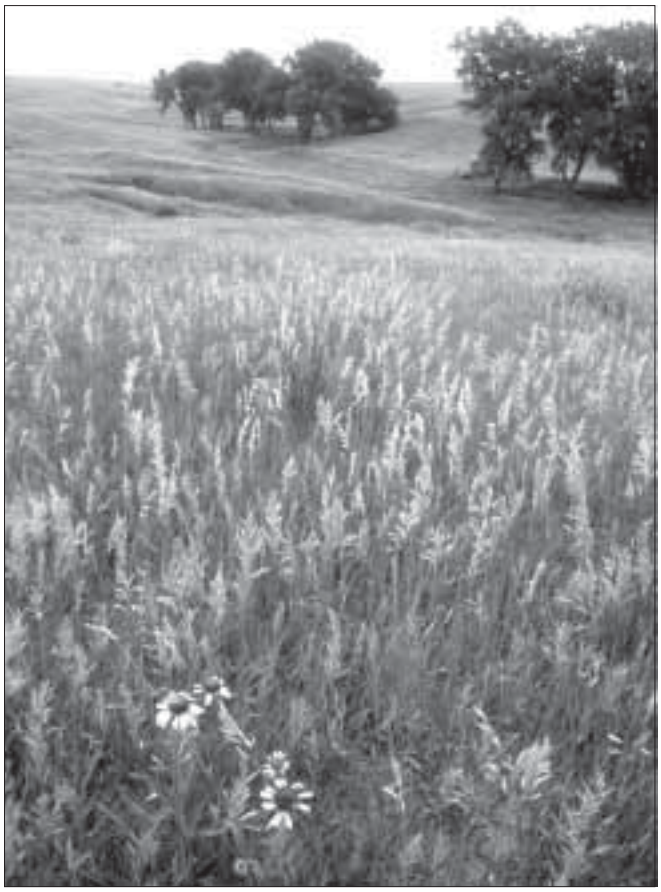
Today, only about 5 percent of Nebraska's original saline wetlands remain. Wetlands with representative salt-adapted vegetation are scarce and shorebird use of the wetlands has dwindled substantially over the years.

What is restoration?

Restoration is the process of recreating a plant community (i.e. prairie or wetland) where one once existed but is now gone. Most of our restorations are sown on land that has been farmed for many years. In some cases, overgrazing, indiscriminant herbicide spraying or exotic plant invasion have degraded remnant prairies and wetlands to a point where few native plants remain, though the natural soil profile remains intact. Such sites are often interseeded with native plants after exotic species are controlled. We also consider this process restoration. Ecologists sometimes use the term "reconstruction" in a context similar to the term restoration – creating a prairie or wetland from scratch where none currently exists.

Native plant composition and diversity, and wildlife habitat values of many prairies and wetlands can be improved through use of prescribed fire, controlled grazing, tree clearing, selective herbicide spraying and other practices without the need for interseeding. We define these activities as management or enhancement.

Restoration stresses ecological accuracy with strong emphasis on plant community composition and structure. We seed only those species that are natural components of the plant



A smooth brome dominated native pasture in northeast Nebraska contains few native plants such as purple coneflower in the foreground.

community. We also use local ecotype seed (see definition below) with genetics similar to the plants native to the region of interest. Ecological accuracy is what distinguishes restoration from plantings that include exotic species, only a few native species or native plant cultivars (plants whose genetics have been modified through selective breeding). For example, Conservation Reserve Program (CRP) plantings sometimes contain five or fewer native grass cultivars and are not considered prairie restorations.

Restorationists recognize that simply seeding native plants is not sufficient to bring back the bacteria, fungi, invertebrates and wildlife that inhabited presettlement native plant communities. However, the plant community provides the basic structural environment for these other life forms and many of these species may colonize the restoration on their own.

Before planting, restoration often involves earthmoving to reshape the natural landscape topography or restore wetland hydrology. For example, farm terraces are often leveled in crop fields before seeding prairie. Sediment is often excavated and ditches filled prior to seeding wetlands.

For the sake of the reader, we feel it is important to define a few terms frequently used in this publication.

Biodiversity – is the diversity of all living things: plants, animals and microorganisms, as well as the genetic material that makes up those organisms. At a higher level, biodiversity includes plant communities, ecosystems and landscapes of which the species are a part. The concept of biodiversity includes both the variety of living things and the genetic variability found within and among them.

Cool-season grass – A grass that generally makes the major portion of its growth during the fall and early spring. These plants usually possess the C-3 photosynthetic pathway. Nebraska has many native cool-season grasses, however, most of the exotic grasses that invade remnant prairies and wetlands are also cool-season species.

Cultivar – A plant developed and improved by various horticultural techniques such as selection and hybridization. Common cultivars of native grasses planted in Nebraska include Omaha Wildrye, Pawnee Big Bluestem and Cave-In-Rock Switchgrass. Cultivar grasses have generally been selected for aggressive growth characteristics for grazing use. Cultivars of native wildflowers are commonly sold as ornamental

plants in Nebraska. These generally are larger plants and have larger flowers than native varieties.

Exotic plant – A plant introduced from other continents or other regions of North America; a non-native plant. This generally refers to plants not found in Nebraska at the time of Euroamerican settlement (CA 1850).

Forb – Any herbaceous (non-woody) plant that is not a grass or sedge. The term forb is commonly used to describe the broad-leaved plants known as wildflowers.

Chris Helzer/The Nature Conservancy

A high-diversity, wet-mesic prairie restoration in the central Platte River valley.

High-diversity restoration – The term diversity refers to the number of plant species seeded in a restoration. We define high-diversity restoration as one in which >75 plant species are seeded. A **moderate-diversity restoration** is one in which 25-75 species are seeded. A **low-diversity restoration** is one in which < 25 species are seeded. These terms and values are for general use and can vary for different plant community types. Before Euroamerican settlement, local prairies were often home to several hundred species of native plants. Saline wetlands, because of difficult growing conditions resulting from high salt concentrations in the soil, naturally contained fewer than 25 plant species.

Local ecotype seed – This term refers to seed collected from native plants that grow near a restoration site. Local ecotype seed is preferred by many restorationists because the plants grown from this seed will likely have genetics similar to plants growing on the site prior to settlement. Local ecotype seed ensures the use of plants well-adapted to the climate and soils of a restoration site. Use of local ecotype seed also prevents potential contamination of the local native plant gene pools that can occur if plants are brought from beyond the region.

Restorationists vary in their opinion as to what constitutes local ecotype seed. Some suggest that to maintain local gene pools seeds should be collected within 100 miles north or south of a restoration site and 200 miles east or west of a site. Others suggest that seed should be collected within 25 miles of a restoration site. As a rule of thumb, we try to use seed collected within a 100-mile radius of a restoration site.

Native plant – A plant native to Nebraska, a plant species that occurred here at the time of Euroamerican settlement (CA 1850).

Remnant prairies – Those prairies that have never been plowed, retain their natural soil profile and support native vegetation though it may be altered from its presettlement condition. Remnant prairies are often referred to as native prairies. Ecologists often use the term **native prairie** to describe restorations planted with local-ecotype seed. This may be somewhat misleading because a prairie's natural soil profile or exact presettlement plant and animal composition cannot be replicated.

Plant community – An assemblage of plants growing under similar environmental conditions (i.e. soils and climate). Examples of plant community types include tallgrass prairie, mixed-grass prairie and Rainwater Basin marsh.

Warm-season grass – A grass that makes most or all of its growth during the late spring to early fall period and is usually dormant other times of the year. These plants usually possess the C-4 photosynthetic pathway. Most of the grasses that dominated Nebraska's prairies, such as big bluestem and Indiangrass, are warm-season grasses.

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Musk thistle, an invasive exotic or non-native plant originally from Eurasia, is a troublesome weed in some native grasslands.

Chapter 2 - Getting Started

Restorations can vary from less than an acre to several thousand acres. The Nature Conservancy is restoring a 5,000-acre sand prairie and wet meadow complex on their Kankakee Sands Preserve in Indiana. Backyard and school restorations are often less than a few thousand square feet.

In general, the larger the restoration, the greater the diversity and abundance of native plants and wildlife it can support. And the more genetically diverse the plant populations, the more resilient the restoration is to climatic change, diseases and other environmental factors. However, even small prairie and wetland restorations provide habitat for native plants, small mammals, birds and a diversity of insects. Prairie restorations can be a relatively low-maintenance native landscaping option. Prairie landscaping is not only dynamic and attractive, but also environmentally friendly, greatly reducing the need for water, fertilizer and lawn chemicals. Backyard and school prairies

School prairie restorations are usually small but create opportunities for educational activities, such as this prescribed burning demonstration.

Creating a school prairie is a great way to involve youth in conservation.

are excellent places to teach about nature and to foster greater appreciation of the prairie.

Restoration is fun and interesting and can be a great family, school or volunteer activity. However, restoration is a slow process with most prairie and wetland plantings taking 3-5 years to become well established. Restoration requires patience and commitment.

Checking Local Ordinances

Some city and county governments have codes or ordinances restricting the height of plants in residential lawns. These restrictions might preclude planting of a prairie in some residential areas. City or county clerks can be consulted to see if such restrictions exist. Local fire departments should be contacted if prescribed burning is planned for restoration management to determine local restrictions and needed permits. State and federal permits are often required for earthmoving in wetlands (i.e. ditch filling or excavation of fill material).

Prairie landscaping is not only attractive, but also environmentally friendly, reducing the need for water, fertilizer and lawn chemicals.

Consulting the Nebraska Game and Parks Commission, U.S. Fish and Wildlife Service or Army Corp of Engineers is recommended prior to such activities.

Choosing a Site

Most prairie plants grow poorly in shaded environments because they need a minimum of 6 to 10 hours of sunlight per day to survive. In addition, cool-season exotic plants such as smooth brome often invade shaded areas of prairie. Prairie restorations should be placed in the sunniest sites available, and removing shelterbelts or other non-native woodlands adjacent to restoration sites should be considered before planting.

If possible, avoid planting restorations adjacent to stands of smooth brome, reed canary grass (*Phalaris arundinaceae*), tall wheatgrass (*Thinopyrum ponticum*) or other aggressive and difficult to eradicate exotic plants. Unless controlled through herbicide application, mechanical means or prescribed fire before planting (see Chapter 6) these species will probably invade a restoration.

Caution must be taken when planting a prairie or wetland downslope of cropland because they may receive runoff and siltation. Cropland terraces and native grass buffer strips upslope of the restorations help prevent runoff and silt from reaching the restorations. Restorations are susceptible to herbicide and pesticide drift and attention must be paid to wind direction and speed when applying herbicides and pesticides to crops or pasture adjacent to a restoration.

Soil texture, drainage and chemistry will influence which species to plant in a prairie or wetland restoration. Many prairie plants will grow on a wide variety of soil textures. For example, in eastern Nebraska, little bluestem grows on sandy, silty and clayey soils. Other prairie plants will grow only on specific soil types. For example, in eastern Nebraska, sand bluestem will grow only on sandy soils. Chapter 5 and Appendix B provide guidance as to what species to seed on various soil types. County soil surveys, available at local Natural Resource Conservation Service offices, can be consulted to determine soil characteristics of a restoration site.

A basic knowledge of soil types and site hydrology (e.g. sand, silt and clay) and their moisture characteristics is helpful in planning the appropriate mix of species for a restoration.

Chris Helzer/The Nature Conservancy

Low-lying sites with standing water for most of the growing season should be sown with marsh plants.

Most prairie and wetland plants have fairly specific moisture requirements and should be seeded on sites with appropriate soil moisture regimes (see Chapter 5 and Appendix B). For example, restorations on low-lying sites with standing water for most of the growing season (seasonally and semi-permanently flooded wetlands) should be sown with marsh plants. Low-lying sites flooded only in spring or after heavy rains and with groundwater always within a few feet of the soil surface (temporary wetlands) should be sown with wet-mesic prairie plants. Upland prairie plants are appropriate for seeding on sites not influenced by groundwater or flooding.

Wetland restorations are complicated because the natural hydrology of sites have often been altered through ditching, tiling or filling and must be restored before seeding. Restoration of wetland hydrology often requires complex engineering, extensive earthmoving and state and federal permits. Consulting with a biologist from the Nebraska Game and Parks Commission, U.S. Fish and Wildlife Service, Ducks Unlimited or other conservation organizations is recommended before undertaking a wetland restoration.

We believe that past herbicide use at a restoration site usually has little influence on establishing seeded species. Atrazine, a broadleaf and grass herbicide commonly applied to cornfields in eastern Nebraska, is the exception. We have found that Atrazine might limit seeding growth of native plants for one or possibly more years after its last application. We recommend not applying Atrazine to a restoration site for 2-3 years before seeding.

Hand collecting is necessary for obtaining seed of most prairie and wetland species.

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Downy gentian, a rare tallgrass prairie species, is a beautiful fall-blooming wildflower. Its seed is not harvestable until October.

Figure 1 (page 9) shows the presettlement distribution of major prairie and wetland types in Nebraska and can be consulted to help determine which plant community type is appropriate for planting on a restoration site. Though this map shows distinct boundaries between community types (e.g. tallgrass prairie and mixed-grass prairie), in reality these transitions are often gradual and sometimes shifting over time in response to climate.

OTHER PLANNING CONSIDERATIONS

Obtaining seed, whether by collection or purchase, is usually the most time-consuming or costly part of the restoration process. Seed cost varies depending on the following factors: 1) size of the restoration, 2) number of species included in the seed mix, 3) seeding rate and 4) whether seed is collected and processed by oneself or purchased. The seed of common prairie species, such as big bluestem or rigid sunflower (*Helianthus pauciflorus*), can usually be collected in large quantities or purchased at reasonable prices. Seed collecting time or cost increase when hard-to-collect or less common species, such as or blue-eyed grass (*Sisyrinchium* spp.) or downy gentian (*Gentiana puberulenta*), are included in the seed mix. We found collecting and processing seed ourselves is more cost efficient than to buy it from a dealer. However, we have made a considerable investment in equipment and staff training, which increases the efficiency of seed harvesting.

There are presently few individuals or companies in Nebraska that collect, grow and sell local ecotype seed. However, several Midwestern seed dealers do sell prairie and wetland seed that may be appropriate for eastern Nebraska. Buying seed mixes is usually

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Seed collecting time or cost increase when hard-to-collect or less common species such as this blue-eyed grass are included in the seed mix.

less expensive than purchasing seed of individual species and making one's own mix. Another point to consider is that many commercial prairie and wetland seed mixes contain seed of horticultural and agronomic native plant cultivars or seed that is not local ecotype seed for eastern Nebraska.

There are several conservation programs including the Nebraska Game and Park Commission's Wild Nebraska Program, the U.S. Fish and Wildlife Service's Partners For Wildlife Program and the Natural Resource Conservations Service's Conservation Reserve Program and Wetland Reserve Program that can provide landowners financial assistance for prairie and wetland restorations. Contact information for these agencies is included in Appendix A.

Timeline

Becoming familiar with prairie or wetland plants before beginning a restoration will prove valuable and increase your enjoyment of the restoration process. Several books on prairie and wetland plants are listed in Appendix A. Visiting a local native prairie or wetland will assist with learning native plants, their growth characteristics and locations on the landscape.

Adequate time must be scheduled for seed collecting and processing, site preparation and planting, which are discussed in Chapters 3-6. For most prairie and wetland restorations seed is collected over an entire growing season, mid-May to late October. Before collecting seed, collecting sites must be located and access permission obtained. Seed is usually processed in late fall and planted in late fall through spring.

For those with little restoration experience, collecting seed for and planting only a small part of a site the first year will allow one to learn the tricks of the trade before jumping headlong into unfamiliar territory. For schoolyard restorations, conducting a partial restoration each year allows subsequent classes to be involved in each aspect of the restoration process. Keeping a written record of each phase of the restoration process, such as seed collection dates and amounts, and planting methods and rates, is a valuable learning process and may increase one's enjoyment of the restoration process.

Becoming familiar with prairie or wetland plants before beginning a restoration will prove valuable.

Chapter 3 - Seed Collecting

Seed Collecting Tips

The seeds of most species planted in restorations in eastern Nebraska can be collected from remnant prairies and wetlands, and occasionally from road right-of-ways. Seed collecting requires a comprehensive knowledge of the plants beyond learning their names and how to identify them. It also requires learning their habitats, locations and seasonal cycles of growth, flowering and seed production. Learning these facts for 100 or so species in a planting is not as an intimidating as it might seem and can be an enjoyable part of the restoration process. Several plant guides for the region are listed in Appendix A.

In eastern Nebraska, the seed-collecting season begins in mid-May when the seeds of early blooming plants such as prairie ragwort (*Senecio plattensis*), pussytoes (*Antennaria* spp.)

A high-diversity mix can include seed of more than 100 species.

and sedges (*Carex* spp.) ripen. Harvest continues through October and into early November when the seeds of the late-blooming wildflowers, such as asters (*Symphyotrichum* spp.) and goldenrods (*Solidago* spp.) ripen. Seed of the dominant warm-season prairie grasses, such as big bluestem and Indiangrass, needed in large quantities for prairie restorations, begin ripening in mid-September.

The seeds of most prairie and wetland plants mature over a 1-2 week period that is fairly consistent from year to year (see Appendix B). For some species, such as spiderworts (*Tradescantia* spp.) and blazing stars (*Liatris* spp.), seeds mature over several weeks.

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Milkweed seeds bursting from their pods in September.

For some species, such as this blazing star, seeds ripen over several weeks. First to ripen are seeds lower on the stem.

Ripening seed should be checked often and harvested when the highest percentage of seed is ripe because the seed of many species begins to fall from the plant soon after ripening. The seeds of New Jersey tea (*Ceanothus* spp.), violets (*Viola* spp.), prairie phlox (*Phlox pilosa*) and a few other prairie species burst from capsules when mature and must be collected immediately upon ripening. Members of the milkweed (*Asclepiadaceae*) and aster (*Asteraceae*) families have wind-blown, dandelion-like seeds that must be collected before they blow away.

Some restorationists recommend collecting only 50 percent of the seed of a given species from a site and less for rare species. Leaving seed at a collection site provides food for wildlife and provides plants an opportunity to reproduce. As a general rule, we collect as much seed as possible for each species needed in a restoration, though limiting the amount we take from each site. Excess seed is used to plant a heavier seed mix. Seed of aggressive native

species (listed in Appendix B), such as Maximillian sunflower (*Helianthus maximilianii*), sawtooth sunflower (*Helianthus grosseserratus*) and Canada goldenrod (*Solidago canadensis*),

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Seed of aggressive native species, such as this sawtooth sunflower, that spread rapidly in a restoration can be collected in limited quantities.

that spread rapidly in a restoration can be collected in limited quantities.

Care must be taken to avoid collecting seed of agronomic and horticultural cultivars that have been planted in many areas of the state. This is generally not a problem when collecting from remnant prairies and wetlands. However, many road right-of-ways have been seeded with horticultural and agronomic cultivars of native wildflowers, such as purple coneflower (*Echinacea* spp.) and blanket flower (*Gaillardia pulchella*), and native grasses, such as eastern gamma grass (*Tripsacum dactyloides*) and big bluestem. Most Conservation Reserve Program (CRP) fields also have been planted with agronomic and horticultural cultivars of native grasses and wildflowers.

It is necessary that seed collectors know when seeds are ripe for harvest and the difference between seed capable of germination and seed that won't germinate. Prairie cordgrass (*Spartina pectinata*), side-oats grama (*Bouteloua curtipendula*) and sedges (Carex spp.) are examples of species that often produce normal healthy looking seed heads that are empty of seed. Significant time and effort can be lost collecting sterile seeds or empty seed heads.

Restorationists use the following indicators to judge when seeds are ripe (not all of these conditions must be present simultaneously in all species to indicate ripeness):

- Ripe seeds are plump and hard, unripe seed is generally soft or milky.
- Earliest formed seeds are starting to drop from the plant.
- Seedpods and seed coats are changing colors – usually from green to a darker hue.
- Seedpods or capsules are starting to open.

Ripe Canada milkvetch pods containing seeds. If the pods have not been attacked by insects the seeds may be visible or make a rattle sound when shaken.

- Stems are dry and no longer nourished by the roots and leaves.

Two general stages of seed development with which collectors should be familiar are the milky stage and the dough stage. If when squeezed between the fingers the seed consists of a milky pulp, the seed is not yet ripe and will not mature into a viable seed if picked at this stage. If the seed is doughy, mealy or hard when squeezed between the fingers, it will generally mature into a viable seed if picked at this stage. In general, the longer the seed is allowed to mature or harden the greater the chance of it being viable. The seeds of many species, such as prairie clovers (*Dalea* spp.) and grasses, are well hidden by bracts and chaff and not easily found. Bracts and chaff are often papery and light in these species while seeds are more solid and have smooth hard surfaces.

A shriveled flower head or seed head/ fruit or the presence of a small entry hole in the seed head might indicate insect damage to the

Including as little as a handfull of leafy spurge or other aggressive weed seed in a seed mix could spell trouble for a restoration.

Seed Testing

Seed of native plants can be tested for viability and purity at seed laboratories such as the Nebraska Department of Agriculture Seed Testing Lab in Lincoln. Tests are conducted on an individual species basis. The Pure Live Seed (PLS) can be calculated by multiplying the bulk seed weight by its purity percentage and germination percentage (viability). PLS values must be provided for any native seed sold in Nebraska. Seed testing is fairly expensive, around $80 per test, but it is the only way to closely estimate the amount of live seed being planted in a restoration.

We believe it unnecessary to know the approximate amount of live seed being planted in a restoration and, therefore, we have done little seed testing. Testing all the seed we collect and plant would be cost prohibitive. We reason that if seeds are plump and ripe when collected, most will be viable and that having some bad seed in a mix will not affect our restoration results. Following are viability tests results from seed that we collected from central Platte River valley prairies during the severe drought summer of 2002: rosinweed (*Silphium integrifolium*) 93%, common evening primrose (*Oenothera villosa*) 88%, stiff sunflower 86%, Illinois bundleflower (*Desmanthus illinoensis*) 78%, wild licorice (*Glycyrrhiza lepidota*) 75%, Maximillian sunflower 72%, big bluestem 86% and Indiangrass 91%. These test results, though from a severe drought period, are not to imply that native plants always produce a high percentage of viable seed. Many native species may not have good seed production in a given year.

seeds. Insect infested seed heads generally produce little viable seed. Infestations often affect entire populations. The seed heads of prairie cordgrass and the seed pods of Canada milkvetch (*Astragalus canadensis*) and wild indigo (*Baptisia* spp.) are often infested by insects, turning a promising looking seed harvest to bust. Drought can also drastically affect the seed yield of many prairie and wetland species. Many species, such as Indiangrass and big bluestem, might still flower during dry years, but produce little viable seed. Late rains in previously dry summers may cause many plants to flower later than normal and produce viable seed.

For all methods of seed collecting, thoroughly scouting an area for troublesome weed species is important. Including as little as a handful of leafy spurge (*Euphorbia esula*) or other aggressive weed seed in a seed mix could spell trouble for a restoration. This is especially true when machine-harvesting seed, which does not allow for the kind of close inspection of vegetation that is possible with hand collecting.

Seed collectors should always obtain permission from landowners when collecting seed on private property and from roads departments when collecting from road right-of-ways. It is also important to inform adjacent private landowners when collecting from road right-of-ways because many will be curious as to what is going on. Seed collecting is not allowed on most public lands, such as state parks and wildlife management areas, without permission of the managing agency.

HAND COLLECTING

For prairie and wetland restorations of less than a few acres, the seed of all species can be collected in sufficient quantities by hand. Even for larger restorations we collect the majority of the forb, sedge and non-dominant grass seed by hand. We machine-harvest seed of the dominant prairie warm-season grasses

A necessary step in collecting porcupine grass and needle-and-thread is cutting the long awns from the seeds. If not done, the awns twist while drying and tangle the seeds together.

and seed of several other prairie and wetland species.

When hand collecting, the seed heads, capsules or fruits of most grasses, sedges and wildflowers can be grasped and easily pulled

Taping fingers protects them from cuts and abrasions while seed collecting.

PPRI's 2000 seed collecting crew with plastic milk jugs. From left to right, Kristy Lee, Mike Bullerman, Jason Johnson and Jon Soper.

from the stems. Taping fingers protects them from cuts and abrasions. We prefer veterinary tape, available at most farm stores, because it adheres well yet allows flexible finger movement. Prickly seed heads and heads that don't detach easily from the stem can be clipped with pruning shears or knives. Short, serrated-edged knife blades work well for this. The seed heads of many grasses, such as prairie cordgrass and slender wheatgrass (*Elymus trachycaulus*), can be swept together by the handful and clipped.

We belt plastic detergent and milk jugs with the tops cut off to our waist for seed storage, freeing both hands for collecting. Two- to five-gallon plastic buckets work well for larger quantities of seed. We keep the seed of most species separate while collecting.

Mechanical seed strippers

Mechanical seed strippers are an effective method for collecting large quantities of seed for many species. The stripper consists of a nylon-bristled brush about 5 feet in length powered by a gasoline engine. Both brush and engine are mounted on a chassis with road worthy tires. The spinning brush dislodges seeds and seed heads and deposits them in a hopper located behind. Seed strippers are somewhat inefficient in that some seed is thrown forward by the brush and misses the bin. Some restorationists view inefficiency as positive in that it ensures that some seed remains on the collection site. We pull our seed strippers with 4-wheel all-terrain vehicles (ATV), but pickup trucks or tractors can also be used.

The strippers are useful only when relatively large patches of target plants are available and free of unwanted weed seed, such as that of smooth brome. In prairies we use them for collecting seed of warm-season grasses, Virginia wildrye (*Elymus virginicus*), Canada wildrye, western wheatgrass (*E. smithii*), sedges,

Collecting the seed of warm-season grasses using a seed stripper designed by Prairie Habitats, Inc.

prairie clovers, leadplant and other species. In wetlands we use them for collecting seeds of bulrushes (*Schoenoplectus* spp.), spikerushes (*Eleocharis* spp.), rushes (*Juncus* spp.), plains coreopsis (*Coreopsis tinctoria*) and other species. Frequently, seed of several species can be harvested at one time with a stripper. Brush strippers are not effective for harvesting species such as prairie cordgrass, whose seed or seed heads do not readily detach from the plant.

We use two models of pull-behind seed strippers, one sold by Prairie Habitats Inc. of Argyle, Manitoba, (204 467-9371) the other developed by Ned Groelz of Arvada, Colorado, (303 424-3162). Both models can be purchased for $7,000 to $8,000. The brush height and direction of spin can be changed on both models. On Prairie Habitat's model the brush is raised or lowered by a hand-operated hydraulic pump operated when the machine is stopped. The Groelz model has an automatic hydraulic system that raises and lowers the brush. This machine has chassis-mounted controls, easily reachable from the ATV, which turns the brush on or off and adjusts brush height and direction of spin. When using the Groelz machine, patches of weeds can be avoided by stopping or raising the brush. The brush height can be easily adjusted when patches of desirable seed heads of different heights are encountered. The Groelz machine also has a durable, road-worthy suspension and tires and can be pulled with a pickup to collecting sites at normal road speeds.

We use a counterclockwise brush spin direction for collecting seeds of middle height to tall species and a clockwise spin direction for shorter species. We recommend experimenting with brush height, spin direction and spin speed to see which works best for target species.

COMBINES

Combines are more efficient at harvesting seed than seed strippers. For example, for every acre of warm-season grass seed harvested by stripper, we can plant 4-5 acres of prairie. Whereas, for every acre of grass seed harvested by combine, we can plant about 10 acres of prairie. The efficiency of combines must be weighed against their cost, high maintenance and transportation concerns.

New combines can cost over $100,000 and are unaffordable for most restorationists. Older, used combines can be purchased for as little as $1,000. Older combines commonly have mechanical breakdowns while harvesting.

Chris Helzer/The Nature Conservancy

The Nature Conservancy's 1974 Massey Ferguson 510 combine with a grain head harvesting warm-season grasses.

When combining, having a good mechanic handy can save time and headaches. Combines can be driven on back roads to nearby collecting sites, but they must be trailered for longer trips.

Combines designed for grain harvesting can be easily modified for harvesting prairie and wetland plant seed. We use two combine types - a 1974 Massey Ferguson 510 and a 1975 Allis Chalmers Gleaner K, both with grainheads. Grainheads consist of a cutting sickle and reel to cut seed heads. Combines use a combination of a hammermill (the cylinder), air and screens to clean the seed once harvested by the cutting or stripper head. Generally, when harvesting grass

U.S. Fish and Wildlife Service

Massey Ferguson 8560 combine with a rice head harvesting Canada wildrye seed.

seed, the cylinder should be set relatively tight with a small space between the rasp bars and the concave, and the air kept to a minimum to prevent seed from blowing out the back. When using a grainhead the screens should be adjusted to allow the most seed to pass through while keeping the most stems and leaves out.

The USFWS in Kearney, Nebraska, harvests native seed with a 1993 Massey Ferguson 8560 combine and a rice head. Rice heads are more efficient at harvesting native seed than grainheads, but they are also more expensive, costing around $15,000 new. Used rice heads can likely be purchased for less. Rice heads were designed to harvest wild rice, which matures over several weeks. Rotating cylinder-mounted teeth catch the seed heads and strip mature seed. It's similar to catching seed heads between the fingers, squeezing and pulling to free seeds. Rice heads leave most of the stems and leaves unstripped providing nesting cover for birds or fuel for prescribed burning the following spring. When using a rice head, most of the screens can be removed because very few stems are harvested and the seed requires little or no cleaning.

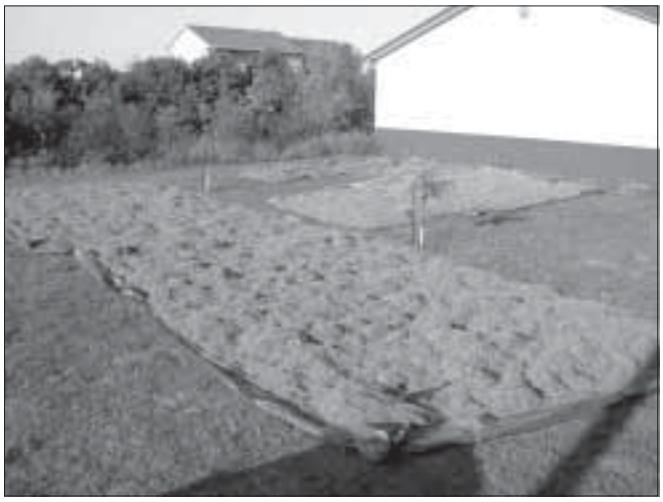
Augering grass seed out of the combine is often difficult when using either grainheads or rice heads. The fluffy seed often "bridges" in the bin and will not feed into the auger located at the bottom of the bin. Building a plywood floor in the bin and simply shoveling the seed out is one way to avoid this problem. Another method is to place a 12-inch or larger diameter PVC pipe vertically into the bin. As grass seed comes into the bin it fills in around the pipe. To auger seed out of the bin the pipe is removed and seed pushed down the resulting hole to the auger below.

We can combine 20-30 acres of prairie grass on days with only minor breakdowns, producing 80-150 barrels (32 gallon capacity) of seed. When combining a vegetatively diverse prairie in mid-September for grass seed, we can harvest seed of up to 40 additional native species. We also combine seed of wildryes, wheatgrasses, sedges, leadplant and other prairie plants as well as wetland sedges, bulrushes, spikerushes and large-fruit bur-reed (*Sparganium eurycarpum*). As with seed strippers, caution must be taken when combining to avoid harvesting weed seeds such as those of smooth brome or musk thistle.

Woodward Flail-vac Seed Stripper

The Woodward Flail-vac Seed Stripper made by Ag-renewal, Inc. of Weatherford, Oklahoma, (800 658-1446) is a popular seed-harvesting machine among many restorationists.

Drying seeds of prairie plants.



Drying stripper- or combine-harvested grass seed outdoors is an option.

It consists of a 6- or 12-foot hydraulic stripper brush and hopper that mounts on a tractor's front-end loader. A 4-foot brush model is also designed for mounting on the front of a 4-wheeler. The fast spinning brush creates a vacuum pulling the seed heads into the bristles, dislodging seeds and depositing them into the hopper.

Seed Drying

Seed of prairie and wetland plants must be dried shortly after collecting to prevent molding and to prepare it for storage. Packard (1997) writes that seed should be dried to a 5-15 percent moisture content. If seeds are not dried to this extent they are susceptible to molding and loss to microorganisms. The cell walls of seeds will break down and their enzymes will become inactive if dried below 5 percent moisture content.

We spread seed of most species on tarps, plastic barrel lids or cardboard laid on shed or garage floors to dry. Elevated wire mesh-bottomed trays also work well and allow for better air movement around seed. Drying areas should be well ventilated. Doors and windows should be open and fans used if needed to increase air movement. Turning most seed every day or two will facilitate even drying. The seed of most species will be adequately dried in 1-2 weeks. Seeds enclosed in fleshy fruits, such as those of roses (*Rosa* spp.) and false Solomon's seal (*Smilacina stellata*), will require longer drying time.

Larger quantities of stripper- or combine-harvested grass seed can be spread on plastic sheeting or tarps to a depth of about eight inches for drying. Large well-ventilated barns or sheds work well for this, or the seed can be dried outdoors as long as it is covered with plastic sheeting before rain. This seed needs to be turned daily with scoop shovels to facilitate drying. Seed that is damp or has green stems or leaves in it needs turning more frequently. Damp conditions could cause decomposition and subsequent heating, which can kill seed or cause combustion.

We also dry grass seed in 4x4x8-foot plywood boxes with 1-foot diameter perforated pipe in the bottom connected to a grain-drying fan. Up to 40 barrels of grass seed can be dried in a day using the boxes. The drying boxes can be mounted on a trailer and transported to the harvesting site and loaded directly from the combine or stripper. Once seed is dry, one side of the box, held in place by clamps, is dropped for easy unloading.

Chris Helzer/The Nature Conservancy

Plywood seed drying box connected to a grain drying fan.

Production Plots

Native grasses, sedges and wildflowers grown using agricultural methods in single species production plots, where they have sufficient water and no competition, produce far more seed than wild grown plants. Seed grown in production plots can be used in restorations or wildlife plantings. Unlike conventional crops that are mostly annuals, most native plants grown in production plots are perennials that do not require replanting each year.

Chris Helzer/The Nature Conservancy

Foxglove penstemon seed production plot at the Nature Conservancy's Platte River Preserve.

Larger-scale native seed production operations require irrigation systems, farm equipment and much labor. The Nature Conservancy, on its Kankakee Sands Preserve in Indiana, grows 110 wildflower species in single-species production plots on 123 acres and five warm-season grass species on 65 acres. Wetland plants are grown in shallow ponds. They use a center pivot to irrigate, herbicides and manual labor to control weeds. They produce far more seed each year than is required to plant 500 restoration acres.

Gayfeather production plot at The Nature Conservancy's Kankakee Sands Preserve in Indiana.

In 2002-03, the Nebraska Game and Parks Commission planted 1.5 acres of prairie cordgrass and 0.5 acres of slender wheatgrass (*Elymus trachycaulus*) production plots using 8,000 greenhouse grown seedlings and 0.5 acres of native legume production plots from seed on the Cornhusker Wildlife Management Area west of Grand Island. We use gravity-flow to irrigate the plots from a well that pumps nearly 1,000 gallons per minute. We control weeds on the site using pre-emergent and post-emergent herbicides and some manual weeding. The plots should produce some seed in the fall of 2003 and be in full production by 2004.

The Nature Conservancy has planted 30 native wildflower and grass species in production plots on 2 acres on its Platte River Preserve in Hall County. A traveling sprinkler system with a 100-foot spray radius attached to a typical outdoor spigot is used to irrigate plots. Weeds are controlled through rototilling, mowing, hoeing and pre-emergent herbicide spraying. Some seed producers place plastic weed barriers between plant rows used in combination with underground drip-irrigation systems. This method greatly reduces the amount of hand weeding and herbicide spraying needed.

It is important to consider the seed source when first planting production plots. Many restorationists prefer local ecotype seed and will not purchase seed that originates outside the region.

CHAPTER 4 - SEED PROCESSING AND STORAGE

Most hand-collected species require some threshing to dislodge and separate seeds from capsules or seed heads. Most stripper- and combined-harvested seed requires no processing before planting. When broadcast planting, this seed requires only minor cleaning after threshing to remove larger pieces of stem and chaff. When drill-planting, seed needs to be fairly clean to pass through the drill.

Small quantities of seed can be threshed by hand. One method is to place seed heads or capsules on newspapers and use a rolling pin or steel pipe to break them open. Rubbing seed heads against 1/8- to 1/2-inch mesh hardware screen also works. The threshed seeds can then be sifted over the screens to remove larger pieces of chaff and stem.

Homemade hammermill consisting of a modified heavy-duty Grasshopper lawn mower conveyor fan run by a gas engine.

Chris Helzer/The Nature Conservancy

Threshed seeds can be sifted over screen to remove large pieces of chaff and stem.

Larger quantities of seed can be threshed with hammermills that use spinning fan blades or small, finger-like paddles to separate seed from pods or heads. One of our hammermills is a modified heavy-duty Grasshopper lawnmower conveyor fan run by a gas engine. Seed heads

Speed King Hammermill model 615.

are vacuumed through flexible plastic tubing into the spinning fan blades, dislodging the seeds and depositing seed and chaff into a hopper.

We also use another homemade hammermill similar to the Speed King Hammermill, model 615, sold by the Winona Attrition Mill Company of Winona, Minnesota, (507 452-2716). With this machine, seed heads are fed down through a metal throat into

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Seed pods of ground-plum.

spinning, plastic, finger-like hammers that dislodge the seed from the head. Screens located below the hammers keep the plant material from leaving the threshing area until reduced in size. A variety of screen sizes can be used with this machine. Smaller mesh sizes work best for smaller seed and larger mesh sizes for larger seeds. Smaller mesh sizes will keep the seed in the threshing area longer producing cleaner seed. Seed heads sometimes must be hammermilled several times before most seed is dislodged.

We do little seed cleaning after hammermilling (threshing) because most medium-sized chaff will pass through broadcast planters. After hammermilling, we screen the seed of some species, such as prairie cordgrass and leadplant, to remove the larger pieces of stem and chaff. A small amount of seed and chaff is placed on the screens and shaken vigorously. The seed falls through the screen into a barrel or bucket located below. The chaff is taken off the screen and the process repeated. We vary mesh size in accordance with seed size when cleaning seed. We use old fanning mill screens, but hardware cloth screen secured to wooden frames also works well.

Many restorationists and seed dealers clean seed using fanning mills, which use

Seed capsules of shell-leaf penstemon.

vibration, gravity, pressure and moving air to separate the heavier seed from the lighter chaff. Fanning mills are commercially available in many sizes and models. The least expensive models sell for about $500. Older fanning mills

Seed heads of purple coneflower.

sometimes can be purchased inexpensively at farm auctions.

After processing, seed must be stored until planted. We usually complete seed processing in late November and plant from December through April. After drying, we store

stripper- or combine-harvested warm-season grass seed in piles in a shed until planted. Seed of other species is stored in paper sacks or plastic buckets and barrels. The USFWS in Kearney mixes their forb and grass seed in the fall and bags it for storage.

It is essential that stored seed is kept in a dry, unheated space, such as a garage or shed. We have experienced little damage to stored

Seed heads of longbeard hawkweed.

seed from rodents or insects, but seed should be checked occasionally to prevent this from happening. Mice often reside in our grass seed piles, and occasionally chew holes in seed storage bags. We have also had problems with cats defecating in our grass seed. Rodent and cat proof seed cages built with 2x4s and wire mesh can be used to store seed piles and containers.

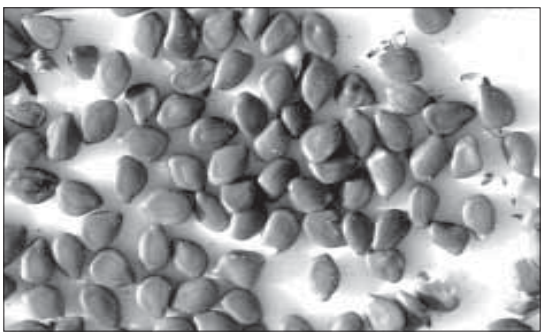
As a rule of thumb, when storing seed for the short-term, the sum of the storage temperature and relative humidity should be kept below 100. For example, if the storage temp is 70 degrees Fahrenheit, the relative humidity should be less than 30 percent. Also, the relatively humidity should never exceed 75 percent, and the lower the better. We have had good restoration results using seed that has been stored for more than a year.

Processing, screening and mixing seed is dusty work. The fine dust can cause allergic reactions and irritate the soft tissues of the eyes, nose and mouth. If mice are present in the seed, the feces can carry diseases – most notably Hanta virus. We strongly advise using high-quality facial dust masks or respirator masks and goggles when working with seed.

Seed Treatment

In the wild, native plant seeds germinate sporadically over time, an adaptation that increases the species' chances of survival. The seed germination rates of most prairie and wetland species will be enhanced by undergoing moist-cold stratification - exposure to moist conditions and cold temperatures (<40 degrees Fahrenheit) for a period of 10-120 days. Other treatments often recommended to enhance seed germination of native plant species include the following: 1) sowing fresh seed, 2) warm-moist stratification, 3) cold-dry stratification, 4) scarification, 5) inoculation of legumes, and 6) light treatment (Beimborn and Lasca 1999 and Packard 1997). We believe special seed treatment is generally not needed for successful restorations. Several of our more successful restorations were planted in late fall or early winter. This exposes the seed to rain, snow, cold temperatures and freeze/thaw cycles providing for cold-moist stratification. In greenhouse tests we found that the seed of most prairie plants over-wintered in an unheated shed successfully germinates the following spring.

Hard-coated seeds, such as those of legumes and roses, require physical breaking of the seed coat prior to germination. This



Chris Helzer/The Nature Conservancy

Hard-coated seeds of Illinois bundleflower.

process, known as scarification, allows the embryo to imbibe water. We believe that hammermilling seed causes some scratching of the seed coat and we do no further scarification. In greenhouse tests we found that sandpapered (scarified) purple prairie-clover

Hand scarifying legume seeds.

(*Dalea purpurea*) and white prairie-clover (*D. candida*) seeds germinated at similar rates to our hammermilled seeds. If seeds are not hammermilled, scarification may increase germination rates for some species with hard-coated seeds. Commercial scarifying machines are available. A homemade model can be built by lining the bottom of an old furniture drawer with number 40 grit, adhesive-backed sandpaper. Place a small amount of seed in the drawer and sand for a minute or two with moderate pressure using a hand sander with number 60-grit sandpaper.

Some restorationists recommend early summer seeding, immediately after collecting, of spring-flowering plants such as prairie dog-toothed violet (*Erythronium mesochoreum*), cool-season grasses and sedges to increase germination rates. We have not tried this method. Many of our restoration sites are farmed the year before planting, making summer seeding impractical. The seed of early flowering species could be collected the summer following the initial seeding and then overseeded.

Greenhouse Propagation of Plants

Seedlings of prairie and wetland plants grown under greenhouse conditions without competition from other plants develop quickly and some species (e.g. prairie clovers) may flower the first year when transplanted into the wild. Growing greenhouse plants is labor intensive. Local ecotype seedlings of some prairie and wetland plants may be available from native plant nurseries, selling for about $2 to $4 apiece.

Small backyard or schoolyard restorations can be planted entirely with greenhouse grown or purchased seedlings. Planting larger restorations entirely with greenhouse grown seedlings is generally not practical or recommended. Seedlings can be used to supplement highly visible areas of sown prairie restorations, such as near trails, where rapid plant establishment is desired. For species that are difficult to establish from seed, seedlings can be used as supplements in restorations. We have used greenhouse-grown seedlings to reintroduce porcupine grass (*Hesperostipa*

Chris Helzer/The Nature Conservancy

Our 8x24-foot solar greenhouse required about $1,500 in materials.

Greenhouse Propagation of Plants

spartea) into a remnant prairie and a prairie restoration in central Nebraska. At both sites, the relatively few planted individuals successfully reproduced, forming larger populations. Many wetland plants spread prolifically from seed and vegetatively. Planting relatively few greenhouse grown seedlings of these species may enhance wetland restorations.

Cone-tainers with grass seedlings.

Using recycled Filon panels, our 8x24-foot solar greenhouse required about $1,500 in additional materials. It has a cobble floor, and insulated plywood walls and roof.

We begin planting seeds in plastic flats or 5 ½-inch or 8 ¼-inch deep plastic Cone-tainers in late January. A Cone-tainer catalog is

Planting production plots with greenhouse grown seedlings.

available from Stuewe and Sons, Inc., 1-800-553-5331 or www. Steuwe.com. At 100 cells per square foot, the 5 ½-inch Cone-tainers make efficient use of greenhouse space. We fill Cone-tainers to within an inch of the top with Vaughan's BP25 bedding mix and then slightly compress the mix. We then place 4-5 seeds in each Cone-tainer and cover them with about 1/8 inch of bedding mix. The seeds and young plants will require watering every few days for several weeks. When temperatures warm and seedling growth rates increase daily watering will be required. Plants started in plastic flats can be transplanted to Cone-tainers after a few weeks growth.

We use a propane heater in winter months to maintain a greenhouse temperature above freezing. On warm days, the greenhouse needs adequate ventilation to prevent overheating. When seedlings reach a few inches in height and appear "strong" we move them outdoors for sun and wind hardening.

Seedlings are transplanted into production plots or restorations beginning in mid-May. Plants can be over-wintered in Cone-tainers or flats and transplanted outside during their second year of growth.

When transplanting into sandy or soft soils, we use a large knife blade or trowel for making the planting holes. In harder soils, we have used dibble bars or electric drills with bulb planting bits for making holes. Various drill bit diameters are available to match the diameter of Cone-tainers. Where possible, water transplanted seedlings every few days for the first few weeks after planting and then occasionally thereafter.

Candle anemone seedling freshly pulled from a Cone-tainer.