Vegetating with Native Grasses in Northeastern North America

USDA-NRCS

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Preface

This document was originally published many years ago; while the represented data is still relevant and applicable, the original Senior Authors noted on the preceding page have both retired. For questions or comments, please contact:

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The appendices in this publication have been updated to reflect up-to-date available varieties and seeding rates.

USDA-NRCS Plant Materials Program would like to thank Ducks Unlimited Canada for the use of this manual and permitting the posting of this publication to the Plant Materials Program website.

Acknowledgments

The information contained in this document was assembled from cited references and from personal experience in the field establishing native grasses on the landscape. We have also drawn on the experience of colleagues in Ducks Unlimited Canada and in the USDA-NRCS Plant Materials Program. Their willingness to share that experience has improved this document.

The format and approach follows the previous manuals jointly published by the NRCS and DUC; *Revegetating with Native Grasses* (1995) and the *Native Grass Seed Production Manual* (1997). Information contained in the 1995 revegetation manual was especially useful during the preparation of this publication.

Encouragement and support for the initiation of this project was received from Dr. Terry Neraasen, then chief biologist with Ducks Unlimited Canada, from Dr. Rick White, program leader, NRCS Plant Materials Program and from Dr. Billy Teels, director, NRCS Wetland Science Institute.

The senior authors also wish to acknowledge the singular efforts of Lynne Miller - who spent countless hours typing the many drafts which preceded the document you now hold - and Bill Poole, who edited the text and combined the input of six authors into a useful publication.

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Introduction

Ducks Unlimited Canada (DUC) and the Natural Resources Conservation Service (NRCS) of the United States Department of Agriculture jointly released *Revegetating With Native Grasses* in 1995[22]. That manual fulfilled a long recognized need to summarize the lessons both agencies had learned about successfully planting native grasses in the western prairie/plains region of the continent. The development of that information had begun with the establishment of the NRCS – formerly the Soil Conservation Service – in the dust bowl days of the 1930s. Recently, government sponsored programs such as the USDA's Conservation Reserve Program and private efforts such as DUC's upland nesting habitat improvement activities have grown closer in function. This common interest also exists in grasslands and wetlands habitats in the eastern climax forest region of the continent.

Grassland islands existed in the eastern forests when European settlers arrived. These became known by many local names including mountain "balds", meadows, coastal sloughs, "openings", and oak savannas. Though dwarfed by the surrounding forests, these grasslands were recognized by Native Americans as having outstanding attraction and benefit to wildlife. They used fire to improve habitat by reducing woody plant encroachment. Many of these openings were the result of activities by the original inhabitants. One interesting example was a grassland of several hundred thousand acres on Long Island which supported good populations of prairie chickens. A sixty acre remnant of this once great grassland still exists just across the road from Nassau Coliseum where the NY Islanders play hockey. Tall grass prairie reached well into southwestern Ontario, where several hundred acres of prairie remain on Walpole Island in the St. Clair River delta.

NRCS and Ducks Unlimited have collaborated again to produce this reference: *Vegetating With Native Grasses in Northeastern North America.* It is intended to meet the information needs of resource conservation professionals in government and in nongovernmental organizations, as well as landowners and operators throughout the northeastern United States and eastern Canada (Figure 1). For ease of reading, only the common names of plant species have been used in the text. Appendix A cross-references those names to one or more of the scientific names used in North America.

There are some distinct challenges to success with native grasses in the east, as well as unique rewards. This handbook attempts to capture both.

Background

Many of the native warm season grasses – the prairie grasses – are also native in the northeast. Coastal stands of eastern gamagrass are locally common in Connecticut and south. Prairie cordgrass can be found mixed with American beachgrass within a foot of the high tide line in Maine and Massachusetts. Switchgrass as well as big and little bluestem line railroad grades and rivers. Halfway up the gorge at Watkins Glen, New York, the aware hiker will see a stand of indiangrass.

Remnant stands of prairie grasses are scattered across the southern parts of eastern Canada. In southern Ontario, a long growing season coupled with average annual precipitation of more than 30 inches (762 mm) results in remarkable stands of warm season grasses. Prairie cordgrass and switchgrass are common in lower, moister areas. Switchgrass is also found on beach ridges and along abandoned railway beds. Big bluestem, indiangrass and little bluestem are present along many roadsides.

In some parts of the northeast, cooler temperatures do not allow warm season grasses to produce as much biomass as they do in the midwest. In spite of that, they have proven to be very useful for revegetation and reclamation work, wildlife habitat improvements, and forage production. They have capabilities which the introduced grasses (cool or warm season) do not possess.

The NRCS, through its Plant Materials Program, has studied, selected and used these native plants on a wide variety of sites. This work is ongoing and has helped spark a growing interest in the use of native grasses in the northeast. Grassland establishment will be occurring within 1996 Farm Bill titles such as the Wildlife Habitat Improvement Program (WHIP), the Conservation Reserve Program (CRP), the Wetlands Reserve Program (WRP) and the Environmental Quality Improvement Program (EQIP).

Ducks Unlimited Canada recognizes the habitat value of native grasses, particularly for early season nesting waterfowl. In Ontario, tall warm season species are used to provide long lived nesting cover that requires minimum maintenance. Efforts over the past several years have shown excellent results with a number of warm and cool season species. Future work will examine the use of native forbs and shrubs with these grasses.

A growing interest in native plants in southern Ontario has lead to the formation of a tall grass prairie roundtable. This diverse group of agencies and individuals is promoting the use of native plants for prairie restoration, revegetation of roadways and fragile agricultural land, biomass for ethanol production and forage. To date, they have initiated activities for local seed collection and production, tested switchgrass varieties for biomass production and tested a variety of mixes in roadside plots.

One cannot usually transfer midwestern native plant cultivars and procedures directly to northeastern conditions. In the northeast, introduced cool season grasses can pose strong competition to native grass seedlings. Wetter, cooler soil conditions may hinder seedling development. Frost heaving on heavy soils can destroy a promising stand during the winter after planting. The climate favors the encroachment of woody species into idled grasslands. Elevation and aspect become important considerations as one moves north and east.

The state of knowledge about revegetation with native species is not as well-developed in the northeast as it is further west. There is, however, much that is

known. The information presented here is mostly based on practical experience, with an emphasis on techniques for large scale revegetation plantings. Much of it was derived from efforts in land stabilization, reclamation and habitat restoration and enhancement on multiacre sites.

This work should not be confused with prairie restoration which is exceedingly difficult and expensive to attempt on a large scale. As time goes by and seed availability for more species and eastern ecotypes improves, these distinctions in goals and approaches may fade. For now, actively choosing to use native grasses, forbs and legumes represents a fundamental step in the right direction.

Figure 1. Northeastern North America

Planting Objectives

Recent History

Remnants of the tall grass prairies and savannas that once dotted eastern forest regions are now mostly limited to pioneer cemeteries, wasteland pastures, roadsides, railroad beds and beach ridges in parks and nature preserves. In recent years there has been a resurgence of interest in the use of native prairie grasses and forbs. Many arboretums, nature preserves, parks and private landowners are dedicating areas to the reestablishment, preservation and observation of these plants. In addition to their beauty and heritage value, they can fill a number of useful roles.

Warm season grasses in particular are very effective for erosion control. Known for their extensive fibrous root systems that hold soil and slow runoff, their use has been successful along roadsides, streambanks, on landfills, abandoned mines and burn areas. Because of those root systems, warm season grasses are notable soil builders and help restore soil health. They have also proven effective as windbreaks, particularly in conjunction with pivot irrigation systems, and when used as a snow barrier.

Warm season grasses are being integrated into grazing systems to increase beef production during the summer months when cool season forage production declines. Unlike the cool season grasses that have their greatest growth during cooler temperatures, warm season grass production peaks at higher temperatures. Utilizing these contrasting patterns of yield distribution helps to ensure adequate feed throughout the summer months and enhances the forage production of cool season grasses in late summer and fall.

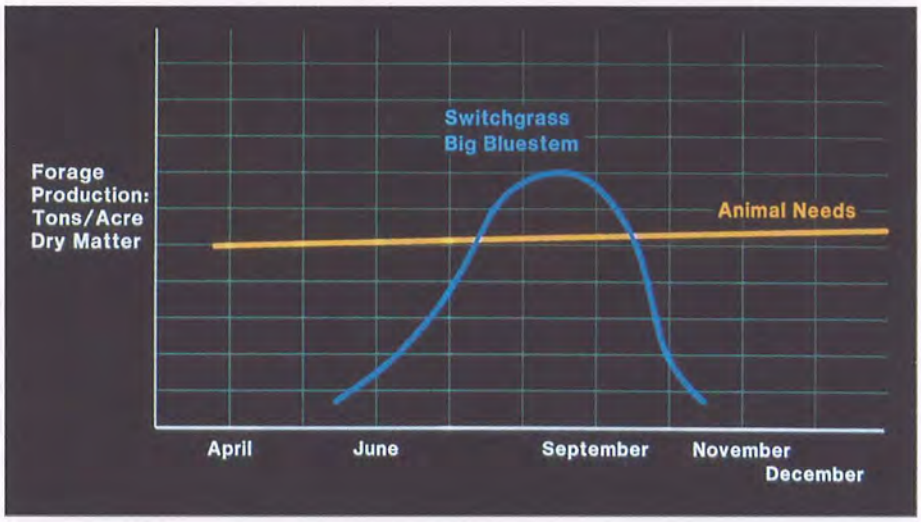
Even urban landscapes are reaping the benefits of native prairie species. Their use as a water conserving alternative to the traditional lawn eliminates the need for expensive irrigation equipment. Additionally, costs associated with maintenance and chemical applications are drastically reduced.

Following the planting of native species, many fauna common to the prairie areas, such as meadowlarks, bobolinks, dickcissels, falcons and foxes, have reintroduced themselves[12]. This should not be surprising, as these areas are complex ecosystems. As reclamation projects increase in size and plant diversity, animal populations will also increase and become more diverse.

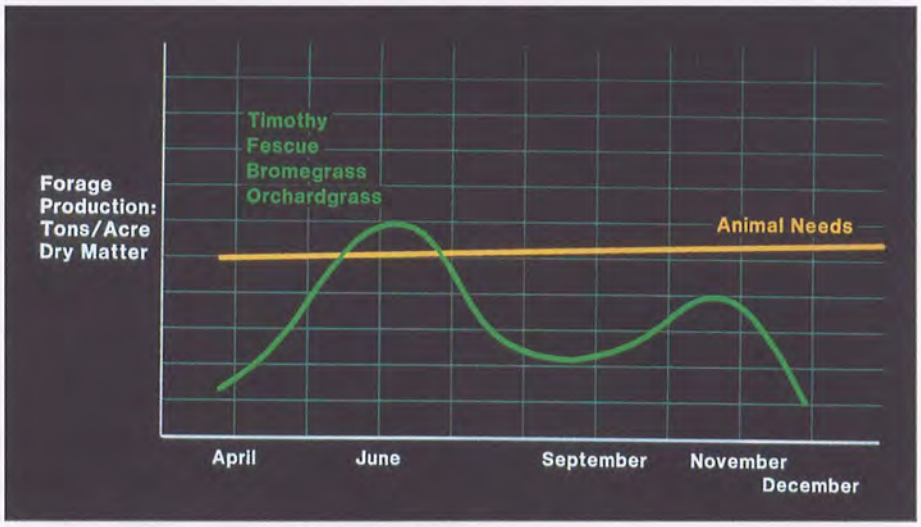
Waterfowl, pheasants, songbirds, deer, rabbits and other small mammals use these areas for nesting, food and shelter. Native grasses – particularly warm season species – resist lodging because of snowpack and maintain a one to three foot ground cover throughout the winter that provides shelter important to many wildlife species. Also, in addition to the plant parts and seeds that provide feed, insect populations develop in these areas and provide another important food source for many wildlife species[11].

For these reasons it is little wonder that many reclamation agencies, groups and individuals are embracing the use of native plant species. However, there is a wide array of native and introduced species available, each with attributes and limitations that must be considered.

Warm season grasses make most of their annual growth during summer and early autumn.



Cool season grasses have their major growth peak in late spring/early summer. They may have a smaller growth peak late in the season when temperatures cool.



This switchgrass pasture in central New York provides high quality summer grazing.

What Is Native?

When applied to plant species, the word **native** often means different things to different people. In this manual, native is used to refer to the species indigenous to a region at the time of European settlement.

The grasses brought to North America by our forefathers were imported primarily for agriculture. These plants were so highly adapted to northeastern conditions and planted so extensively that they have outcompeted native grasses in many of the ecosystems of the region. Those grasses have long been naturalized in the eastern regions of North America. A **naturalized** plant is one that is known to have originated outside of a particular region, but currently exists in the wild in self-perpetuating populations.

While there are specific characteristics common to a species – regardless of place of origin – that distinguish it from other species there are also adaptations within a species that separate it into **ecotypes**. One ecotype differs from another in specific morphological and physiological traits such as height, hardiness or growth rate.

An ecotype grown out of its area of adaptation is not likely to perform well and may not even survive. However, the opposite may also be true; a species brought into an area may be overly competitive to other desirable plants. Either of these situations could be costly and time consuming to correct. Experience has shown that ecotypes moved too far north tend to have hardiness problems, while those moved too far south are likely to have disease problems.

A **cultivar**, or variety, is an ecotype that has been selected for specific characteristics such as rate of growth, disease resistance, forage yield or seedling vigor. Most are developed through planned breeding programs with selections from diverse initial plant collections. As with other ecotypes, cultivars have specific areas of adaptation.

The selection of species for reclamation plantings should be based on a combination of criteria including the nature of the land base, purpose of seeding, likely management regimes, seed availability, seed costs, longevity, ease of stand establishment and the attributes of available plant species[25]. Many of these same criteria are also likely to influence decisions regarding potential seed sources for each species used in a planting mixture. Seed of a species that could be used in relatively small amounts to increase the diversity of a planting may only be available from suppliers of locally harvested ecotypes. Conversely, the seed of another species may only be available in sufficient quantity from the producer of an adapted cultivar.

Plant/Cover Types

The discussion in this manual will focus primarily on large scale, long-lived plantings which create diverse, easily managed cover that is attractive to a wide range of wildlife. This objective is often best accomplished by revegetation with native grass, forb and shrub species. Unlike introduced species, adapted native species are virtually permanent – given effective management – making it unnecessary to reseed after several years. The additional cost of reseeding is avoided as is the risk of exposing the land to further erosion during subsequent stand reestablishment.

For sites where nonpermanent cover is the objective, mixtures of introduced grasses and legumes may be more cost effective than native species. In addition, adapted native species may not be available to match the specific conditions found on some sites. In both of these cases, a list of recommended introduced species should be obtained locally.

Cool Season (C3) and Warm Season (C4) Plants

Native grasses are divided into two main categories: cool season and warm season. They are also referred to as C3 and C4 plants because of their particular photosynthetic pathways. Cool season grasses produce most of their growth during the spring and late fall when the soil and air temperatures are cooler. In extremely cold climates, they are forced into dormancy by the cold weather. In temperate climates they generally go dormant or nearly so in midsummer. For this group of plants, the minimum air temperature for active shoot growth is 40 to 42°F (4 to 5°C). Most of the commercially available turf and forage grasses used in the northeast are introduced cool season grasses.

Conversely, the warm season grasses produce most of their annual biomass during the hot summer months from July through September. Growth of this group of plants does not begin until the minimum daily air temperature reaches 60 to 65°F (15 to 18°C) and soil temperatures reach 50°F (10°C). Optimum biomass production occurs when temperatures average 85°F (29°C). At higher temperatures C4 grasses have a greater potential photosynthetic rate and use nitrogen and phosphorus more efficiently than do C3 grasses[7]. They also survive and adapt better than many C3 species under conditions of high water stress, high temperature, high oxygen concentration, low carbon dioxide concentration and high irradiance.

Big bluestem, indiangrass and switchgrass are among the dominant tall warm season grasses of this region. They are best adapted to sites which have deep, moist, fertile soils, but will also grow well on many droughty sites in the northeast. Good seed supplies of these species are available. Many other warm season native grasses can also thrive on drier sites in this region. Locally important species with good drought tolerance include little bluestem, prairie sandreed, sideoats grama, and sand dropseed.

Due to the recent interest in native plant material, the availability of local and adapted species is constantly increasing. Check current information before making your selections.

Sculptured Seeding

Realizing environmental factors such as soil, topography and climate influence the composition of plant communities, it seems logical to design seeding mixtures which approximate the relative composition that may occur naturally on a planting site. This technique, called sculptured seeding[9], can greatly enhance the longevity and diversity of reestablished grasslands.

Sculptured seeding (See Appendix B) is an ecological approach to revegetation based on knowledge and understanding of the natural vegetation in the ecoclimatic region where the site is located. The objective is to establish a diverse native plant community capable of regeneration and long term plant succession. It is intended to match plant species with the site conditions under which they are known to persist. Seed mixtures are developed to match soil and climatic conditions not only within a region but also within a specific field.

In the central Great Plains, variations in elevation within a field usually determine where site characteristics (range site capability) change enough to warrant a different seed mixture. As elevations increase, the soil's moisture holding capacity often decreases and the seed mixture must be changed to include species with greater drought tolerance (Figure 2).

Because of the higher amounts of average annual precipitation received in the northeast, elevation differences within a field may not produce the "topographic drought" that often occurs on the central Great Plains. However, changes in

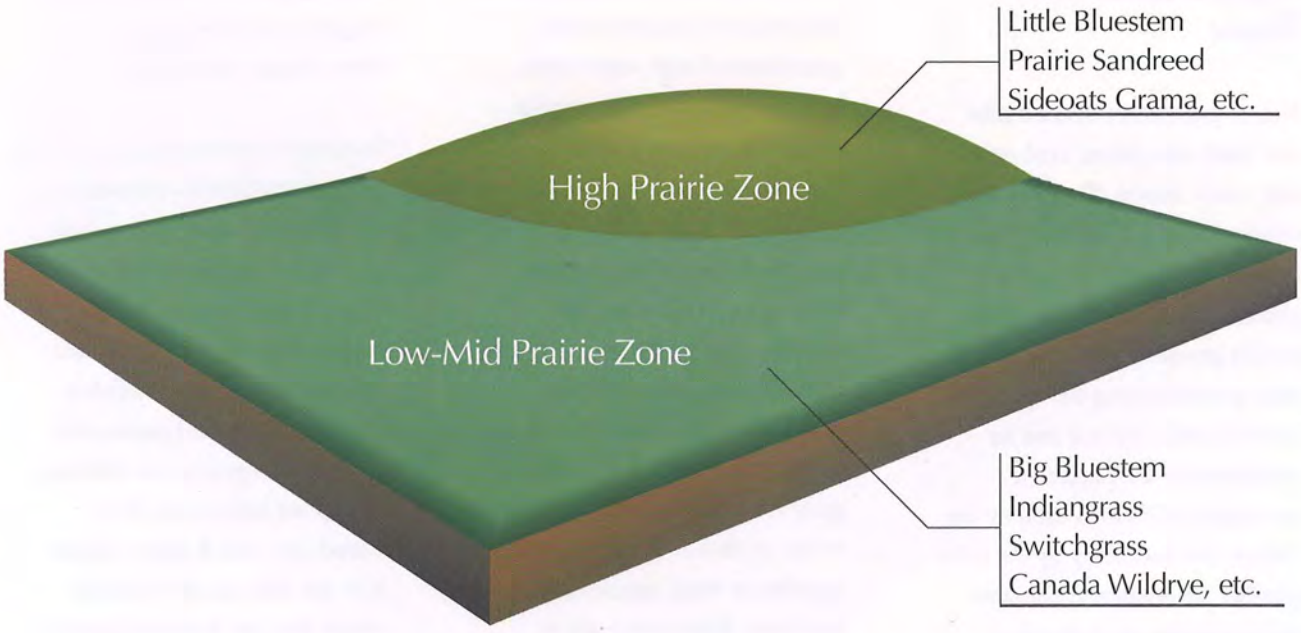


Figure 2. Effect of elevation changes on plant material selection.

factors such as soil type, internal soil drainage or aspect may produce such significant differences in site characteristics that the sculptured seeding technique should be adopted. Surface and internal drainage differences and soil texture can affect species selection, particularly if those differences are likely to cause either droughty conditions or excess soil moisture during the growing season or lead to frost heaving (Figures 3 and 4).

Sculptured seeding is not an attempt to replicate or restore a true prairie. It is, within the constraints of current technology and seed availability, designed to produce a rough approximation of what may occur in a natural situation.

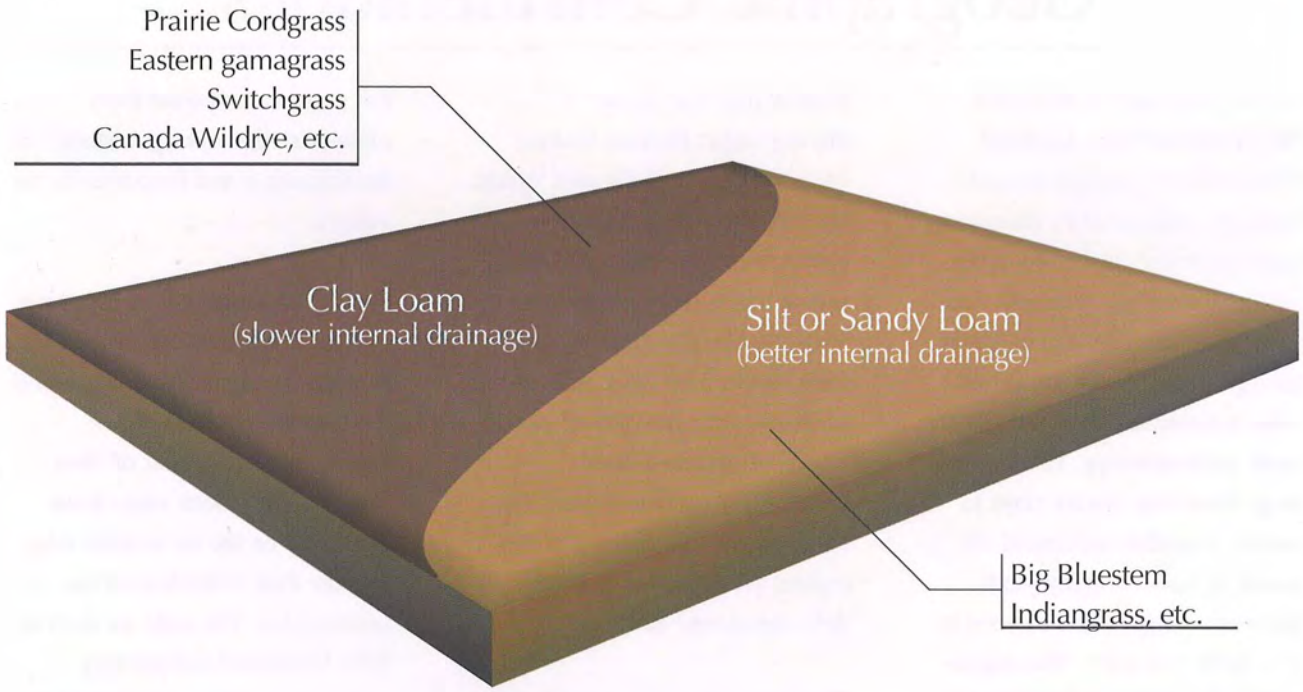


Figure 3. Effect of soil type and internal drainage on plant material selection.

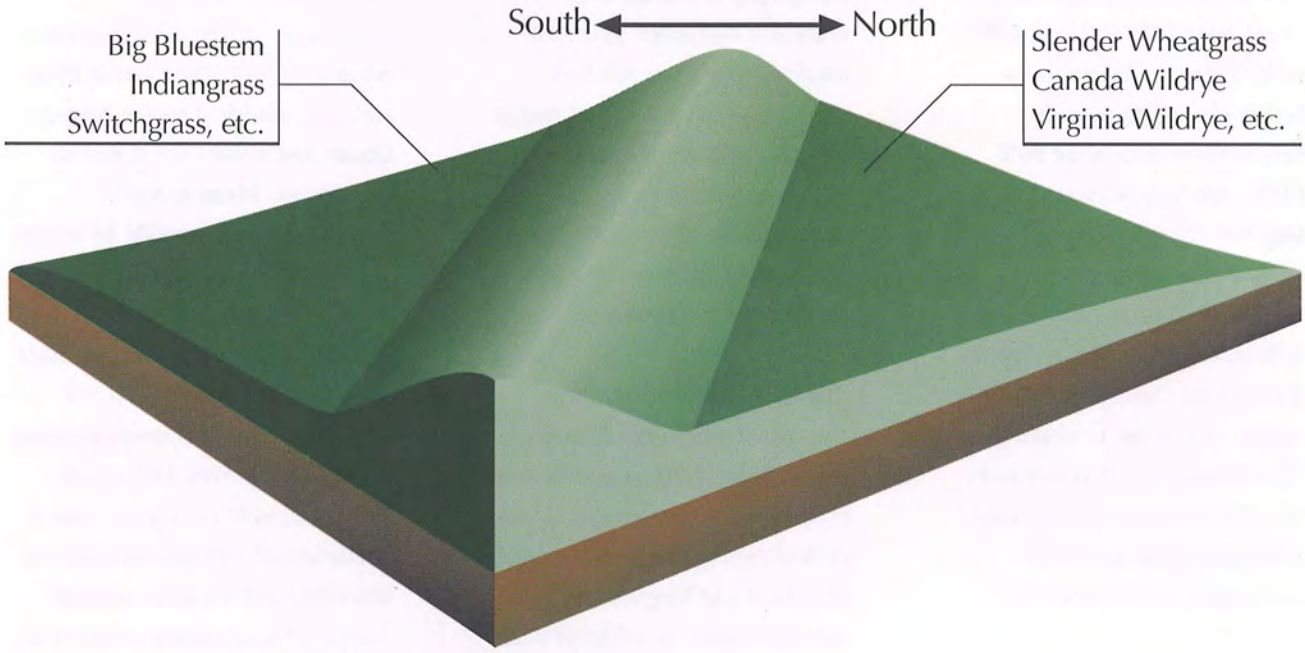


Figure 4. Effect of aspect on plant material selection

Geographic Considerations

The physiography of **northern New York and New England** (Vermont, New Hampshire and Maine) is dominated by alternating mountain ranges and major river and/or lake valleys. The area was almost entirely glaciated in recent geologic history, with glacial till soils, sedimentary soils and coastal sands predominating. These soils range from blue marine clays to neutral limestone influenced silt loams, to acid, droughty sands. Elevations range from sea level to over 6200 feet at Mt. Washington in New Hampshire's Presidential Range. The climate of this area is strongly influenced by elevation and aspect. Heavy snowfalls insulate the soil surface from cold winter temperatures in most years. Winter low temperatures range from -20 to -40°F (-28 to -40°C), with colder conditions at the higher elevations. Summer temperatures exceeding 90°F (32°C) are very infrequent and may not occur in some years. Coastal Maine and New Hampshire climates are further influenced by the cold waters of the Atlantic Ocean. The growing season in extreme northern Maine, New Hampshire, Vermont and New York is less than 100 days with an average annual air temperature of 40°F (4.5°C).

The mid-Atlantic and southern New England states can be divided into four broad physiographic regions; Coastal Plain, Piedmont, Ridge and Valley, and Appalachian Plateau as you go east to west. The Coastal Plain region which occupies portions of Virginia, Maryland, Delaware, New Jersey, New York and Massachusetts, consists of varying depths of unconsolidated sediments. Coarse textured soils comprise very large areas of this region. Elevation above sea level does not exceed 500 feet.

The Piedmont region extends from the Hudson River in the north through northern New Jersey, southeastern Pennsylvania and into central Maryland and Virginia west of the Chesapeake Bay. Its topography is rolling with relatively low relief, generally ranging from 50 to 300 feet elevations above sea level with a few hills as high as 1,000 feet. Soils are derived from metamorphic schists and gneisses and igneous granites. Soil textures range from fine to coarse.

The Ridge and Valley region consists of the highly folded sedimentary rocks extending from northeastern Pennsylvania through central Pennsylvania into western Maryland and Virginia and the extreme eastern portions of West Virginia. Local relief varies from 1,000 to 2,000 feet. The soils of this region are derived from sandstones on the ridges, shales on the sideslopes and limestone in the valleys.

Finally, the Appalachian Plateau at the extreme interior of the mid-Atlantic occupies the north central and western portions of Pennsylvania and most of West Virginia. Elevations range from 1,000 feet on the far western edge to more than 4,000 feet on the eastern edge. The soils are derived from flatbedded sedimentary sandstones, shales, conglomerates and some coal.

The climate in the mid-Atlantic and southern New England states is extremely varied because of differences in elevation, topography and proximity to the Atlantic Ocean. The Coastal Plain region is modified by the Atlantic Ocean, but it does not dominate the climate. Mean annual precipitation is generally 44 inches (1115 mm) throughout the mid-Atlantic and southern New England area with isolated pockets of 48 and 52 inches (1220 and 1320 mm). The maximum growing season ranges from 180 to 200 days in most of the region, with a maximum of 220 days in southern Maryland and Virginia. Average annual air temperature ranges from 60°F (15.5°C) in southern Virginia to 50°F (10°C) in coastal

Massachusetts.

The Great Lakes area can be broken down into two physiographic regions: the Great Lakes section of the Central Lowlands and the Superior Uplands. The distinction between these two regions is largely due to the bedrock formation.

The Great Lakes section stretches from the Michigan upper peninsula and the Ontario peninsula southward to northeastern Illinois, northern Indiana and Ohio as well as northwestern New York. Sedimentary deposits of sandstone, limestone, dolomite, evaporites and shale form the primary bedrock in this region. Modern physiography and soils are the result of glacial and postglacial erosion and other soil forming processes acting on this sedimentary material. Besides the thousands of lakes, this area is characterized by large areas of rolling ground moraine sandwiched between areas of marginal moraine and outwash plains. Elevations range from 300 feet on the shores of Lake Ontario to over 1,600 feet along the western border in Wisconsin.

The Superior Uplands include portions of northeastern Minnesota, northern Wisconsin and the western upper peninsula in Michigan, also extending northward into Canada as the Laurentian Upland. This is a glacial drift region where soils were primarily derived from igneous or metamorphic bedrock. Generally, these soils are more acidic and less productive than the soils derived from sedimentary bedrock. The elevations vary from 600 feet along the Lake Superior shore to 2,300 feet in the Misquah Hills of Minnesota.

The climate in the Great Lakes region and the Superior Uplands varies with elevation, topography, latitude and lake effect. The tendencies are for growing seasons to lengthen and average annual temperatures to rise near the lakes and as one moves south. For the Great Lakes section average annual temperatures range from 39 to 52°F (4 to 11°C) and annual precipitation from 28 to 45 inches (710 to 1140 mm). Typical growing seasons vary from 100 to 180 days with extremes to 70 days in the lowlands of the Michigan interior and 200 days along Lake Erie in Ohio. The Superior Uplands have mean annual temperatures ranging from 36 to 45°F (2 to 7°C), annual precipitation from 24 to 36 inches (610 to 915 mm) and a growing season that varies from 75 to 150 days.

The midwest states that form most of the south central, southwestern and western boundaries of the area covered in this manual lie primarily in the Central Lowland physiographic region. This can be further divided into the till plain, dissected till plain, driftless and western young drift sections and extends from Minnesota down to northern Missouri across Illinois, Indiana and into western Ohio. Distinctions between these sections are provided largely by the amount and type of glacial and post glacial erosion that has occurred. Occasional surface exposures of granite or other rocks mark the northern reaches of this area while relatively thick till, outwash and loess deposits typify the southern sections. Elevations range from 1,650 feet in the northern upland down to 300 feet in the southern valleys.

The average annual precipitation is 25 to 35 inches (635 to 890 mm) in much of the region, but ranges from 19 inches (480 mm) in northern Minnesota to 45 inches (1140 mm) along the eastern and southern borders. Average annual temperatures vary from 43 to 55°F (6 to 13°C), dropping as low as 36°F (2°C) in the northern fringe. Frost free day extremes are 105 and 190 in the far north and south respectively, with averages ranging from 140 to 180 days in most of the region.

South of the Canadian Shield, **Ontario and Quebec** contain four major ecoregions – the Lake Erie lowland, Manitoulin Lake Simcoe, the St. Lawrence lowlands and the

Appalachians[6]. In addition, there are 11 plant hardiness zones. Soils range from heavy clays through loams and fine silts to sands.

Much of the best agricultural land in the southwest part of Ontario was originally marsh and wetland. Other high quality cropland was developed by clearing mixed hardwood forests. Morain and esker areas are scattered across the central region. Extensive areas of limestone overlain with shallow soils occur in the northwest, central and eastern regions.

The average annual temperature for southern Ontario is 44 to 48°F (6.5 to 9°C). The extreme southern part of Ontario is at the same latitude as northern California with a climate that is further moderated by the Great Lakes. Depending on elevation, the growing season ranges from 3,500 growing degree days in the extreme south to less than 2,100 growing degree days in the central region. Average annual precipitation is 32 inches (815 mm), with most of it arriving as spring and fall rains and as snow.

Geographic Considerations For Cool Season Grasses

The mid-Atlantic States, Great Lakes States, the New England States and eastern Canada are all relatively easy areas for achieving successful plantings of cool season grasses. When cool season grass seed is planted in the spring or late summer, following appropriate preparation and technique, it really is difficult to fail in establishing these grasses. The common use of hydroseeders (and other broadcasting techniques) for planting these grasses is proof of the ease of growing them in the region. The climate of the region is reliably cool and moist in the spring and fall. Cool season grasses germinate rapidly under these conditions. Even on soils with poor moisture holding capacity, the frequency of rain and cool temperatures will typically bring these seedlings along. Moderate drought can sometimes occur in the late summer and fall.

There are relatively few conditions of soils, climate, elevation or aspect in this region that make cool season grasses a challenge to establish. Some of these conditions include:

- droughty soils on southwest aspects during unusually warm, dry planting seasons.
- north and east aspects in Canada, the Adirondacks of New York and northern New England at elevations above 2,000 feet during atypically cold planting seasons.
- isolated toxic soil conditions such as salt concentrations above 3 mmhos per cm.
- unstable soils with too much movement for seedling establishment.
- heavily eroded or otherwise drastically disturbed sites where subsoil will not support vegetation due to high bulk density (1.8 gm per cc or greater), pH below 4.8 (where aluminum and manganese toxicity becomes a factor), and/or extremely poor nutrient status.

Early European immigrants recognized the utility of cool season grasses. They brought the familiar seeds with them to this continent. The rapid clearing of the forest was followed by extensive planting of species like orchard grass. The settlers planted what they knew from the old countries and it grew well in this region. This association still continues with the use of bluegrass, ryegrass and fescue for lawns, and orchardgrass, bromegrass, timothy and reed canarygrass in pastures and hayfields.

The wealth of knowledge that we currently have about the use of introduced cool season grasses is in sharp contrast to our lack of knowledge about the use of the native cool season grasses. In the east, we are just beginning to explore the potential of grasses like Canada bluejoint and Virginia wildrye. Seed of these plants, and certainly the eastern ecotypes of them, is not now widely available to use in plantings, however this is expected to change in the future.

Though the establishment of cool season grasses is relatively easy throughout the region, there are droughty, acid or low nutrient sites where long-term maintenance of these grasses is a challenge. This aspect of their use is discussed elsewhere in this manual.

Geographic Considerations for Warm Season Grasses

In addition to the factors that affect cool season grasses, there are specific concerns for warm season grasses. Warm season grasses grow well under conditions that are generally warmer than the best performance range for cool season grasses. This creates some significant challenges for the successful use of warm season grasses throughout the northern states in our region. These challenges are most often encountered during the establishment year and the following spring. In the geographic region covered by this manual there are two primary concerns due to climate and microclimate that affect warm season grass establishment and growth, and one major concern due to climate and soil interaction. Specifically, these are:

- length of growing season.
- warmth (heat units) received during the growing season.
- frost heaving during the fall, winter and spring after planting.

How Growing Degree Days Are Calculated

Growing degree day (GDD) calculations incorporate both the effective length of the growing season for a particular crop and the amount of heat received each day into one measurement. For corn production, GDDs are based on the adjusted mean daily air temperature within the range of 50°F to 86°F.

$$\text{Corn GDDs} = \frac{[\text{Max. temperature } (\leq 86°F) + \text{Min. temperature } (\geq 50°F)] - 50}{2}$$

If the minimum air temperature for a particular day was 60°F and the maximum was 90°F, 23 corn GDDs would have been accumulated:
(86 + 60) ÷ 2 - 50 = 23 GDDs

If the minimum and maximum temperatures on the following day were 56°F and 80°F respectively, that would represent a further 18 GDDs for an accumulated total of 41 corn GDDs for the two days.

Corn GDD values are readily available from agricultural extension agencies for most areas in the northeast. They may also serve as a useful initial indicator of the prospects for success with warm season grass plantings. Based on field experience in the region, 1,400 corn GDDs should be considered a tentative lower practical limit for warm season plantings.

The length of the growing season and heat units received can be thought of together as growing degree days. Either factor alone can limit seed germination and seedling growth to the point that stand density is too low for effective erosion control or adequate nesting cover. In the northeastern states and eastern Canada these factors combine to challenge success; a relatively high incidence of cloudy days and the high evapotranspiration rates of forest cover moderate summer temperatures compared to those commonly experienced in the prairie/plains states and provinces.

It has been previously estimated that a minimum growing season of 140 days is necessary for success with native warm season grasses in the east[19]. Field planting experience has shown this to be a conservative estimate. Successful plantings have been made in well drained soils at locations with about 100 day growing seasons. These plantings utilized eastern and Kansas and Nebraska cultivars. Stand development and seedling growth were slowed at these locations, from the typical

two years to four years for full establishment. Contrast this growth response with that experienced in North Dakota, where equally short growing seasons have more solar radiation and growing degree days. Larimore, in northeastern North Dakota, receives 2,000 GDDs in a 120 day growing season while Roscoe, in the southeast part of New York, only receives 1,600 GDDs in a 120 day growing season. In North Dakota, it is common for good stand density and plant growth to be achieved in the second or third season.

In the mid-Atlantic and southern New England states, warm season grasses generally occupy an ecological niche where the dominant introduced cool season grasses have little physiological adaptation. These sites are generally sandy, sterile, acidic sites that only the C4 plants can tolerate for the long term. The common dominant species on these sites include switchgrass, little bluestem, broomsedge, deertongue and, to a lesser extent, big bluestem and indiangrass.

Specifications for warm season grass establishment must reflect regional characteristics. The user is strongly advised to contact regional USDA-NRCS plant material specialists or DUC staff for information on proper seeding regimes, variety selection, seeding rates, planting dates and fertilizer treatments. For example, clear regional differences are seen in seeding rates, with much lower rates used for the same species mix in the Great Plains than in the northeast.

Local residents can give the best estimate of growing season length for microclimates. Frost pockets, north and east aspects with poor air drainage and higher elevations all tend to make the site more limiting for warm season grass success by reducing soil and air temperatures through the growing season. When these conditions are combined with soils that tend to be somewhat poorly drained or wetter (even if only seasonally) then warm season grass use becomes a low success project. Even on sites with 140 or more days in the growing season, poorly drained soils are a problem in the upper northeast and eastern Canada.

These sites are prone to a condition known as **frost heaving**. Frost heaving occurs primarily during the spring after the planting year, when marginally developed plants are literally jacked out of the ground by ice crystals that alternately form and thaw along the roots. This action can totally ruin an otherwise promising grass stand. The best defense is to avoid soils prone to frost heaving, and try to develop the biggest, most robust plants possible during the first growing season. Plants with 10 or more stems are much less vulnerable than those with fewer stems.

When identifying frost pockets, local farmers, especially those who plant alfalfa, know where young plants have been lost to frost heaving. It is wise to be wary of soils that have caused frost heaving with alfalfa when planning warm season grass plantings. Sometimes this may be a risk on only part of a field, allowing for the use of two different seed mixes (cool and warm season mixes) to be strategically placed. The soils map (printed by county in the US) is an excellent resource in predicting where this problem is likely because it identifies soil types by drainage class and landscape position. Soil survey maps may not show "inclusions", areas of a soil type which are five acres or smaller in size. As a result, they should not be used as a substitute for on-site evaluation. In general, frost heaving is more likely to occur on soils which have poor surface or internal drainage. Soils of this type are often classified as "poorly" or "somewhat poorly" drained on soil maps.

Slopes with north and northeast aspects are easy to spot. Where these occur in USDA plant hardiness zone 4 and especially zone 3 (Figure 5), at elevations above 1,000 feet, reduced growth should be expected with warm season grasses. A pair of sites near

Montpelier, Vermont illustrate the effects of aspect. These two sites had the same history of gravel pit use, were on opposite slopes of the same hill, and were planted with the same warm season grass mixes and rates using the same amendments and planting technique, on the same day. The result, after three years, had the south facing slope covered in three to five foot tall, robust growth, while the north facing slope, which was steeper, had eight to 15 inches of growth, very marginal for wildlife use.

Long, narrow fields with tall trees along the sides increase the potential for problems on north-facing slopes. Shading from the trees further reduces incoming light, making marginal sites a poor bet for warm season grasses. On other aspects, especially southwestern exposures, bordering trees will have little affect.

North aspect, September of the seeding year

North aspect, one year after seeding

South aspect, September of the seeding year

South aspect, two years after seeding

This series of photographs from a gravel pit reclamation planting at Montpelier, Vermont, illustrates the influence of aspect on the growth of warm season grasses on some sites. In the seeding year, plants were about six inches tall on the north facing slope (upper left) and 10 to 12 inches tall on the south facing slope (lower left). In July of the year following seeding (upper right), plants on the north facing slope were still only averaging ten inches. By July of the second year (lower right), the plants on the south facing slope were averaging 30 inches tall and were maintaining their height advantage over the plants on the north aspect.

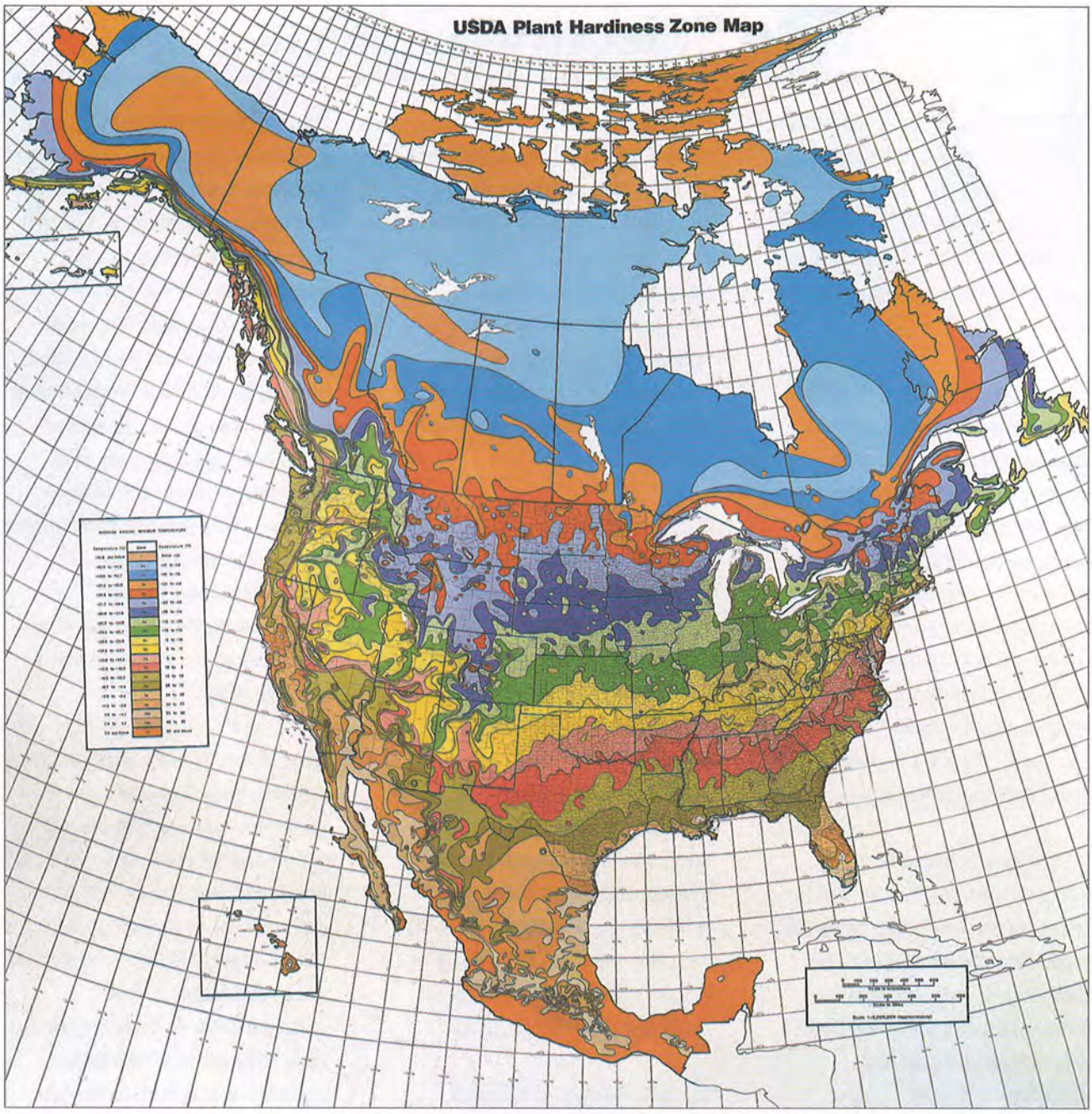


Figure 5. USDA Plant Hardiness Zone Map (courtesy *Agricultural Research* magazine, USDA)

Site Selection Criteria

The influences of climate, location and soils discussed previously along with site and cropping history, future site use and fire management issues should all be considered when selecting planting sites.

Evaluation of the soil characteristics and topographic features will assist in determining the type of vegetation needed to meet the desired habitat management objectives. However, some site conditions are simply not conducive to growing warm season grasses. This is the situation with soils that remain wet because of poor internal drainage, continuous flooding or certain geomorphological features.

If a planting is intended to trap nutrient laden runoff from highly erosive sites, bunch forming grass species should not dominate the seed mixture. Rhizomatous (sod forming) species would be better able to meet that planting objective.

Future site use may seem an odd concern, but if the site is likely to be shifted to a new land use such as a housing development or a park in a few years, then planting to native grasses makes little sense. Fire management of warm season grasses becomes much more difficult when buildings or other structures exist within or immediately adjacent to the grass stand. Where such conditions exist, it may not be practical to use native grass species if controlled burns should be used as a management tool. Conversely, human activities that are better served by turf can become difficult or impossible to carry out in tall native grasses.

Since some historically significant sites fall under legal protection, site history should also be a consideration, particularly on areas undisturbed by farming operations. Occasionally, remnants of Native American burial grounds or villages, pioneer cemeteries or other culturally rich settings occur in these locations. As records of these sites often do not exist, a transect of the area should be conducted by a trained individual. Sensitive sites may sometimes be planted using no-till methods to avoid risk to buried artifacts.

Cropping history, if known, provides important information about herbicide use, crops grown and weed problems that have occurred in the past. Herbicide history from previous years is most important to determine if carry over problems may exist. With most of the chemicals in use today this is unlikely to be a factor. Exceptionally high rates of atrazine or simazine in the previous year could pose a threat, particularly to cool season grasses and forbs or wildflowers. Warm season grasses will typically benefit from residual effects of normal triazine rates. Very high rates in the previous year (4 lb/ac and up) could hinder establishment of even these grasses on lighter soils. Indiangrass appears to be particularly sensitive to triazine residues. Very persistent chemicals such as Tordon can negatively affect the success of forbs and other broadleaf plants even when used several years prior to the planting date.

Crop history is most important for predicting weed pressures on a given site. Of particular interest is the number of years since the field was last in sod. Pasture and hay crops are the most difficult to follow, especially for warm season grass establishment. Poorly managed fields in those crops may have infestations of persistent perennial weeds such as thistles and quackgrass, or may have competitive rhizomatous grasses such as reed canarygrass and smooth bromegrass. These strong competitors can exist as living rootstocks that will reappear immediately or as seed which germinates along with the planted species.

Warm season grass plantings have been very successful when they follow an annual cropping rotation in which the preceding crop was corn treated with atrazine. For cool season grasses the same scenario is most favorable when the last crop was a small grain. It is a safe bet that there will be surprise weeds in some plantings. These typically arise from seeds that were dormant in the soil for an extended period of time. Most of the surprises seem to occur in plantings that follow long-term sod.

Soil drainage was mentioned under Geographic Considerations, but will be considered again here. Poor soil drainage can be caused by natural factors such as a seasonally high water table over hardpans or it may be due to farming practices that cause compacted layers below the surface. A soil survey report will help in spotting soils with natural problems and the report can also help to predict where soil compaction is most likely. Digging test holes can help determine where an impervious layer is, how thick it is and with lab analysis, the bulk density – the weight of a given volume of soil. Soil bulk densities greater than 1.4 to 1.5 g/cc can be detrimental to seedling establishment and growth. A penetrometer can also be used to measure the toughness of the hardpan or compacted layer. Roots have a difficult time penetrating the dense layers regardless of whether these are natural or created compaction zones. Sites where compacted zones are suspected or identified should have sampling and analysis done to determine the extent and degree of compaction. Research is currently underway to better understand how some native warm season grasses are able to penetrate the denser soil zones.

Compacted soils have a secondary impact on successful grass establishment by creating artificially wet conditions during the spring freeze and thaw period. Frost heaving is accentuated on these sites. Clay soils can be naturally dense and poorly drained, and are more easily damaged than are most silt loams and sandy loams. Clay contents above 30 percent should alert planners to the possibility of negative clay influences. Some natural hardpans and most compacted layers can be modified through the use of mechanical equipment. A visit to the site by a soil scientist can help determine the nature of the obstacle and estimate the cost and feasibility of remedial action. Such action may not be necessary for a cool season grass planting, but may be mandatory for warm season grass success.

Representative soil samples should be taken for each proposed planting site and analyzed by a reputable soil testing laboratory. If the site contains significant areas of two or more distinctly different soil types or conditions, each of those areas should be sampled separately (Figure 6). Conditions may be sufficiently different to warrant using individualized treatments (seed mixtures, etc.) for each distinct area.

The soil test results will guide lime and fertilizer applications. Nutrient and lime status can be improved relatively inexpensively. Therefore, low nutrient status or moderately low pH are not major site selection limitations. The exception to this is where the soil is strongly acid and lime requirements are high. For cool season plantings pH readings should be corrected to at least 6.0 and 5.5 for warm season plantings. A good rule of thumb is to use a ton of lime for each tenth of a point below those targets to figure out where the critical expense point will fall for a particular project. Applications of over three tons per acre need to be incorporated. Heavy applications should have a year to react and bring the pH up to acceptable levels before planting.

Site selection inspections should also include a thorough monitoring of the weed species present on the site. The weed/weed seedling identification guides available from many universities or agriculture departments are useful aids when monitoring weed populations. The information can be invaluable when planning the preplanting weed control program for the site.

These frost heaved eastern gamagrass seedlings are exposed to dessication during the spring after they were planted on a somewhat poorly drained soil.

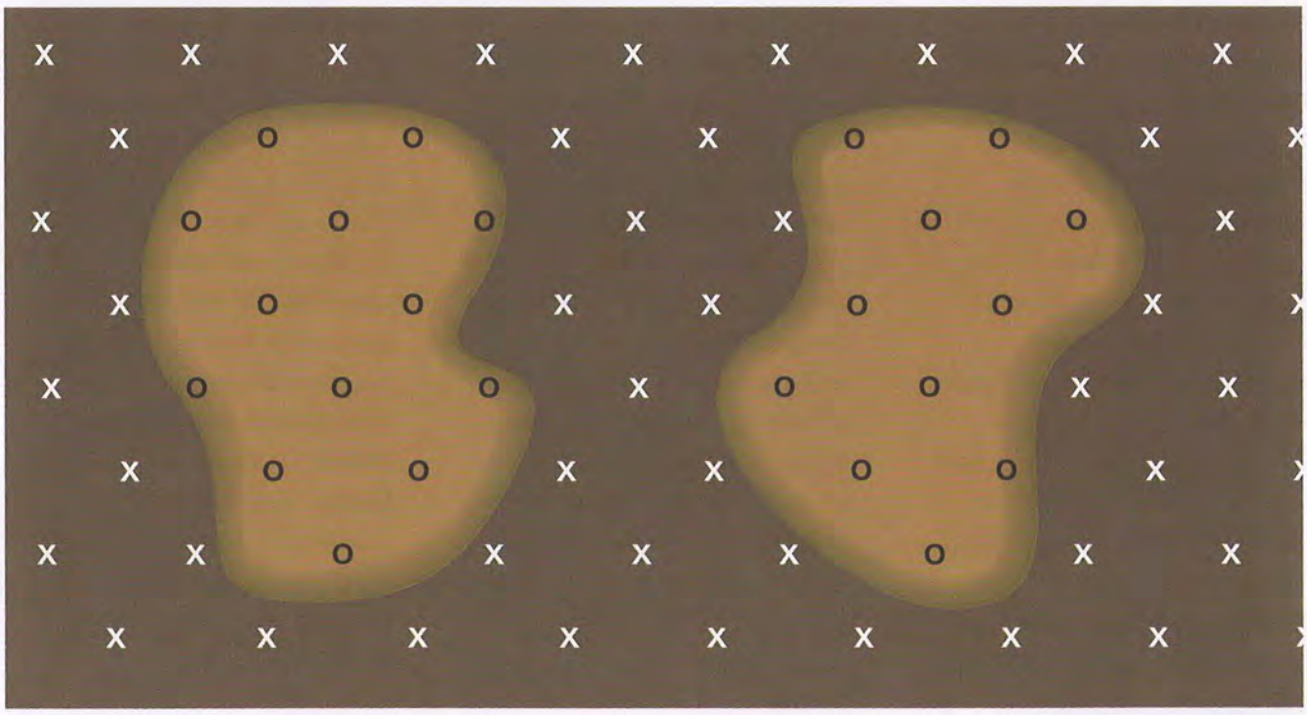


Figure 6. Soil testing locations (x and o) to sample two different soil types in one planting site.

Planting Considerations

It is often recommended that warm season grasses be sown in late winter to early spring at roughly the same time as cool season grasses. If this is done, there is a risk that the warm season grasses will be subject to severe competition from cool season weeds. In those parts of the country where warm season grasses dominate, this competition may not be a problem. Where cool season grasses and weedy herbaceous plants are aggressive and persistent, the cool season species can dominate a newly sown site before the warm season grasses even germinate.

In steeply sloping areas where erosion control is essential or on soils which tend to crust, a cool season companion grass may be necessary. It is imperative that noncompetitive species be used for this purpose. Many regional NRCS Plant Material Specialists and USDA Plant Material researchers are cautious of mixing warm season and cool season grasses because of repeated failures with the warm season component of the mix.

Ducks Unlimited frequently uses mixtures of warm and cool season grasses in plantings in the Canadian prairie provinces. To offset the apparent competitive advantage enjoyed by cool season seedlings during early stand establishment, DUC attempts to favor the warm season plants in two different ways. Very competitive cool season species like slender wheatgrass and western wheatgrass are only included in the mixtures at very low rates (0.1 to 0.5 PLS pounds per acre). If seed of a less competitive early successional cool season grass like Canada wildrye is available, it is often used in place of slender wheatgrass in the planting mixture. In addition, wherever possible, the stands are managed with a late spring controlled burn timed to favor the warm season grasses in the year following planting. While those techniques have been successful in retaining the warm season component in those plantings on the Great Plains, they have not yet been adequately tested under the soil and climatic conditions found in the northeast. This approach may be particularly useful on heat deficient sites, sites which are prone to frost heaving or droughty, erosion prone sites. In those situations, the inclusion of cool season grasses may provide improved vegetative cover. It will become more feasible as regionally adapted plant material becomes more readily available.

If a companion crop is absolutely necessary, an annual such as oats (at a rate of 20 lb/acre) or a noncompetitive perennial such as redtop (1 lb/acre) or one of the fine fescues (15 lb/acre) should be used. It may also be possible to use an early successional cool season native species like Canada wildrye (0.5 lb/acre) or slender wheatgrass (0.25 lb/acre). One should be aware that using these species may limit the selection of herbicides that can be used for postplanting grassy weed control.

Nitrogen fertilizer should not be applied until midsummer on warm season plantings and then only on sites with very low fertility that have very low populations of weeds or cool season grasses. Earlier application will favour the cool season plants. A second application of nitrogen fertilizer is highly desirable during the second growing season. In most instances, if a starter fertilizer is applied with the seed, it should contain a high proportion of phosphorus to stimulate root development. On very coarse soils, it may be appropriate to apply nitrogen with the initial fertilizer.

Warm season native grass plantings are a relatively recent development in much of the northeast. A wide variety of establishment techniques have been attempted with equally variable degrees of success. Given

the fact that conditions vary greatly within relatively small distances, it is likely to be some time before standardized successful establishment techniques are identified for all the conditions found in this region. Revegetation practitioners who test new methods, keep detailed records and then share the information they gain with others can help hasten the development of successful seeding techniques for the northeast.

The importance of keeping detailed records cannot be overemphasized. In their absence, there is no way to determine the reasons for the success or failure of any individual planting or seeding technique.

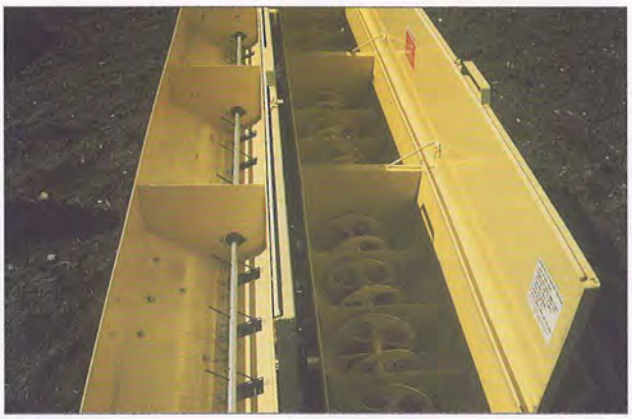
Until successful methods are identified for areas in which they are not presently known, all plantings should attempt to meet certain basic standards. Seed placed into a firm, moist, weed free seedbed by equipment which ensures good seed to soil contact has a much better chance to establish than does seed which is planted without ensuring that any or all of these standards are met.

Stands of warm season grasses are generally much slower to develop than cool season stands. The success of the seeding is often difficult to judge until midseason of the second year. Judgement after the first growing season may lead to the false conclusion that the seeding has been a failure. The low amounts of first year cover may lead to problems in determining compliance with establishment criteria and cover requirements.

Most specialists in warm season grasses strongly favor the use of a native seed drill or a range drill equipped with chaffy seed boxes to handle awkward seed shapes. The normal lawn or landscape seed drill will not be able to properly sow the varied seed shapes of the warm season grasses and the seed boxes may clog. All these seed drills are difficult to use on wet soils because of soil sticking to the packers. It is not impossible to manufacture a wet ground native seed drill, but such drills are very rare.

If warm season grass establishment is so troublesome, why provide specifications for its use? The answer is straightforward. If successfully established, native warm season grasses offer superb wildlife habitat regardless of the season. They are also among the most esthetically pleasing habitats.

Drills specially designed to plant native grasses can seed into many different types of seedbeds.



Seed box agitators help to maintain an even flow of native grass seeds to the furrow openers.

Native grass plantings can provide both nesting and escape cover for wildlife.

The addition of adapted forbs to the seed mixture increases the diversity and beauty of a planting.

Incorporating lime to adjust soil pH prior to making a native grass planting at Londonderry, NH.

Seed

Purchasing quality seed is an essential first step for a successful planting. The purchase of Certified seed will assure quality and proper seed identity. Certified seed provides the maximum possibility for a successful planting, because it assures the buyer about three key seed variables:

- The seed you are buying is certified by an independent organization to be of the genetic makeup you desire.

- The germination percentage of the seed lot meets the quality standards for certified seed. Poor germinating seed will not be certified and the frustration of planting dead seed can be avoided.

- The weed seed content of the certified seed lot also meets quality standards. There will be few weed seeds and no noxious weed seeds. The embarrassment (and potential legal responsibility) of planting noxious weeds can be avoided and failure due to weed competition is less likely.

Bags of certified seed will have a certified identification tag attached (Figure 7). Certified seed tags from some US states also list some of the parameters found in seed analysis reports – percent pure seed, percent inert (dead materials including leaf and stem pieces), percent germination, and percent dormant seed. Bags without a certified tag contain common seed.

If certified seed of adapted cultivars is not available, it may be necessary to purchase common seed. In Canada these bags generally display a tag (Figure 8) marked Canada #1 or Canada #2 which refers to the level of weed seed contamination. While common seed cannot be sold by cultivar name in Canada, it can in the United States. The best the purchaser can do is to attempt to determine the genetic origin of the seed lot. Note that this is different than the source of the seed lot. A seed lot may contain genetic material that was originally collected in West Virginia (the origin) but grown in Michigan (the source). The marketplace sometimes confuses origin and source. As a safeguard, seed buyers should request that the point of origin be stated on the seed analysis report for common seed.

It is recommended that native seed not be moved more than 300 miles (480 km) north or 200 miles (320 km) south of its point of origin[21]. These limitations serve to minimize problems with hardiness and disease susceptibility. These guidelines were developed after decades of experience in testing cultivars in the plains region. In the region covered by this manual, east-west movement is not critical because precipitation variation is not a limiting factor. Elevation is important, however, because an increase in elevation of 1000 feet is equivalent to a move of roughly 175 miles (280 km) north.

The number of native grass cultivars that have been selected for use in the northeast is limited compared to the number for the plains region. Efforts are underway to improve the situation. In the interim, some midwestern cultivars have proven to be useful and adapted in the northeast, and these are listed along with the eastern cultivars in Appendix C.

Figure 7. US Certified Seed Tag

Figure 8. Canadian Common Seed Tag

Test No. 4845 *(Always indicate this number when referring to this report)*

PI-430340

Switchgrass Shelter *

Lot SBR96PAVI1 Germination 57 %

Pure Seed 98.35 % With Prechill ____ %

Weed Seed .01 % Hard Seeds ____ %

Inert Matter 1.63 % Total ____ %

Crop Seeds .01 %

Seeds Per Pound**

Date Test Completed 3/13/97

Sam Received: 2/13/97

Marked:

Field No.

Crop:

IMPORTANT: - Since the Seed Laboratory has no control over the manner in which the sample sent for testing is drawn, it is understood that this report is presumably accurate only for the sample sent and is not a guarantee of the lot from which it was taken. Whoever makes use of this information or copies it upon a tag or label is guaranteeing that the sample is representative of the lot from which it was taken and therefore must stand responsible.

*In most cases it is not possible in laboratory analysis to identify varieties. Therefore, unless otherwise specified, any variety name given here is merely that designated by the person who submitted the sample. Under the provisions of the New York seed law, the vendor of the seed is held responsible for making certain that the seed is actually of the variety indicated on the label. If the variety is not definitely known, its name should not appear on the label.

** These seeds and the number per pound of each are required to be listed on the label if the seed is offered for sale in New York State.

The inert matter consists of empty glumes, diseased seeds

The noxious weed seed examination was made on 40 grams ____ lbs. Contaminants not indicated above are as follows:

CONTAMINANT	Approximate No. of Seeds per Pound of Sample*	Per Cent by Weight	CONTAMINANT	Approximate No. of Seeds per Pound of Sample*	Per Cent by Weight
Weed Seeds:					
Redroot amaranth					
			Crop Seeds:		
			Deertongue		

☐ N.R. - The Association of Official Seed Analysts has not adopted rules for testing the germination of this kind of seed. In the absence of such rules, we have provided the best estimate of germination that we could.

- Where the number per pound is not indicated, the seeds were present in relatively small amounts and the rate of occurrence was not determined.

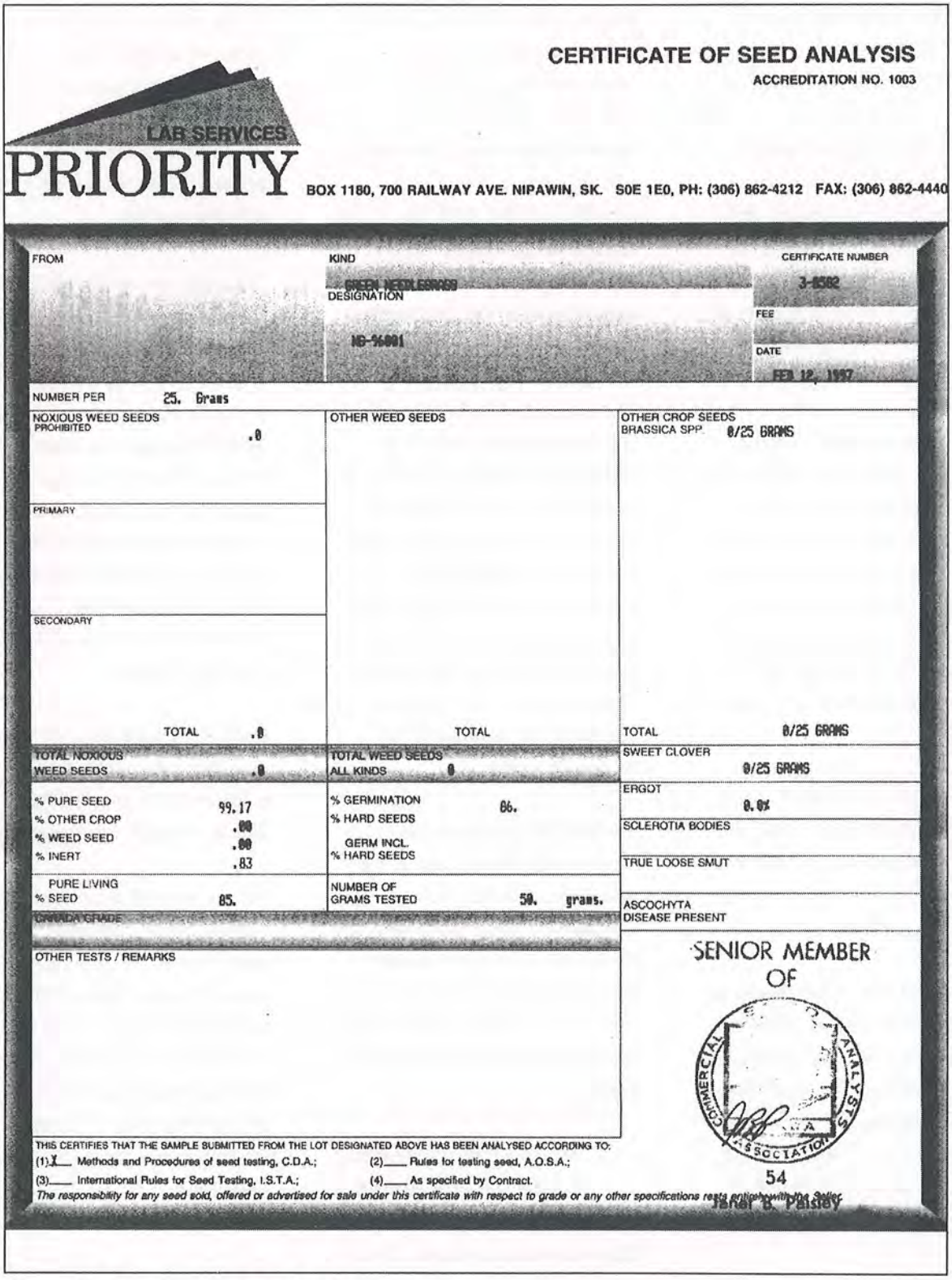
Charge for analysis and test reported on this sheet..... Paid $ ____ Due $ 22.00

Prechill to follow.

SEED TESTING LABORATORY
New York State Agricultural Experiment Station
Geneva, New York 14456

Ellen M. Chirco, Director of Seed Testing Services
(315) 787-2242

Figure 9. US Seed Analysis Report



CERTIFICATE OF SEED ANALYSIS

ACCREDITATION NO. 1003

LAB SERVICES

PRIORITY

BOX 1180, 700 RAILWAY AVE. NIPAWIN, SK. S0E 1E0, PH: (306) 862-4212 FAX: (306) 862-4440

FROM

KIND
GREEN NEEDLEGRASS

CERTIFICATE NUMBER
3-8582

DESIGNATION
NB-96001

FEE

DATE
FEB 12, 1997

NUMBER PER 25. Grams

NOXIOUS WEED SEEDS PROHIBITED	OTHER WEED SEEDS	OTHER CROP SEEDS
.0		BRASSICA SPP. 0/25 GRAMS
PRIMARY		
SECONDARY		
TOTAL .0	TOTAL	TOTAL 0/25 GRAMS

TOTAL NOXIOUS WEED SEEDS	TOTAL WEED SEEDS ALL KINDS	SWEET CLOVER
.0	0	0/25 GRAMS

% PURE SEED	99.17	% GERMINATION	86.
% OTHER CROP	.00	% HARD SEEDS	
% WEED SEED	.00	GERM INCL. % HARD SEEDS	
% INERT	.83		
PURE LIVING % SEED	85.	NUMBER OF GRAMS TESTED	50. grams.

ERGOT 0.0%

SCLEROTIA BODIES

TRUE LOOSE SMUT

ASCOCHYTA DISEASE PRESENT

CANADA GRADE

OTHER TESTS / REMARKS

SENIOR MEMBER OF

COMMERCIAL SEED ANALYSTS ASSOCIATION

54

Janet B. Paisley

THIS CERTIFIES THAT THE SAMPLE SUBMITTED FROM THE LOT DESIGNATED ABOVE HAS BEEN ANALYSED ACCORDING TO:

(1) X Methods and Procedures of seed testing, C.D.A.; (2) ___ Rules for testing seed, A.O.S.A.;

(3) ___ International Rules for Seed Testing, I.S.T.A.; (4) ___ As specified by Contract.

The responsibility for any seed sold, offered or advertised for sale under this certificate with respect to grade or any other specifications rests entirely with the seller.

Figure 10. Canadian Seed Analysis Report

When purchasing seed, request that the dealer provide a seed analysis report. The seed analysis report is the buyer's only opportunity to exercise quality control on seed lots. This report will identify the laboratory where the analysis was performed, the data listed on the certified seed tag plus percent hard seed, percent of other crop seed (a big bluestem seed lot might contain some switchgrass seed, etc.) and a list of weeds seeds and their amounts. Ask the dealer to report the data at the 0.01 percent level. Avoid dealers who will not provide this information prior to the sale. A call to the test lab can clarify the information if there appear to be problems. Typical seed analysis reports were presented in Figures 9 and 10.

To ensure access to suitable seed, purchases should not be delayed. Seed procurement activities should begin at least three months before the seed is required.

Seed should not be purchased as mixtures. Buy seed of individual species and create the mix that you require. Mix the seed only when the planting is sure to be done. Once the seed is mixed, it cannot be separated except at great expense.

Ducks Unlimited Canada has established a zero tolerance for weed species such as downy brome, hairy chess, rattailed fescue, Japanese brome, smooth brome, quackgrass, purple loosestrife and other invasive species in seed lots. These weeds present management challenges in plantings and may escape to neighboring land. DUC has a clear understanding with distributors and dealers that all seed lots containing objectionable weeds will be rejected.

There are many desirable native species which are valuable in plantings for which no tested and released cultivars are available. For these, seed from native stand harvests may be all that is available in the marketplace. This seed is useful, provided it was harvested in the vicinity (within 150 miles/240 km) of the area proposed for planting and has acceptable quality.

The NRCS' Plant Materials Program developed many of the native species which are now available for revegetation work in the United States. Traditionally, plant material was released as a cultivar (i.e. named variety) which had been extensively selected and tested.

Since 1993, the NRCS and others have also adopted some alternative methods to release plant material[20]. These new methods have helped to address two major needs. Firstly, plant material which has undergone testing can be released for commercial production and be on the market in just two to four years, rather than the six to ten year testing period that is common for cultivars. Secondly, plants which are adapted to a limited area or need can be released in a cost effective manner.

Plant releases can now fall into one of two groups: **natural**, where no intentional manipulation of the original germplasm has occurred or **manipulated**, where purposeful genetic manipulation (multiple crosses, selection for superior traits) has taken place. Within each of these groups, four levels of release would be possible (Table 1). With the exception of bulk populations, each release level could be certified.

Bulk Populations are not usually released to the public, but may be made available to individuals for further research and development.

Source Identified material is seed or plants from a naturally growing population in a known or defined geographic area. It has had no selection or testing. Seeds for commercial sale may be collected from the wild or grown under cultivation. It may be certified by the seed certification agency in the source state.

Table 1. Levels of release for manipulated and natural plant material

Manipulated	Natural
1. Bulk Populations (F1's)	1. Source Identified Class
2. Selected Class	2. Selected Class
3. Tested Class	3. Tested Class
4. Cultivar/Variety	4. Cultivar/Variety

Selected material, as the name implies, has been through some testing and shows some desirable superior trait or promise of performance when compared to other plant material of the same species at a common site. It has not been tested at multiple sites or for more than one year, so its performance has not been proven.

Tested material has been through additional testing – multiple sites, replicated plots – to verify performance and the heritability of desirable traits. Its complete range of adaptation may not be known.

Cultivars have been through replicated tests at multiple sites for two or more generations. That testing will prove and document the heritability of traits, the superiority and/or performance and the range of adaptation.

Table 2 lists the species presently under development at northeastern Plant Materials Centers. The cultivars which have already been released by PMC's in this region are shown in Table 3.

Table 2 . Native and naturalized (*) herbaceous species in selection and development processes at northeastern Plant Materials Centers.

Species	Origin	PMC	Goal of Cultivars(s)?
GRASSES			
beaked panicum	mid-Atlantic	MD	yes
bitter panicgrass	mid-Atlantic	NJ	no
big bluestem	WI, MI, IN	MI	yes
	mid-Atlantic	MD	yes
bushy bluestem	VA	MD	yes
eastern gamagrass	KS, MD, others	NY	yes
	mid-Atlantic	MD	yes
Florida paspalum	mid-Atlantic	MD	yes
indiangrass	NY and mid-Atlantic	NY	yes
	mid-Atlantic	MD	yes
little bluestem	mid-Atlantic	MD	yes
poverty oatgrass	ME	NY	no
prairie cordgrass	NY and N. England	NY	yes
prairie sandreed	Great Lakes shoreline	MI	yes
purple lovegrass	mid-Atlantic	MD	yes
purpletop	KY, WV, NC, OH	KY	yes
	mid-Atlantic	MD	yes
red fescue*	ME	NY	no
redtop*	NY and MI	NY	yes
sea oats	mid-Atlantic and SE	NJ	yes
shortbeard plumegrass	mid-Atlantic	MD	yes
splitbeard bluestem	mid-Atlantic	MD	yes
sugarcane plumegrass	mid-Atlantic	MD	yes
slender woodoats	mid-Atlantic	MD	yes
sweetgrass	MI	MI	no
switchgrass	VA, NY	NJ	yes
	NC	NJ	yes
	mid-Atlantic	MD	yes
Virginia wildrye	mid-Atlantic	MD	yes
FORBS			
New England aster	ME	NY	no
New York aster	ME	NY	no
seaside goldenrod	mid-Atlantic	NJ	no
stiff goldenrod	ME	NY	no
LEGUMES			
tickclover (3)	Great Lakes	MI	yes

Table 3. Native herbaceous species and cultivars selected for northeastern conditions at Plant Materials Centers

Species	Cultivar	Origin	PMC
GRASSES			
American beachgrass	'Cape'	MA	NJ
big bluestem	'Niagara'	NY	NY
coastal panicgrass	'Atlantic'	mid-Atlantic	NJ
deertongue	'Tioga'	PA, NY	NY
saltmeadow cordgrass	'Avalon'	NJ	NJ
smooth cordgrass	'Bayshore'	NJ	NJ
switchgrass	'Shelter'	WV	NY
FORBS			
blackeyed susan	'Golden Jubilee'	VT	NY

As part of its seed mix development program, DUC planted a 42 cultivar, nine species warm season grass test plot in southern Ontario in 1994. Located on moderately heavy soils in plant hardiness zone 6a, the plot was designed to examine the performance of varieties from a range of origins in a region typical of DUC's eastern nesting cover plantings. The varieties were assessed for plant vigor, viable seed production and resistance to lodging. Assessment of the plot is still ongoing, but to date several varieties (bolded in Table 4) have performed well enough to be included in DUC seed mixes for Ontario.

Table 4. Varieties of warm season grasses with potential value as wildlife cover in southern Ontario

Species	Cultivar (Origin)
Big bluestem	**'Bison'** (ND), 'Bonilla' (SD), 'Champ' (KS), 'Kaw' (KS), **'Niagara'** (NY), 'Pawnee' (KS), 'Rountree' (MO), 'Sunnyview' (SD/MN)
Little bluestem	**'Aldous'** (KS), **'Blaze'** (NE), 'Camper' (NE), **'ND-4115'** (ND)
Sand bluestem	'Garden' (NE), 'Goldstrike' (NE)
Indiangrass	'Holt' (NE), 'Oto' (KS), **'Rumsey'** (MO), **'Tomahawk'** (ND/SD)
Sideoats grama	'Killdeer' (ND), **'Pierre'** (SD), **'Trailway'** (NE)
Prairie cordgrass	'PMK-686' (NE)
Switchgrass	'Blackwell' (KS), **'Cave-In-Rock'** (MO/IL), 'Dacotah' (ND), 'Nebraska 28' (NE), **'Shelter'** (NY), **'Summer'** (SD), 'Sunburst' (SD), 'Trailblazer' (NE)

Preparing a Seed Mix

Pure Live Seed

Native warm season grass seed has been specified and sold for many years as pure live seed (PLS). This methodology was developed to compensate for the wide variation in quality of the seed of chaffy grasses like big and little bluestem, indiangrass and sideoats grama. The PLS approach is spreading to other types of seed as people understand the method and the importance of buying and selling on a uniform system. One way to approach the PLS concept is to compare it to net weight. When we buy most products by weight, we think in terms of the price of the actual product. The corn flakes box has a net weight printed on it and we compare one brand with another by how many ounces of flakes we get per dollar. We can do the same thing with seed by using the PLS system to factor out the weight of dead seed, sticks and stems, and weed seeds. We only want to pay for the viable seed of the species or cultivar we are buying. To do that we calculate the PLS percentage from the information on the seed analysis report for a given lot of seed.

To determine pure live seed (PLS) percentage, use this calculation:

PLS % = (purity % x viable seed %) ÷ 100

Where: Purity % = 100% – (weed seed % + inert matter % + other crop seed %)
Viable seed % = germination % + dormant %
Viable seed % can also be determined by the use of a tetrazolium (TZ) test rather than a standard short term germination test.

The percent viable seed is a combination of the seed that is dormant and the easily germinated seed. Dormant seed may not germinate during the first year of planting, but it can add to the stand later. Therefore, one usually adds the percentage of dormant seed to the percent germination to find the total percentage of viable seed which is used in the PLS calculation.

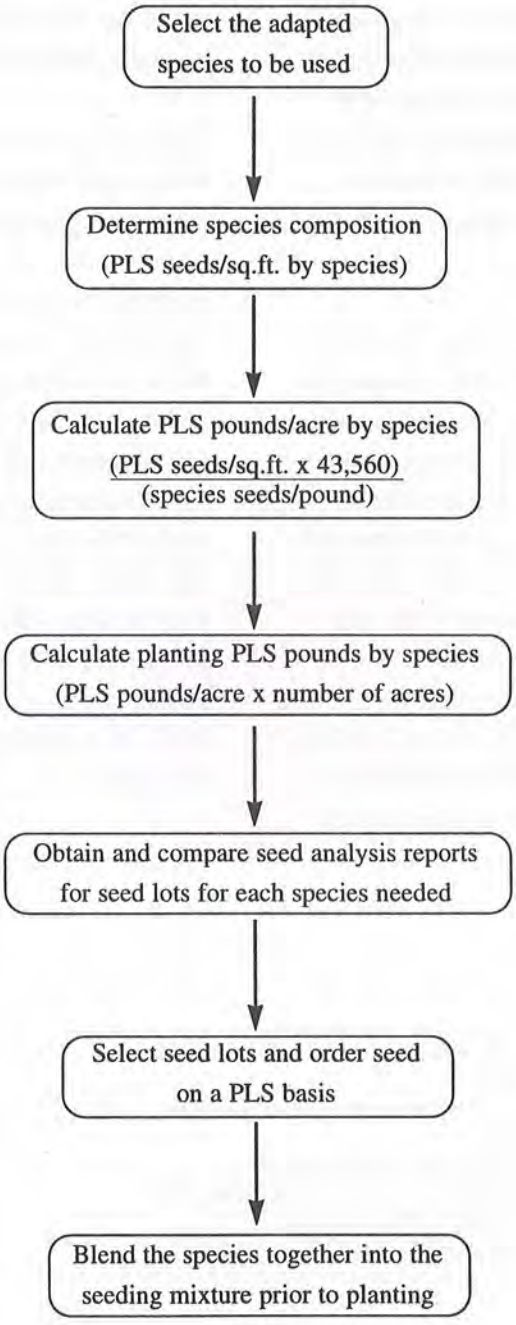
Seed Processing

Chaffy seeds like the bluestems, indiangrass and others, can be processed to rub off some of the appendages that make the seed difficult to plant. Debearded big bluestem is the species most commonly available from this process. While debearding adds to the cost of the seed and may be more or less successful on different lots of seed, it can help to improve seed flowability. Debearded seed may not be necessary when native grass drills are used. Another seed processing technique called seed coating can also help improve flowability, particularly for species like little bluestem which have light, chaffy seeds.

The Seed Mix

Typical seeding rates for warm season grass mixtures range from 10 to 15 PLS pounds per acre, which should provide over 30 pure live seeds per square foot. Compared to cool season grass seeding rates, this recommendation seems low. However, the native warm season grass plants are much larger, and a healthy two to three year old plant can easily occupy a square foot of space. Also, most cool season seeding rates are based upon the likelihood of seeding with a hydroseeder, a far inferior method of planting to those recommended in this manual. If satisfactory populations are not obtained with 10 to 15 PLS pounds of warm season grass seed, then the fault lies in technique or unsuitable site conditions, not the seeding rate. Figure 11 presents a flow chart of activities to follow when planning and obtaining a seed mixture for a specific planting.

Figure 11. Planning and Obtaining a Seed Mixture



Seed mix options for native grass plantings in the east are currently limited due to the modest number of cultivars that are available commercially. There is seed of native forbs and legumes that can be added to the basic warm season grass mix to add diversity.

The most extensive work in the northeast on establishment of warm season grasses has been done on sand and gravel pits in New England.[4] The researchers based their planting recommendations on the percentage of fines in a soil sample. If fines, soil particles passing a 200 mesh sieve (fine sands or finer), were below 15 percent, warm season grasses were the best choice for long term stability of the site. If fines were between 15 percent and 20 percent, a warm season grass/legume mix is recommended. As the percentage of fines increased above 20 percent, the flexibility of recommended mixes increased and could include a drought tolerant cool season mix.

Ducks Unlimited Canada usually designs their seed mixtures based on PLS seeds per square foot. Due to relatively poor seedling vigor, native grass seedling establishment is normally estimated at 20 to 25 percent of the PLS seeding rate. To achieve an establishment rate of eight or ten seedlings per square foot, for example, a PLS planting

rate of approximately 40 seeds per square foot is required.

The species composition of the planting is determined by assigning relative proportions of the total of 40 seeds to each of the species being included in the mixture. If a five species planting was intended to present each species in equal amounts, the mixture would include eight PLS seeds of each per square foot. If the planting objective were different, the mixture might still contain the same five species, but each would be present in differing amounts.

Once the species composition and proportions have been determined, the number of PLS pounds of each species needed for an acre of the planting are calculated by multiplying the number of PLS seeds of that species per square foot by 43,560 (the number of square feet in an acre) and dividing the product by the number of seeds per pound for the species (Table 5). Multiplying the PLS pounds of the species required for an acre by the number of acres in the planting determines the total PLS pounds needed for each species. The seed is then ordered on a PLS basis.

After examination and approval of the seed analysis reports for each species, the seed is shipped to the facility which will blend the lots of each species into the planting mixture. To facilitate the seed blending process, DUC prepares mixing instructions for each seed mixture. Those instructions specify the number of bulk pounds of each seed lot required for the mixture. Since all the specifications to this point have been based on PLS values, a conversion factor (CF) is calculated to make it easier to determine bulk amounts from the PLS values.

After the seed mixture has been thoroughly blended, it is rebagged. Special tags are attached to each bag which show the mix number and name, the number of bulk seeds to be planted per square foot and the number of acres that a bag of that seed mixture will cover. The latter two numbers are especially useful when the operators doing the actual seeding are calibrating their drills. The number of bulk seeds per square foot are equal to the number of seeds per linear foot of row for a drill with 12 inch row spacings. If the drill has a different row spacing, the number of linear feet of row required to equal one square foot can be determined by using the values in Table 6.

The process of securing quality seed supplies should begin as early as possible, preferably no later than midwinter before the proposed planting date. By this time, growers will have most seed lots tested and prices established. Waiting until April or May virtually guarantees a reduced number of suppliers with suitable seed still available and may lead to late shipments and subsequent planting delays. US Farm Bill programs have led to increased demand and prices for seed in 1997. Early ordering is vitally important.

Appendix D presents examples of

To calculate a PLS:bulk conversion factor (CF):
CF* = 100 ÷ PLS %
* to minimize the effects of rounding, the CF should be calculated to four decimal places.
Using the CF:
CF x PLS pounds = Bulk pounds
CF x PLS seeds/sq.foot = Bulk seeds/sq.foot
Bulk pounds ÷ CF = PLS pounds
Bulk seeds/sq.foot ÷ CF = PLS seeds/sq.foot

Table 5. Approximate number of seeds per pound of native grass species

Species	Seeds/Pound	Seeds/square foot @ 1 lb/acre
Beachgrass, American	n/a	n/a
Bluestem		
big	165,000	3.8
bushy	n/a	n/a
little	240,000	5.5
sand	100,000	2.3
splitbeard	n/a	n/a
Broomsedge	n/a	n/a
Cordgrass		
prairie	197,000	4.5
saltmeadow	n/a	n/a
smooth	175,000	4.0
Deertongue	400,000	9.2
Dropseed		
sand	5,600,000	128.5
Gamagrass		
eastern	7,500	0.2
Grama		
sideoats	191,000	4.4
Hairgrass		
crinkled	2,400,000	55.0
Indiangrass	175,000	4.0
Lovegrass		
purple	n/a	n/a
sand	1,550,000	35.6
Oatgrass		
poverty	447,200	10.3
Panicgrass		
bitter	n/a	n/a
coastal	350,000	8.0
Panicum		
beaked	n/a	n/a
Paspalum		
Florida	n/a	n/a
Plumegrass		
shortbeard	n/a	n/a
sugarcane	n/a	n/a
Purpletop	161,000	3.7
Sandreed		
prairie	274,000	6.3
Sea oats	n/a	n/a
Sweetgrass	n/a	n/a
Switchgrass	389,000	8.9
Wheatgrass		
northern	154,000	3.5
slender	159,000	3.6
western	110,000	2.5
Wildrye		
Canada	121,000	2.8
Virginia	96,000	2.2
Woodoats		
slender	n/a	n/a

Table 6. Linear feet of row per furrow opener equal to one square foot at various row spacings

Row Spacing	Linear Feet
6″	2.0
7″	1.8
8″	1.5
10″	1.2

several native species mixtures which have been used in this region.

Seed Importation

With the Canadian native seed production industry in its infancy, reclamation agencies in that country will undoubtedly find it necessary to import some seed from U.S. sources. This need not be a daunting task. If desired, seed orders can be placed with any of the larger Canadian seed supply companies. Clearly specify species required, seed quality (certified), minimum standards for weed contamination, warm season grasses debearded (when appropriate), pounds PLS required and delivery date. Request copies of seed analysis reports reported at the .01 percent level prior to accepting delivery. Once a suitable seed lot has been located, the seed supply company will handle seed importation. Remember, only accept certified seed of cultivars known to be suitable for Canadian conditions (Appendix C).

To maintain tight quality control or to buy seed at a reduced rate, a purchaser can deal directly with U.S. suppliers. If possible, always get quotes from three or more suppliers. Clearly specify the requirements and ask to see a seed analysis report prior to agreeing to purchase any seed lot. Grass seed does not require a phytosanitary certificate. However, certain shrub and wetland species do.

Inform the seed supplier that each seed lot must be tested to meet Canadian import standards. This greatly improves the speed with which seed clearance occurs. We do not recommend accepting a seed lot/analysis report that does not specify "Tested to meet Canadian import standards". Without this designation, a seed lot must be retested at an accredited seed laboratory in Canada before Agriculture and Agri-Food Canada (AAFC) will release it to the importer. Purity and germination tests can take a month or more to complete, at a cost of approximately $100. If the retest reveals that the seed lot does not meet AAFC or the reclamation agency's standards, a serious delay could result.

Deal with a customs broker when importing seed from the U.S. The broker will handle border crossing formalities. Virtually every customs broker is familiar with the procedure. Always ensure that the seed supplier provides a copy of the invoice and copies of the seed analysis reports to Canada Customs officials. The broker or Canada Customs then forwards copies of the invoice and the seed analysis reports to the AAFC District Program Officer who ultimately releases the shipment. To expedite the process, the seed purchaser should furnish seed analysis reports to AAFC at or before the time the seed arrives at Customs. Also, notify AAFC about port of entry at the time of first contact.

Seed import regulations are undergoing changes. Close communication with the Agriculture and Agri-Food Canada official (Table 7) in your region at the time of seed importation is advised.

* To import a species which has

Table 7. Agriculture and Agri-Food Canada contacts for seed importation*

Name/Title	Address	Phone Number
Paul Mailloux, District Seed Program Officer	PO Box 577, Station B, London ON N6A 4W8	(519) 645-4021
Allan Hamilton, District Seed Program Officer	PO Box 6088, Moncton NB E1C 8R2	(506) 857-7670
Jacques Fafard, District Seed Program Officer	Complex Guy-Favreau, 200 Q Blvd Rene Levesque Tour est, Bureau 1002-I, Montreal QB, H2Z 1Y9	(514) 285-8888

not been previously imported to Canada, write to Agriculture and Agri-Food Canada in Ottawa requesting permission well in advance of the expected importation date. Local AAFC representatives can supply submission details and an indication of which species require special permission. Once permission is obtained, future imports of that species can be handled in the standard manner.

Preplanting Preparations

Once a site has been selected for planting, there are several actions that should be taken to ensure success of the project. A closer look at topography, soils and drainage patterns is worth the effort to determine where species mixture changes are practical. The soil types as shown on soil maps may well have inclusions which were not identified during the initial survey. These inclusions may be too wet for reliable establishment of upland species of warm season grass, yet pose no real threat to cool season grasses or the use of lowland warm season species like prairie cordgrass. A closer look to identify such spots is time well spent.

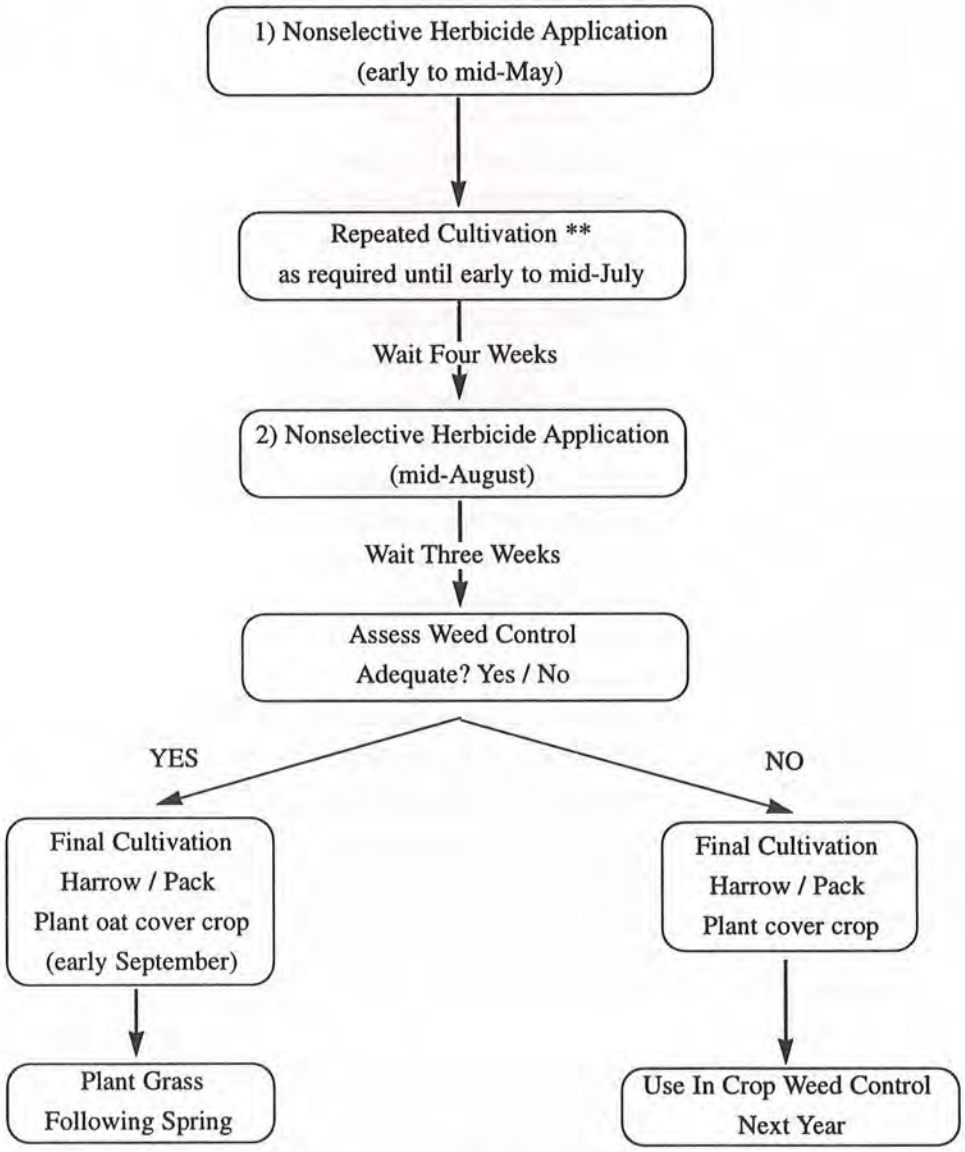
Heavy mulches of crop residues or organic layers from old sods can pose three problems when warm season grasses are being planted with no-till systems. First, the organic layer may be thick enough to hinder the placement of seed into the mineral soil where it needs to be planted. Second, the organic layer will keep the soil cold later into the spring to slow down germination and emergence. A third problem in killed sods is the possibility of high slug populations overwintering in the organic layer and emerging in the spring to find only the young seedlings to eat. These conditions can be overcome by using tillage to incorporate the organic matter, but this works best if done the year prior to planting as part of a preplanting strategy (Figure 12).

As was mentioned in the Site Selection section, soil samples should be taken the year before the grass seed is to be planted. The samples should come from the top four to six inches (10 to 15 cm), and should be collected and analyzed in time for lime applications to be made during the fall if they are required. Soil samples are typically sent to the test lab along with information about the crop to be grown. If the planting will be warm season grasses, be aware that some labs do not have experience with these plants and fall back to a corn recommendation. The nutrient levels required for warm season grasses are much lower than needed for a corn crop, and moderate levels are very adequate. High nutrient levels will be detrimental because this will encourage weed competition. Nitrogen especially must be withheld from new warm season grass seedings, so none should be applied until the second year. The only exception to this rule applies to sand and gravel pit reclamation where there is no weed pressure potential, and also no nutrient content or organic matter. On these sites 80 to 100 lb/ac of ammonium nitrate is needed for the establishment year, but reduce the rate to no more than 40 lb/ac over groundwater recharge areas.

If perennial weed problems like quackgrass and Canada thistle were identified during the initial site selection process, a year or two of advance treatment may be possible with minimal extra effort or expense. It may be possible to modify the herbicide spray program and/or the crop rotation during the last crop year to attack the problem weeds. A preharvest

Some references to specific herbicides and rates of application in this section are based on preliminary research and field experience. Unless stated otherwise, they should not be construed as recommendations for herbicide use under differing conditions and label recommendations. For example, the effect of a particular herbicide on seedlings can vary with the level of weed infestation. In addition, a herbicide may not have an impact on vegetative growth or biomass production, but may significantly reduce seed yields. For specific recommendations for local conditions, refer to state or provincial weed control publications, herbicide label information and experienced local personnel.

Figure 12. Preplanting Year Removal of Invasive Perennial Plants *



* Flowchart for removal of invasive perennials like quackgrass, smooth bromegrass and Canada thistle from headlands, old hayfields, etc.
** Frequency of cultivation will vary depending on soil moisture conditions. One or more cultivations may be replaced by additional herbicide treatments.

Weed	Date	Herbicide	Rate* (L/ac)	Chemical Name	Active Ingred. (g/L)	Active Ingred. (g/ac)	Leaf Stage	
							Crop	Weed
1) annual, perennial weeds	early to mid-May	Roundup	2.0 – 3.5	glyphosate	356	712 – 1245	n/a	3 to 4 actively growing leaves up to 8 inches
2) Canada thistle, quackgrass	late Aug. to early Sept.	Banvel + Roundup + Agsurf	0.5 + 0.7 -1.0 + 0.14	dicamba glyphosate sufactant	480 356 n/a	240 249 – 356 n/a	n/a	quackgrass – 3 to 4 actively growing leaves. Canada thistle – fall rosettes

* Application rates are based on Canadian experience. For appropriate recommendations for U.S. conditions, contact your State cooperative extension service.

application of Roundup on crops for which that label use has been granted can improve the effectiveness of a perennial weed control program. Figures 13, 14 and 15 outline some options for preplanting weed control strategies. State and provincial extension publications are a source of information about herbicide use and effectiveness.

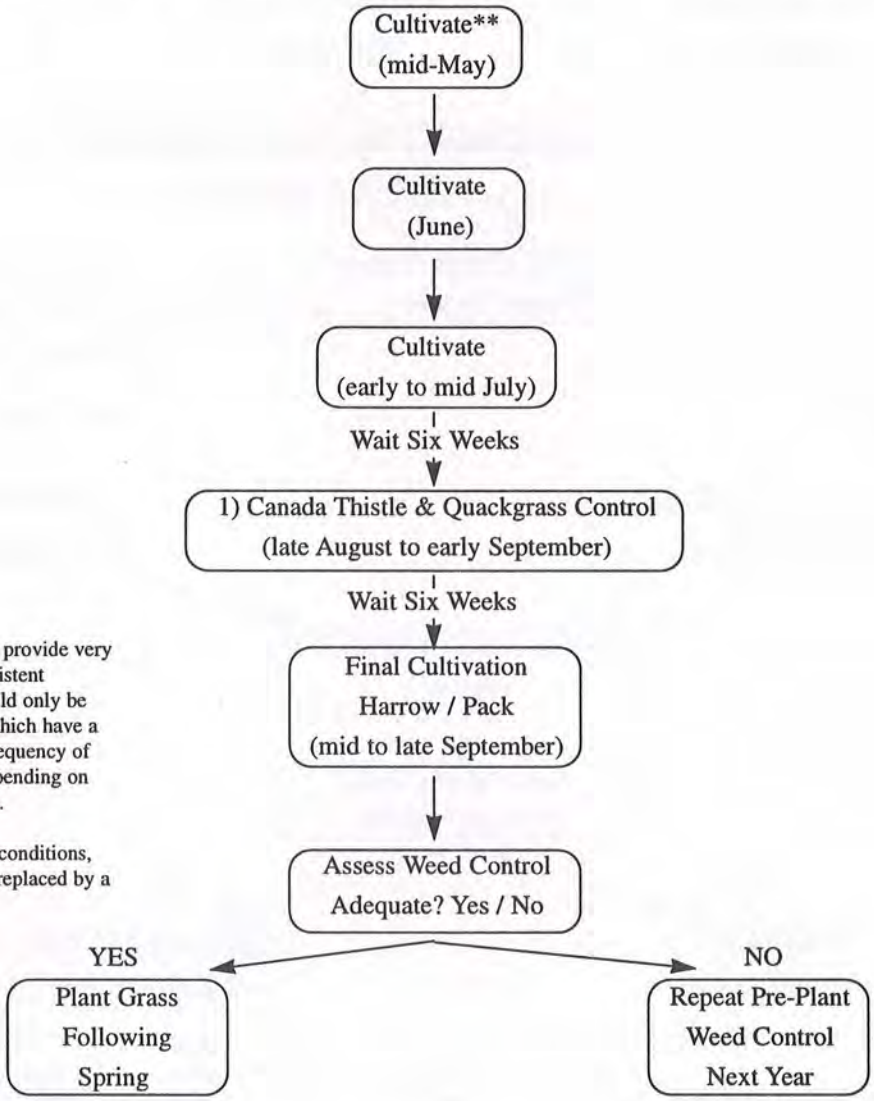
In planning the last year of a crop rotation before planting native grasses, it is a good policy to avoid a cereal rye crop. This grain crop is suspected of adding compounds to the soil which are toxic to some other species. This is known as allelopathy. There are some who believe that winter wheat may cause a similar condition, although the effects can be reduced by removing the windrows of straw after harvest.

The risk to native grasses from allelopathy has yet to be clearly demonstrated, so this a precaution due to the possibility of a negative affect. If a winter cover is needed prior to spring planting, oats are a good choice. Oats will winterkill in our region and do not interfere with planting in the spring. Interestingly, it is sometimes hypothesized that oat stubble is allelopathic to some annual weed species, but we have seen no evidence that it affects the germination or growth of desirable plants.

When planting warm season grasses, some of the most troublesome "weeds" can be introduced cool season grasses such as bromegrass, reed canarygrass, and orchardgrass. Bromegrass and reed canarygrass are a problem because the deep rhizomes can continue to initiate new plants. The new plants aggressively crowd the developing seedlings. Even older warm season plants are pressured in the spring by these species. Orchardgrass is a bunchgrass, but it is a problem because it is somewhat tolerant of contact herbicides such as glyphosate. In no-till plantings where these three grasses are present it is wise to spray both the fall prior to, and the spring of, seeding. Hold off on your planting if the field has a heavy stand of bromegrass, reed canarygrass or orchardgrass and you have doubts about the effectiveness of the control efforts.

Roundup will also provide quackgrass control. For best results do not perform any tillage operation for several months prior to application or for three to five days following application. This will permit the herbicide to be translocated through the undisturbed rhizomes[1]. Be sure to follow label directions and apply recommended rates when using any herbicide.

Figure 13. Preplanting Year Tillage and Herbicide Summerfallow *



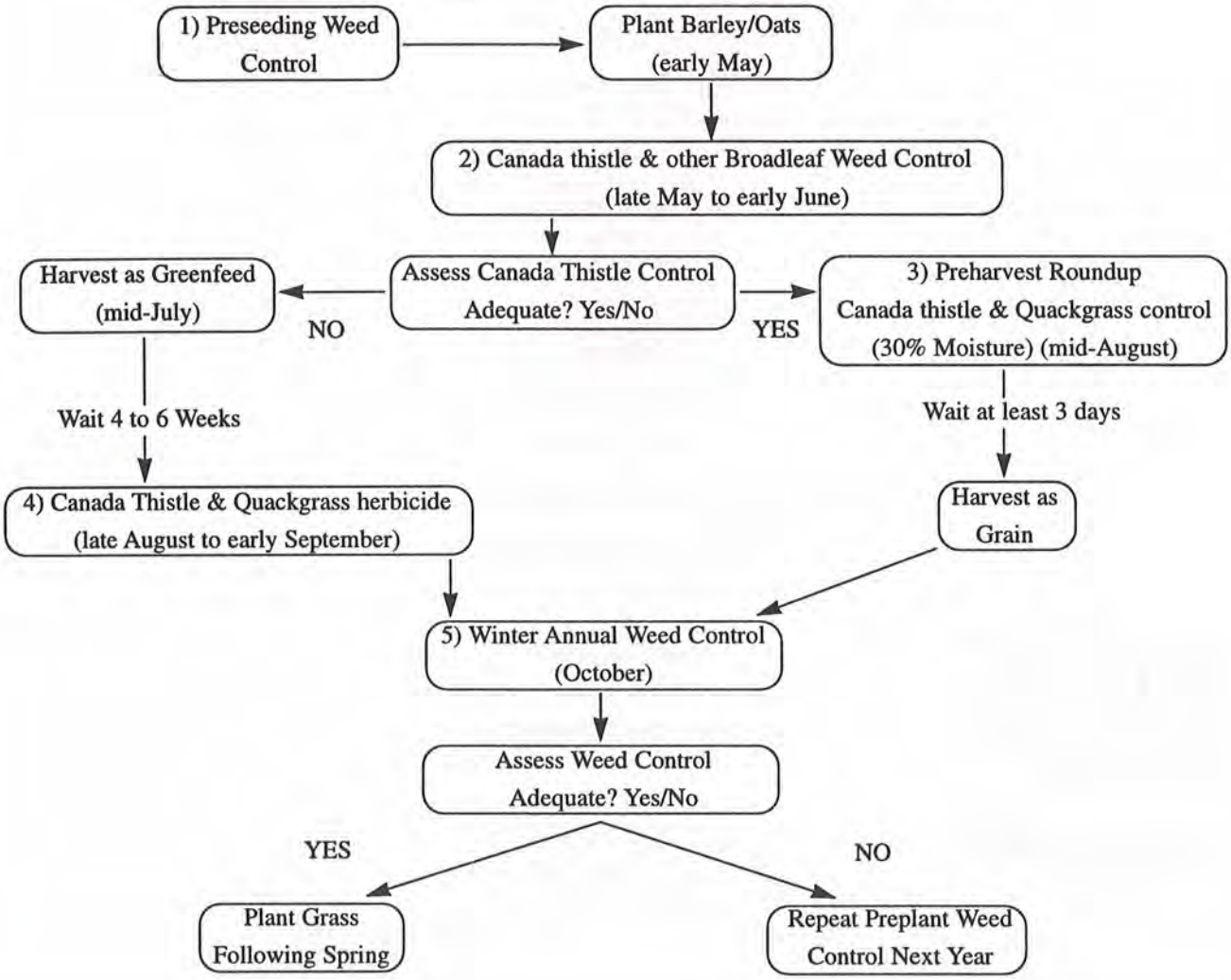
*While this method can provide very effective control of persistent perennial weeds, it should only be used on planting sites which have a low erosion risk. The frequency of cultivation will vary depending on soil moisture conditions.

**Depending upon site conditions, this cultivation may be replaced by a herbicide application.

Weed	Date	Herbicide	Rate* (L/ac)	Chemical Name	Active Ingred. (g/L)	Active Ingred. (g/ac)	Leaf Stage	
							Crop	Weed
1) Canada thistle, quackgrass	late Aug. to early Sept.	Banvel + Roundup + Agsurf	0.5 + 0.7 -1.0 + 0.14	dicamba glyphosate sufactant	480 356 n/a	240 249 – 356 n/a	n/a	quackgrass – 3 to 4 actively growing leaves. Canada thistle – fall rosettes (less than optimal conditions)
quackgrass, grassy weeds	late Aug. to early Sept.	Roundup	1.0	glyphosate	356	356	n/a	quackgrass – 3 to 4 actively growing leaves. Canada thistle – fall rosettes (optimal conditions only)

* Application rates are based on Canadian experience. For appropriate recommendations for U.S. conditions, contact your State cooperative extension service.

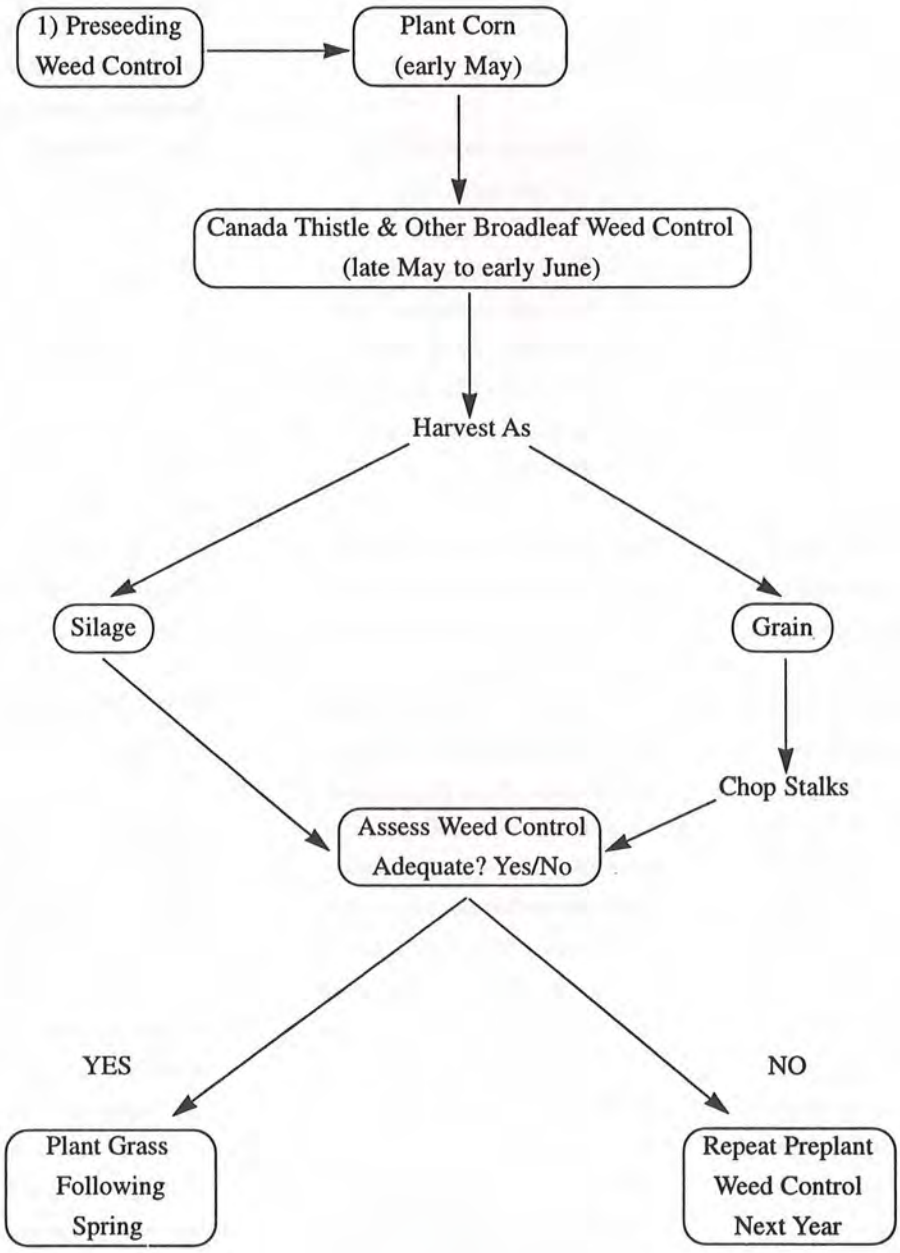
Figure 14. Preplanting Weed Control in a Preceding Small Grain Crop



Weed	Date	Herbicide	Rate* (L/ac)	Chemical Name	Active Ingred. (g/L)	Active Ingred. (g/ac)	Leaf Stage	
							Crop	Weed
1) annual weed, quackgrass	preseeding	Roundup	1.0	glyphosate	356	356	n/a	less than 6 inches
2) annaul broad-leaf, Canada thistle	early June	Lontrel + MCPAester	0.17 - 0.23 + 0.51 -0.69	clopyralid MCPA	360 500	61 – 83 255 – 345	3 to flag	annual weeds – 2 to 4 majority of Canada thistle are 4 inches but prior to bud stage
3) quackgrass, Canada thistle	preharvest	Roundup	1.0	glyphosate	356	356	n/a	quackgrass – 4 to 5 actively growing leaves. Canada thistle – bud stage or beyond
4) Canada thistle, quackgrass	late Aug. to early Sept.	Banvel + Roundup + Agsurf	0.5 + 0.7 - 1.0 + 0.14	dicamba glyphosate surfactant	480 356 n/a	240 249 – 356 n/a	n/a	quackgrass – 3 to 4 actively growing leaves. Canada thistle – fall regrowth
5) winter annual broadleaf weeds	late fall	2,4-D amine MCPA amine	0.34 - 0.45 0.28 - 0.45	2,4-D MCPA	500 500	170 – 225 140 – 225	n/a	fall or spring rosettes

* Application rates are based on Canadian experience. For appropriate recommendations for U.S. conditions, contact your State cooperative extension service.

Figure 15. Preplanting Weed Control in a Preceding Field Corn Crop



Some of the herbicides used for broad spectrum weed control in corn (atrazine, Ultim, etc.) will provide residual control of a range of annual grassy and broadleaf weeds in the following year. If corn is to be used in a cropping rotation the year prior to seeding a warm season native grass planting, contact your local state or provincial extension agent for specific recommendations.

Planting Year Activities

In addition to the planning and preparation that occurs during the preplanting year, a number of decisions must be made in the planting year before the seed actually goes into the ground. These include planting date, seedbed condition, preseeding weed control, seeding rate and equipment and fertilization.

Planting Date

Except for dormant seedings, all grasses should be seeded when soil moisture and temperature conditions are optimal for germination. Cool season grasses will germinate and emerge at about 40°F (4.5°C) or higher. Optional seeding times within this region are spring, late summer or after dormancy occurs in the fall.

Warm season grasses require soil temperatures of at least 50°F (10°C) before they will germinate. The optimal seeding time, whether alone or with cool season grasses, usually occurs between mid-spring and early summer. Later plantings of warm season grasses may reduce problems with weed competition. Early plantings allow more time for stand establishment. Because of the possibility of fall germination and frost heave, seed loss to wildlife through the winter and early weed competition in the spring, dormant seeding of warm season species is not recommended.[18]

All plantings should be made into a seedbed that has a high probability of having adequate moisture after seeding. Moisture conditions are considered to be ideal if the soil can be readily formed into a ball in the palm of the hand and the ball breaks easily when dropped.

Specific date ranges for both warm and cool season grasses will vary, depending on local climate. The window of opportunity will obviously vary from year to year. Seeding dates may be extended two or three weeks past normal when moisture conditions are favorable. In years when slow growing conditions cause a delay in preseeding weed control, it may be necessary to delay seeding until after the normal date.

Seedbed Condition

A firm seedbed is important when seeding native grasses. It helps conserve moisture and ensures good seed to soil contact, a factor which is critically important for warm season grasses. Recently tilled ground should be packed with a coil or roller packer prior to seeding. Packing can also be accomplished by traversing the field once or twice with an empty press drill. The seedbed is considered firm enough when a footprint penetrates 1/4 to 1/2 inch deep.[5] Packing is rarely necessary when seeding into standing stubble as soil compaction is usually adequate.

It can be especially challenging to prepare a suitable seedbed on heavy clay soils. If they are tilled when they are too wet, the surface can become very cloddy. No-till planting into the residue left from a previous crop can often result in a more uniform seedbed.

Preseeding Weed Control

Though weed control procedures during the site preparation year should eliminate most of the major weed problems from a field, the effectiveness of these measures should be evaluated again prior to seeding and a control plan developed accordingly. Weeds or volunteer cereal grains present at seeding time will have a competitive advantage over the slower developing native seedlings, so they must be controlled before seeding.

Nonselective herbicides can be used in the spring immediately prior to seeding or up to four days after seeding. Applications later than four days after planting may

cause seedling damage. In no-till fields where annuals are a concern, use Roundup or paraquat when weeds reach two to six inches in height. A tank mix of Roundup with one pound per acre of atrazine can provide effective weed control prior to planting warm season grasses.

Planting Equipment

The equipment used to seed native plants should provide a uniform distribution of seed, place seed at the proper depth and provide for good seed to soil contact. Given suitable moisture levels and temperatures, meeting all three of those conditions should result in optimum germination and emergence. The characteristics of some native grass seeds require the use of specialized equipment or modifications to standard agricultural equipment or seeding practices to accomplish that objective.

Seeds of some species are awned or have sharply pointed tips. Others are light and fluffy. Any of those characteristics can result in uneven rates of seed flow in standard gravity fed grain drills and undesirable skips within seed rows. To overcome that problem, a light rate of oats (five to ten pounds per acre) or, preferably, an inert carrier like cracked wheat, cracked corn, oat groats or vermiculite at half the bulk seed rate can be mixed with the grasses to improve seed flow. If the inert carrier and seed are to be mixed in the drill box, first mix some of the carrier and seed in a separate container. The seed cups should be full of this mixture before filling the drill box.

Although seeding a companion crop is generally not recommended, the use of oats as a carrier can be valuable on soils subject to erosion or crusting. In drier areas, however, native plant seedlings may have difficulty competing with oats and an inert carrier should be used. Fertilizer is generally not recommended as a carrier due to the possibility of damaging the seed or seedling.

Specialized grass seeding drills usually have seed box agitators and/or specially designed seed cups to help ensure a uniform flow without carriers. These adaptations are particularly useful when seeding mixtures containing more than 50 percent warm season grasses.

Equipment used for seeding native grasses must be capable of operating at a consistent, shallow depth. Seed should be placed at 1/4 to 1/2 inch depths in fine to medium textured soils and 1/2 to 3/4 inch deep in sandy soils. The depth is about right when some seed is occasionally visible on the soil surface after seeding.[1] Do not seed deeper than one inch in an attempt to seed to moisture.

Incorrect seed placement can significantly reduce stand establishment. Depth bands or gauge wheels linked to the openers provide positive seed depth control on disc type seeders. Packer/gauge wheels are used to ensure depth control on seeders which use hoe or knife openers.

If the seeding machine does not provide adequate on row packing after the seed has been placed, the site should receive an additional packing operation to ensure good soil to seed contact.

Tilled seedbeds and standing residue are the most common surface conditions encountered when undertaking a revegetation planting. Occasionally, plantings are also made into existing sod.

Tilled Seedbeds

Sites which have been tilled during the preplanting year are normally in suitable condition for seeding with all types of equipment. The minimal amount of surface residue remaining should not interfere with the operation of seed drills with disc, knife or hoe openers. In areas where the lack of surface residue may increase the risk of wind erosion, it is preferable to seed into standing residue. Herbicide treatments should replace tillage for weed control immediately prior to planting. Avoiding tillage at that time will

leave a firmer seedbed, making depth control more precise. Also, tilling may accelerate the rate at which the surface soil dries out, making conditions less suitable for rapid germination. If tillage cannot be avoided, the site should be packed prior to seeding.

Standing Residue

Planning for planting into standing residue must include the management of the harvest from the preceding crop. Purely from the standpoint of seedbed preparation, removal of the crop as green feed, either in bales or as silage represents the ideal situation. That treatment will remove most of the seed from weeds which may have escaped the in crop herbicide program and removes the potential problem created by heavy crop residues. It also provides sufficient time for any remnant weed population to reach a growth stage where it can be further controlled by postharvest herbicide application.

In many cases the preceding crop will be harvested for grain rather than green feed. When that occurs, both the straw and chaff must be managed to minimize potential problems at seeding time. Straw should be baled and removed from the field or finely chopped and spread uniformly throughout the field. The chaff can also be collected and removed, a practice which also removes weed seeds and waste grain coming through the harvesting machinery. Chaff can also be spread on the field. If the straw or chaff has not been spread satisfactorily, harrowing after harvest can help solve the problem. All of these techniques will help to reduce the risk of straw hairpinning into the seed slot during seeding.

Distributing the chaff as widely as possible is very important. If not done properly the resulting chaff row can interfere with seed placement as well as germination and emergence.

Disc, knife or hoe openers can all seed into standing stubble. To optimize their performance, especially in heavy residue, the openers are often preceded by a coulter or trash plow. These implements, respectively, cut through or clear a narrow strip of residue preventing the residue from hairpinning. A narrow band of blackened ground directly over the seed row can hasten germination and emergence by creating somewhat warmer soil temperatures near the seed.

Provided residue is properly managed and the seed is well placed, clean standing stubble is an excellent seedbed for revegetation plantings on agricultural soils. The soil is firm, allowing good depth control. The standing stubble reduces wind speed and evaporation at the soil surface, provides erosion protection to the soil and may provide some partial shade to tender, newly emerged seedlings and cover for ground nesting birds.

Existing Sod

Seeding into existing sod presents some special challenges. While the roots and top growth of the old vegetation provide excellent soil erosion protection, they can make it difficult to achieve good seed placement. Removal of the above ground biomass is very important before attempting to plant into existing sod.

Standard knife and hoe openers tend to tear existing sod, leaving a rough surface. Because of that tearing action, seed depth and soil seed contact can be extremely variable resulting in uneven seedling establishment.

Proper seed placement into existing sod requires the use of specialized equipment. Sod seeders usually have disc openers or very narrow knives and cutting coulters. The coulter makes a slot in the sod for the opener to follow. It is important for sod seeders to provide good on row packing to ensure the slot is closed and the soil is firmed around the seed.

Existing sod will compete very strongly with new seedlings for moisture and nutrients. For that reason, a non selective herbicide

should be applied prior to planting to suppress competition. If the planting site contains a significant remnant native plant population, serious consideration should be given to a management program that would favor remnant plants rather than eliminating them with a herbicide and then reseeding.

Sod seeding, particularly with native species, is still not well understood. This technique, therefore, represents the highest risk of the options considered. Since research into sod seeding is a continuing activity, anyone considering this technique is urged to seek the most current information available.

Seeding Rate and Equipment

Seeding rates for native grass stands usually vary from ten to fifteen pounds PLS per acre. The lower rates are normally used in drier prairie regions, with rates in the northeast near the high end of the range.

Prior to planting, the seed drill must be serviced and repairs carried out. Regular maintenance such as greasing, checking seed cups and seed tubes for obstructions as well as removing old seed from the seed box, cups and tubes should be done before each planting. It is advisable to disassemble and clean the distribution manifolds on an air seeder or air drill before each planting as they tend to be somewhat prone to blockages, resulting in seeding misses. The seed delivery system on all drills should be checked periodically during seeding to ensure that it is operating properly.

To ensure the desired PLS seeding rate is achieved, the drill must be calibrated for each seed mixture to be planted. Once planting is underway, the operator should stop several times in the first acre or two to ensure that the seeding depth is appropriate. A quick look in the seed box during those stops can also give an indication that all seed cups are feeding.

Appendix E presents two methods of drill calibration, one based on the bulk weight of seed and the other on seeds per row foot. The following alternative method can be a time saver on a windy day when drill calibration using the seeds per row foot method may be difficult.

a) Jack up the drive wheel end of the drill and measure the drive wheel circumference in feet. Mark the side of the tire as a reference point.
b) Place containers under three or more seed spouts.
c) Rotate the drive wheel one half turn or one full turn and calculate the distance travelled by the circumference of the wheel.
d) Count the number of seeds in each container and divide by the number of feet of wheel travel to determine the number of seeds delivered per linear foot.
e) If all the spouts are not delivering the same amount of seed, adjust them to feed uniformly.

Broadcast seeding is not a recommended practice if site conditions allow the use of a drill. If conditions dictate that it is the only possible method, however, there are some techniques which will improve the prospects for success. The site should be harrowed prior to broadcast seeding, then harrowed and firmly packed after seeding. Good success has also been experienced when broadcasting is followed by tracking – driving a bulldozer up and down slope to completely cover the site with cleat marks. While broadcast seeding rates double those used for drill plantings are usually recommended, those elevated seeding rates have not been necessary on tracked sites in New York, Vermont, New Hampshire and Maine.

Fertilizing

Fertilizer applications are not usually required for native species in the establishment year. The results of the soil test taken in the fall of the preplanting year will give an accurate picture of the nutrient status of the planting site.

Clean standing crop stubble can provide a suitable seedbed for native grass plantings.

With proper seeding equipment, plantings can be established in chemically suppressed sod.

Depth control bnads ensure uniform, shallow seed placement.

Grass seeding drills can be calibrated by counting the seeds delivered per measured length of row.

Sites which have infertile soils or those which have been cropped in the preplanting year may benefit from fertilizer. In those cases, it is particularly important to ensure that adequate phosphorus levels are provided since it promotes root development.

Potassium and phosphorus may be applied either prior to or when planting. If the application is a separate operation in late fall or early spring prior to seeding, it should be made with equipment that creates a minimum of soil disturbance. A spring preseeding application may loosen the seedbed to such an extent that a repacking operation is required prior to seeding. However, repacking at that time may pulverize the soil surface and increase the risk of wind erosion.

Nitrogen should not be applied to warm season grasses until the second growing season. Earlier applications will stimulate weed growth and encourage encroachment of cool season grasses. Generally, excessive rates of nitrogen will not result in higher yields.

If fertilizer of any type is applied at seeding time, ensure that there is sufficient separation between the seed and fertilizer to minimize the risk of seedling injury.

When established stands of big bluestem or switchgrass are subject to annual use for hay or pasture, they may require fertilizer applications to maintain their productivity. Apply the nitrogen and phosphate in a 3:1 ratio based on soil test results.[17] For a nitrogen application of 90 pounds per acre, for example, it is recommended to apply 30 pounds of phosphate. Applications should not be made until spring grass growth has reached four to six inches or the soil temperature reaches 60°F (15°C).

Special Considerations

Most warm season native grasses grow best on moderately deep to deep, well drained, medium to moderately fine textured soils with moderate permeability and high to very high water holding capacity. Many sites lack these or other ideal conditions; some may merit special consideration.

Coarse Textured, Droughty Soils

On sandy sites where droughty conditions prevail attention should be given to species or ecotype selection. As previously mentioned there are several drought tolerant species available. Even species typically not tolerant may have adapted ecotypes that are less susceptible to moisture stress. Since competition for moisture between species, as well as with weeds, will be keen, use the lower end of the prescribed seeding rate. Planting an annual grain crop for one year then seeding directly into the standing stubble without further tillage will help conserve moisture and protect the emerging grass from wind and blowing sand. Drilling into suppressed existing sod has also shown great promise under these conditions.

Fine to Medium Textured Soils

When an adequate herbicide program is not an option and erosion is not a problem, one method of combating heavy weeds is to plant as late as possible but before mid-season. Since weeds germinate as soon as the soil warms a late planting allows time to eliminate the weeds through light, shallow cultivation; deep cultivation will only bring up more weed seeds. Discing or harrowing at two to three week intervals will eliminate much of the problem.[18] The danger with late plantings is the possibility of not receiving enough precipitation to germinate the seed or having insufficient plant size to overwinter successfully.

Floodplains or Muck Soils

Cool, wet springs may delay access to floodplains or muck soils until mid-June. If seeding is scheduled on these soils the seedbed should be worked the previous late summer or fall. Some native grasses tolerate some spring flooding or high water tables but grow best on organic soils that dry

out by mid-spring and remain dry during the growing season.[24]

Stand Evaluation

To determine the overall success of the planting a monitoring program should evaluate the number of seedlings, distribution of seedlings across field gradients, seedling vigor, height and growth stage and overall diversity of seeded plants[2]. Preliminary evaluation of fall and spring planted native grasses should be made four to six weeks after germination. For spring plantings, this would normally occur six to eight weeks after planting. This inspection of seedling density and distribution can easily be combined with an inspection for postplant weed control requirements. A second inspection late in the summer of the planting year will be necessary to evaluate stand adequacy based on density of established plants and their stage of development. However, the final establishment inspection should ideally be made after the stand has gone through at least one winter.

It is often difficult to decide when establishment occurs following grass seeding. A grass seedling should be completely autotrophic (not reliant on seed reserves) before being considered established[23]. Successful establishment of grass seedlings also requires the formation of adventitious roots[8+13] (Figure 16).

Sampling Techniques

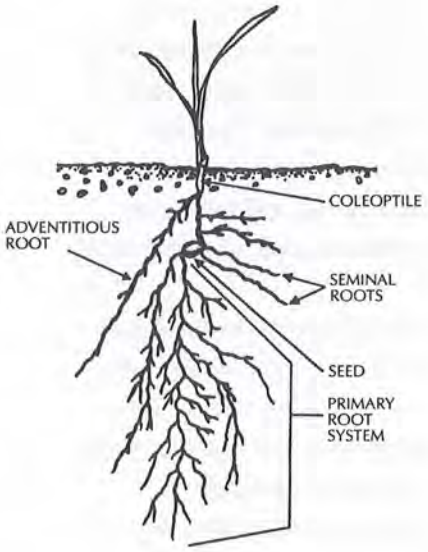
The systematic collection of stand establishment data is especially important when an individual or organization first becomes involved with native grass revegetation or when new seed mixtures are being tested. As part of a comprehensive system of field records, establishment data can play a key role in determining the reasons for the ultimate success, or failure, of a planting.

Several methods can be used to collect stand establishment data. Density measurements, taken by counting the number of individual plants and species within a standard one square foot quadrat, are the most commonly used. The accuracy and usefulness of the data collected will depend on the number and location of the sites sampled. As a general rule, there should be at least one sample site per acre in fields of 40 acres or less. A minimum of 50 sites is required on fields larger than 40 acres.

The location of the sites within the field deserves special attention. Sample locations should reflect the nature of the field. If 25 percent of the field has a sandy soil, the same percentage of samples should be taken from the sandy areas. If the sculptured seedling approach has been used, it would be advisable to sample each part of the field which received a different seed mixture separately.

At the time of the first inspection, species with high rates of seed dormancy may not have emerged. Experienced personnel can usually determine by visual observation if plant emergence has been satisfactory.

Figure 16. Grass Seedling Root Morphology



Postplanting Weed Control

Planting Year

Prompt attention to postplant weed control is required on all sites during the establishment year. Weed control options and strategies will vary depending on the type of planting (cool season, warm season or mixed grasses), the weed species present, whether forbs or legumes have been included and whether the stand will be harvested for forage.

There are four basic methods that can be used to control weeds in developing grass stands: clipping, herbicides, grazing and fire. Of these, only the first two are normally used during the planting year.

Clipping is the simplest method of assisting establishment of new grass stands, especially warm season grasses. The goal is to reduce the shade pressure that the weeds are exerting, and secondarily to keep the weeds from producing seeds. The best equipment to use for this method is a sickle bar mower that can operate horizontally within an elevation range of 6 to 12 inches (15 to 30 cm). Sickle bars are preferred over rotary mowers because they cut and drop each stem individually. Weeds are spread evenly over the entire swath and do not clump as tends to happen with the rotary machine. If at all possible, clipping should be delayed until July to allow ground nesting birds to complete incubation.

The height of cut is not critical if clipping cool season grasses. Cool season grasses generally have good seedling vigor and the growing point (meristem) is near the soil where it is not likely to be cut off. It is acceptable to cut off some of the grass leaf with the weeds. Leaving two thirds or more of the leaf length uncut is a good policy. Plants need leaf surface to capture light and generate food for growth so cutting half or more of the leaf off can have a retarding effect on growth.

When first year warm season grass stands are clipped, one has to account for the weaker seedling vigor of the plants and the elevated growing point. With these grasses, only the leaf tips should be cut. Clipping either grass type has the effect of promoting stooling out of the plant, which is the stimulation of basal buds to produce more stems and leaves.

Herbicides, used correctly, can provide effective control of many weeds in a timely and cost-effective manner. As with other weed control methods, the development of a herbicide use strategy should begin with a field inspection four to six weeks postplanting to identify the weed species present.

As mentioned in preplanting preparations, herbicides should be used to target problem weeds during the year or two before planting native grass stands. Not only does this allow for greater flexibility and opportunity for effective control, but it avoids the potential problem of herbicides not being labeled for use with species that you wish to plant. These

Some references to specific herbicides and rates of application in this section are based on preliminary research and field experience. Unless stated otherwise, they should not be construed as recommendations for herbicide use under differing conditions and label recommendations. For example, the effect of a particular herbicide on seedlings can vary with the level of weed infestation. In addition, a herbicide may not have an impact on vegetative growth or biomass production, but may significantly reduce seed yields. For specific recommendations for local conditions, refer to state or provincial weed control publications, herbicide label information and experienced local personnel.

herbicide applications can be especially valuable for controlling weedy cool season grasses and persistent broadleaf perennials like Canada thistle.

In the past, very few herbicides were specifically tested for their efficacy on native plant materials. The cost of testing, combined with the relatively small size of the potential market for use on native plants compared to annual agricultural crops, have mitigated against testing being undertaken by the producers of crop protection chemicals. As a consequence, very few herbicides currently carry label recommendations for use on native plants.

That situation has begun to change in recent years. In Canada, DUC has been actively collaborating with weed scientists at Agriculture and Agri-Food Canada and other agencies to undertake the testing required for the granting of what is called a "minor use registration". Such a registration leads to supplemental label information which allows the use of the product on specified native plant species. Registration for the use of Achieve to control wild oats and green foxtail in western, northern and slender wheatgrass is one example of a registration which has resulted from that program. A number of other herbicides are currently being tested on a wide range of native grasses. As the testing is completed, those products which have demonstrated acceptable performance will be put forward for minor use registration.

Some of the new crop protection products which have been released in recent years carry registered uses for native plant species, either on their original labels or on supplemental labels which were issued soon after the products were released. In the United States, for example, some members of the imidazolinone family of herbicides carry such labelled uses. A comparison of three of those products – Arsenal, Plateau and Pursuit – versus atrazine as part of an integrated weed management strategy to establish or restore warm season grasses in the Great Plains has been reported.[10]

Each herbicide controls or suppresses a range of annual grassy and broadleaf weeds as well as some broadleaf and cool season grass perennials, but they do differ in their effects on specific warm season species. Plateau, for example, is labelled for use on big bluestem, little bluestem, indiangrass, sideoats grama, blue grama and buffalograss while the Pursuit label covers big bluestem, little bluestem and switchgrass.

The US label for Plateau also contains tolerance information for a range of seedling and established forbs and legumes, including such species as black-eyed susan, yellow coneflower and partridge pea. As a result, it may be a useful weed control product in plantings which include forbs and legumes or on degraded sites where restoration work is being undertaken. Consult the product label for complete, specific information.

Even after a diligent weed control program in the preplanting year(s), additional control measures are often required in the establishment year. Annual broadleaf weeds are fairly easy to control in warm or cool season grass stands by using chemicals like 2,4-D or Banvel. If annual grassy weeds are also present, other products or tank mixes of products, may control them both in one application. Figure 17 outlines a number of herbicide treatments which might be considered.

In special problem situations like cool season grasses in a warm season stand, the herbicide options become more limited. In some situations, it may be possible to use products like atrazine or Plateau. It may also be possible to apply Roundup to growing cool season grasses while the warm season grasses are dormant in early spring or late fall. If the warm season grasses are dormant to the soil (green does not show) and the cool season plants are actively growing, this treatment

Figure 17. Planting Year Weed Control

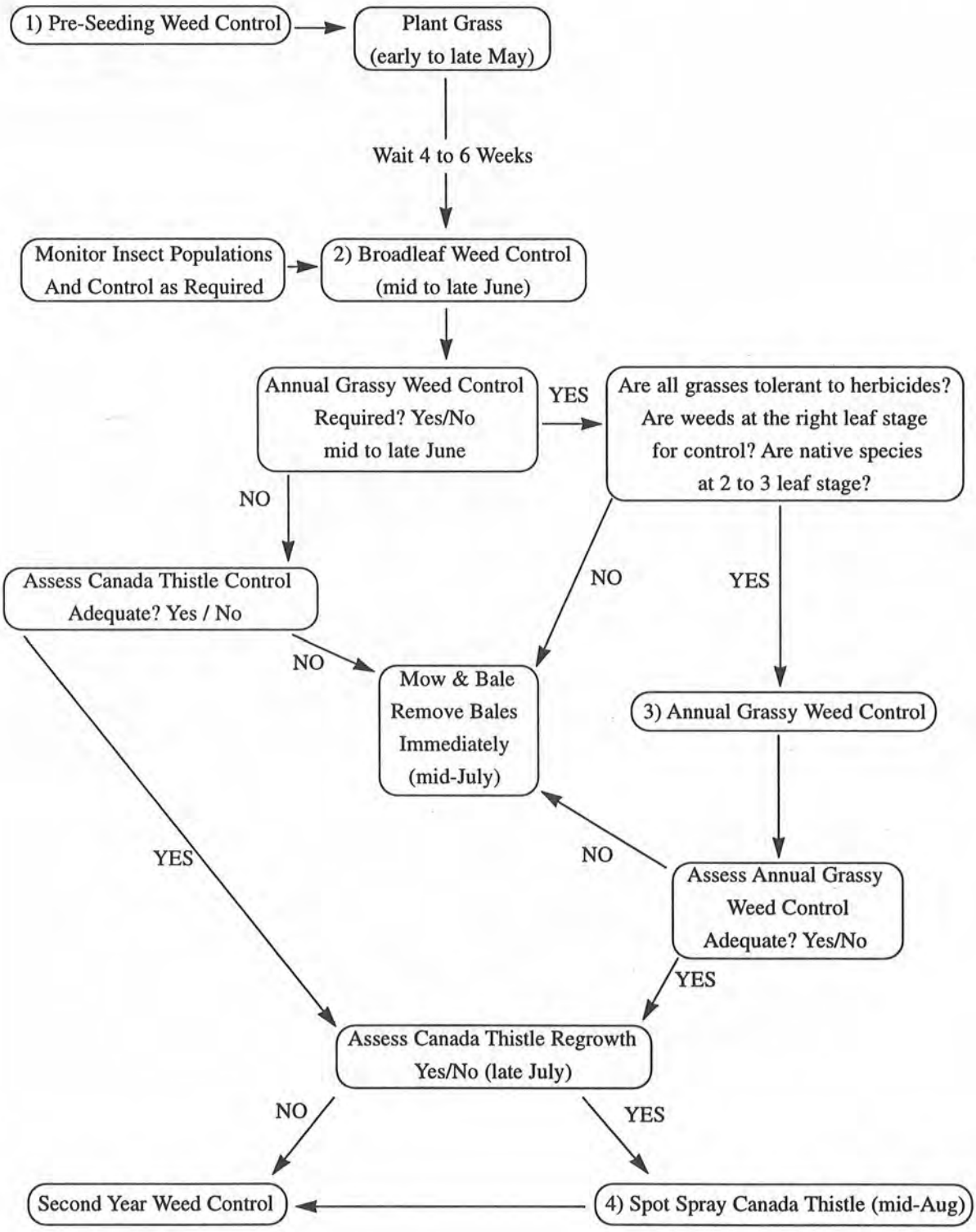


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Figure 17 continued

Planting Year Preseeding Weed Control*

Weed	Date	Herbicide	Rate* (L/ac)	Chemical Name	Active Ingred. (g/L)	Active Ingred. (g/ac)	Leaf Stage	
							Crop	Weed
1) annual weeds, quackgrass	various	Roundup	1.0	glyphosate	356	356	n/a	less than 6 inches
		Roundup + Pardner	1.0 + 0.5	glyphosate bromoxynil	356 280	356 140		
2) annual broadleaf weeds	various	2,4-D amine	0.45	2,4-D	500	225	n/a	2 to 4

Planting Year Postemergent Weed Control*

Weed	Date	Herbicide	Rate* (L/ac)	Chemical Name	Active Ingred. (g/L)	Active Ingred. (g/ac)	Leaf Stage	
							Crop	Weed
1) annual broadleaf weeds	mid to late June	Banvel + 2,4-D amine	0.2 + 0.4 - 0.6	dicamba 2,4-D	480 500	96 200 – 300	2 to 4	2 to 5 wild buckwheat to 3 inches
		Target	0.61	MCPA mecoprop dicamba	275 62.5 62.5	167 38 38	2 to 4	2 to 3
2) Canada thistle annual broadleaf weeds	mid to late June	Lontrel + MCPA ester	0.17 - 0.34 + 500	clopyralid MCPA	360 500	61 – 122 170 – 225	2 to 4	majority of Canada thistle are 4 inches but prior to bud stage, annual weeds 2 to 4 leaf
3) annual grassy weeds	mid to late June	Hoe-Grass** 284	1.0 - 1.4	diclofop-methyl	284 284	284 – 398	2 to 3	1 to 4
4) Canada thistle	mid-Aug.	Lontrel + MCPA ester	0.11 - 0.34 + 0.34 - 0.45	clopyralid MCPA	360 500	40 – 122 170 – 225		fall regrowth (spot treatment)

* Application rates are based on Canadian experience. For appropriate recommendations for U.S. conditions, contact your State cooperative extension service.

** Do not apply Hoe-Grass 284 to plantings which contain warm season grasses other than big bluestem and switchgrass.

can provide some control.

Wick applicators can be used to apply Roundup to susceptible broadleaf weeds and grasses if they have grown above the desired plants, but this method is not very effective if the weed population is high. Unless the wick method can be used, cool season grass weeds in a stand of native cool season grasses are essentially untouchable with herbicides.

Grazing can be used to advantage, but has several potential pitfalls. It must be carefully controlled or the stand can be destroyed by over grazing, hoof damage, or physically uprooting the seedlings as the animals bite and tear off the forage.

In the second year and beyond, risk from hoof damage and the dislodging of plants is greatly reduced. Grazing can be used to reduce weed pressure early in the season where cool season grasses are invading a warm season grass stand. Livestock are attracted to the tender new growth of the cool season grasses before the warm season grasses begin to grow. Intense grazing at this time can weaken the cool season grasses significantly. The animals' feed intake may need to be supplemented as grass growth slows. They should be removed as soon as the warm season grass starts to grow. Sheep or goats can be used to selectively graze broadleaf weeds early in the season. If a planting is grazed, it is sometimes useful to build an exclosure to leave a small plot ungrazed so one can monitor plant growth.

Fire is an excellent tool to use to stress weeds in a warm season grass stand, but great care must be used to control the fire and not allow it to escape. Smoke, in the wrong place, will be a hazard to road traffic and airplanes as well as being bothersome to neighbors. Local regulations must be met. Enlisting the aid of fire control experts, perhaps to use your controlled burn as a training exercise, is a good idea. Standing warm season grass residues burn fast and this is the effect that you want without losing control at the downwind end of the field. Slow backfires are not desirable because they can create hotter soil temperatures than fast moving fire does and can damage the crowns of the plants. If local authorities insist that you backfire all the way through the stand, abandon the plans to burn. Generally, controlled burns should be spring events that are timed to take advantage of dry fuel and winds around 10 miles per hour from a favorable direction. The warm season grasses should have one to three inches of new growth. After the burn, the black ash will absorb solar radiation, warm the soil rapidly and in turn cause more rapid grass growth. The warm season grasses gain some advantage at the same time the weeds and cool season grasses are set back.

Fire may be a less useful tool for managing cool season grass stands in the northeast. The native cool season grasses of the northeast probably did not evolve in a frequent fire environment, as did the warm season grasses.

Cool season grasses can be used as an effective firebreak around warm season stands, but they will carry a fire if not raked free of dead material and thatch. If in doubt, wetting the firebreak with water immediately before a burn is good insurance. **Before any use of fire is attempted, a plan must be in effect, necessary permits arranged, the right equipment and sufficient personnel to control the fire must be on hand. As well, effective preparation of firebreaks must be achieved and the weather and timing must be favorable.**

Post-establishment Management

Stand evaluation

Cool season grass turf and lawns require high seedling density to create even walking surfaces and crowd out weeds under very close, frequent mowings. Nearly everyone has had some experience with planting lawns, so the expectations and measures of success developed tend to be carried over to other grass plantings, regardless of plant type or planting objective. This carryover can get in the way of objective stand evaluation and cause needless reseeding and repetitive effort. For turf establishment, thick stands of seedlings (one per square inch) are desired; for erosion control, forage or wildlife cover success can be achieved with stands that are initially much less dense. On dry sites it is important to not have dense stands. Why? The objectives of the plantings makes all the difference.

Wildlife, erosion control and forage plantings need to grow much taller than turf plantings, so individual plant vigor is important. There is a relationship between individual plant size and rooting depth. Bigger plants root more deeply and are more drought tolerant and productive. If too densely spaced, these plants will crowd each other and inhibit plant development. Plant size and vigor are also important for competition with weed species. Since several of the native grasses spread by rhizomes, the stand density will improve until limited by the shade and competition of the taller plants. When we take these objectives into account, a seedling density of 20 cool season native grass plants per square foot is a good target.

The tall warm season grasses are larger and more robust (after the establishment period) than are most cool season grasses. They are also much more deeply rooted. The preceding information on cool season grasses applies even more to the warm season grasses. Mature stands of the tall warm season grasses can develop full stand density with only one seedling per square foot (10 per sq. m). However, keep in mind the frost heaving potential of these grasses on soils that are less than well drained. The time to declare success is not at the end of the first growing season, but at the beginning or middle of the second growing season (June or July of the second year). Frost heaving does not appear to be a problem in stands of warm season grasses that are older than one and a half years. If a warm season grass stand has two strong plants per square foot (20 per square meter) in June of the second year, the stand will be successful in the great majority of cases.

The relative germination and seedling vigor of different species within the warm season grass group is worth mentioning here. Coastal panicgrass and switchgrass have the strongest vigor and little bluestem and indiangrass have the least vigor. When evaluating mixed plantings, it is common to see few indiangrass seedlings. These tend to become visible in the second or third years and usually remain as a minor part of the stand.

Plantings for erosion control and wildlife cover often have forbs or herbaceous legumes included in the seed mix. It is important that these be planted in relatively smaller numbers than the grasses, not exceeding 20 to 25 percent of the total seed count. The reason is the grasses are providing the bulk of the on-site benefits for erosion control and cover.

Controlled burns are a valuable stand management technique in both seeded plantings and prairie remnants like this one in Illinois.

Spot mowing can provide weed control and stand management benefits.

Even livestock as exotic as bison can be used to supply managed grazing treatments on plantings.

Stand maintenance

While native plantings may be considered permanent, periodic management is required. Management interval will vary with soil, climate, plant species and other factors. In the northeast, management may be required every three years. It is important that management occurs before stand vigor declines dramatically or competitive invasive species overrun a planting. A program of systematic monitoring of stand vigor is recommended to guide management decisions.

Management treatments on either planted or naturally occurring native sites may be undertaken for a variety of reasons. Chief among these is the removal of accumulated plant litter which can impede light penetration. Experience indicates that a two to three inch (6 to 8 cm) continuous layer of plant litter can reduce seed culm and total culm densities. These features are indicators of stand vigor. Exposing growth points to sunlight and recycling nutrients tied up in old plant growth with a controlled burn generally stimulates vigorous new growth.

Properly timed management, especially a properly timed burn, can stimulate tillering in new plantings, accelerating the establishment of newly seeded native grasses. In a warm season grass planting, a burn in the spring of the second or third year after establishment when the grasses have one to three inches of new growth is strongly recommended as an initial management treatment. Fire management also serves to reduce the risk of large and potentially damaging wildfires by removing accumulations of old growth. Haying and grazing are also accepted management techniques on seeded native areas.

Planned well controlled fire is a useful and inexpensive management technique in warm season grass stands. Unplanned, uncontrolled fire is obviously dangerous and becomes more likely as the number of public users is increased. Few people have experience with tall grass fires that involve stands with several years of fuel built up. Therefore it is wise to manage the hazard with planned cool season grass firebreaks and consider the relative need for these in the site selection process.

Although these burns may and should be supervised by qualified personnel, distances considered safe for fire may be shorter than for the associated smoke. Smoke damage to property or smoke inhalation by humans or livestock could be a costly situation. This is equally true if one is considering a roadside site. Traffic management, posting and permits need to be addressed before burning.

Timing, weather, moisture conditions and firing techniques are important factors influencing the effectiveness of a managed burn. If the burn is intended to control shrubs and saplings, timing is critically important. Research at several universities has shown that the most effective time to injure woody plants with fire is just as they reach full leaf. At that stage, they have expended large energy reserves to create new growth and have not yet been able to replenish their carbohydrate stores through photosynthesis and respiration. Warm season grasses will likely have achieved more than one to three inches of new growth – the stage at which fire is most beneficial to them – when woody plants reach full leaf. However, warm season grass vigor will not be seriously affected as long as late burns are not a frequent occurance. Careful management is required if controlled burns are being used to maintain a savanna type plant community where shrubs and/or trees are interspersed throughout the grassland. Before undertaking a burn, consultation with experts and a review of the literature is recommended.

Mowing and grazing can provide many benefits similar to burning. If mowing is used we recommend waiting until after June 30 when most ground nesting birds have completed incubation and left their nest sites. Cut as low as possible

with a mower conditioner or a flail type mower. Remove as much of the old plant litter as possible to stimulate new growth. Experience suggests that mowing does not provide a long lasting treatment effect if the lower litter layer is not removed. If mowing or haying don't provide sufficient impact on old plant litter, scarification of the soil surface with heavy harrows or similar equipment may enhance the treatment effect.

Grazing is also a management option. On wildlife priority areas, we recommend that grazing be well regulated, infrequent and intended to provide maximum benefits to the grass stand. Grazing should be designed to maximize stand vigor, with secondary agricultural benefits. Extensive reclamation areas or areas of existing pasture revegetated with native plant material can be maintained in a productive state and provide nutritious long lived forage under a managed grazing system. Local pasture experts should be consulted to set up a system that is appropriate for your soil and climate zone.

Where it can be practiced, controlled fire is the most effective technique for maintaining warm season grass stands in the northeast. We know that vegetation can shift rapidly from grassland to shrub and tree communities when no management occurs. When that happens, broad scale herbicide applications, chain saws or bulldozers may become the only remaining management alternatives.

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Appendices

Appendix A

Cross Reference of Common Names

and Scientific Names of Plant Species

Common and Scientific Names for Plant Species

GRASSES

Beachgrass, American	*Ammophila breviligulata* Fern.
Bluejoint, Canada	*Calmagrostis canadensis* (Michx.) Beauv.
Bluestem, big	*Andropogon gerardii* Vitman
bushy	*A. glomeratus* (Walt.) B.S.P.
little	*Schizachyrium scoparium* (Michx.) Nash
	Andropogon scoparius Michx.
sand	*A. hallii* Hack
splitbeard	*A. ternarius* Michx.
Bromegrass, downy	*Bromus tectorum* L.
Japanese	*B. japonicus* Thunb.
smooth	*B. inermis* Leyss.
Broomsedge	*Andropogon virginicus* L.
Buffalograss	*Buchloe dactyloides* (Nutt.) Engelm.
Canarygrass, reed	*Phalaris arundinacea* L.
Chess, hairy	*Bromus commutatus* Schrad.
Cordgrass, prairie	*Spartina pectinata* Link.
saltmeadow	*S. patens* Ait.
smooth	*S. alterniflora* Loisel.
Deertongue	*Dicanthelium clandestinum* (L.) Gould
Dropseed, sand	*Sporobolus cryptandrus* (Torr.) Gray
Fescue, rattailed	*Vulpia myuros* (L.) K.C. Gmel.
red	*Festuca rubra* L.
Gamagrass, eastern	*Tripsacum dactyloides* L.
Grama, blue	*Bouteloua gracilis* (H.B.K.) Lag. Ex Steud.
sideoats	*B. curtipendula* (Michx.) Torr.
Green needlegrass	*Nassella viridula* (Trin.) Barkworth
	Stipa viridula Trin.
Hairgrass, crinkled	*Deschampsia flexuosa* (L.) Trin.
Indiangrass	*Sorghastrum nutans* (L.) Nash

Lovegrass, purple	*Eragrostis spectabilis* (Pursh.) Steud.
sand	*E. trichodes* (Nutt.) Wood.
Oatgrass, poverty	*Danthonia spicata* (L.) Beauv. ex Roemer & J.A. Schultes
Orchard grass	*Dactylis glomerata* L.
Panicgrass, bitter	*Panicum anarum* Ell.
coastal	*P. amarulum* A.S. Hitchc. & Chase
Panicum, beaked	*Panicum anceps* Michx.
Paspalum, Florida	*Paspalum floridanum* Michx.
Plumegrass, shortbeard	*Erianthus brevibarbis* Michx.
sugarcane	*E. giganteus* (Walt.) Muhl.
Purpletop	*Tridens flavus* (L.) Hitchc.
Redtop	*Agrostis gigantea* Roth.
Quackgrass	*Agropyron repens* (L.) Beauv. *Elytrigia repens* (L.S.) Nevski
Sandreed, prairie	*Calamovilfa longifolia* (Hook.) Scribn.
Sea oats	*Uniola paniculata* L.
Sweetgrass	*Hierochloe odorata* (L.) Beauv.
Switchgrass	*Panicum virgatum* L.
Wheatgrass, northern	*Elymus lanceolatus* (Scribn. & J.G. Sm.) *Agropyron dasystachyum* (Hook.) Scribn.
slender	*Elymus trachycaulus* (Link) Gould ex Shinners subsp. *trachycaulus* *Agropyron trachycaulum* (Link) Malte
tall	*Elytrigia elongata* (Host) Nevski *Elymus elongatus* (Host) Runemark *Agropyron elongatum* (Host) Beauv.
western	*Pascopyrum smithii* (Rydb.) A. Love *Elytrigia smithii* (Rydb.) Nevski *Elymus smithii* (Rydb.) Gould *Agropyron smithii* Rydb.
Wildrye, Canada	*Elymus canadensis* L.
Virginia	*E. virginicus* L.

Woodoats, slender	*Chasmanthium laxum* (L.) H. Yates
ANNUAL CROPS:	
Barley	*Hordeum vulgare* L.
Canola	*Brassica napus* L.
Corn	*Zea mays* L.
Oats	*Avena sativa* L.
Rye, cereal	*Secale cereale* L.
Wheat	*Triticum aestivum* L.
FORBS:	
Aster, heath	*Aster pilosus* Willd.
New England	*A. novae-angliae* L.
New York	*A. novi-belgii* L.
Bergamot	*Monarda fistulosa* L.
Black-eyed susan	*Rudbeckia hirta* L.
Bush clover, round-headed	*Lespedeza capitata* Michx.
Butterfly milkweed	*Asclepias tuberosa* L.
Coneflower, grey-headed	*Ratibida pinnata* (Vent.) Barnh.
purple	*Echinacea angustifolia* DC.
yellow	*Ratibida columnifera* (Nutt.) Woot. and Standl.
Coreopsis, lanceleaved	*Coreopsis lanceolata* L.
Daisy, oxeye	*Chrysanthemum leucanthemum* L.
Gayfeather, spiked	*Liatris spicata* (L.) Willd.
Goldenrod, Canada	*Solidago canadensis* L.
seaside	*S. sempervirens* L.
showy	*S. nemoralis* Ait.
stiff	*S. rigida* L.
Indigo, blue false	*Baptisia australis* (L.) R.Br.
Lead plant	*Amorpha canescens* Pursh.
Lespedeza, roundhead	*Lespedeza capitata* Michx.
Lupine, prennial	*Lupinus perennis* L.
Partridge pea	*Chamaechrista fasciculata* Greene

Rosinweed, cup	*Silphium perfoliatum* L.
Sunflower, false (oxeye) maximilian	*Heliopsis helianthoides* (L.) Sweet *Helianthus maximiliani* Schrad.
Tick trefoil, Canada	*Desmodium canadense* (Michx.) MacM.

LEGUMES:

Alfalfa	*Medicago sativa* L.
Prairie clover, purple	*Petalostemon purpureum* (Vent.) Rydb. *Dalea purpurea* Vent.

WEEDY PLANTS:

Canada thistle	*Circium arvense* (L.) Scop.
Foxtail, green	*Setaria viridis* (L.) Beauv.
Wild oats	*Avena fatua* L.
Loosestrife, purple	*Lythrum Salicaria* L.

Appendix B

Sculptured Seeding: An Ecological Approach to Revegetation

TECHNICAL REPORT

Sculptured Seeding

An Ecological Approach to Revegetation

by Erling T. Jacobson, D. Brent Wark, Roy G. Arnott, Russell J. Haas, and Dwight A. Tober

A promising technique for establishing and maintaining adapted native grass species.

The sculptured seeding technique, an ecological approach to revegetation based on a knowledge and understanding of the natural vegetation of an area, establishes a diverse, effective native plant community capable of regeneration and plant succession. It is intended to match site capability with plant species known to thrive under particular conditions. Sculptured seeding is an option available to land managers interested in establishing and maintaining adapted native species and ecotypes within the limits of current technology and available seed sources.

The concept of sculptured grass seeding was introduced in Stutsman County, North Dakota, in 1981 by E.T. Jacobson, plant materials specialist with the United States Department of Agriculture, Soil Conservation Service (SCS) in Bismarck, North Dakota. This project was undertaken in cooperation with H.F. Duebbert and K.F. Higgins, research biologists, United States Department of Interior, Fish and Wildlife Service, Northern Prairie Research Center, Woodworth Field Station.

Our experience in establishing native grass on cultivated fields in the northern Great Plains of the United States and Canada has shown that success is closely correlated with soil type, slope, moisture regime, and other site factors. Our approach has been to evaluate relationships between species behavior and environmental gradients in the literature and the field.

Major differences occur within all natural plant communities. Coupland (1950) states that by far the largest proportion of the mixed-prairie area in Canada is occupied by the Stipa-Bouteloua association. The relationship of certain species of grass to differences in climate, soil texture, and topography within this association is significant.

Field observations indicated that the relative abundance of needle and thread (*Stipa comata*) compared to northern porcupine grass (*Stipa curtiseta*) is greatest in the drier areas and on the drier soils; and that the increase of needle and thread on the upper part of the slopes results in the frequent absence of the latter species on the dry knolls. Lower on the slope and in the moister parts of the dark-brown soil zone the northern porcupine grass is relatively more abundant.

Realizing that these differences occur in natural plant communities, it seemed logical to Jacobson to design, in 1981, seeding mixtures to approximate the relative composition that occurred naturally on the planting site. D.B. Wark, special projects biologist with Ducks Unlimited Canada (DUC), supported this rationale and applied it to the sculptured-seeding method.

Planning Considerations

To acquire the information needed to design the mixtures we started by searching the literature recommended by individuals with broad field experience and understanding of grassland/range management. Dix and Smiens (1967) discuss drainage regime gradients relative to species behavior. They describe the position of each vegetative unit in the landscape based on the amount of moisture received and re-

Seedlings emerge eight weeks after seeding, showing an excellent response to the sculptured-seeding technique.

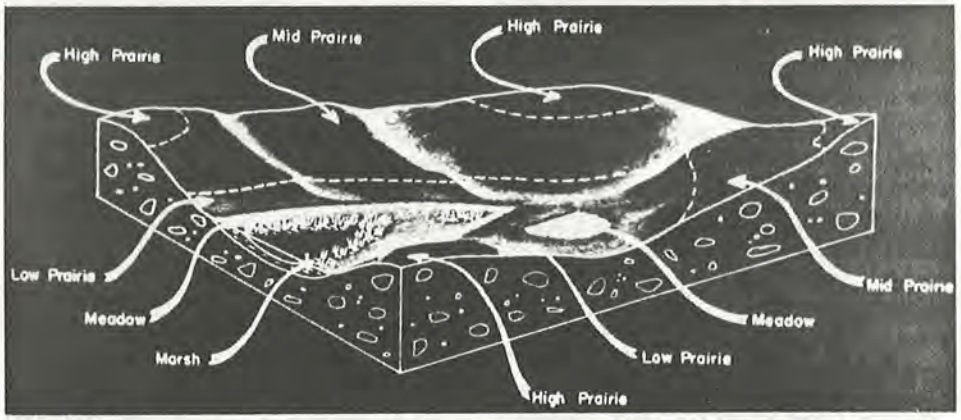

Figure 1: In planning a sculptured-seeding project, consider the interrelationships between vegetation, distribution, soils, topography, and other environmental characteristics.

tained by the stand. The interrelationships between vegetation units within the landscape, drainage regime gradient, soils, topography and other environmental characteristics are shown in a hypothetical block diagram (Figure 1). Dix and Smiens classify uplands as high prairies, mid prairies, and low prairies, and delineate lowlands as meadows, marshes, and cultivated depressions. Genera and species characteristic of the various components of the plant community are identified.

Duebbert *et al.* (1981) discuss planning considerations designed to facilitate establishment of seeded native grassland communities on cultivated land. In the United States a standard soil survey is useful as a means to inventory the soil resources of an area. This survey includes aerial photographs; soil maps; information on texture, physical and chemical properties; and a description of the soil profile.

Some soil surveys identify range sites and associated native plant species. When interpreted properly, range-site descriptions provide valuable information for the development of native grass and forb seeding specifications, (Sedivec *et al.*, 1991). A range site is a distinctive area of natural grassland able to produce a characteristic native plant community.

If published guidelines are not av able, the individual developing the see ing standards and specifications should survey the kind and frequency of each major species on a similar site in the same vegetation zone. Ideally, a different seeding mixture should be developed for each range site or vegetational unit within the landscape. For practical reasons, this is not possible to achieve because seeds of many species are not available.

In identifying the kinds and proportions of species to include in the potential plant community, the initial array is approximate and subject to change along environmental gradients. Plant community boundaries are distinct where changes in soils, topography, or moisture conditions are abrupt. Boundaries are broader and less distinct where plant communities change gradually along broad environmental gradients of relatively uniform soils and topography.

Historical Perspective—United States

For the first sculptured grass seeding a Woodworth Field Station, project organizers selected a 30-acre cultivated field that had been farmed for several years and then converted to a wildlife habitat of introduced cool-season grasses and legumes. The field was fallowed and a clean, firm seedbed was prepared for seeding native mixed-grass prairie species. The topography of the site is typical of the glaciated prairie pothole region in the north-central United States. The soils are a Barnes-Buse loam with 7-percent slopes facing primarily in an easterly direction. The field was classified as a silty upland range site with three small wetlands and associated wet meadow and overflow range sites.

We planted the entire field with a base mixture of native grasses, including SD-93 green needlegrass (*Stipa viridula*), 'Rodan' western wheatgrass (*Pascopyron smithii*), 'Critana' thickspike (northern) wheatgrass (*Elymus lanceolatus*), and 'Killdeer' sideoats grama (*Bouteloua curtipendula*).

We then loaded the drill with a m ture of 'Bison' big bluestem (*Andropogon*

gerardi), 'Tomahawk' Indiangrass (*Sorghastrum nutans*), and 'Dacotah' switchgrass (*Panicum virgatum*). This mixture is over-seeded at a rate of eight pure live seeds per square foot on the wet meadow, overflow range sites adjacent to the wetlands, and saddles with deep moist soils. Topography and changes in soil color indicated where to begin and end the overseeding operations.

A year later the USDA SCS completed a second sculptured mixed-grass prairie seeding on a 71-acre cultivated field located in Bottineau County, North Dakota. The Boundary Creek Water Management District collaborated on the project.

The soils are a Barnes-Buse loam (silty-thin upland range sites) with slopes ranging from 3 to 25 percent that grade to a Svea-Tonka complex (overflow-wet meadow range sites) with 0 to 6 percent slopes. The topography is complex, again typical of the glaciated prairie pothole region, and transected by a major creek channel. We planted a base mixture of the native grasses in a manner similar to the planting at the Woodworth Field Station (Table 1).

Then we loaded the drill with 'Bison' big bluestem and 'Dacotah' switchgrass and seeded at a rate of two pure live seeds per square foot on the deep moist soils (wet meadow and overflow range sites) and associated drainages.

We used commercial grass drills designed to facilitate planting of a wide range of native species. Our drills were equipped with special seed boxes, depth control bands, and packer wheels to meet the requirements of planting native mixed-grass prairie species. The requirements for seeding native grasses and forbs are more precise than for introduced cool-season grasses. By following proven methods, one can expect successful establishment. In fact, the excellent stands on both of these sites continue to demonstrate the ecological potential of sculptured seeding.

State-of-the-Art: Canada

DUC annually purchases thousands of acres under the auspices of the North American Waterfowl Management Plan (NAWMP). We believe that if long-term, easily maintained cover on these lands is the objective of a revegetation program, a more ecologically sensitive approach to planting should be adopted and would provide greater multi-wildlife species benefits.

Much of the purchased land is Agriculture Class 4, 5, or 6 land. These soils generally have inherent fertility limitations that are challenging to a revegetation program. When combined with a rolling terrain, as is common in many areas where knolls have been badly degraded through former cultural practices, the revegetation process becomes even more difficult.

Historically, DUC managers have prepared combinations of three or four cool-season native grass species and seeded the entire field with the same mixture regardless of terrain. This initially produces a tall, homogeneous cover. While this cover provides attractive habitat to many duck species, it is not the preferred habitat of many smaller ground-nesting birds (Wilson *et al.*, 1989).

Manitoba Experience

In Manitoba, DUC has used native plant material in the revegetation program for the past 10 years. Several older plantings have now undergone controlled burn management treatments. Subsequent evaluations indicated shifts in plant species composition and differing post-management plant responses within fields. These changes undoubtedly were occurring prior to the burns, but residual vegetation obscured them.

It is evident that grass species that prefer deeper, fine-textured soils are less robust on the eroded knolls than on the heavier soils around the base of hills. Some plant species—such as western wheatgrass—have established a heavy sod layer that provides good erosion control on the middle and lower parts of the slopes. However, plant height and, more importantly, plant species diversity have suffered. While this does provide some heterogeneity through a variety of cover heights, it poses other potential problems more common to monotypic stands. For example, it raises the concern that under prolonged adverse climatic conditions such as drought, weedy species may be able to invade knoll areas as the planted species struggle to survive.

Ideally some species planted on the knolls should persist under adverse conditions. The literature indicates that wildlife species diversity decreases as habitat becomes monotypic (Wilson *et al.*, 1989; Romo *et al.*, 1990). Several references outline the soil, drainage regime gradient, and moisture requirements of native species (Thornburg, 1982; Dix *et al.*, 1967; Coupland, 1950, Bultsam *et al.*, 1988).

Table 1. **The base seed mixture planted in Bottineau County, North Dakota, Spring 1982.**

Cultivar	Common Name/ Scientific Name	Percent in Mix	PLS # Acres	Seeds Sq. Ft.
Rosana	western wheatgrass	0.25	3.00	7.5
Critana	thickspike wheatgrass	0.05	0.43	1.5
Sodar	streambank wheatgrass *Elymus lanceolatus*	0.05	0.42	1.5
Revenue	slender wheatgrass *Elymus trachycaulus*	0.05	0.41	1.5
Common	green needlegrass	0.35	2.20	9.9
Killdeer	sideoats grama	0.05	0.34	1.5
Common	blue grama *Bouteloua gracilis*	0.05	0.08	1.5
Blaze	little bluestem *Schizachyrium scoparium*	0.10	0.50	3.0
			7.38	27.9

Seeding the tops of knolls first helps offset the disadvantage these sites have due to erosion and less-robust soils.

Historically, seed was limited or not available for many native species suited for eroded soils. This was the major factor that led to originally using three or four species mixes seeded across an entire field. Fortunately, seed availability has improved and a much wider variety of species are now on the market.

In response to post-management grass stand behavior and increased seed availability, DUC in Manitoba has adopted the concept of seeding different mixes of native plant material in different areas of a field. The objective of this sculptured seeding approach is to re-establish, wherever possible, native plant material well-adapted to differing soils and drainage gradients encountered across a field (Figure 1).

Planting Mixes

For example, a high prairie mix is seeded on eroded knolls. A typical mix consists of prairie sandreed (*Calamovilfa longifolia*), sand dropseed (*Sporobolus cryptandrus*), sideoats grama, green needlegrass, and, to a lesser extent, western wheatgrass and purple prairie clover (*Dalea purpurea*). Beginning in 1993, additional species such as blue grama, white prairie clover (*D. candida*), little bluestem and, in the near future, needle and thread and northern porcupine grass will be used in the high prairie mix. The proportion used at a given site will vary with soil type. Prairie sandreed and sand dropseed are well-suited for sandy areas, little bluestem and blue grama to shallow eroded sites.

A mid-prairie mix seeded on medium to fine-textured soils consists of western wheatgrass, northern wheatgrass, green needlegrass, slender wheatgrass, big bluestem, and switchgrass. This habitat zone also receives limited amounts of purple prairie clover and white prairie clover, western snowberry (*Symphoricarpos occidentalis*), and leadplant (*Amorpha canescens*).

Low prairie to wet meadow zones are seeded with species such as switchgrass, big bluestem, basin wildrye (*Leymus cinereus*), western wheatgrass, Indiangrass, beardless wildrye (*Leymus triticoides*), whitetop (*Scolochloa festucacea*), slender wheatgrass, and northern reedgrass (*Calamagrostis canadensis*). Species composition and proportion in this mix will vary with moisture regime and salinity.

Planting Techniques

While the logic of an ecological approach to revegetation is fairly straightforward, the logistical aspects of sculptured seeding can initially be intimidating. However, the field procedures are quite simple.

The easiest method to determine the required mix is to combine a field inspection with a review of aerial photos. Eroded soils are readily apparent both in the field and on the photo. Delineation of boundaries of the various planting zones on the air photo will enable accurate determination of the acreages involved and generally take less than two hours per quart section. If air photos are not available, acreages can be estimated with reasonable accuracy in the field.

Precision is not mandatory. All that's necessary is that the estimated acreage of the various zones roughly equals the known size of the area to be planted. An easy guide to boundary delineation between high prairie and mid prairie mix is to look for the color change from light-eroded through grey-to-black in the soil along the gradient of the knolls. Present experience indicates it is advisable to seed the high prairie mix down to the grey/black soil interface.

Prior to seeding it is advisable to delineate the high and mid-prairie boundary by driving around the knoll areas with a truck or tractor. The operator can then use the tire marks as a guide. When seeding into standing stubble a more aggressive drag-type marking device should be used. If air photos are available, a quick field review of the planting site with the operator is recommended. Seed the high prairie mix on the knoll areas first. A 10- overlap along the mix boundary is recommended to avoid drill misses. When contour-seeding on a steep slope, the operator must check the seed boxes to ensure that seed has not piled up at the down slope end of the seed box, which can expose seed cups and thus cause drill skips.

Very little additional field time is required to carry out sculptured seeding. In order to document time requirements for sculptured seeding versus regular seeding, operators were required to keep accurate time logs of operating hours on all fields seeded in 1992, including six sculpture-seeded fields (Tables 2 and 3).

Seed Sources

We found that an understanding of the inherent variability within a native plant community is essential in selecting species and developing a seed mixture. Duebbert *et al.* (1981) indicate that the site on which the original seed or plants were collected is vital in determining plant adaptation.

Table 2. **Seeding Rate (acre/hr) Comparisons—All Projects**

ɜding Type	Average Field Size	N	Acres/Hr (av.) Seeding Rate	Average Acres Knoll Mix/Field
Without knoll mix	81.3	11	4.13	—
With knoll mix	85.0	6	4.39	15

Table 3. **Seeding Rate (acre/hr) Comparisons—Knoll Mix Projects**

Project	Size/Acres	Acres/Hr Seeding Rate			Additional Man Hours/Field
		Regular	Knoll Mix	Combined	
McNabb	90– 6.5*	4.8	3.25	4.75	1.5
Slobodzian	106–47.6	4.06	4.32	3.93	1.5
Kolesar	103– 6.0	4.0	4.0	4.00	0.5
Goods	76–20.0	3.23	3.23	3.23	4.0
Turner 1	35– 7.0	5.2	5.2	5.2	2.0
Turner 2	15– 3.0	5.2	5.2	5.2	1.0
Average	70.8–15	4.42	4.2	4.39	1.75

*Acres of knoll mix/field.

The USDA SCS, in cooperation with DUC and other agencies, has planted fields in the northern plains to evaluate the adaptation and performance ᶜ selected species and released cultivars. ıe results indicate that when seed or plants of native grasses from northern sources are moved southeastward, they mature earlier, are shorter, produce less forage, and are more susceptible to leaf and stem diseases. When southern sources are moved northward they generally mature later, are taller, and produce more forage. When southern sources that are not winter-hardy are moved too far north, they may be injured or killed during the year of establishment or under adverse climatic or management conditions in later years.

Cultivars of native plants in commercial seed production exhibit superior performance within a proven area of adaptation. Selection of the proper ecotype is as important as selection of the proper species. When planning a sculptured-seeding project, use source-identified seed that has been harvested in the vicinity of the area proposed for revegetation. This seed can be used with confidence, provided it has been tested for purity and germination.

Field experience of the SCS (Cooper, 1957) in the central and northern Great Plains indicates that a source-identified ecotype can be moved 400 to 480 km (250 to 300 miles) north or 160 to 249 km (100 to 150 miles) south of its origin without having serious problems with winter hardiness, longevity, or disease. Some species, especially cool-season plants, have a wider range of ecological amplitude and perform satisfactorily over a wider range of climate conditions. Changes in annual precipitation and elevation affect movement of ecotypes east or west. Generally, an increase of 1,000 feet in elevation is equivalent to a move of 300 km (175 miles) north.

These guidelines do not apply to introduced species. Each introduced cultivar has a greater though definite range of adaptation (Thornburg, 1982). In establishing native plant communities on cultivated fields, the success rate will be higher with certified seed from sources known to be adapted to the specific geographic area. Other benefits of sculptured seeding include reduced long-term maintenance and improved ecological balance.

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Appendix C

Native Grass Cultivars Adapted for Use in
Northeastern North America

Cultivar Recommendations for the Northeastern States and Eastern Canada

SPECIES	CULTIVAR	ORIGIN	GEOGRAPHIC USE AREA*	USDA PLANT HARDINESS ZONE
Bluestem, big	'Bison'	ND	northern MI to central MN & north	2,3,4
	Bonanza'	NE	southern WI south	5,6
	'Bonilla'	SD	central MI to central MN	4,5
	'Champ'	IA/NE	southern WI south	5,6
	Goldmine	KS	southern VT/NH & south	5,6,7
	'Kaw'	KS	southern VT/NH & south	5,6,7
	LI, NY ecotype	NY	Long Island, south	6,7
	'Pawnee'	NE	southern WI south	5,6
	'Rountree'	MO	southern MN to central MI & s	4,5,6
	'Sunnyview'	SD/MN	central MI to central MN	4,5
	Suther Germplasm	NC	NJ south through the Carolinas	6,7,8
	Southlow Germplasm	MI	MI southern lower penninsula	4,5
	Prairievier Germplasm	IN	northern and central IN	4,5
Bluestem, little	'Aldous'	KS	southern WI, NY & south	4,5,6
	'Blaze'	NE	southern MN, WI, MI	4,5
	'Camper'	NE	central MN south, NY & north	4,5
	Suther Germplasm	NC	NJ south through the Carolinas	6,7,8
	Southlow Germplasm	MI	MI southern lower penninsula	4,5
	Prairievier Germplasm	IN	northern and central IN	4,5
	Albany pine bush	NY	NY, lower New england	4,5
	CT ecotype	CT	NY, lower New England	5,6
	LI, NY ecotype	NY	Long Island, south	6,7
	PA, ecotyope	PA	south central NY south	5,6
Bluestem, Coastal little	Dune Crest Germplasm	NJ, MD, DE	coastal MD, DE, and NJ	6,7
Bluestem, sand	'Goldstrike'	NE	NY & north	3,4,5
Cordgrass, salt meadow	'Avalon'	NJ	VA to NH	4,5
Deertongue	'Tioga'	NY	all	3,4,5
Gamagrass, eastern	Meadowcrest'	MD	Long Island, south	6,7
	'Pete'	KS/OK	all	4,5,6
Grama, sideoats	'Butte'	NE	central MN to southern MI	4,5
	'El Reno'	OK	NY & south	4,5,6
	'Killdeer'	ND	northern MI & north	2,3
	'Pierre'	SD	central MN to central MI	4,5
	'Trailway'	NE	southern New England & north	3,4
Indiangrass	'Cheyenne'	OK	VA & south	6,7
	Chief"	NE/KS	southern MN & south	4,5
	Coastal Germplasm	CT, RI, MA	Southern NE south to MD	5,6,7

Cultivar Recommendations for the Northeastern States and Eastern Canada (continued)

SPECIES	CULTIVAR	ORIGIN	GEOGRAPHIC USE AREA*	USDA PLANT HARDINESS ZONE
	'Holt'	NE	central MN & south	4,5
	'Lometa'	TX	VA & south	6,7
	LI, NY ecotype	NY	Long Island, south	6,7
	'NE-54'	NE	NY & north	3,4,5
	'Osage'	KS/OK	central PA & south	6,7
	'Oto'	KS/NE	southern MN & south	4,5
	PA ecotype	PA	Central NY, PA	4,5
	Prairieview Germplasm	IN	northern and central IN	4,5
	'Rumsey'	IL	PA & north	4,5,6
	Scout'	NE	NY & north	4,5
	Suther Germplasm	NC	NJ south through the Carolinas	6,7,8
	Southlow Germplasm	MI	MI southern lower penninsula	4,5
	'Tomahawk'	ND/SD	central MI, northern WI & north	2,3,4
	Warrior	KS/NE	southern MN & south	4,5
Lovegrass, sand	'Bend'	KS/OK	central VT, NH & south	5,6
	'NE-27'	NE	NY & north	3,4,5
Panicgrass, coastal[1]	'Atlantic'	VA	Long Island, south	5b, 6, 7
Switchgrass	'Alamo'	TX	southern MD & south	6b,7
	'Blackwell'	OK	southern WI to NY & south	5,6,7
	Bomaster'	NC	northern NJ south to the Carolinas	6,7,8
	Carthage	NC	PA & south	6,7,8
	'Cave-In-Rock'	IL	southern WI to NY & south	5,6,7
	'Dacotah'	ND	central MN to northern MI & north	2,3,4
	'Forestburg'	SD	central MN to central MI, north	3b, 4,5
	High Tide Germplasm	MD		5,6,7
	'Kanlow'	OK	Long Island & south	6,7
	LI, NY ecotype	NY	Long Island, south	6,7
	'Nebraska 28'	NE/KS	central MN to central MI	4,5
	'Pathfinder'	NE/KS	southern MN to southern MI	4,5
	Shawnee'	IL	southern WI to NY & south	5,6,7
	'Shelter'	WV	WV to southern NH	5,6
	Southlow Germplasm	MI	MI southern lower penninsula	4,5
	Summer'	NE	central MN to central MI, north	3,4
	'Sunburst'	SD	central MN to central MI	4,5
	'Trailblazer'	NE	southern MI, MN; central VT & north	3,4
	Timber Germplasm	NC	northern NJ south to the Carolinas	6,7,8
Sandreed, prairie	Koch Germplasm	MI	western MI	4,5

* The north and south is referenced within the NE region, see map.

[1]This is the only cultivar of coastal panicgrass. It is not reliably winter hardy north of central Pennsylvania. However, it is often used as a temporary companion throughout the region due to its good seedling vigor, especially on droughty sites.

Appendix D

Examples of Seed Mixtures Suitable
for Use in the Northeast

Examples of Seed Mixtures Suitable for Use in the Northeast

SPECIES	PLS LB/AC	SEEDS/LB	PLS SEEDS/SQ FT
switchgrass	2	259,000	11.9
big bluestem	3	165,000	11.4
indiangrass	3	175,000	12.1
eastern gamagrass (optional)	2	7,500	0.3
little bluestem[1]	2	240,000	11.0
coastal panicgrass (zone 5b)	1	300,000	6.9
sideoats grama[1]	2	191,000	8.8
purpletop (zone 5b)	1	161,000	3.7

Option 1. On droughty sites with less than 10 percent fines passing 200 mesh seive, add and subtract:

sand lovegrass [2]	add 2	1,550,000	71.2
sand bluestem [2]	add 2	125,000	5.7
deertongue	add 1	400,000	9.2
coastal panicgrass	add 1	300,000	6.9
eastern gamagrass	sub 2	7,500	0.3
prairie sandreed[2]	add 2	274,000	12.6
sideoats grama	sub 1	191,000	4.4

Option 2. On wetter sites add and subtract:

prairie cordgrass	add 1	197,000	4.5
little bluestem	sub 2	240,000	11.0
coastal panicgrass	sub 1	300,000	6.9

[1] On well drained to excessively well drained infertile soils these species have a better chance of competing

[2] If native to your region other wise increase the little bluestem by 1 lb/ac, big bluestem 1 lb/ac and deertongue 2 lb/ac

Option 3. To the above mix add some genera of the following forbs and legumes. This list presents a cross section of bloom dates, flower color and se of consideration may also be available.

butterfly milkweed	0.01	50,000	0.01
New England aster	0.01	1,216,000	0.30
New York aster	0.01	4,600,000	1.0
heath aster	0.01	800,000	0.2
blue false indigo	0.01	63,140	0.01
partridge pea	0.1	3,500	0.008
tall white beard tongue	0.1	400,000	0.9
lanceleaved coreopsis *	0.05	210,000	0.2
purple coneflower	0.1	97,000	0.2
sunflower heliopsis	0.01	126,000	0.03
roundhead lespedeza *	0.01	144,000	0.03
spiked gayfeather	0.01	162,000	0.04
perennial lupine	0.05	18,800	0.02
wild bergamot	0.01	1,418,000	0.3
grey-head coneflower	0.01	410,000	0.09
blackeyed susan *	0.01	1,750,000	0.4
gray goldenrod	0.01	1,000,000	0.2

* not rated high for pollinator enhancement but could provide other benefits and aestetic value

Great Lake States - Michigan, Minnesota, Indiana and Wisconsin

1. For mesic to dry sites (warm season mix)

Species	PLS lbs/ Acre	Seeds/ Pound	Seeds/ Acre	PLS Seeds/ Sq.Ft
Big bluestem	2.0	165,000	330,000	7.6
Little bluestem	1.0	240,000	240,000	5.5
Indiangrass	2.0	175,000	350,000	8.0
(Adapted forbs may be added)				21.0

2. For deep well drained, moderately well drained and somewhat poorly drained soils (warm season mix)

Species	PLS lbs/ Acre	Seeds/ Pound	Seeds/ Acre	PLS Seeds/ Sq.Ft
Switchgrass	2.0	259,000	518,000	11.9
Big bluestem	4.0	165,000	660,000	15.2
Indiangrass	1.5	175,000	262,500	6.0
(Adapted forbs may be added)				33.0

3. For shallow and/or excessively drained soils (warm season mix)

Species	PLS lbs/ Acre	Seeds/ Pound	Seeds/ Acre	PLS Seeds/ Sq.Ft
Big bluestem **or**	2.0	165,000	330,000	7.6
Sand bluestem*	2.0	110,000	220,000	5.0
Sideoats grama	2.5	191,000	477,500	11.0
Indiangrass	1.5	175,000	262,500	6.0
Switchgrass	1.0	259,000	259,000	5.9
Little bluestem	1.5	240,000	360,000	8.3
(Adapted forbs may be added)				43.8

* if native to your region

4. For somewhat to poorly drained soils, pH >6.5 (cool season mix)

Species	PLS lbs/ Acre	Seeds/ Pound	Seeds/ Acre	PLS Seeds/ Sq.Ft
Western wheatgrass	10.0	110,000	1,100,000	25.2
Tall wheatgrass*	5.0	79,000	395,000	9.1
Slender wheatgrass	1.0	159,000	159,000	3.6
Virginia wildrye	3.0	100,000	300,000	6.9
Riverbank wildrye	3.0	125,000	375,000	8.6

(Adapted forbs may be added)

*Tall wheatgrass is an introduced cool season grass

5. Conservation practice mix (warm season)

Species	PLS lbs/ Acre	Seeds/ Pound	Seeds/ Acre	PLS Seeds/ Sq.Ft
Big bluestem	1.0	165,000	165,000	3.8
Indiangrass	1.0	175,000	175,000	4.0
Little bluestem	2.0	240,000	480,000	11.0
Sideoats grama	1.0	191,000	191,000	4.4
Switchgrass	0.5	259,000	129,500	3.0
(Adapted forbs may be added)				26.2

Great Lake States - Michigan, Minnesota, Indiana and Wisconsin (continued))

6. Warm season mix

Species	PLS lbs/ Acre	Seeds/ Pound	Seeds/ Acre	PLS Seeds/ Sq.Ft
Big bluestem	1.0	165,000	165,000	3.8
Switchgrass	1.0	259,000	259,000	5.9
Indiangrass	3.0	175,000	525,000	12.0
Little bluestem	1.0	240,000	240,000	5.5
(Adapted forbs may be added)				27.2

New England States/Mid-Atlantic

1. For acid soils/mine spoil reclamation

Species	PLS lbs/ Acre	Seeds/ Pound	Seeds/ Acre	PLS Seeds/ Sq.Ft
Deertongue	15.0	400,000	6,000,000	137.7
Broomsedge	5.0	800,000	4,000,000	91.8
Bush clover	2.0	144,000	288,000	6.6
Redtop	1.0	4,990,000	4,990,000	114.5
				350.6

2. For sand and gravel pits, landfill cover seeding

Species	PLS lbs/ Acre	Seeds/ Pound	Seeds/ Acre	PLS Seeds/ Sq.Ft
Big bluestem	5.0	165,000	825,000	18.9
Indiangrass	2.0	175,000	350,000	8.0
Switchgrass	3.0	259,000	777,000	17.8
Little bluestem	3.0	240,000	720,000	16.5
Redtop **or**	1.0	4,990,000	4,990,000	114.6
perennial ryegrass	5.0	227,000	1,135,000	26.1
			with redtop -	175.9
			with ryegrass -	42.6

3. For Coastal Dunes

Species	PLS lbs/ Acre	Seeds/ Pound	Seeds/ Acre	PLS Seeds/ Sq.Ft
Coastal panicgrass	8.0	350,000	2,800,000	64.3
Coastal little bluestem	5.0	240,000	1,200,000	27.5
Seaside goldenrod	1.0	1,700,000	1,700,000	39.0
beach pea	3.0	12,000	36,000	0.8
evening primrose	1.0	1,376,000	1,376,000	31.6
				163.3

Appendix E

Drill Calibration Methods

Drill Calibration*

I Bulk Weight of Seed Method[5]

a) Jack up the drive wheel end of the drill and measure the circumference of the drive wheel in feet. Make a mark on the side of the tire as a reference point.
b) Measure the distance between the seed spouts or openers in inches to determine the row spacing.
c) Use Table I, below, to determine the number of revolutions (R) to turn the drive wheel for the row spacing and wheel circumference (C) of the drill.
d) Put enough seed in the box to cover the appropriate number of seed spouts (from Table 1) for the drill and turn the drive wheel until those spouts are feeding evenly.
e) Collect seed from the appropriate number of spouts by placing containers under them and turning the drive wheel the number of revolutions already determined.
f) Combine the collected seed and weigh it in grams. Multiply that weight by 0.5 to determine the pounds per acre being delivered at that drill setting.
g) Adjust the drill setting and continue trials until the desired seeding rate is obtained.

Table 1

Row Spacing (inches)	No. of Spouts to Collect	Drive Wheel Revolutions
6	4	96/C = R
7	4	82/C = R
8	3	96/C = R
10	3	77/C = R
12	2	96/C = R

Example: The drill has 7 inch row spacing and a drive wheel circumference of 6.8 feet. The desired bulk seeding rate is 15.1 pounds per acre.

a) 6.8 feet
b) 7 inches
c) 87/6.8 = R = 12
d) 4 seed spouts (from Table 1 for 7 inch row spacing)
e) Collect the seed delivered by 4 seed spouts with 12 revolutions of the drive wheel.
f) The drill is properly adjusted when the 4 seed spouts deliver 30 grams of seed:
30 grams x 0.5 = 15 pounds per acre

* This method determines the seeding rate in bulk pounds of seed per acre. The bulk seeding rate may have to be adjusted to achieve the desired PLS seeding rate if the conversion from PLS to bulk rates was not done prior to determining the amount of bulk seed being delivered.

2. Seeds Per Row Foot Method

After the planting mixture and desired seeding rate per square foot have been established, the drill can be calibrated by counting the number of seeds being delivered per foot of row when the machine is in operation.

a) Fill the drill with seed and make a preliminary setting based on the seeding chart and operators manual for the drill.
b) Operate the drill until all seed spouts are delivering seed normally and then drive over a tarpaulin or hard ground surface.
c) Use Table 2, below, to determine the number of linear feet of row necessary to equal one square foot of planting area for the row spacing of the drill.

Table 2

Row Spacing (inches)	Linear Feet of Row Equal to One Square Foot
6	2.0 feet
7	1.8 feet
8	1.5 feet
10	1.2 feet
12	1.0 foot

d) Count the number of seeds in the length of row determined from Table 2. Make several counts and determine the average number of seeds per square foot being delivered.
e) If necessary, adjust the drill setting and repeat steps b, c and d until the desired seeding rate is obtained.

Appendix F

Native Plant Material
Species Descriptions

Species Descriptions

The following pages present brief descriptions of a number of species of native plants that are available for use in revegetation plantings in the northeast. It is not intended to serve as a complete listing of all species that may be available for ornamental or landscaping purposes. A much wider range of species, particularly forbs, is available for those uses. Because they cannot be obtained in quantity for large scale plantings, they are not included.

The intent of this section is directed toward large scale plantings. The description of each species focuses on its adaptation and potential use. A limited number of key field identification features are noted for each species. For a more complete description of vegetative characteristics, species adaptation and use, see the publications listed as references and supplemental reading elsewhere in this manual. The conservation plant sheets produced by the NRCS are a particularly good source of more detailed information about many species.

The factors listed as preferred environmental conditions are not the only conditions under which a species may occur in nature. Many native plants can adapt to a wide range of growing conditions, so it is possible that a species may be encountered in conditions outside the ranges noted. When a species occurs outside its preferred range, it may not exhibit its normal growth potential. It may eventually be outperformed by other, better adapted species.

Information respecting seed availability and adapted cultivars is presented for each species. Seed sources known to the authors at the time of printing are listed in Appendix G.

Grasses

Grasses will be a primary component of the planting material used in most revegetation work. The range of species available, their relative ease of establishment and subsequent management, their soil building properties and the range of surface cover conditions they can provide make grasses an ideal foundation for revegetation and reclamation plantings.

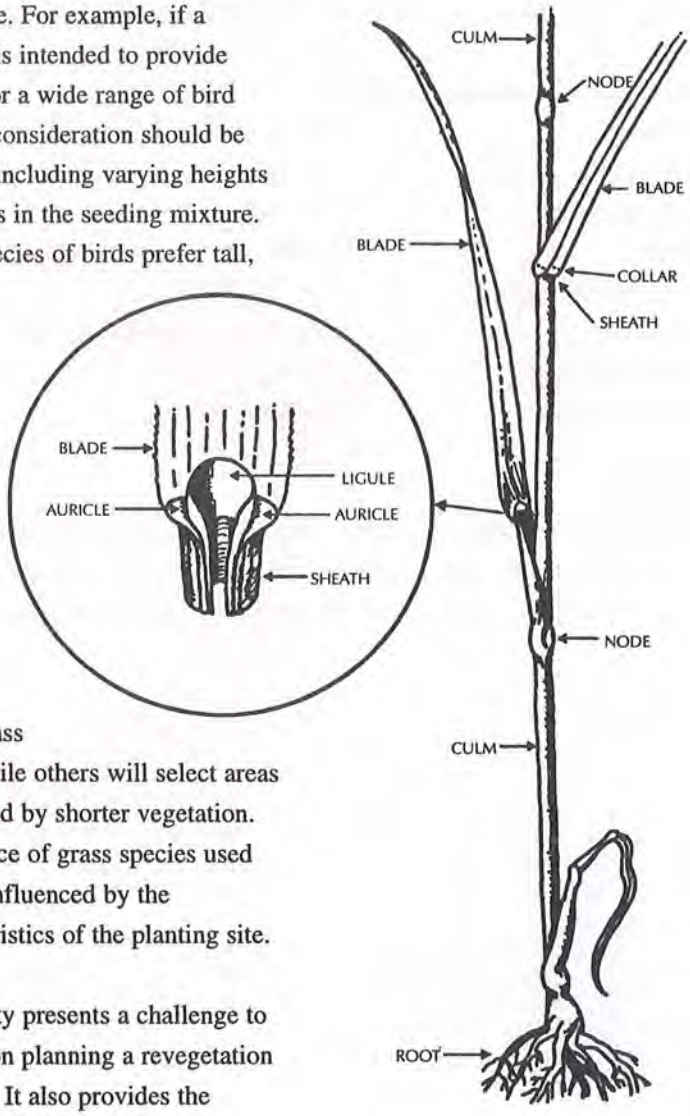
The native grasses listed in this section have been characterized by their physiology and phenology into warm season and cool season types. As a general rule, warm season grasses require a soil temperature of at least 50°F (10°C) to germinate while cool season species will germinate at lower soil temperatures. Established warm season grasses initiate growth in the late spring, usually in late May to early June, and make their maximum growth during the warmest part of the summer. Cool season plants, on the other hand, begin growth earlier in the season and often become dormant in the summer. They continue growth again when the cooler fall weather returns if moisture conditions are adequate. Warm and cool season grasses also differ in their tolerance to some herbicides.

Those fundamental differences between the classes may well influence the choice of species combined in a mixture to achieve planting objectives on a specific site. They also affect the establishment techniques used for that planting and the type of future management the site receives.

While the species within a class, either cool season or warm season, share some characteristics with each other they also exhibit differences. One species may vary in stature, moisture requirements, salinity tolerance or preferred soil type from another species of the same type. For example, if a planting is intended to provide habitat for a wide range of bird species, consideration should be given to including varying heights of grasses in the seeding mixture. Some species of birds prefer tall, dense grass cover while others will select areas dominated by shorter vegetation. The choice of grass species used will be influenced by the characteristics of the planting site.

Variability presents a challenge to the person planning a revegetation planting. It also provides the opportunity to "custom design" a mixture of grass species to accomplish specific objectives within the physical limitations of a site. As more species become available, the challenges and the opportunities will increase.

Vegetative Parts of a Grass Plant



AMERICAN BEACHGRASS

(Ammophila breviligulata)

Adaptation & Use

American beachgrass is native to the Atlantic Coast and the Great Lakes. It differs from European beachgrass in being strongly rhizomatous, less sensitive to high temperatures immediately after transplanting and somewhat longer lived.

Plantings are established vegetatively on eroding sandy areas and shifting dunes where slopes are no greater than two to one. When planting will extend over a period of several seasons, it is usually best to start on the windward side. Plant only in the spring or fall when weather is cool. Average temperatures should not exceed 50°F (10°C) for two weeks after planting.

Key Field Identification Features

American beachgrass is a tough, coarse, erect perennial with thick culms commonly 30 to 40 inches (75 to 100 cm) tall, and hard, scaly, creeping rhizomes. The base of the dense, spike-like panicles is often enclosed in the sheath.

Preferred Environmental Conditions

Precipitation:	> 20 inches (50 cm) annually
Soil texture:	Medium to coarse
Soil drainage:	Well drained
Soil pH:	Moderately acidic to moderately basic
Fertility requirement:	Low
Salt tolerance:	Conductivity (mmhos/cm) < 16
Flood tolerance:	Poor
Drought tolerance:	Excellent

Availability

Two varieties are currently available. 'Cape' is a selection made by the Cape May Plant Materials Center from a single plant growing on a sand dune on Cape Cod. 'Hatteras' was selected at the North Carolina Agricultural Experiment Station in Raleigh from a group of 18 clones ranging in plant types.

GREEN NEEDLEGRASS

(Nassella viridula) (Stipa viridula)

Adaptation & Use

An erect bunch grass with a dense root system extending 6 to 10 feet (2 to 3 metres), green needlegrass is native to the western edge of the area covered in this manual and to New York. It most commonly grows on clay soils, although it occurs rarely in this region. Germinating seedlings establish rapidly, and the plants are relatively pest free.

The species is characterized by a relatively high level of seed dormancy. Even in a cultivar selected for dormancy rates lower than those occurring naturally, it is not uncommon for only 40 percent of the viable seed to emerge in the planting year. More seedlings emerge in subsequent years, improving the amount of ground cover.

Key Field Identification Features

Green needlegrass leaves are prominently veined and rough to the touch on the upper surface, with a prominent midrib on the underside. There are white hairs at the junction of the leaf blade and sheath and along the edge of the sheath. Seed heads are erect to slightly nodding with small, hairy black seeds and awns that are seldom more than three cm long.

Preferred Environmental Conditions

Precipitation:	> 14 inches (35 cm) annually
Soil texture:	Medium to moderately fine
Soil drainage:	Moderately to well drained, water table > 35 inches (90 cm)
Soil pH:	Neutral to weakly basic
Fertility requirement:	Moderate
Salt tolerance:	Conductivity (mmhos/cm) < 6
Flood tolerance:	Fair
Drought tolerance:	Moderate

Availability

No work is presently underway with green needlegrass in this region. It is unlikely that northeastern origin plant material will be available in the foreseeable future.

NORTHERN WHEATGRASS

(Elymus lanceolatus) (Agropyron dasystachyum)

Adaptation & Use

Northern wheatgrass is native to the western portion of the area covered by this manual (Wisconsin, Illinois and Michigan). An erect, rhizomatous plant, it reaches a height of 16 to 27 inches (40 to 70 cm). Because of its three way root system – rhizomes for vegetative spreading, dense shallow roots to 10 inches (25 cm) and a few deep feeder roots to 24 inches (60 cm) – northern wheatgrass is adapted to a wide range of soil and moisture conditions. It occurs in mixed stands with western wheatgrass and the needlegrasses on clay and loam soils and occasionally in pure stands on sandy soils.

Because of its wide range of adaptation and relatively good seedling vigor, northern wheatgrass is a valuable species in many revegetation plantings. When established, it is hardy, long-lived and more drought tolerant than western wheatgrass.

Key Field Identification Features

Northern wheatgrass leaves are usually light green with prominent veins and an upper surface which is rough to the touch. The collar is light green, smooth and has clasping auricles to 2 mm long. Seed florets are usually hairy.

Preferred Environmental Conditions

Precipitation:	> 10 inches (25 cm) annually
Soil Texture:	Moderately coarse to fine
Soil drainage:	Moderately to well drained, water table 6 to 35 inches (15 to 90 cm)
Soil pH:	Weakly acidic to moderately alkaline
Fertility requirement:	Low
Salt tolerance:	Conductivity (mmhos/cm) < 8
Flood tolerance:	Good
Drought tolerance:	Excellent

Availability

Two cultivars are presently available. 'Critana' was developed by the USDA Natural Resources Conservation Service from a Montana source, while 'Elbee' was released by Agriculture and Agri-Food Canada from a prairie Canadian source. An additional cultivar is being developed by Agriculture and Agri-Food Canada from the assemblage which produced 'Elbee'. No eastern cultivars have been selected.

SLENDER WHEATGRASS

(Elymus trachycaulus sub *trachycaulus)*
(Agropyron trachycaulum var. *trachycaulum)*

Adaptation & Use

Slender wheatgrass is an erect bunch grass with dense fibrous roots extending to a depth of 20 inches (50 cm). Young (two to three year old) plants may develop tillers to increase their basal area. Unlike other native wheatgrasses, it has a relatively short life span – usually not longer than five years. Slender wheatgrass is native to all states.

It is adaptable to a wide range of soil conditions provided moisture supplies are adequate, and is tolerant of relatively high salinity levels. In addition, slender wheatgrass seed usually has a high germination rate and excellent seedling emergence and vigor. As a result, it can be a valuable component in a seeding mixture with slower developing, long-lived species. Slender wheatgrass will provide early ground cover in the planting and gradually decline in importance as other species develop. It is particularly well suited for use in low areas having saline soils.

Key Field Identification Features

Slender wheatgrass stems are usually a reddish or purple color near the base. The leaf collar is distinct, continuous and yellowish green. Auricles are rudimentary or absent; frequently only one rudimentary auricle occurs.

Preferred Environmental Conditions

Precipitation:	> 14 inches (35 cm) annually
Soil texture:	Moderately coarse to moderately fine
Soil drainage:	Well-drained, water table 6 to 35 inches (15 to 90 cm)
Soil pH	Weakly acidic to strongly basic
Fertility requirement:	Low
Salt tolerance:	Conductivity (mmhos/cm) < 16
Flood tolerance:	Good
Drought tolerance:	Moderate

Availability

Slender wheatgrass was the first native grass species to be developed for cultivated production in Canada. As a result, seed supplies are usually abundant. 'Revenue', which was developed by Agriculture and Agri-Food Canada, is the most commonly used cultivar on the Canadian prairies. No cultivars of slender wheatgrass have been developed for use in the east.

WESTERN WHEATGRASS

(Pascopyrum smithii) (Agropyron smithii)

Adaptation & Use

Western wheatgrass occurs in the western half of the area covered by this manual and also in New York, although it is absent from the coastal states. It has aggressive rhizomes for vegetative spreading, a dense shallow rooting system and some deeper feeding roots extending to 24 inches (60 cm).

While plants develop somewhat slowly from seed, they usually spread rapidly in their second year and provide good ground cover from then on. Because of its tolerance for a wide range of soil, moisture and salinity conditions, western wheatgrass is an extremely valuable species for use in revegetation plantings. Due to its aggressively rhizomatous growth, it is usually included at a relatively low seeding rate with other species in a planting mixture.

Key Field Identification Features

Western wheatgrass plants have a very characteristic blue green color. The leaves are rigid, prominently veined and grow from the stem at a 45 degree angle.

Preferred Environmental Conditions

Precipitation:	> 14 inches (35 cm) annually
Soil texture:	Moderately coarse to very fine
Soil drainage:	Poorly drained, water table 0 to 16 inches (0 to 40 cm)
Soil pH:	Neutral to strongly basic
Fertility requirement:	Low
Salt tolerance:	Conductivity (mmhos/cm) < 16
Flood tolerance:	Good (50 to 60 days)
Drought tolerance:	Good

Availability

No cultivars of western wheatgrass have been developed for use in the east. Performance of the existing midwest varieties has been marginal in the area covered by this manual.

CANADA WILDRYE

(Elymus canadensis)

Adaptation & Use

Canada wildrye is a tall, erect bunch grass which may have short rhizomes when young. It is found throughout North America, usually growing as individual plants and not in dense stands. It most frequently occurs on sandy soils, in wooded areas and on disturbed sites like riverbanks. Establishing quickly in disturbed areas, it could be an important early successional species in revegetation plantings.

Key Field Identification Features

Canada wildrye has wide (to 0.8 inch/20 mm), waxy green pointed leaves growing from the base of the stems to the spike. The auricles are claw-like and clasping, arising from a broad yellowish or light green collar. Nodding awned seed heads about 6 to 8 inches (15 to 20 cm) long have two spikelets at each node.

Preferred Environmental Conditions

Precipitation:	> 10" (25 cm) annually
Soil texture:	Coarse to moderately fine
Soil drainage:	Moderately to well drained, water table 6 to 35 inches (15 to 90 cm)
Soil pH:	Moderately acidic to weakly basic
Fertility requirement:	Low
Salt tolerance:	Conductivity (mmhos/cm) < 4
Flood tolerance:	Moderate
Drought tolerance:	Moderate

Availability

The only cultivar currently available is 'Mandan', released by the USDA Agricultural Research Service at Mandan, North Dakota from a plant assemblage from northern North Dakota. No cultivars of eastern origin are known to be available at this time.

VIRGINIA WILDRYE

(Elymus virginicus)

Adaptation & Use

Virginia wildrye is common throughout the eastern region. It is shorter than Canada wildrye and is commonly found in wetter, more shaded sites that the larger species. Like Canada wildrye, this species could be important to revegetation work if eastern selections were available.

Key Field Identification Features

Virginia wildrye is variable, but typically has an erect spike with more densely packed seeds than the other wildryes. Also, the awns are straighter than those for Canada wildrye. The species typically occurs in mixtures with other native and introduced grasses.

Preferred Environmental Conditions

Precipitation:	> 10 inches (25 cm) annually
Soil texture:	All but heavy clays
Soil drainage:	Somewhat poorly to well drained
Soil pH:	Moderately acidic to weakly basic
Fertility requirement:	Low
Salt tolerance:	Conductivity (mmhos/cm) < 2
Flood tolerance:	Good
Drought tolerance:	Moderate

Availability

The only cultivar currently available is a proprietary product of a breeding program in Nebraska. The name is 'O Ma Ha'. The performance of this cultivar is under study in the east.

BIG BLUESTEM

(Andropogon gerardii)

Adaptation & Use

Big bluestem is an erect, tall bunch grass with short scaly rhizomes. A major component of the tall grass prairie of the eastern Great Plains, big bluestem occurs in all eastern states and Ontario and seems to be increasing along highway systems in northern New England. It also occurs on favorable sites as far west as the Qu'Appelle Valley in Saskatchewan. Big bluestem is most abundant on moist, well drained, fertile loams, where its roots may reach deeper than 10 feet (3 m).

With its warm season growth habit and adaptation to management by fire, big bluestem can be a valuable component in revegetation plantings in areas receiving greater than 20 inches (50 cm) of annual precipitation and on sites receiving run-on moisture. It is slower to establish than switchgrass. Big bluestem is a highly preferred forage, ranking second only to eastern gamagrass.

Key Field Identification Features

Stems are solid and pithy rather than hollow as in most grasses. They are often purplish at the base and exhibit a bluish to bronze color in late summer and fall. The seed head is a characteristic turkey foot shape with numerous white hairs between the seeds.

Preferred Environmental Conditions

Precipitation:	> 20 inches (50 cm) annually
Soil texture:	Moderately coarse to moderately fine
Soil drainage:	Well drained, water table > 35 inches (90 cm)
Soil pH:	Slightly acidic to weakly basic
Fertility requirement:	Moderate
Salt tolerance:	Conductivity (mmhos/cm) < 4
Flood tolerance:	Moderate
Drought tolerance:	Moderate to fair

Availability

'Bison', a cultivar released from a North Dakota source by the USDA Natural Resources Conservation Service, has been used successfully in plantings in Manitoba and on suitable sites in eastern Saskatchewan. It should perform well on sites in central Minnesota to central Michigan. 'Niagara' is the only eastern cultivar of big bluestem. It was selected from a collection made near Buffalo, NY. Plant Materials Centers in Michigan and Maryland are continuing to work with this species.

LITTLE BLUESTEM

(Schizachyrium scoparium)

Adaptation & Use

Little bluestem is one of the most widely distributed native grasses in North America. A mid height bunch grass with a dense root system reaching 8 feet (2.5 m), it can spread by seed, tillers and short rhizomes. More drought tolerant than big bluestem, it frequently occurs on the thin soils found on knolls and steep slopes as well as on gravelly or sandy soils.

Because of its growth habit and adaptability to a wide range of soil conditions, little bluestem can be a valuable component in revegetation plantings. It is especially well-suited for use on thin upland range sites.

Key Field Identification Features

Little bluestem produces many pith filled stems from a densely tufted base. Basal shoots are flat and bluish colored. Vegetative parts of the plant turn a warm bronze color in late summer or early fall. When mature, the densely hairy seed heads have a silvery appearance.

Preferred Environmental Conditions

Precipitation:	> 10 inches (25 cm) annually
Soil texture:	Moderately coarse to moderately fine
Soil drainage:	Well drained, water table > 35 inches (90 cm)
Soil pH:	Slightly acidic to weakly basic
Fertility requirement:	Moderate to low
Salt tolerance:	Conductivity (mmhos/cm) < 4
Flood tolerance:	Fair to poor
Drought tolerance:	Good

Availability

'ND-4115' Badlands Origin 1995, released by the USDA Natural Resources Conservation Service from a North Dakota source, has been used successfully in prairie Canada. No eastern cultivars of little bluestem have been developed due to the relatively poor seedling vigor of eastern ecotypes. Kansas and Nebraska cultivars like 'Aldous', 'Blaze' and 'Camper' grow well in most eastern locations.

SAND BLUESTEM

(Andropogon hallii)

Adaptation & Use

Sand bluestem is very closely related to big bluestem, but is native to the Midwest as far east as Iowa. The plant is adapted to sandy soils and has been used successfully as a mixture component for droughty site revegetation in the northeastern States.

Sand bluestem is typically found on sand hills from North Dakota to Texas in mixtures with other species such as sand lovegrass, switchgrass, big bluestem and little bluestem. It will grow on better soils, but may be crowded out by better adapted species on such sites over time. Sand bluestem will hybridize with big bluestem and one such cross is in commercial production.

Key Field Identification Factors

Sand bluestem has the same form and size as does big bluestem, although it tends to have a greater percentage of plants that are tightly columnar, and plants that have short rhizomes. Sand bluestem often has characteristically yellow or gold colored stems during the growing season prior to maturity. The seed head has a hairy look but otherwise is shaped like big bluestem.

Preferred Environmental Conditions

Precipitation:	18 to 30 inches (45 to 75 cm) annually
Soil texture:	Sand, sandy
Soil drainage:	Well to excessive
Soil pH:	Slightly acidic to slightly basic
Fertility requirement:	Low to moderate
Salt tolerance:	Conductivity (mmhos/cm) unknown, probably < 10
Flood tolerance:	Poor
Drought tolerance:	Very good

Availability

There are currently four cultivars of sand bluestem available and one of a big blue/sand bluestem hybrid. Of these, 'Goldstrike' sand bluestem from Nebraska performed best in plot work in New Hampshire and has been most often used on sand and gravel mine reclamation sites.

PRAIRIE CORDGRASS

(Spartina pectinata)

Adaptation & Use

Prairie cordgrass is a tall, strongly rhizomatous robust plant well adapted to marsh edges and nonsaline wet meadows where it often occurs in almost pure stands. It will also grow in mixed communities with other adapted plants on upland areas associated with freshwater marshes. Prairie cordgrass is native to the Atlantic coast and can be found mixed with American beachgrass within a foot of the high tide line. Prairie cordgrass has very little forage value.

Key Field Identification Features

Prairie cordgrass leaves are very rough on the upper surface and margins, smooth and shiny green below. Seed heads are composed of 10 to 20 spikes attached to the main stem. Each spike has up to 40 spikelets, all growing in two rows on the side of the spike away from the main stem.

Preferred Environmental Conditions

Precipitation:	> 20 inches (50 cm) annually
Soil texture:	Coarse to fine
Soil drainage:	Well to poorly drained, water table 6 to 35 inches (15 to 90) cm
Soil pH:	Slightly acidic to slightly basic
Fertility requirement:	Moderate
Salt tolerance:	Conductivity (mmhos/cm) < 4
Flood tolerance:	Excellent
Drought tolerance:	Fair

Availability

Selection work is presently underway at the NRCS Plant Materials Center at Big Flats, New York and Bismarck, North Dakota. The original plant material was from North Dakota sources, with Manitoba source material added in the spring of 1994. The assembly at Big Flats includes collections from Long Island to Washington County Maine. Releases are pending from the Kansas and New York Plant Materials Centers.

SALTMEADOW CORDGRASS

(Spartina patens)

Adaptation & Use

Saltmeadow cordgrass is most commonly found growing in open marshes along the eastern seaboard from Newfoundland to Florida and along the shores of the Great Lakes. In coastal marshes, it most frequently occurs in a band between the normal high tide level and the 15 foot elevation above high tide. It is the primary component of salt hay which is widely used as a weed free mulch by landscapers and vegetable producers.

From one to three feet tall, saltmeadow cordgrass spreads extensively by long, slender rhizomes. Because it is a sparse seed producer, it is usually propogated vegetatively. Saltmeadow cordgrass is used for shoreline protection, tidal marsh restoration and sand dune stabilization plantings.

Key Field Identification Features

Saltmeadow cordgrass leaf blades are rolled, usually six inches to one foot (15 to 30 cm) long and 0.1 to 0.2 inches wide. They are drooping and wiry in appearance. Seed heads consist of two to ten two inch long spikelets. The florets within each spikelet are arranged in an overlapping scale-like fashion.

Preferred Environmental Conditions

Precipitation:	> 20 inches (50 cm) annually
Soil texture:	Coarse to fine
Soil drainage:	Well to poorly drained
Soil pH:	Slightly acidic to slightly basic
Fertility requirement:	Low to moderate
Salt tolerance:	Conductivity (mmhos/cm) < 16
Flood tolerance:	Good to excellent
Drought tolerance:	Fair

Availability

There are two named cultivars available commercially. 'Avalon' was released in 1986 by the Cape May Plant Materials Center for use in the coastal area north of the Carolinas. 'Flageo', released by the Americus, GA and Brooksville, FL PMCs is suited to use on the southern Atlantic and Gulf coasts.

DEERTONGUE

(Dicanthelium clandestinum)

Adaptation & Use

Deertongue is a pioneer plant that occurs most often on sandy soils and dry, sterile or disturbed sites. It is infrequently found throughout the east region and has been used extensively to revegetate coal strip mines along with other plants. Deertongue will not tolerate somewhat poorly drained soils or those that are wetter.

Deertongue is a semierect plant with dense leaves that retains much of the seed head wrapped within the sheath around the stem. This is not a forage grass, but does provide nesting cover and seed for wildlife as well as erosion control on suitable soils.

Deertongue can be successfully used in mixtures with other warm season grasses and forbs and it is rarely, if ever, planted in pure stands. As a stand of grass fills in and matures, deertongue is often crowded off the site by more aggressive species.

Key Field Identification Features

Deertongue is a relative of switchgrass and coastal panicgrass, however, it is a shorter plant (typically about 36 inches or 90 cm tall) with much wider and shorter leaves – hence the name deertongue. There are many short hairs along the stem. Some plants are rhizomatous, spreading by new plants originating from rootstock at some distance from the mother plant.

Preferred Environmental Conditions

Precipitation:	> 30 inches (75 cm) annually
Soil texture:	Coarse to medium
Soil drainage:	Well to excessive
Soil pH:	Strongly acidic to slightly basic
Fertility requirement:	Very low to moderate
Salt tolerance:	Conductivity (mmhos/cm) unknown
Flood tolerance:	Very poor
Drought tolerance:	Very good

Availability

The only cultivar of deertongue is 'Tioga', a blend of 18 collections from Pennsylvania, and one each from New York and New Hampshire. Seedling vigor was the primary selection factor. The releasing agencies were the USDA Natural Resources Conservation Service and the Pennsylvania and New York Agriculture Experiment Stations. 'Tioga' is available from several seed vendors in the coal mining region of the east.

SAND DROPSEED

(Sporobolus cryptandrus)

Adaptation & Use

Sand dropseed is a native bunchgrass found on open, sandy soils throughout the United States, except for the eight most southeastern states. It is most abundant in the southern Great Plain states.

This grass is characterized by high yields of very small seed (> 5,000,000/lb) which shatter at maturity. Sand dropseed moves in quickly on disturbed areas and its presence often indicates drought or unfavorable soil conditions. It is particularly valuable in mixtures to provide cover until other slower developing native grasses can become established.

Key Field Identification Features

Sand dropseed grows to 3 feet (90 cm) in height with flat, 1/8 inch wide leaf blades that roll inward as the plant matures. It can be identified by a ring of short stiff hairs at the leaf collar and by a typically enclosed or covered seed head.

Preferred Environmental Conditions

Precipitation:	> 10 inches (25 cm) annually
Soil texture:	Medium to coarse
Soil drainage:	Well drained
Soil pH:	Slightly acidic to slightly basic
Fertility requirement:	Low
Salt tolerance:	Conductivity (mmhos/cm) < 4
Flood tolerance:	Poor
Drought tolerance:	Excellent

Availability

No information available.

EASTERN GAMAGRASS

(Tripsacum dactyloides)

Adaptation & Use

Eastern gamagrass can be found in natural grassland prairies of the central, eastern and northeastern United States along streambanks and other lowland sites. Deep, wet and nonalkaline soils favor its development and it tolerates extended periods of flooding.

It is highly productive, palatable and nutritious relative to other native, perennial warm season grasses. Although primarily used for pasture and hay production, it is an excellent source for wildlife food and cover.

Key Field Identification Features

This plant spreads by thick, knotty short jointed rhizomes. It grows in large clumps 1 to 4 feet (30 to 120 cm) in diameter and reaches up to 8 feet (2.5 m) in height. The seed heads typically have 1 to 3 spikes with the pistillate part below the staminate part. When mature, the seed bearing parts break at the joints with each part containing one seed. Leaves are up to one and a half inches (4 cm) wide, smooth with a prominent midrib. The ligule has a ring of short hairs.

Preferred Environmental Conditions

Precipitation:	> 20 inches (50 cm) annually
Soil texture:	Medium to fine
Soil drainage:	Moderately well to poor
Soil pH:	Neutral to weakly acidic
Fertility requirement:	High
Salt tolerance:	Conductivity (mmhos/cm) < 4
Flood tolerance:	Excellent
Drought tolerance:	Poor

Availability

The two main cultivars on the market are 'Pete' from the Manhattan Plant Materials Center in Kansas, and 'Iuka' from the Agricultural Research Service in Woodward, Oklahoma. Plant Materials Centers in New York and Maryland are currently working with eastern collections of this species.

SIDEOATS GRAMA

(Bouteloua curtipendula)

Adaptation & Use

Sideoats grama is an erect, tufted grass with short, scaly rhizomes. It is typically 1 to 2 feet (30 to 60 cm) shorter than switchgrass. This species is said to be native throughout the east, but is rarely encountered.

While sideoats seedlings are vigorous, the plants are only weakly rhizomatous so they do not usually provide solid ground cover until the second year after planting.

Key Field Identification Features

Sideoats grama leaves are normally flat with a few long hairs on both surfaces and on the margins. The oat-like seeds are borne in two rows which hang down from the spike.

Preferred Environmental Conditions

Precipitation:	> 12 inches (30 cm) annually
Soil texture:	Moderately coarse to moderately fine
Soil drainage:	Well drained, water table > 35 inches (90 cm)
Soil pH:	Neutral to weakly basic
Fertility requirement:	Moderate to low
Salt tolerance:	Conductivity (mmhos/cm) < 4
Flood tolerance:	Poor
Drought tolerance:	Good

Availability

'Killdeer', a cultivar released by the USDA Natural Resources Conservation Service from a North Dakota assemblage, has been used successfully in plantings on the Canadian prairies. No eastern cultivars of sideoats grama have been released to commercial producers. Of the Midwest varieties, 'El Reno' seems to perform best in New York while 'Butte', 'Pierre' and 'Trailway' have also been used in other parts of the northeast.

INDIANGRASS

(Sorghastrum nutans)

Adaptation & Use

Indiangrass was one of the common species which occurred in association with big and little bluestem and switchgrass in tall grass prairie. Indiangrass is native throughout the east, but is not as common as switchgrass or the bluestems. In Canada, its primary range is east of the Manitoba escarpment, although the species does occur on favorable sites further to the west. Best suited to fertile, well drained soils, indiangrass does have some tolerance to droughty conditions. It is not well adapted to saline soils.

Erect and rhizomatous, indiangrass can be a useful component in planting mixtures for nonsaline overflow and subirrigated range sites. It produces forage somewhat later than other warm season grasses and often is the last to flower. Therefore, this species is most sensitive to being moved north of its range.

Key Field Identification Features

Indiangrass has a prominent ligule (to 5 mm long), the sides of which seem to be projections of the sheath margins. The ligule appears like a rifle sight. Seed heads are a characteristic shiny golden yellow with long greyish hairs and twisted awns.

Preferred Environmental Conditions

Precipitation:	> 20 inches (50 cm) annually
Soil texture:	Moderately coarse to moderately fine
Soil drainage:	Medium to well drained, water table 6 to 35 inches (15 to 90 cm)
Soil pH:	Slightly acidic to slightly basic
Fertility requirement:	Moderate
Salt tolerance:	Conductivity (mmhos/cm) < 4
Flood tolerance:	Good
Drought tolerance:	Moderate

Availability

'Tomahawk', a cultivar released cooperatively by the USDA Natural Resources Conservation Service, USDA Agricultural Research Service and the North Dakota, South Dakota and Minnesota Agricultural Experiment Stations from seed collections made in North and South Dakota, has been used with success in revegetation plantings in Manitoba. Several varieties are appropriate for use in the east. 'Holt', 'NE-54', 'Osage', 'Oto' and 'Rumsey' are all locally applicable (please refer to Appendix C).

COASTAL PANICGRASS

(Panicum amarulum)

Adaptation & Use

Deep rooted, robust and erect, coastal panicgrass grows to a height of three to six feet (1 to 2 m). It occurs naturally from Massachusetts south to Florida and west to Texas. It is long lived within that range, although it becomes more susceptible to winter kill as one moves inland or further north. While it flourishes on fertile well drained soils, coastal panicgrass will also perform well on droughty, very sandy sites.

Because of its adaptability to a wide range of site conditions, coastal panicgrass is used extensively for secondary sand dune stabilization in the mid-Atlantic states. gravel pit and mineland reclamation and for wildlife cover on sandy coastal soils. It has also been recommended as a vegetative wind barrier because of its upright growth form.

Key Field Identification Features

Coastal panicgrass culms may be up to one-half inch thick with bluish green leaves from eight to twenty inches (20 to 50 cm) long and one-quarter to one-half inch wide. The seed head is a large, tightly arranged, densely flowered terminal panicle.

Preferred Environmental Conditions

Precipitation:	> 30 inches (75 cm) annually
Soil texture:	Coarse to medium
Soil drainage:	Well to excessive
Soil pH:	Strong acidic to slightly basic
Fertility requirement:	Low to moderate
Salt tolerance:	Conductivity (mmhos/cm) < 16
Flood tolerance:	Poor
Drought tolerance:	Good to excellent

Availability

Only one cultivar is grown for commercial distribution. 'Atlantic' was evaluated and selected for release from the Cape May Plant Materials Center in 1981. Certified seed is available from a number of commercial producers.

PURPLETOP

(Tridens flavus)

Adaptation & Use

Purpletop is a bunchgrass found in the United States east of the 30 inch (760 mm) rain belt. This plant is well adapted to sandy, wooded areas and shallow, droughty infertile soils, however it can also be found in bottomland. It will often appear early in plant succession.

Purpletop is used as wildlife cover and the seed is consumed by birds. Plant palatability increases considerably after the fall frost. It also has potential use as a conservation plant for critical areas.

Key Field Identification Features

This native bunchgrass can be identified by the tuft of stiff short hairs located on either side of the leaf sheath at the collar. The seed head is an open, pyramid shaped, panicle tinged purple to nearly black during bloom stage and early maturity. The brachlets droop and are covered with an oily or grease-like substance.

Preferred Environmental Conditions

Precipitation:	> 20 inches (51 cm) annually
Soil texture:	Coarse to moderately fine
Soil drainage:	Moderate to well drained
Soil pH:	Acidic to neutral
Fertility requirement:	Low to moderate
Salt tolerance:	Unknown
Flood tolerance:	Good
Drought tolerance:	Good

Availability

No cultivars are presently available. Both the Maryland and Kentucky Plant Materials Centers are currently working with this species.

PRAIRIE SANDREED

(Calamovilfa longifolia)

Adaptation & Use

A tall, erect grass with long, scaly rhizomes, prairie sandreed grows on sandy prairie and dune sand sites across the prairies. It may also occur along lakeshores and in open wooded areas on sandy soils. The dense root system is well-adapted to stabilize sandy soils. Michigan is the eastern limit of prairie sandreed's native range.

Prairie sandreed's primary role in revegetation plantings is to provide erosion protection and tall, erect cover on sandy soils. Wildlife will also feed on the plant's seeds in autumn.

Key Field Identification Features

Stems and leaves are pale green, becoming straw yellow in autumn. The leaves are smooth and are not prominently veined, with a distinct broad yellowish collar which has tufts of fine hairs at the edges.

Preferred Environmental Conditions

Precipitation:	> 10 inches (25 cm) annually
Soil texture:	Coarse to medium
Soil drainage:	Well drained, water table > 35 inches (90 cm)
Soil pH:	Weakly acidic to weakly basic
Fertility requirement:	Low to moderate
Salt tolerance:	Conductivity (mmhos/cm) < 4
Flood tolerance:	Poor
Drought tolerance:	Excellent

Availability

Both 'Goshen' and 'ND-95', releases from the USDA Natural Resources Conservation Service, have been used successfully in western Canada. They were selected from Montana and North Dakota sources respectively. No eastern cultivars are presently available, although the Michigan Plant Materials Center has Great Lakes shoreline plant material in the selection and development process.

SWITCHGRASS

(Panicum virgatum)

Adaptation & Use

Switchgrass, with big bluestem and indiangrass, is one of the major grasses in tall grass prairies. The species has a somewhat wider range of adaptation than the other major tall grasses, occurring across the eastern region. It is a tall, erect plant with numerous short scaly rhizomes.

It is found in prairies, open woods and brackish marshes. Switchgrass produces well on subirrigated lowlands or overflow sites on glacial till as well as on level swales, depressions and bottomlands along rivers and streams. It has some potential for use in warm season pastures and grassed waterways as well as in revegetation plantings. Song and upland game birds will feed on switchgrass seeds. At least two plant types are common, an upland type with fine stems and a lowland type with thicker and longer stems. Both types have been selected for cultivars.

Key Field Identification Features

Switchgrass has few basal leaves but long, somewhat bluish leaves occur along the stem from the base to the seed head. The leaves are distinctly veined with a prominent midvein. There are long hairs on the upper surface of the leaf near the sheath.

Preferred Environmental Conditions

Precipitation:	> 18 inches (45 cm) annually
Soil texture:	Medium to fine, also common on sandy soils in the east
Soil drainage:	Well to poorly drained, water table 6 to 35 inches (15 to 90 cm)
Soil pH:	Moderately acidic to moderately basic
Fertility requirement:	Moderate
Salt tolerance:	Conductivity (mmhos/cm) < 16
Flood tolerance:	Good
Drought tolerance:	Good

Availability

'Dacotah', a cultivar selected for hardiness, improved drought tolerance, persistence and early maturity from a North Dakota source and released cooperatively by the USDA Natural Resources Conservation Service and Agricultural Research Service and the North Dakota and Minnesota Agricultural Experiment Stations, should perform well in central Minnesota to northern Michigan and north.

Several cultivars perform well in the east. Upland types include 'Blackwell', 'Trailblazer' and 'Pathfinder'. Lowland types include 'Shelter', 'Cave-In-Rock' and 'Kanlow'. 'Shelter' and 'Kanlow' are not recommended for forage plantings. 'Shelter' has exceptionally stiff stems, resisting lodging from winter snow loads and retaining upright nesting cover into the spring. Additional selections are under study for future release.

Appendix G

Seed Suppliers

This information is provided as a public service and constitutes no endorsement by the United States Department of Agriculture or the Natural Resources Conservation Service of any supply, service, or equipment listed. While an effort has been made to provide a complete and accurate listing of services, supplies, and equipment, omissions or other errors may occur and, therefore, other available sources of information should be consulted.

Editor's Note: *The following is a partial list of potential suppliers of plant material for native species referred to in this Manual. It was compiled from information provided by USDA-NRCS staff at the Manhattan, KS, Plant Materials Center (PMC), Bismarck, ND, PMC, Elsberry, MI, PMC, Alderson, WV, PMC, Cape May, NJ, PMC, Roselake, MI, PMC and Big Flats, NY, PMC.*

A. Suppliers of cultivar seed and/or plant stocks

Note: Foundation class seed sources are identified as Foundation (F).

American beachgrass	
'Cape'	32, 33, 45F, 46F 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 65, 68
Bluestem, big	
'Bison'	30F, 34, 35, 36, 37, 38, 39, 40, 41
'Bonilla'	
'Champ'	13, 18, 20, 22, 24, 25, 26
'Niagara'	2, 7, 8
'Pawnee'	10, 13, 18, 24, 25, 26
'Rountree'	7, 8, 9, 10, 13, 14, 16, 17, 18, 25, 31F
'Sunnyview'	
Bluestem, little	
'Aldous'	8, 9, 10, 13, 14, 16, 19, 24, 25, 26, 29F
'Blaze'	10, 13, 18, 24, 26
'Camper'	2, 8, 9, 10, 13, 14, 18, 19, 20, 22, 24, 26
Bluestem, sand	
'Goldstrike'	18, 20, 22, 28
Cordgrass, salt meadow	
'Avalon'	48, 49, 51, 52, 55, 60, 61, 62, 64, 65, 66
smooth	
'Bayshore'	49, 51, 52, 61, 65
Deertongue	
'Tioga'	1, 2, 3, 4, 67
Gamagrass, eastern	
'Pete'	8, 9, 11, 12, 13, 16, 27, 29F

Grama, sideoats	
'Butte'	10, 13, 14, 18, 19, 20, 22, 24, 25, 26, 28
'El Reno'	10, 13, 14, 16, 17, 18, 19, 23, 25, 26, 27, 28, 29F
'Killdeer'	28, 30F, 36, 40, 43, 44
'Pierre'	9, 13, 24, 28 30F
'Trailway'	9, 10, 13, 18, 24, 51
Indiangrass	
'Holt'	9, 10, 13, 18, 20, 24, 26
'NE-54'	9, 10, 13, 14, 18, 24, 26
'Osage'	9, 13, 14, 16, 25, 26, 29F
'Oto'	9, 13, 24
'Rumsey'	8, 9, 10, 13, 15, 16, 25, 31F
'Tomahawk'	9, 13, 24, 30F
Lovegrass, sand	
'Bend'	13, 25, 29F
'NE-27'	13, 18, 32
Panicgrass, coastal	
'Atlantic'	2, 46F, 48, 49, 51, 52, 60, 61, 63, 64, 68
Switchgrass	
'Blackwell'	2, 5, 8, 9, 10, 13, 14, 16, 17, 18, 23, 25, 27, 28, 29F, 67
'Cave-In-Rock'	2, 8, 9, 10, 13, 14, 16, 17, 18, 24, 26, 28, 31F
'Dacotah'	30F, 34, 36, 37, 38, 39, 40, 43
'Forestburg'	
'Nebraska 28'	9, 10, 13, 14, 18, 20, 21, 24, 26, 28
'Pathfinder'	10, 13, 18, 22, 24, 25, 26, 28
'Shelter'	2, 8, 9, 13, 31F
'Sunburst'	
'Trailblazer'	9, 10, 13, 18, 22, 24, 25, 28
Virginia wildrye	
'O Ma Ha'	9

Name, Address, Zip Code	Telephone
1. BEACHLEY-HARDY Box 336, Camp Hill, PA 17011	717-737-4529
2. ERNST CONSERVATION SEEDS (Seed Only) 9006 Mercer Pike, Meadville, PA 16335	800-873-3321
3. SEED, INC. 307 Horsham Road, Horsham, PA 19044	215-675-2186
4. VALLEY SEED CO. Sugarloaf, PA 18249	717-788-3338
5. SEEDWAY Box 250, Hall, NY 14463	302-349-4478
6. C.P. DANIEL'S SONS Box 119, Waynesboro, GA 30830	706-554-2446
7. BLUESTEM SEED CO. Rt. 3, Box 32, Grant City, MO 64456	816-786-2241
8. SHARP SEED CO. Rt. 4, Box 237A, Clinton, MO 64735	816-885-7551
9. STOCK SEED FARMS RR 1, Box 112, Murdock, NE 68047	402-867-3771
10. OSENBAUGH GRASS SEEDS RR 1, Box 106, Lucas, IA	515-766-6476
11. GAMAGRASS SEED CO. Rt 1, Box 111A, Falls City, NE 68355	402-245-5842
12. SHEPPARD FARMS Clifton Hill, MO	816-261-4567
13. SHARP BROS SEED CO. Box 140, Healy, KS 67850	316-398-2231
14. STAR SEED INC 101 Industrial Ave, Osborne, KS 67473	913-346-5447

Name, Address, Zip Code	Telephone
15. FLICK BROS SEED 1781 NW 50th Road, Kingsville, MO 64061	816-597-3822
16. HAMILTON SEEDS 16786 Brown Rd, Elk Creek, MO 65464	417-967-2190
17. J & J SEED CO RR #3, Gallatin, MO 64640	816-663-3165
18. ARROW SEED COMPANY Box 722, Broken Bow, NE 68822	308-872-6826
19. C & H MILLS FARMS 29606 Mill Road, Murdock, NE 68407	402-867-2956
20. HERITAGE SEED COMPANY, INC Box 544, Crawford, NE 69339	308-665-1672
21. LAUX SEED FARM, INC HC 85 P.O. Box 48, Bridgeport, NE 69336	308-262-0512
22. OSLER SEED FARMS HC 55 P.O. Box 123, Elsie, NE 69134	308-228-2287
23. CURTIS & CURTIS INC Star Rt, Box 8A, Clovis, NM 88101	505-762-4759
24. THE SEXAUER COMPANY Box 58, Brookings, SD 57006	605-696-3600
25. BAMERT SEED COMPANY Rt 3, Box 1120, Muleshoe, TX 79347	806-272-5506
26. GARRISON & TOWNSEND, INC Drawer 2420, Hereford, TX 79045	806-364-0560
27. TURNER SEED 211 Cr 151, Breckenridge, TX 76424	817-559-2065
28. WIND RIVER SEED 3075 Lane 51½, Manderson, WY 82432	307-568-3361

Name, Address, Zip Code	Telephone
29. MANHATTAN PLANT MATERIALS CENTER USDA-NRCS	
3800 S 20th St, Manhattan, KS 66502	**913-539-8761**
30. BISMARCK PLANT MATERIALS CENTER USDA-NRCS	
3308 University Dr, Bismarck, ND 58504	**701-223-8536**
31. ELSBERRY PLANT MATERIALS CENTER USDA-NRCS	
RR 1, P.O. Box 9, Elsberry, MO 63343	**573-898-2012**
32. VAN PINES NURSERY	
West Olive, MI 49460	616-399-1620
33. APPALACHIAN NURSERIES	
Box 36, Waynesboro, PA 17268	717-762-4733
34. AGASSIZ SEEDS, INC	
4121½ South University Drive, Fargo, ND 58104	701-241-9760
35. ALBERT LEA SEEDHOUSE	
1414 West Main, Albert Lea, MN 56007	507-373-3161
36. CHESAK SEEDHOUSE	
220 N 23rd St, Bismarck, ND 58501	701-223-0391
37. GULLICKSON, Mark and Russell	
Route 2, Box 150A, Fertile, MN 56540	218-945-6894
38. HANSMEIER and SON, INC	
Box 136, Bristol, SD 57219	605-492-3611
39. KASTE, Paul	
Box 153, Fertile, MN 56540	218-945-6738
40. LINCOLN-OAKES NURSERIES	
Box 1601, Bismarck, ND 58502	701-223-8575
41. BLIGHT NATIVE SEEDS	
Box 244, Oakville, MB R0H 0Y0	204-267-2376
42. CARLSON, Oscar T	
Box 157, Lake Bronson, MN 56734	218-754-4475

Name, Address, Zip Code	Telephone
43 HEARTLAND, INC Box 1877, Bismarck, ND 58502	701-223-4065
44. WILBER'S FEED and SEED, INC 800 North Broadway, Box 41, Miller, SD 57362	605-853-2414
45. BIG FLATS PLANT MATERIALS CENTER USDA-NRCS **Box 360A, RD1, Rt 352, Corning, NY 14830**	**607-562-8404**
46. CAPE MAY PLANT MATERIALS CENTER USDA-NRCS **1536 Rt 9 North, Cape May Court House, NJ 08210**	**609-465-5901**
47. ALDERSON PLANT MATERIALS CENTER USDA-NRCS **Box 400, 1224 Airport Rd, Beaver, WV 25813-0400**	**304-256-2884**
48. CAPE FARMS (Plants Only) RD #1, Box E134A, Lewes, DE 19958	302-945-1840
49. BENEDICT NURSERIES (Plants & Seed) Box 347-A, Pemberton Drive, Salisbury, MD 21801	410-228-2540
50. CHURCH'S GREENHOUSE & NURSERY (Plants Only) 522 Seashore Road, Cape May, NJ 08204	609-884-3927
51. COASTAL NURSERY, INC. (Plants Only) Box 42, Mauricetown, NJ 08329	609-785-1102
52. COASTAL WETLANDS NURSERY (Plants Only) Box 1018, Gloucester Point, VA 23062	804-693-2619
53. PHIL & STEVEN DUBREVILLE (Plants Only) Old Cellar Creek Farm, 801 N. Shore Road, Beeselys Point, NJ 08223	609-390-0806
54. FINE TREE FARM (Plants Only) 24 Smith Street, Rehoboth, MA 02769	508-222-3477
55. TIM FRIARY (Plants Only) Friary Landscaping, 241 Commerce Road, Barnstable, MA 02630	508-362-5980
56. HARPER FARMS (Plants Only) 4645 ENM-Rhodesdale Road, Rhodesdale, MD 21659	410-943-4173

Name, Address, Zip Code	Telephone
57. HATCHVILLE FARM (Plants Only) Box 241, Falmouth, MA 02541	508-457-9695
58. JUDY ORD (Plants Only) 1145 Fathom Road, Manahawkin, NJ 08050	609-597-6077
59. PEAT & SONS NURSERY (Plants Only) 32 Old Country Road, Westhampton, NY 11977	516-288-3458
60. PINELANDS NURSERY (Plants Only) 323 Island Road, Columbus, NJ 08022	609-291-9486
61. SEABURY FARM (Plants Only) 2560 Main Street, West Barnstable, MA 02668	508-362-4595
62. WINSLOW CONSERVANCY (Plants Only) 303 Messina Avenue, Hammonton, NJ 08037	609-561-0628
63. CROWSHAW NURSERY (Plants Only) Box 339, Columbus, NJ 08022	609-298-6388
64. SYLVA NATIVE NURSERY & SEED CO. (Plants & Restoration Seed Mixes) RD #2, Box 1033, New Freedom, PA 17349	717-227-0486
65. H.R. TALMAGE & SONS (Plants Only) 36 Sound Avenue, RFD1, Riverhead, NY 11901	516-727-0124
66. BESTMANN GREEN SYSTEMS (Plants Only) Salem, MA	508-741-1166
67. JONATHAN GREEN SEED CO. Box 326, Squankum-Yellowbrook Rd, Farmingdale, NJ 07727	(NJ) 1-800-243-0047 1-800-526-2303
68. OCTORARO WHOLESALE NURSERY Box 24, Oxford, PA 19363	717-526-3160
69. AGRI-CULVER 3900 McIntyre, Trumansburg, NY 14886	607-387-5788

Name, Address, Zip Code	Telephone

70. SOUTHERN TIER CONSULTANTS
    2701A, Rt 305, Box 30, W. Clarksville, NY 14786 716-968-3120

71. STANFORD SEED CO.
    RR 1, Box 320, Denver, PA 17517 215-267-3805

72. AGWAY SEED DIV.
    Box 4741, Syracuse, NY 13221 315-477-6682

* USDA Plant Materials Centers provide Foundation seed to commercial seed producers to initiate their Registered and Certified seed production fields. Seed is not available for purchase from Plant Materials Centers.

B. Suppliers of local genotypes (seed and plants)

Supplier	Address	City	State	Zip	Phone	Product
Agrecal	1984 Berlin Rd	Sun Prairie	WI	53520	608-876-8547	grass, forbs(plants, seed)
Amenity Plant Products	RD 5, Box 265	Mt Pleasant	PA	15666	412-423-8170	
Appalachian Nurseries		Waynesboro	PA	17268	717-762-4733	
Applied Ecological Services Inc/Taylor Creek Nursery	PO Box 256	Brodhead	WI	53520	608-897-8547	grass,forbs,woody species (plants)
Bluestem Farm	S5920 Lehman Rd	Baraboo	WI	5391	608-356-0179	wide variety
Boehlke's Woodland Gardens	Country Aire Rd	Germantown	WI	53022	414-251-8677	woodland species (plants)
Bowman's Hill Wildflowers	Box 103 Washington Crossing		PA	18977		grass & forb seed
Brandywine Conservancy	Box 141	Chadds Ford	PA	19317		forbs
Cadys Falls Nursery	RD 3, Box 2100	Morrisville	VT	05486	802-372-8805	
Cold Stream Farm	2030 Free Soil Rd	Free Soil	MI	49411	616-464-5809	trees shrubs (plants)
Country Road Greenhouse	19561 E Twombly	Rochelle	IL	61068	815-384-3311	forbs, grasses, sedges (plants)
Country Wetlands Nursery	Box 126	Muskego	WI	53150	414-679-1268	prairie, woodland species (plant,seed)
Enders Greenhouse	104 Enders Dr	Cherry Valley	IL	61016	815-332-5255	wide variety prairie, woodland, wetland (plants)
Environmental Concern		St.Michaels	MD		410-745-9620	tidal marsh plants
Exeter Wildflower Gardens	Box 510	Exeter	NH	03833	603-772-5763	
Fruit Full Acres	4166 Co. 416 20th Rd.	Gladstone	MI	49837	906-786-3899	grasses forbs (seed)
Genesis Nursery	23200 Hurd Rd	Tampico	IL	61283	815-438-2220	wide variety, prairie,wetland, savanna (plants, seed)
Grand Isle Nursery	Box 350 50 Ferry Rd	South Hero	VT	05486	802-372-8805	
Grass Roots	PO Box 4001	E.Lansing	MI	48826	517-337-2405	woodland forbs (plants)
Great Lakes Nursery Co	1002 Hamilton St	Wausau	WI	54403	715-845-7752	trees, shrubs (plants)
Grimes Gardens	14650 Center	Bath	MI	48808	517-641-4053	forbs (plants)

Supplier	Address	City	State	Zip	Phone	Product
Grow Wild Nursery	PO Box 401	Byron	MI	48418	810-266-9453	grasses (plants, forbs seeds)
Hortech	PO Box 533	Spring Lake	MI	49456-0533	616-842-1392 800–875-1392	perennial ground covers, vines,ferns (plants)
Huria Nursery	4687 Grenadier	Wyoming	MI	49509	616-538-4359	trees, shrubs (plants)
Ion Exchange	1878 Old Mission Drive	Harpers Ferry	IA	52146	319-535-7231	prairie, wetland, savanna species (plants, seed)
I.F. New & Associates	P.O. Box 243	Walkerton	IN	46574	219-586-3400	
Kaste, Inc	RR2, Box 153	Fertile	MN	56540	218-945-6738	grass, forbs (seed)
Kettle Moraine Natural Landscaping	W996 Birchwood Drive	Campbellport	WI	53010	414-533-8939	wide variety (seed)
Landscape Alternatives	1705 Albans St	Roseville	MN	55113	612-488-3142	prairie, wetland, woodland (plants)
Land Use Company	2576 Sound Ave	Baiting Hollow	NY	11933	516-727-2400	
Little Valley Farm	RR3, Box 544	Spring Green	WI	53588	608-935-3324	grass, forbs, shrubs (plants, seed)
Meadowview Farm	5994 Byron Holly Road	Byron	NY	14422	716-548-2207	
Midwest Wildflowers	Box 64	Rockton	IL	60172		wildflowers (seeds)
Munro Ecological Services	990 Old Sunney-Town Pike	Harleysville	PA	19438	610-287-0671	forb & wetland seed & plants
Murn Environmental Inc	10282 Riverview Drive	Edgerton	WI	53534	608-884-6563	prairie, wetland woodland species (plants, seeds)
Nature's Nursery	6125 Mathewson Road	Mazomanie	WI	53560	608-795-4920	prairie, wetland, woodland species (plants, seeds)
Nesta Prairie Perennials	1019 Miller Rd	Kalamazoo	MI	49001	616-343-1669 800-233-5025	grasses, forbs (plants)
New England Wetland Plants	800 Main Street	Amherst	MA		413-256-1752	wetland grasses & forbs
North Creek Nurseries	RR 2, Box 33	Landenberg	PA		215-255-0100	forb (plants)
Octoraro Nursery	Box 24	Oxford	PA	19363	717-529-3160	tidal grasses, (plants) wetland shrubs

Supplier	Address	City	State	Zip	Phone	Product
Oikos Tree Crops	PO Box 19425	Kalamazoo	MI	49019 -0425	616-342-6504	shrubs (plants) trees (nutbearing)
Otis Willey Seed Co	Box 65	Trevose	PA	19047		
Oliver Seed Co	Box 156 Sunset Av	Milton	VT	05468	802-893-1241	
Palmers	RFD 1	Durham	NH	03824	603-659-3818	
Panfield Nurseries	322 Southdown Rd	Huntington	NY	11743	516-427-0112	forb (plants)
Prairie Future Seed Co.	PO Box 644	Menomonee Falls	WI	53052	414-246-4019	prairie species (seed)
Prairie Moon Nursery	RR3, Box 163	Winona	MN	55987	507-452-1362	wide variety prairie wetland, woodland species (plant, seed)
Prairie Nursery	PO Box 306	Westfield	WI	53964	608-296-3679	prairie, wetland, woodland species (plants, seed)
Prairie Restorations Inc	PO Box 327	Princeton	MN	55371	612-389-4342	prairie species (plants)
Prairie Ridge Nursery (Specify MI genotypes)	9738 Overland Rd	Mt. Horeb	WI	53572 -2832	608-437-5245	grasses (plants, forbs seed)
Prairie Seed Source	PO Box 83	North Lake	WI	53064 -0083	414-673-7166	wide variety prairie & savanna species (seed)
Providence Center, Inc.	370 Shore Acres Road	Arnold	MD	21012		wetland plants
Putney Nursery	RT 5	Putney	VT	05346	802-387-5577	
Reeseville Ridge Nursery	PO Box 171	Reeseville	WI	53579	414-927-3291	trees, shrubs
Retzer Nature Center	W284 51530 Road DT	Waukesha	WI	53188	414-521-5407	prairie, woodland wetland species (plants, seed)
Rohde's Nursery	N 8098 Duck Creek Ave	Neshkoro	WI	54960	414-293-4373	prairie, woodland wetland species (plants)
Sand Hill Farm	11530 10 Mile Rd	Rockford	MI	49341 -9039	616-691-8214	grasses, sedges, forbs,ferns, wetland plants (plants)
Schramm, Peter (Prairie Restorations)	766 Bateman	St Galesburg	IL	67401	309-343-2608	
Seed, Inc	307 Horsham Rd	Horsham	PA	19044	215-675-2186	
Shooting Star Nursery	444 Bates Rd	Frankfort	KY	40601	502-223-1679	

Supplier	Address	City	State	Zip	Phone	Product
Southern Tier Consultants	2701-A RT305 Box 30	W.Clarksville	NY	14786	716-968-3120	
Spence Nursery Inc	P.O. Box 546	Muncie	IN	47308	317-286-7154	
Sylva Native Nursery	RD 2, Box 1033	New Freedom	PA	17349	717-227-0486	
H.R. Talmage & Sons	36 Sound Avenue	Riverhead	NY	11901-9879	516-727-0124	warm season grass & tidal plants
The Michigan Wildflower Farm	11771 Cutler Rd	Portland	MI	48875	517-647-6010	grasses (plants, forbs seeds)
Vanats Perennial Flowers	Box 38	Jefferson	VT	05464	802-644-5026	
Van Pines Inc	Box 733	W.Olive	MI	49460	616-399-1620	dune grass (plants)
Vermont Wildflower Garden	RT 7	Charlotte	VT	05445	802-425-3500	
Vicks Wildflower Gardens	Box 115	Gladwyne	PA	19035	412-525-6773	
Wehr Nature Center	7107 West College Avenue	Franklin	WI	53132	414-425-8550	prairie species (seed)
Wetlands Nursery	PO Box 14553	Saginaw	MI	48601	517-752-3492 517-777-6678	wetland forbs, grasses, sedges (plants)
Wild Earth Nursery	49 Mead Avenue	Freehold	NJ	07728	732-308-9777	grass, wetland forb plants
Wildtype Design, Nursery & Seed	1015 Marigold Av	E.Lansing	MI	48823	517-336-0951	forbs, grasses, trees shrubs (plants,seed)
Wisconsin Prairie Enthusiasts	4192 Sleepy Hollow Trail	Boscobel	WI	54805	608-375-5271	prairie species (seed)
Wood's Edge	532 Stanek Rd	Muscoda	WI	53574	608-729-3527	woodland wild-flowers (plants)

C. Other known suppliers of native grass and forb plants and seed.

NOTE: The Editor was unable to determine if the following suppliers provide local ecotypes. If your objective is to establish local ecotypes, please inquire before placing your order.

Name, Address, Zip Code	Telephone
ARROW SEED CO. Box 722, Broken Bow, NE 68822	308-872-6826
ARROWHEAD, INC. 4001 15th Ave NW, Fargo, ND 58102	n/a
ARTHUR LONEGRAN NURSERY Paradise Drive, West Bend, WI 53095	n/a
BAILEY NURSERIES, INC. 1325 Bailey Road, St. Paul, MN 55119	n/a
BEEBE, Joe RD 4, Towanda, PA 18848	717-265-6536
BEERSHEBA WILDFLOWER GARDEN Beersheba Springs, TN 37303	n/a
BERGESON NURSERY Fertile, MN 56540	218-945-6988
BERTHOLD NURSERY 4510 Dean Street, Woodstock, IL 60098	708-439-2600 or 815-338-4914
BLUESTEM SEED CO. Grant City, MO 64456	816-786-2401
BLUESTEM PRAIRIE NURSERY RR 2, Box 92, Hillsboro, IL 62049	217-532-6344
BRANCH RIVER TROUT HATCHERY 8150 River Road, Greenleaf, WI 54126	414-864-7761
BREHM'S WONDER CREEK NURSERY N6050 South Crystal Lake Rd, Beaver Dam, WI 53926	414-885-4300

Name, Address, Zip Code	Telephone
BUSSE GARDEN CENTER 635 East 7th St, Cokato, MN 55321	n/a
CASCADE FOREST SERVICE INC. Route 1, Cascade, IA 52033	319-852-3042
CENEX SEED, Ole Jallo 2101 Ridgewood, Alexandrea, MN 56308	n/a
CENEX SEED, Jack Stumf 507 South 10th Street, ,MN 56277	n/a
CENEX SEED CO. PO Box 1061, Grand Island, NE 68801	308-384-1111
CLARK, Marvin Box 444, Paola, KS	913-294-4041
COLD STREAM FARM 2030 Free Soil Rd, Free Soil, MI 49411-9752	616-464-5809
CREATIVE LANDSCAPES 3412 Superior Avenue, Sheboygan, WI 53081	n/a
DEAN STEVENS FARM Rt 1, Box 45, Hiawatha, KS 66434	913-742-3699
ERNST CONSERVATION SEEDS 9006 Mercer Pike, Meadville, PA 61335	800-873-3321
FEDER'S PRAIRIE SEED CO. Rt 1, Box 41, Blue Earth, MN 56013	507-526-3049
FERNDALE NURSERY & GREENHOUSE Box 218, Askov, MN 55704	n/a
FLOWER FACTORY 40062 Highway A, Stoughton, WI 53589	608-873-8329
GAMAGRASS SEED CO. Rt 1, Box 111A, Falls City, NE 68355	402-245-5842

Name, Address, Zip Code	Telephone
GRAND FORKS SUPPLY COMPANY Hwy 81 North, Grand Forks, ND 58201	n/a
H & R NURSERY, INC. 6520 West Silver Spring Drive, Milwaukee, WI 53218	414-466-6289
HAUSER'S SUPERIOR VIEW FARM Rt 1, Box 199, Bayfield, WI 54814	715-779-5404
HAMILTON SEEDS HCR RR #9, Box 138, Elk Creek, MO 65464	417-967-2190
HORIZON SEEDS Box 81823, Lincoln, NE 68503	402-475-1232
ITASCA GREENHOUSE, INC. PO Box 273, Cohasset, MN 55721	218-328-6261
J & J SEED CO. RR #3, Gallatin, MO 64640	816-663-3157
J and J TRANZPLANT PO Box 227, Wild Rose, WI 54984-0227	414-622-3552
JOHNSON'S NURSERY INC. W180 N6275, Marcy Road, Menomonee Falls, WI 53051	414-252-4988
JOHNSTON SEED CO. West Chestnut, Box 1392, Enid, OK 73701	405-233-5800
JONATHAN GREEN SEED CO. Box 326, Squankum-Yellowbrook Rd, Farmingdale, NJ 07727	(NJ) 1-800-243-0047 1-800-526-2303
JUNG SEEDS PO Box 77990, Madison, WI 53707	608-249-9291
KESTER'S WILD GAME FOOD NURSERIES, INC. PO Box 516, Omro, WI 54963	414-685-2929

Name, Address, Zip Code	Telephone
LAFAYETTE HOME NURSERY Lafayette. IL 61449	309-995-3311 Fax 309-995-3809
LANDSCAPE LADY, LTD 3312 North Weil Street, Milwaukee, WI 53212	414-933-0540
LITTLE VALLEY FARM Rt 3, Box 544, Snead Creek Rd, Spring Green, WI	n/a
LOFTS SEEDS, INC 347 Elizabeth Avenue, Somerset, NJ 08873	732-356-8700
MANGELSDORF & BROS. PO Box 327, St. Louis, MO 63166	314-421-1415
MARSHLAND TRANSPLANT AQUATIC and WOODLAND NURSERY PO Box 1, Berlin, WI 54923	414-933-0540
McKAY NURSERY CO. Waterloo, WI 53594	414-478-2121
MIDWEST AQUATICS Route 360-5, Wautoma, WI 54982	414-787-3282
MILAEGER'S GARDENS 4838 Douglas Avenue, Racine, WI 53402-2498	414-639-2371
MOHN SEED CO. RR 1, Box 152, Cotton Wood, MN 56229	507-423-6482
MORNING SKY GREENERY RR 1, Box 385, Morris, MN 56267	612-795-2436
NATIVE SEEDS INC. 14590 Triadelphia Mill Road, Dayton, MD 21036	301-596-9818
NATURAL GARDEN 38W443 Highway 64, St. Charles, IL 60174	708-584-0150
OAK PRAIRIE FARM W4642 Highway 33, Pardeeville, WI 53959	608-429-3882

Name, Address, Zip Code	Telephone
OASIS WATER GARDENS 2968 Pine Tree Road, Oneida, WI 54155	414-869-1085
OHIO SEED CO. PO Box 87, West Jefferson, OH 43162	614-879-8366
OLSON, Wendell Box 161A, Glyndon, MN 56547	n/a
ORCHID GARDENS 2232 139th Avenue NW, Andover, MN 55304	n/a
OSENBAUGH GRASS SEEDS RR 1, Box 106, Lucas, IA 50151	515-766-6476
OXCART SEED COMPANY Rt 3, Box 226, Hawley, MN 56549	n/a
PEAVY SEED COMPANY Bismarck, ND 58502	n/a
PICQUA GROWERS 30454 Orr Road, Circleville, OH 43113	n/a
PRAIRIE HILL WILDFLOWERS Rt 1, Box 191-A, Ellendale, MN 56026	507-451-7791
R-8 LANDSCAPE DESIGN and CONSULTATION 1337 South 114th St, West Allis, WI 53214-2235	414-771-3392 Fax 414-771-8898
RICE CREEEK GARDENS Blaine, MN	612-754-8090
RICHARD OWEN NURSERY 2300 East Lincoln, Bloomington, IL 61701	n/a
ROYAL SEEDS, INC. 1011 W Miller, Jefferson City, MO 65101	314-636-3309
ROYAL SEEDS, INC. 1212 W 8th Street, Kansas City, MO 64101	816-842-6830

Name, Address, Zip Code	Telephone
SHADY ACRES NURSERY 7777 Hwy 212, Chaska, MN 55318	612-466-3391
SHADY ACRES NURSERY, INC. N73W2505 Howard Lane, Sussex, WI 53089-1823	414-679-1610
SHELDON COTTON Volga, SD 57071	n/a
SHEPARD FARMS RR 1, Clifton, MO 65244	816-261-4567
SHOOTING STAR NATIVE SEED Rt 2, Box 191, Spring Grove, MN 55974	507-498-3993
SMITH NURSERY CO. PO Box 515, Charles City, IA 50616	515-228-3239
SOUND SOLUTIONS 708 Roosevelt Road, Walkerton, IN 46574	219-586-3400 Fax 218-586-3446
SPECIALTY SEEDS 210 Grell Lane, PO Box 400, Johnson Creek, WI 53058	1-800-824-4668
STEGALL, B M Box 227, Rt 1, Abingdon, IL 61410	n/a
URSUS STUDIOS LTD 2019 North 10th Street, Sheboygan, WI 53081	414-459-9699
VOGT, DAN Rt 3, Box 178, Owatonna MN 55060	n/a
WARREN'S GROUP, 4238 E 100 S, Anderson, IN 46017	n/a
WHEELER, MASON W. Wheeler Farm, Inc, Aurora, SD 57002	n/a

Name, Address, Zip Code	Telephone
WILDFLOWERS FROM NATURE'S WAY RR 1, Box 62, Woodburn, IA 50275	515-342-6246
WILDLIFE HABITAT RR 3, Box 178, Owatonna, MN 55060	507-451-6771
WILDLIFE NURSERY PO Box 2724, Oshkosh, WI 54901	414-231-3780
WINDRIFT PRAIRIE SHOP Douglas Wade, RD 2, Oregon, IL 61081	n/a
ZELLER SEED FARM Bird Island, MN 55310	n/a

Appendix H

Crop Protection Products Cross-Reference

Crop Protection Products Cross-Reference

US Trade Name	Active Ingredient	Canadian Trade Name
Arsenal	imazapyr	
Atrazine/others	atrazine	Aatrex/others
Banvel	dicamba	Banvel
Buctril	bromoxynil	Pardner
Gramoxone/others	paraquat	Gramoxone/others
Hoelon	diclofop-methyl	Hoe Grass 284
MCPA/many	MCPA	MCPA/many
Plateau	AC263222	
Princep	simazine	Princep/Simazine
Pursuit	imazethapyr	Pursuit
Roundup/others	glyphosate	Roundup/others
Stinger	clopyralid	Lontrel
Tordon 22K	picloram	Tordon
	tralkoxydim	Achieve
	dicamba/MCPA/mecaprop	Target
	rimsulfuron/nicsulfuron	Ultim
2,4-D/many	2,4-D	2,4-D/many