Summary of
Native Seed Mix Design Methodology Steps

SEE CHAPTER 3, pp. 5-15 FOR MORE DETAILED INSTRUCTIONS

Step 1. Analyze Project Site and Set Goals

A. Obtain or draw a basic map of project site.
B. Fill out the "Site Analysis Checklist" in Appendix A (pp. A-1 and A-2).

Step 2: Choose Whether to Use a Standard or Site-specific Mix (see p. 6 for guidance)

- ⇨ To use **standard mixes**, go to **Appendix C**.
- ⇨ To design **site-specific mixes**, proceed to **step 3**.

Step 3: Analyze Seeding Zones

A. Divide your site into the seeding zones listed on the "Seeding Zone Analysis" form (Appendix A, pp. A-3 to A-5).
B. Fill out a "Seeding Zone Analysis" form for each seeding zone on your project.

Step 4: Select a Seed Mix Design Worksheet for Each Seeding Zone on Your Project (see Table 3-1 p. 10)

Step 5: Design Seed Mixes: Go Through These Steps for Each Seeding Zone

A. Core Species

1. Use the core species recipe on the Worksheet to choose core species quantities.

B. Pick List Species

1. Narrow down the pick list to species appropriate for your project
    i. Remove species that do not belong in the project area ("ecosections" column)
    ii. Remove species that will not grow in the soil type ("soil" column)
    iii. Remove species that will not grow in the amount of sun or shade ("sun exposure" column)
    iv. Remove species that can't tolerate salt if the seeding zone will have salt impacts ("soil salt" column)
    v. Remove species that will grow taller than the maximum height you want (height column)
    vi. Remove species that are not available.
2. Use the pick list species recipe on the Worksheet to choose pick list species and quantities for your project from the list of species that you narrowed down in steps i-vi above.
3. If your project has specific wildlife, aesthetic, conservation or other goals not reflected in the recipes, incorporate your project specific requirements into your mix design.

C. Cover Crop Species

1. Determine cover crop seeding rate using the cover crop recipe.

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16. Abstract (Limit: 250 words)

This manual sets forth a method to design site-specific native grassland seed mixes with long-term resilience that will meet the multi-pronged goals of roadside vegetation.

Primary goals of the site-specific native grassland seed mix design methodology presented in this manual are to:

1. Empower users of varied backgrounds, including transportation engineers and maintenance workers with limited or no knowledge about native plants, to design reliable site specific native grassland seed mixes that are well suited to their project and create grasslands that are resilient over time
2. Allow for flexibility in species selection based on current seed availability and cost
3. Maximize seed market demand/supply balance
4. Result in the most diverse possible species use statewide to maximize resilience and biodiversity on a landscape ecological scale.

To meet the above goals, the methodology provides "recipes" that provide guidelines to create a seed mix, starting from a master list of all native grassland species in Minnesota that are commercially available, based on project site characteristics, context, goals, seed availability, and cost. The framework of the recipes allows users with no prior knowledge of native plants to easily design seed mixes very specifically tailored to their unique site, goals, and current state of the native grassland seed market.

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Final Report

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Chuck Dale, MN Department of Agriculture Seed Unit (honorary member)
Bonnie Harper Lore, FHWA (honorary member)

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Executive Summary

This manual sets forth a method to design site-specific native seed mixes that will meet the multi-pronged goals of roadside vegetation.

Roadside vegetation needs to be designed to be able to:

- maintain visibility and safety for roadside travelers
- withstand harsh conditions
- minimize maintenance costs
- minimize erosion
- improve water quality
- infiltrate stormwater runoff
- maintain good public relations.

Grasslands are favored by roadside vegetation managers to meet these goals. Research and experience have shown that native grasslands are especially well suited to accomplish these goals. Although roadsides are often seeded with non-native plants, some of which are on the Minnesota Department of Natural Resource's invasive species list, several studies, including one in Minnesota, showed that native species performed roadside vegetation functions more effectively than non-native species.

Although these native grasslands are a valuable part of Minnesota's rich natural heritage, often described in glowing terms by early settlers to the Midwest, less than one percent of the tallgrass prairie found by settlers in the 1860's remains today! Minnesota's roadsides, needing grasslands to meet the functional requirements of roadside vegetation, therefore provide a unique opportunity to restore some of our lost native grassland natural heritage on public lands where it can be experienced and treasured on daily basis by drivers passing by. The Southern two-thirds of Minnesota has 525,000 roadside acres that could be restored to native grassland (Nelson in DeVore 2009).

In addition to meeting the functional requirements of roadside right-of-ways as well as celebrating our regional heritage, roadsides with native vegetation also have significantly greater wildlife habitat value, especially for butterflies and pollinators, compared to roadsides with non-native species. Restoring roadsides to native grasslands benefits wildlife in two ways: by adding more habitat and by connecting fragmented existing landscape patches. Several studies have found significantly more total individuals as well as higher numbers of species of wildlife along roadsides with native vegetation vs. those with non-native vegetation.

While native grassland vegetation is well suited to provide the multiple functions needed along roadsides, seeding of native grassland vegetation along roadsides will fail if the right plants are not used in the right place. This manual was therefore developed to provide a reliable method to design site-specific native seed mixes that accomplish functional, heritage, and conservation goals.

The method was developed based on a literature review, stakeholder workshops, a Technical Advisory Panel (TAP), and a seed market survey. The field of native grassland establishment and

research has grown dramatically since the early 1900's. Our combined effort enabled us to capitalize on and synthesize a vast wealth of past and present expertise to create a scientifically sound, yet user-friendly method and manual for designing site-specific native seed mixes.

Primary goals of the site-specific native grassland seed mix design methodology presented in this manual are to:

1) Empower users of varied backgrounds, including transportation engineers and maintenance workers with limited or no knowledge about native plants, to design reliable site-specific native grassland seed mixes that are well suited to their project and create grasslands that are resilient over time
2) Allow for flexibility in species selection based on current seed availability and costs
3) Maximize seed market demand/supply balance
4) Result in the most diverse possible species use statewide to maximize resilience and biodiversity on a landscape ecological scale.

To meet the above goals, the methodology guides seed mix design based on project site characteristics, context, goals, seed availability, and cost. No prior knowledge of native plants is required.

Because conditions in many conservation projects are similar to those along roadsides, in that they often face harsh conditions, pressure from invasive species, and limited maintenance budgets, the methodology presented in this manual is also applicable to a wide range of native grassland seeding projects beyond the roadside right-of-way.

The need for grassland vegetation to meet roadside right-of-way (ROW) goals is of course not limited to Minnesota. While there is much variability in native grasslands throughout the US, some type of native grasslands exist to some extent in all states. Moreover, with more than 12 million acres of ROW in the US, choice of roadside vegetation significantly impacts maintenance costs, wildlife habitat value, and aesthetics on a national scale. This manual therefore also provides guidelines for other states to develop their own site-specific native grassland seed mix design methodology.

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Chapter 1:
Introduction

"In all my life, I never saw or dreamed of so beautiful a sight as the rolling prairies. Nothing can equal the surpassing beauty of the rounded swells and the sunny hollows, the brilliant green of the grass, the number less varieties and splendid hues of multitudes of flowers. I gazed in admiration too strong for words."

Ellen Bigelow, 1835 (quoted in Sullivan, no publication year given)

An important part of Minnesota's rich natural heritage includes the tallgrass prairie, often described by early settlers in glowing terms. Today, less than one percent of the prairie discovered by settlers in the nineteenth century remains.

Planting native grasslands along roadways is a cost effective way to meet the goals of roadside vegetation and at the same time restore much of Minnesota's lost natural heritage on public lands, where it can be experienced and treasured daily by drivers passing by. The southern two-thirds of the State has 525,000 roadside acres that could potentially be restored to native grassland (Nelson in DeVore 2009)!

Since the 1930's roadside managers have favored the use of turfs to meet right-of-way vegetation goals: provide visibility and safety for travelers, withstand harsh conditions, minimize erosion, maintain good public relations and minimize maintenance costs. Following the 1973 Clean Water Act, goals expanded to include improved water quality and controlled stormwater runoff.

In recent years, research and experience have shown that native grasslands are particularly well suited to accomplish the functional goals of roadsides. A survey of Minnesota roadsides found that "rights-of-way containing established native vegetation communities were less susceptible to drought-kill, weedy invasion, and erosion" (Jacobson, et. al 1992).

In addition to meeting functional requirements and celebrating our regional heritage, planting roadsides with native grassland species increases conservation benefits. Native plantings create more wildlife habitat, connect fragmented landscape patches, and sustain more pollinators. Native grassland studies in Iowa and Kansas, for example, found native grasslands support significantly more habitat-sensitive species as well as total numbers of bees and butterflies compared to nonnative roadside plantings. (Reis, 2003 and DeVore 2009). Up to 19 species of mammals and 23 species of birds have also been found to use roadsides for their homes (Moncada 2005).

Furthermore, the Minnesota legislature supports use of native vegetation along roadsides with the clause: "When feasible, road authorities are encouraged to utilize low maintenance, native vegetation that reduces the need to mow, provides wildlife habitat, and maintains public safety." (Statute 2005 Section 160.232).

Although native forbs and grasses have been planted for at least half a century, Minnesota learned seedings fail if the right plants are not matched to the right place. This manual was

therefore developed to provide a reliable method to design site-specific native seed mixes that accomplish functional, heritage, and conservation goals.

Conditions in many conservation projects are similar to those along roadsides: they face harsh conditions, pressure from invasive species, and have limited maintenance budgets. The methodology presented in this manual is therefore also applicable to a wide range of native grassland seeding projects beyond the roadside right-of-way.

The need for practical, long-lasting, affordable, and environmental solutions on roadside rights-of-way is of course not limited to Minnesota. With some 12 million ROW acres in the U.S. (U.S. Department of Transportation, Publication No. FHWA-EP-03-005 HEPN-30), choice of vegetation used can significantly impact maintenance costs, habitat value and aesthetics on a national scale. While there is variability among native grasslands throughout the nation, some type of native grassland exists in each State. Therefore this manual provides suggestions for other States to develop their own site-specific native seed mix design methodology.

Photo: The Kestrel Design Group, Inc.

Figure 1-1: Prairie Smoke Flowers, Minneapolis, MN

Chapter 2:
How the Methodology Was Developed

The methodology set forth in this manual is based on a literature review, stakeholder workshops, a Technical Advisory Panel (TAP), and seed market survey. The field of native grassland establishment has grown dramatically since the early 1900's. Our combined effort enabled us to capitalize on and synthesize a vast wealth of past and present expertise to create a scientifically sound, yet user-friendly method and manual for designing site-specific native seed mixes.

2.1 Literature Review

The literature review summarizes the following research topics and experience applicable to the design of site-specific native grassland seed mixes:

- Native Grassland Plant Community Composition
- Native Grassland Plant Ecology: Diversity and Succession
- Cover Crops: Erosion Control Benefits and Weed Suppression
- Native Species Seeding Rates
- Effects of Herbicides on Grassland Species
- Implications of Genetics Research for Seed Standards.

2.2 Stakeholder Workshops

A series of workshops provided a forum to capture the expertise of a team of native grassland seed market stakeholders via brainstorming and synthesis. The team included: vendors, producers, installers, highway maintenance personnel, designers, researchers, and regulatory agencies.

2.3 Technical Advisory Panel Meetings

In similar fashion, information was gathered from ecologists, agronomists, botanists, seed industry, University of Minnesota, State and federal land-managing agencies, and Mn/DOT maintenance and environmental staff. This group provided written review and comments, as well as individual phone and meeting input.

2.4 Seed Market Survey

To better understand supply and demand of native seed in Minnesota, or the potential of applying this methodology, we crafted a market survey. Representatives of vendors, installers, MnDOT staff, researchers, planners, and agencies filled out a survey tailored to their view or need of the native seed market. Questions focusing on available species, desired species, local origin, and origin standards were included.

Copies of the literature review, workshop syntheses, and survey results are available from the Minnesota Department of Transportation, Office of Environmental Services.

Chapter 3:
Native Seed Mix Design Methodology for Minnesota

3.1 How to Design a Native Seed Mix

The steps below guide the user through the methodology. Each step is broken into 2 sections:

1. "HOW", provides step by step instructions for how to carry out this step
2. "CONCEPTS AND BACKGROUND" explains underlying concepts and background information related to this step. It is helpful but not necessary to read the "CONCEPTS AND BACKGROUND" sections to be able to use the seed mix design methodology.

For easy access, a summary of the seed mix design steps is also provided in the manual's inside cover.

STEP 1. ANALYZE PROJECT SITE AND SET GOALS

➢ STEP 1: HOW

A. Obtain or draw a base plan of the project site for use in site analysis and planning.

B. Fill out the form labeled "Site Analysis Checklist" in Appendix A, pp. A-1 and A-2.

Resources for filling out the "*Site Analysis Checklist"* include:

- Minnesota County Biological Survey Native Plant Community and Rare Species County Maps and database, see http://www.dnr.state.mn.us/eco/mcbs/maps.html
- Minnesota Board of Water and Soil Resources (BWSR)'s MN Wetland Restoration Guide available at http://www.bwsr.state.mn.us/publications/restoration_guide.html

➢ STEP 1: CONCEPTS and BACKGROUND

Completing the **Site Analysis Checklist** provides information needed to design your seed mixes.

Ecological Provinces referenced on the **Site Analysis Checklist** are "units of land defined using major climate zones, native vegetation, and biomes such as prairies, deciduous forests, or boreal forests" by the Minnesota Department of Natural Resources (MNDNR) and the U.S. Forest Service (Minnesota Department of Natural Resources 2005a). In other words, they are areas in Minnesota that are similar ecologically at a broad scale. There are four Provinces in Minnesota, as shown in **Figure 3-4**: the Laurentian Mixed Forest Province (LMF), Eastern Broadleaf Forest Province (EBF), Prairie Parkland Province (PPA), and the Tallgrass Aspen Parklands Province (TAP).

STEP 2.
CHOOSE WHETHER TO USE A STANDARD OR SITE-SPECIFIC MIX.

➢ STEP 2: HOW

A. Use these guidelines with the site information and goals determined in Step 1 to determine whether to use standard native seed mixes or site-specific native seed mixes for your project site:

Use standard mixes OR site-specific mixes for:

- Sites where rapid establishment of aggressive species is needed because the sites will be exposed to high invasive species pressure.
- Sites where soil stabilization is the primary goal.

Use site-specific mixes for:

- Sites with more than 10 acres to be seeded.
- Sites for which there is no suitable standard mix (e.g. wet prairie).
- Sites where wildlife habitat enhancement is the primary goal.
- Sites where conservation is the primary goal.
- Sites where beautification is the primary goal (e.g. along a scenic byway).
- Sites with specific height requirements.
- Wetland mitigation sites.

To use standard mixes, go to Appendix C.

To design site-specific mixes, proceed to step 3. The remainder of the body of this manual describes the site-specific native grassland seed mix design methodology.

➢ STEP 2: CONCEPTS and BACKGROUND

Standard mixes are "off the shelf", standardized mixes for use on degraded sites where restoration to fully functioning native grassland is not feasible. Standard mixes have lower species diversity than site-specific mixes.

This site-specific seed mix design methodology was created for projects aiming to restore a native grassland that functions more closely like a native grassland than the standard mix grasslands. Site-specific seed mixes contain greater species diversity than standard mixes. However, because the site-specific methodology is designed to be able to respond to current market costs, site-specific mix costs can be similar to those of standard mixes.

STEP 3. ANALYZE SEEDING ZONES.

➢ STEP 3: HOW

A. Divide your site into the seeding zones listed on the "Seeding Zone Analysis" form (Appendix A, pp. A-3 to A-5).
B. Fill out a "Seeding Zone Analysis" form for each seeding zone on your project.

STEP 4.
SELECT A SEED MIX DESIGN WORKSHEET FOR EACH ZONE ON THE PROJECT.

➢ STEP 4: HOW

A. Select a **Seed Mix Design Worksheet** for each seeding zone on your project using Table 3-1, *Determining which Seed Mix Design Worksheet(s) to Use*, (p. 10).
B. Note on your base plan which Seed Mix Design Worksheet you will use for each Seeding Zone in the project.

➢ STEP 4: CONCEPTS and BACKGROUND INFORMATION

Seed Mix Design Worksheets are provided at www.mndot.gov for each of the **seeding zones** encountered in a typical road section. Seeding zones are defined as areas that will have the same seed mix. The worksheets provide a **list of species** to choose from, along with all the **information about each species** needed to follow this seed mix design methodology, as well as a "**recipe**" to guide the user in determining species and quantities for each seed mix.

The **list of species** included in a Seed Mix Design Worksheet consists of species that could potentially grow in that seeding zone and are commercially available as seed or projected to be commercially available as seed in the near future.

Species that could potentially grow in a seeding zone were derived from:

- Analyzing species composition of native plant communities with conditions similar to the seeding zone conditions. These "reference" communities are described in detail in a series of field guides produced by the Minnesota Department of Natural Resources (MNDNR) (MNDNR 2003, 2005a, 2005b). The last column of Table 3-1 shows which plant communities were used as reference plant communities for each Seed Mix Design Worksheet.
- Analyzing other plant studies applicable to Minnesota (see references).
- Field experience and restoration experience of stakeholders and TAP members.

Current commercial availability and potential availability in the near future was determined through input from commercial native seed growers.

Examples of **information included for each species** in the Seed Mix Design Worksheet include sun exposure tolerance and soil type tolerance, successional stage, salt tolerance, bloom time, height, and Ecological Sections in Minnesota where the species is native.

While this manual does not provide images of each of the 250+ species included in the worksheets, images of most of these species, as well as additional information about these species can be found at many on-line resources, such as, for example:

- Mn/DOT plant selector at http://dotapp7.dot.state.mn.us/plant/faces/index.jsp
- USDA plant database at http://plants.usda.gov/
- Illinois Plant Information Network (ILPIN) Database at http://www.fs.fed.us/ne/delaware/ilpin/ilpin.html
- Lady Bird Johnson Center Native Plant Database at http://www.wildflower.org/plants/
- Illinois Wildflowers Database at http://www.illinoiswildflowers.info/

The **recipes** provided on each worksheet consist of 3 parts: (1) a **core species recipe** that sets guidelines for determining quantities of a fixed list of "core" species, (2) a **pick list recipe** that sets guidelines for selecting species from the pick list as well as determining quantities for these species, and (3) a **cover crop recipe** to determine cover crop rate needed based on site conditions (cover crop is not applicable for the permanently flooded or wet meadow worksheets).

The **core species** are species that will provide the *"backbone"* of the seed mix. They are reliable, generally readily available species. They are also very common in native plant communities that the mixes will represent. For example, core species on the Mesic Prairie Seed Mix Design Worksheet are found in most mesic prairies throughout Minnesota.

Pick list species are additional species added to *improve performance by increasing species diversity.* More diverse communities establish faster, require fewer nutrients, cover the soil better, and grow more vigorously. More diverse communities are also better able to resist weed invasion, prevent erosion and tolerate drought and disease. This all results in *lower maintenance requirements*. The recipe specifies the *minimum* number of species to select from each guild in the pick lists. **Guilds**, or **functional groups**, are the basic components (i.e. ingredients or kinds of species) needed from each pick list to maximize long-term resilience of the seeded vegetation. The first column of the Seed Mix Design Worksheet shows which guild each species belongs to.

The **cover crop** establishes quickly the first year and then fades away. It is included in the seed mix to provide the benefits of vegetated cover (such as, soil stabilization, moisture and nutrient retention, etc.) until the slower growing native species mature.

The recipes are designed to create viable mixes yet allow flexibility. Such flexibility with built-in safeguards will result in:

- ecological benefits
- a more balanced seed market
- more economical seed mixes.

Ecological benefits will be created because statewide species diversity will be maximized. A **more balanced seed market** will be created because seed mix composition will be more flexible to respond to fluctuating supplies that result because seed production of various species can change from year to year. **More economical seed mixes** will be possible because the buyer will have more flexibility to select suitable species that are available in adequate supply at the time of the seeding, while still being assured of a reliable seed mix within the safeguards of the functional group recipes. ***No prior knowledge of native plants is needed to use these recipes***.

These mixes are calculated based on the number of seeds per square foot for each species rather than weight. Seeds of different species vary greatly in size and ability to germinate and grow. Each species has been given a "seed count multiplier" to account for these differences. The worksheet automatically applies these multipliers to create a "net number of seeds per square foot," so that one net seed of a given species is comparable to one net seed of any of the other species. The worksheet then calculates the final weights of each species in a mix based on the net seeds per square foot.

In addition to specifying which **Seed Mix Design Worksheet** to use for each **seeding zone** on your site, **Table 3-1** also shows:

- examples of typical uses for each Seed Mix Design Worksheet
- where each Seed Mix Design Worksheet is applicable within a typical roadside management zone
- which ecological provinces each Seed Mix Design Worksheet applies to (because some plant communities are restricted to a limited number of Ecological Provinces within Minnesota, not all the Seed Mix Design Worksheet are applicable statewide)
- the reference plant community on which the Seed Mix Design Worksheet is based.

Table 3-1: Determining which Seed Mix Design Worksheet to Use.

For areas that are:	**Use this Seed Mix Design Worksheet:**	**Example Uses** (see Figures 3-1 through 3-3 for typical road sections with example uses of each type of mix)	**Roadside Management Zone** (see Figures 3-1 through 3-3 for typical roadside management zone sections)	**For use in the Following Ecological Provinces** (see Figure 3-4 for map of Ecological Provinces)	**Reference Plant Community**
Persistently Flooded: always under water	A. Persistently Flooded	Pond edge or lakeshore: sow along water's edge and plants will eventually spread into water over time	Zone 3: Backslope	All	Marsh System
Temporarily Flooded: subjected to fluctuating water levels, periodic ponding, seasonally wet-dry	B. Temporarily Flooded	Ditch, streambank, pond margin above persistently flooded zone	Zone 2: Ditch, Zone 3: Backslope	All	Species from Wet Meadow/ Carr, Wet Prairie, and Mesic Prairie that can tolerate fluctuating water level
Wet Meadow: soils are saturated to flooded following spring thaw or heavy rains; water level often slowly recedes during growing season but water table remains at or near soil surface	C. Wet Meadow	Wet meadow restoration	Zone 3: Backslope	All	Wet Meadow/ Carr System
Wet Prairie: typically the water table remains 12" to 24" below the surface for much of the growing season but the surface is usually not saturated except during brief periods of snow melt or heavy rains	D. Wet Prairie	Wet prairie restoration	Zone 3: Backslope	EBF, PPA, TAP	Wet Prairie System
Upland mesic with full sun exposure: moderate moisture, well drained but not excessively dry	E. Mesic Prairie	Low maintenance, multifunctional roadside; mesic prairie restoration	Zone 3: Backslope	EBF, PPA, TAP	Mesic Prairie
Upland dry with full sun exposure: excessively dry	F. Dry Prairie	Low maintenance, multifunctional roadside; dry prairie restoration	Zone 1: Inslope; Zone 3: Backslope	EBF, PPA, TAP	Dry Prairie
Upland with partial shade: well drained or dry	G-J. Woodland Edge	Revegetation at edge of woodland or forest	Zone 1: Inslope; Zone 3: Backslope	All: see Figure 3-6 for which woodland edge worksheet to use for your project	Fire Dependent Forest/ Woodland Systems

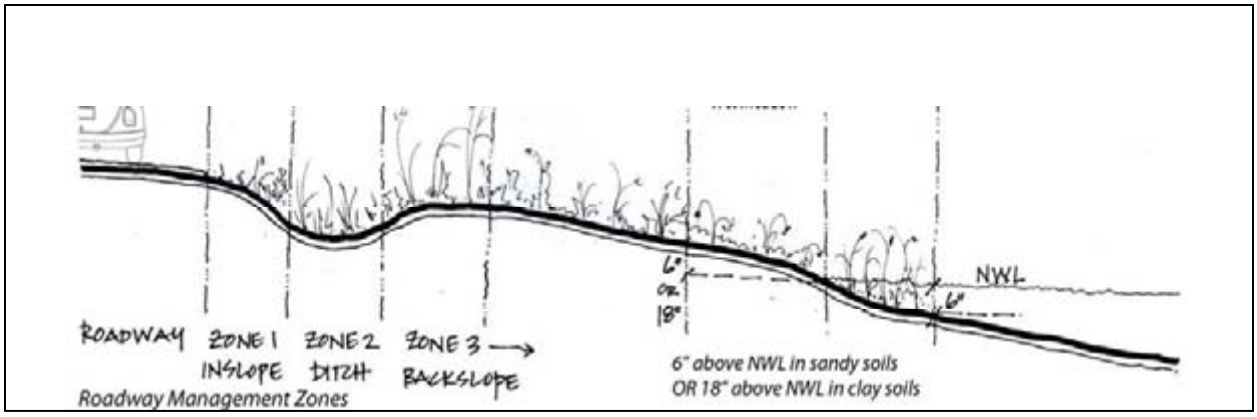

Figure 3-1: Typical Native Grassland Seeding Zones for Roadsides Exposed to Full Sun in EBF, PPA, and TAP Provinces (See Figure 3-4 for Ecological Provinces Map and Abbreviations)

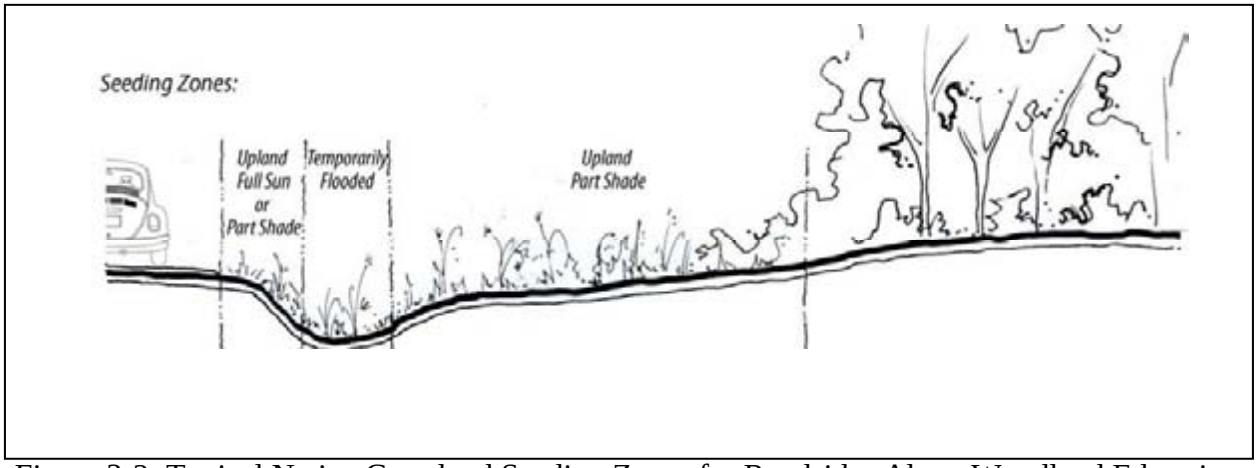

Figure 3-2: Typical Native Grassland Seeding Zones for Roadsides Along Woodland Edges in EBF, PPA, TAP Provinces (See Figure 3-6, Woodland Edge Seeding Regions for Minnesota, to see in which woodland edge seeding region your project is located, see Figure 3-4 for Ecological Provinces Map and Abbreviations)

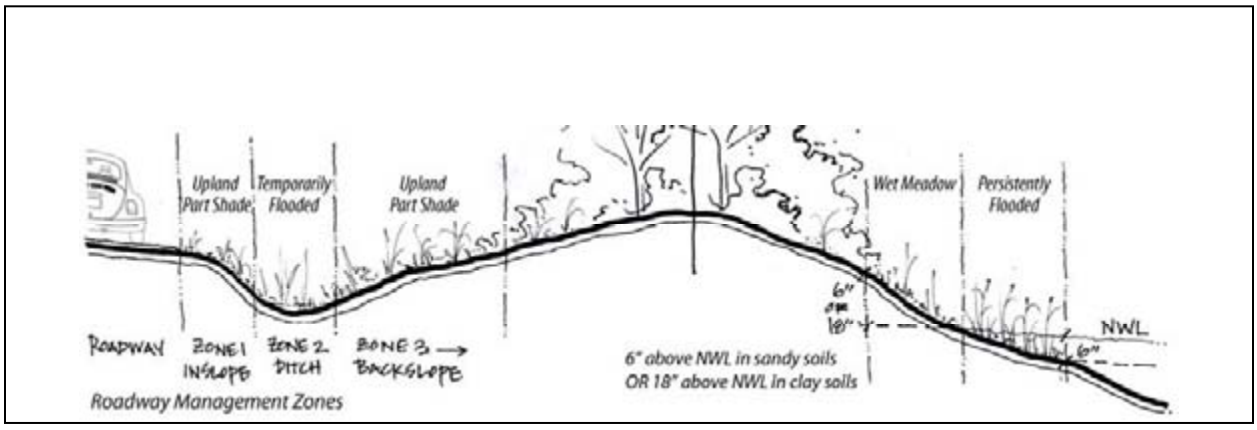

Figure 3-3 Typical Native Grassland Seeding Zones for Roadsides in LMF Province (See Figure 3-6, Woodland Edge Seeding Regions for Minnesota, to see in which woodland edge seeding region your project is located, see Figure 3-4 for Ecological Provinces Map and Abbreviations)

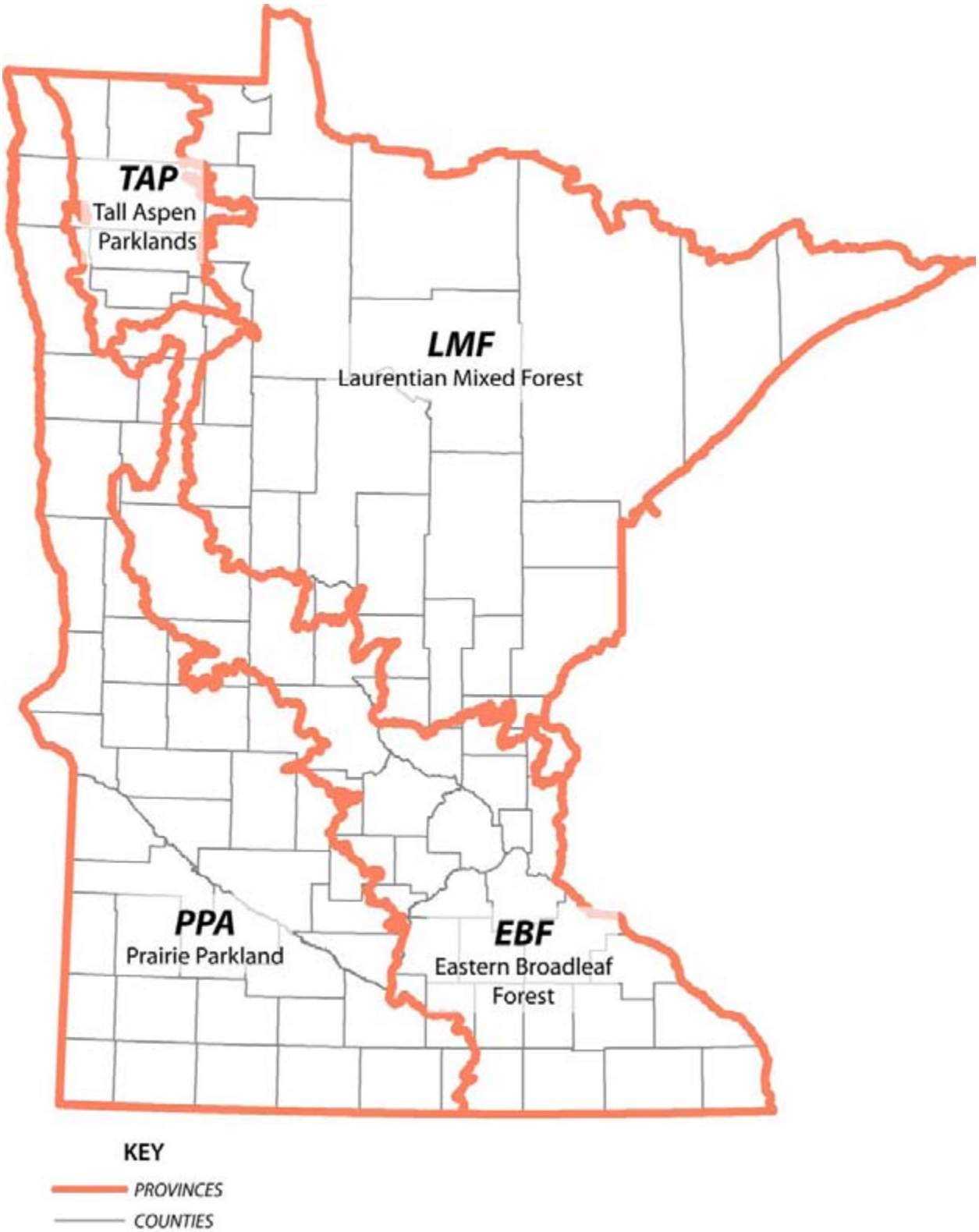

Figure 3-4: Minnesota's Ecological Provinces (Adapted from MNDNR 2005a)

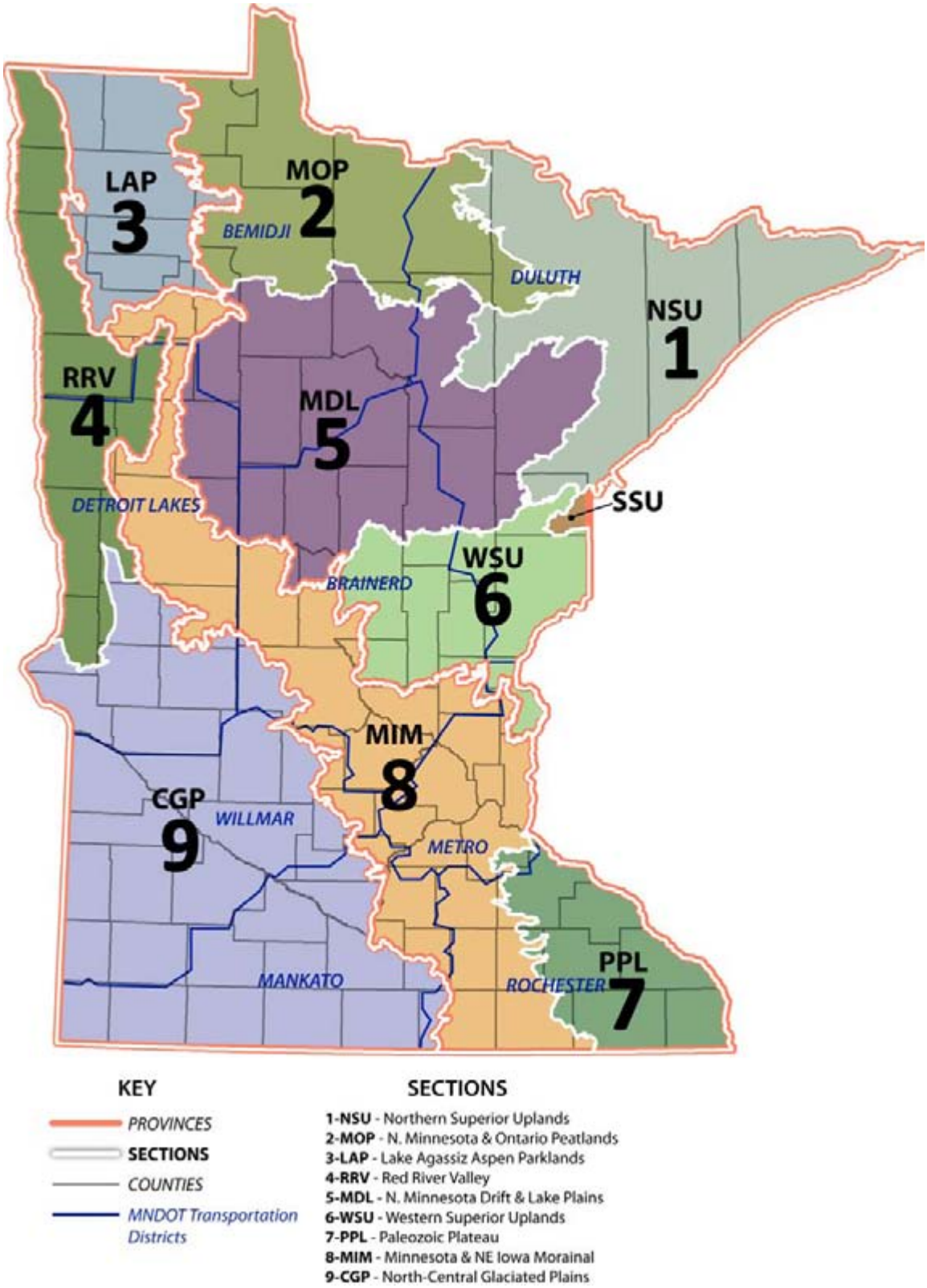

Figure 3-5: Minnesota's Ecological Sections (Adapted from MNDNR 2005a)

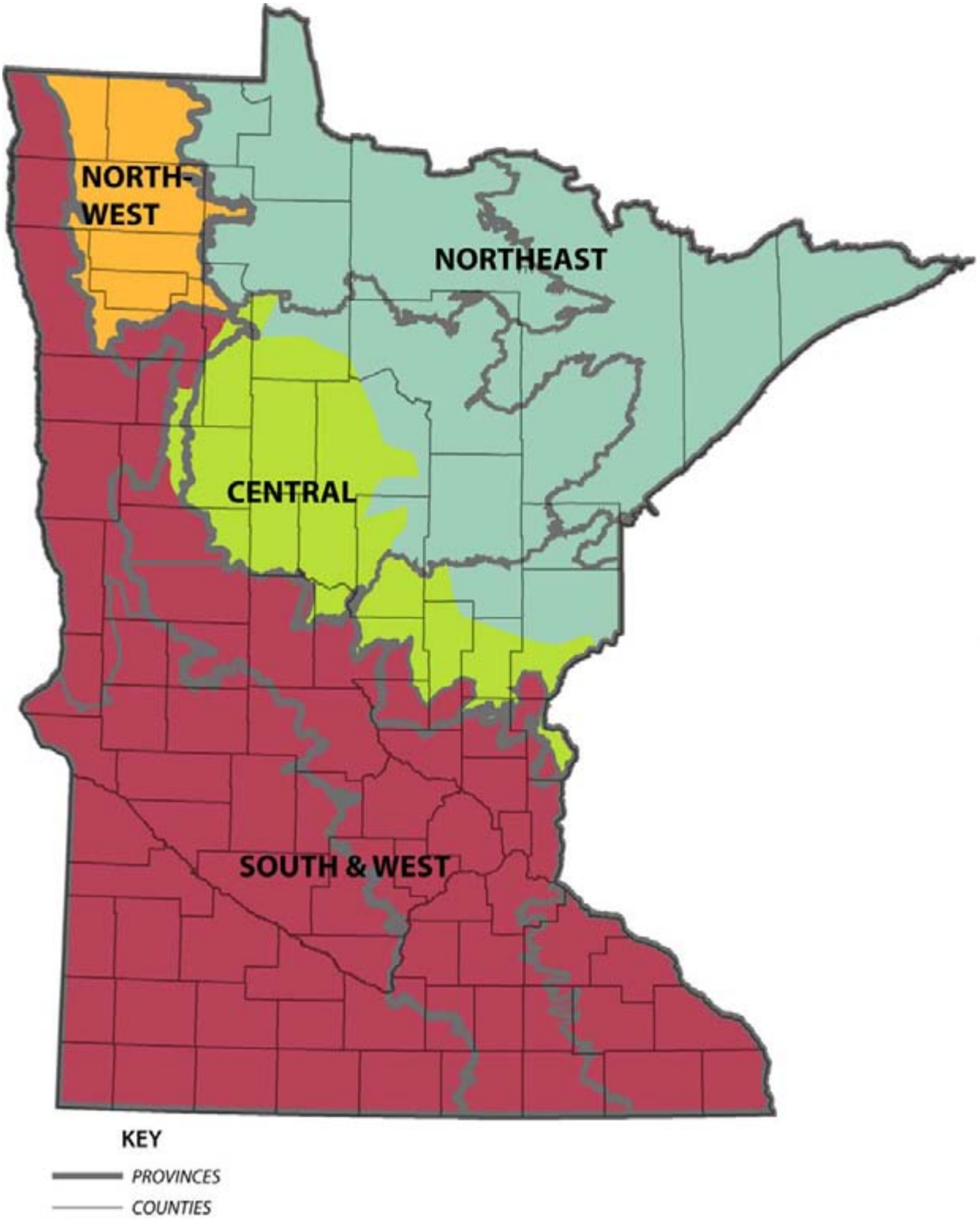

Figure 3-6: Woodland Edge Seeding Regions for Minnesota
(Adapted from MNDNR 2005a Fire Dependent Forest/Woodland Systems Floristic Regions)

STEP 5.
DESIGN SEED MIXES: GO THROUGH THESE STEPS FOR EACH SEEDING ZONE

➢ **STEP 5: HOW**

A. Core Species

1. Use the core species recipe on the Worksheet to choose core species quantities.

B. Pick List Species

1. Narrow down the pick list to species appropriate for your project:
    i. Remove species that do not belong in the project area ("ecosections" column)
    ii. Remove species that will not grow in the soil type ("soil" column)
    iii. Remove species that will not grow in the amount of sun or shade ("sun exposure" column)
    iv. Remove species that can't tolerate salt if the seeding zone will have salt impacts ("soil salt" column)
    v. Remove species that will grow taller than the maximum height you want (height column)
    vi. Remove species that are not available.
2. Use the pick list species recipe on the Worksheet to choose pick list species and quantities for your project from the list of species that you narrowed down in steps i-vi above.
3. If your project has specific wildlife, aesthetic, conservation or other goals not reflected in the recipes, incorporate your project specific requirements into your mix design.

C. Cover Crop Species

1. Determine cover crop seeding rate using the cover crop recipe.

➢ **STEP 5: CONCEPTS and BACKGROUND INFORMATION:** see description of core species, pick list species, and cover crop species in Step 4.

YOUR SEED MIXES ARE NOW COMPLETE

Tips for printing your final seed mixes:

A. To print the combined core species, pick list, and cover crop species and quantities, **hide all the columns** you no longer need and **hide** the rows for the **pick list species that you did not select to be part of your mix**. It is recommended to print the following columns:
    - Guild
    - Scientific Name
    - Common Name
    - Successional Stage
    - Seed Count Multiplier
    - Net Seeds per s.f.
    - Lb/acre or Oz/acre

- Max Oz/acre Allowed

B. See **Appendix D** for how to hide columns you do not need and how to filter the pick list to show only the species you selected for your project.

3.2 Specifying Standards for Seed Quality, Origin, and Installation

Successful native seeding requires more than a list of species quantities. Factors such as seed quality, origin, certification, packaging, labeling, and installation will affect usability and outcomes. The following section provides references and guidelines regarding these factors.

3.2.1 Seed Quality

See Mn/DOT Specifications Section 3876 for seed quality standards.

3.2.2 Seed Origin

The following excerpts from *BWSR's Native Vegetation Establishment and Enhancement Guidelines* (12/23/09) summarize guidelines for selecting seed origin and seed labeling standards appropriate for native grassland seed projects in Minnesota:

> ***"Seed and Plant Source:** As individual wetland, forest and prairie species have unique dispersal mechanisms and genetic sensitivities, local resource staff should work together to determine appropriate distances for obtaining seed of individual species. Seed must be selected to match site conditions (soils, hydrology, etc.) and have original harvest locations (original remnant population) from as close to the project site as possible to protect local ecotypes of species from genetic contamination. The first step in obtaining seed should be to identify remnant populations that could act as seed sources. As source distances increase there should be an emphasis on obtaining seed from the local eco-type region. The recommended maximum distance is 150 miles (including into an adjoining state or province). It will be important to work with local resource staff and seed/plant vendors through the process.*
>
> *The following is a recommended sequence for obtaining seed/plants:*
>
> *A) Areas as close to the project site as possible*
> *B) Minnesota Ecological Sub-sections (see www.bwsr.state.mn.us/wetlands/vegetation/index.html)*
> *C) Minnesota Ecological Sections*
> *D) Within 75 miles of project*
> *E) Within 150 miles of project*
>
> *If a project encounters seed availability issues, local resource staff can approve species substitutions, an alternative geographic source or changes to the project schedule. See Appendix A for information about documentation standards.*

Native Variety Use: *The first priority for seed should be that which originated as close to the project site as possible. Named germplasms/varieties (i.e. Red River Germplasm Prairie Cordgrass) may be acceptable if their original collection sites represent the closest available source for an individual species, and they have not been intentionally selected for traits such as height, leafiness, forage quality and color. Information about NRCS varieties is found at the following website: (http://plant-materials.nrcs.usda.gov/ndpmc/pubs/publications_available.pdf)...*

Yellow Tag Seed: *When available, source identified (Yellow tag) seed through the Minnesota Crop Improvement Association (MCIA) shall be used over non-source identified seed. See the following website for a survey of yellow tag seed availability: (www.mncia.org/). Flexibility regarding the use of yellow tag seed can be granted by local staff when seed from local remnant communities (generation 0 seed) will be used for a project, or the available yellow tag seed is not of a local source. Yellow tag seed may not be available for tree and shrub species.*

Seed Labeling: *All seed mixes must be labeled according to the requirements of the Minnesota Seed Law, section 21.8, including limits on noxious weeds. The origin (area where the original seed was harvested) shall be listed on the seed tag for all species in a mix to provide verification of original (generation 0) seed source. The smallest known geographic area (township, county, ecotype region etc.) shall be listed. Seed must be cleaned to an extent sufficient to allow its passage through appropriate seeding equipment. Information pertaining to pure seed, germination, and hard (dormant) seed of individual components in a mix is required on seed tags. For wild harvest mixes, "germination", "hard seed" and "Pure Live Seed" information is required on seed tags for the number of species that are required through a program or project diversity standard. When listing purity for wild harvest mixes, undetermined wild harvest seed should be listed as "other crop seed" and there should be categories for "inert material" and "weed seeds". Unless otherwise requested, small, large, and cover crop seeds should be packaged separately.*

Protecting Existing Native Prairies: *Remnant prairies must be protected from non-local sources of seed. Experienced resource professionals should be involved in seed collection and management planning when working in, or near, remnant prairies. Varieties/cultivars (selected germplasms) of native species cannot be used adjacent to these areas (recommended one-half mile buffer) to limit genetic influences. Seed must come from local sources when planting buffers adjacent to medium and high quality remnant communities. Whenever possible, seed should be collected directly from local remnants (generation 0) or from the first generation of production (generation 1). The DNR County Biological Survey Program can provide more information about remnant communities in the state. Data about mapped remnant prairie communities can be found at: (http://deli.dnr.state.mn.us/data_search.html)."*

3.2.3 Seed Installation

See *Mn/DOT Specifications Section 2575* and *Mn/DOT District Seeding Recommendations* for installation, mulch/erosion control requirements, installation and payment. *Mn/DOT District Seeding Recommendations* are available at:
http://www.dot.state.mn.us/environment/erosioncontrol/seedmixes.html

Photo: Nathalie Hallyn

Figure 3-7: Prairie at Sherburne National Wildlife Refuge, Zimmerman, MN.

"…I started with surprise and delight. I was in the midst of a prairie! A world of grass and flowers stretched around me, rising and falling in gentle undulations, as if an enchanter had struck the ocean swell, and it was at rest forever… You will scarcely credit the profusion of flowers on these prairies. We passed whole acres of blossoms all bearing one hue, as purple, perhaps, or masses of yellow or rose; and then again a carpet of every color intermixed, or narrow bands, as if a rainbow had fallen upon the verdant slopes. When the sun flooded this Mosaic floor with light, and the summer breeze stirred among their leaves the iridescent glow was beautiful and wondrous beyond anything I had ever conceived…"

Eliza Steele, 1840 (from Steele, 1975)

Chapter 4:
Suggestions for other State Departments of Transportation On Developing a Local Site-specific Native Seed Mix Design Methodology

The more than 12 million acres of ROW in the United States present opportunity to significantly increase the native grassland area on a national scale. While the exact methodology and native species presented in this manual will not be applicable to all states, all states do have native grassland suitable for roadside vegetation. The same framework used to develop Minnesota's site-specific native grassland seed mix design methodology can be used to develop similar methodologies suitable for other states.

4.1 Steps to Reproduce Minnesota's Framework in Other States

1. For each ecologically distinct region of the state, determine suitable reference native grassland plant communities for each type of seeding zone found in a typical road section.
   Key Resources:
   - Local ecologists and natural areas specialists such as representatives from State Departments of Natural Resources or The Nature Conservancy
   - Field studies
   - Local natural areas studies and inventories

2. Develop a master list of native grassland species that are, or could be, commercially available.
   Key Resources:
   - Studies of reference native plant communities
   - Native seed producers

3. Develop "recipes" that provide the key components needed to establish mixes for each type of seeding zone based on the reference native grassland communities.
   Key Resources:
   - Through field studies, natural areas inventories, and input from local natural areas resources specialists, determine:
     - plant species and family distribution, abundance, and frequency in reference native grasslands over time
     - changes in reference native grasslands over time
     - performance of species and grassland as a whole in past grassland restorations over time
     - keystone species crucial to successful seed mix design

4. Create Site Analysis and Seed Mix Design Worksheets to guide the user through the use of the recipes.

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APPENDIX A:
Site Analysis Checklist and Seeding Zone Analysis Form

A.1 Site Analysis Checklist (for use in Step 1)

DETERMINE THE FOLLOWING FOR YOUR SITE AS A WHOLE:

Site Name:_____
Location: _____
Ecological Province: (see Figure 3-4) _____
Ecological Section: (see Figure 3-5) _____
Total Acres to be Seeded: _____
Project Goals - note top 3 project goals, ranked from 1 to 3:

- ☐ Erosion control
- ☐ Water quality treatment
- ☐ Wildlife habitat enhancement
- ☐ Conservation
- ☐ Beautification (e.g. along a scenic byway)
- ☐ Wetland mitigation
- ☐ Other goals and requirements:_____

Previous land use:_____

Crops and herbicides on land within 3 years of seeding:_____
Note: If herbicides that could negatively affect native seed germination (e.g. Aminopyralid - Milestone, Clopyralid - Transline or Stinger, or products with Atrazine) were previously used on the site, note where on base plan and wait to install the native seed in these areas until these areas are free from carry-over. Use temporary erosion control until these areas are ready for native seeding.

Invasive Species Adjacent to Site (e.g. reed canary grass, Canada thistle, purple loosestrife, see the invasive species section of MNDNR's website at http://www.dnr.state.mn.us/invasives/index.html for list of invasive species in Minnesota):

- List invasive species adjacent your site in table below and note extent of each species on base plan.
- If maintenance budget does not allow for persistent and thorough control of invasive species adjacent site, use a standard mix or design site-specific mix able to compete with invasive species adjacent to the site given proposed maintenance budget and techniques.
- See Section titled, *Additional References: Invasive Species Control,* of this Manual for more information about invasive species control.

Invasive Species	**% Cover**	**Estimated surface area of invasive species**

A.1 Site Analysis Checklist (for use in Step 1)

Disturbance:

Compacted soil: yes or no
If yes, note extent on base plan and remediate per subsoiling in Section 2575, Erosion Control, of Mn/DOT specifications.

Topsoil removed: yes or no
If yes, note extent on base plan and import topsoil per Mn/DOT requirements or per project plans, whichever is most stringent.

Other disturbances - note extent on base plan and describe: _____
_____
_____

Exceptional natural resource features (e.g. rare plants, rare habitat, exceptional wildlife value) - note extent on base plan and describe:
_____
_____

Notes:

- If your project site is adjacent to any MNDNR or TNC owned lands (State Forests, Wildlife Management Areas, Aquatic Management Areas, State Parks, and Scientific and Natural Areas), notify DNR or TNC unit that administers the land.
- If the project is within 0.50 miles of a Scientific and Natural Area notify MNDNR - Scientific and Natural Areas Program.
- If there are any rare, endangered or otherwise protected species or communities on your site, follow applicable regulations.
- See Section 3.2.2, Seed Origin, for additional guidelines for sites within a half mile from a remnant prairie.

Maintenance resources and plan:_____
_____
_____
Note: if maintenance resources are limited and significant invasive species pressure is expected (for example, if there are invasive species in the seed bank or adequate site preparation will not be possible), use a standard mix or design a site-specific seed mix able to compete with anticipated invasive species given available maintenance budget. See Section titled, *Additional References: Invasive Species Control,* of this Manual for more information about seed mix design and invasive species control.

PROCEED TO Step 2 on page 6

A.2 Seeding Zone Analysis Form (for use in Step 3)

FILL OUT A SEPARATE SEEDING ZONE ANALYSIS FORM FOR EACH ZONE.

Seeding Zone (*see Figures 3-1 through 3-3 for typical road cross section seeding zones*):

- ☐ **Persistently Flooded:** always under water *(i.e. your feet are always wet standing in this zone)*
- ☐ **Temporarily Flooded:** subjected to fluctuating water levels, periodic ponding, seasonally wet-dry *(i.e. flashy water table - your feet only get wet in this zone within a few days after a big rainstorm)*
- ☐ **Wet Meadow**: soils are saturated to flooded following spring thaw or heavy rains; water level often slowly recedes during growing season but water table remains at or near soil surface *(i.e. your feet typically get wet in this zone until about mid-summer; after mid-summer soil is typically still saturated to at, or near, the top of the soil so your feet are sometimes wet or sometimes dry in this zone)*
- ☐ **Wet Prairie:** typically the water table remains 12" to 24" below the surface for much of the growing season but the surface is usually not saturated except during brief periods of snow melt or heavy rains *(your feet typically get wet in this zone until about mid spring, after mid spring soil is saturated only in the lower part of the rooting zone, and your feet are dry standing in this zone)*
- ☐ **Upland mesic with full sun exposure:** well drained but not excessively dry *(i.e. your feet do not get wet any time of the year standing in this zone)*
- ☐ **Upland dry with full sun exposure:** excessively dry
- ☐ **Upland with partial shade:** well drained or dry

Acres of this zone on your site: _____

Soil type:

- ☐ Coarse textured soil (*sand, coarse sand, fine sand, loamy coarse sand, loamy fine sand, loamy very fine sand, very fine sand, loamy sand*)
- ☐ Medium textured soil *(silt, sandy clay loam, very fine sandy loam, silty clay loam, silt loam, loam, fine sandy loam, sandy loam, coarse sandy loam, clay loam)*
- ☐ Fine textured soil *(sandy clay, silty clay, clay)*
- ☐ Peat

Note: If soil will be imported, tailor seed mix to imported soil specifications.

Sun exposure:

- ☐ Full sun (up to 20% of the ground is shaded)
- ☐ Partial sun (20% to 70% of the ground is shaded)
- ☐ Shade (more than 70% of the ground is shaded)

Slope steepness (this will affect mulch and erosion control requirements - see Section 3.2.3, as well as cover crop rate in Step 5):

- ☐ Flat to 1:20 (5%) slope
- ☐ 1:20 (5%) slope to 1:10 (10%) slope
- ☐ 1:10 (10%) to 1:3 (33%) slope
- ☐ Steeper than 1:3 (33%) slope

Slope aspect: slope faces

- ☐ North
- ☐ East
- ☐ South
- ☐ West

Note: Steep north and east facing slopes are more shaded and are therefore wetter and shadier, steep south and west facing slopes receive more direct sun and are therefore hotter and drier.

Water level fluctuation anticipated (when, how much, and how often):

_____

Notes:

- See Section 3.2.3, Seed Installation, for mulch and erosion control requirements in ditches and swales.
- Do not seed if seeded area will be exposed to standing water, moving water or fluctuating water levels prior to germination. Use live plants or pre-vegetated mats if moving water, standing water, or fluctuating water levels are anticipated prior to germination. Even live plants and pre-vegetated mats will not survive in extreme situations where water level fluctuations or water velocity are too high to allow for any vegetation to survive. See Shaw and Schmidt, 2003, for flooding and fluctuation tolerances of live plants.

A.2 Seeding Zone Analysis Form (for use in Step 3)

Soil salt exposure:

- ☐ Will this zone be within 50' from an urban parking lot or road where salt is used as a deicer? Yes or No
- ☐ Will this zone be located within 200' of an outlet of runoff from an urban parking lot or road where salt is used as a deicer? Yes or No

Invasive Species currently in this zone:

- List invasive species in this zone in table below and note extent of each species on base plan.
- If the zone currently has high cover of invasive species, significant site preparation will be needed to eliminate or minimize invasive species pressure prior to seeding.
- If maintenance resources are limited and significant invasive species pressure is expected (for example, if adequate site preparation will not be possible), use a standard mix or design a site-specific seed mix able to compete with anticipated invasive species given available maintenance budget.
- See Section titled, *Additional References: Invasive Species Control,* of this Manual for more information about site preparation and invasive species control.

Invasive Species	**% Cover**	**Estimated surface area of invasive species**	**Will topsoil (and invasive species roots and seed) be removed prior to seeding?**

Other factors that will affect seed mix design:_____

_____

PROCEED TO Step 4 on page 7

APPENDIX B:
Seed Mix Design Worksheets

B.1 List Of Seed Mix Design Worksheets Available

The following Seed Mix Design Worksheets are available on the Mn/DOT website, www.mndot.gov.

A. Persistently Flooded
B. Temporarily Flooded
C. Wet Meadow
D. Wet Prairie
E. Mesic Prairie
F. Dry Prairie
G. Woodland Edge – Northeast*
H. Woodland Edge - Central*
I. Woodland Edge – South & West*
J. Woodland Edge - Northwest*

*See Figure 3-6 for where to use Northeast, Central, South & West, and Northwest Woodland Edge Worksheets.

Notes:

1. For master list of all species in the Seed Mix Design Worksheets, see the Mn/DOT website, www.mndot.gov.
2. Blanks in the Seed Mix Design Worksheets reflect information that was unknown at the time of publication of this manual. If you are able to supply any of the information needed to fill in the blanks, please e-mail Mn/DOT's Office of Environmental Services Erosion Control Department.

B.2 Seed Mix Design Worksheet and Master List Abbreviations and Definitions

Guild
A = wildflowers belonging to the Aster family, Asteraceae.
F= all the wildflowers that are not from the Aster or Legume family.
G = grasses and grass-like species.
L = wildflowers belonging to the Legume family, Fabaceae.

Scientific Name
Nomenclature follows Gleason and Cronquist, 1991, because that is the nomenclature most commonly used in the industry. See the master species list on Mn/DOT's website, www.mndot.gov for updated names used by the Minnesota Department of Natural Resources and USDA PLANT Database.

Common Name
Note that many plants have several common names. Always use scientific names when placing an order.

Wetland Indicator Status
United States Fish and Wildlife Service's Wetland Indicator Status for Region 3 (which includes Minnesota) using the following abbreviations, taken from U.S. Fish and Wildlife Service, 1988:

Indicator Code	Wetland Type	Comment
OBL	Obligate Wetland	Occurs almost always (estimated probability 99%) under natural conditions in wetlands.
FACW	Facultative Wetland	Usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands.
FAC	Facultative	Equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%).
FACU	Facultative Upland	Usually occurs in non-wetlands (estimated probability 67%-99%), but occasionally found on wetlands (estimated probability 1%-33%).
UPL	Obligate Upland	Occurs in wetlands in another region, but occurs almost always (estimated probability 99%) under natural conditions in non-wetlands in the regions specified. If a species does not occur in wetlands in any region, it is not on the National List.
+		A positive sign indicates a frequency toward the higher end of the category (more frequently found in wetlands), e.g. FACW+
-		a negative sign indicates a frequency toward the lower end of the category (less frequently found in wetlands), e.g. FAC-

Sun Exposure:
The amount of light in which the plant grows best, indicated by the following abbreviations:

- SU: Full Sun (up to 20% of the ground is shaded)
- PS: Part Shade (20% to 70% of the ground is shaded)
- SH: Full Shade (more than 70% of the ground is shaded)

Soil
Soil types in which the plants can grow as indicated by the following abbreviations, following the USDA PLANTS database soil texture group classification:

- C: Coarse textured soils = sand, coarse sand, fine sand, loamy coarse sand, loamy fine sand, loamy very fine sand, very fine sand, loamy sand
- M: Medium textured soils = silt, sandy clay loam, very fine sandy loam, silty clay loam, silt loam, loam, fine sandy loam, sandy loam, coarse sandy loam, clay loam
- F: Fine textured soils = sandy clay, silty clay, clay

Height
Typical mature height is given in inches. Actual mature heights will vary depending on site-specific growing conditions.

Seed Mix Design Worksheet
The species Master List includes a column that shows in which Seed Mix Design Worksheet(s) species are listed. See Table 3-1 for which Seed Mix Design Worksheet(s) to use. Abbreviations used in the master list are as follows:

A. Persistently Flooded
B. Temporarily Flooded
C. Wet Meadow
D. Wet Prairie
E. Mesic Prairie
F. Dry Prairie
G. Woodland Edge – Northeast**
H. Woodland Edge - Central**
I. Woodland Edge – South & West**
J. Woodland Edge - Northwest**

**See Figure 3-6 for woodland edge Seed Mix Design Worksheet applicability.

Successional Stage
E: early successional species - colonizes readily from seed in newly created habitat; rapid re-seeders; may not persist after 10 years
M: mid successional species - slow to colonize initially but can establish early
L: late successional species - slow to establish, persist long term

Planting Zones – definitions adapted from Jacobson 2006.

E = Emergent – Standing water - Plants are partially submerged with leaves, stems and flowering parts partially or entirely out of the water. They can often grow under saturated conditions and may survive short periods of dry-down. Emergent species are generally installed as plants or pre-vegetated mats because they are planted in the water. When planted in the water, they need to have a portion of their leaves or stems above the water surface at planting time, or they will drown. If seeded, the seed should be placed either on a mud flat or at the water's edge.

S = Saturated – Soils are saturated most of the year, plants will tolerate periodic flooding and dry-down periods. Species categorized as "Saturated" should generally be planted at the water's edge. Many species can be established as seed. However, a number of desirable species are only available as plants or pre-vegetated mats.

M = Moist – Soils are saturated seasonally with flooding in the spring and dry-down in the summer. Most species can be established as seed.

MZ = Mesic – Upland soils may be saturated for short periods of time but are generally well drained, though not excessively dry. Many mesic species will tolerate saturated and moist soil conditions for extended periods of time. Most species can be established as seed.

D = Dry – Upland soils are generally excessively dry except for after spring snowmelt or briefly after heavy rains. Most species can be established as seed.

Bloom Time
Indicates months in which species typically blooms, indicated as follows:

1. January
2. February
3. March
4. April
5. May
6. June
7. July
8. August
9. September
10. October
11. November
12. December

Soil Salt
Soil salt content levels may be seasonally high in the spring before road salt is flushed from the soil. This identifies the probable amount of damage that will occur to plants located within 30 to 40 feet of the road, with an average daily traffic (ADT) from 0 to 40,000 vehicles, using the following abbreviations:

L = Low tolerance to soil salt - Plants are not able to withstand the damaging effects of soil salt.
M = Medium tolerance to soil salt - Caution should be used.
T = Tolerant to soil salt - Plants are able to withstand the damaging effects of soil salt.

Eco-sections: Indicates Ecological Section in which species are native. See Figure 3-5 for a map of Minnesota's ecological sections. Species with an "*" in the Eco-section column have a very limited range within the sections noted. See the notes column for description of extent limits.

USDA Scientific Name
This column shows the scientific name used in the USDA PLANTS database for species for which the USDA name is different than the name used in the "Scientific Name" column (the second column).

DNR Scientific Name
This column shows the scientific name used by the MNDNR in their 2009 County Record Checklist for species for which they use a different name than is used in the "Scientific Name" column (the second column).

Seed Count Multiplier
Seeds of different species vary greatly in size and ability to germinate and grow. Each species has been given a "seed count multiplier" to account for these differences. The worksheet

automatically applies these multipliers to create a “net number of seeds per square foot,” so that one net seed of a given species is comparable to one net seed of any of the other species.

Seeds/oz
Approximate number of seeds per ounce is provided, but exact seed weight will vary from year to year.

Cost/oz and Cost/lb
These columns are to be filled in by user based on supplier costs.

Gross # seeds/s.f.
Number of seeds per square foot based on percent of total seed count per square foot, before multiplying by the seed count multiplier. Once you enter % of gross seed count, worksheet automatically fills in gross # of seeds/s.f., net seeds/s.f., oz or lb/acre and cost/acre (if you filled in cost/oz and cost/lb).

Net # seeds/s.f.
Net # seeds/s.f. is the gross seeds per square foot multiplied by seed count multiplier (see above for seed count multiplier definition). Worksheet fills this column in automatically via pre-programmed formulas once you enter % of gross seed count.

Oz or Lb/acre
Ounces or pounds needed per acre; worksheet fills this column in automatically via pre-programmed formulas once you enter % of gross seed count.

Max Oz or Lb/acre allowed
For a few very aggressive species, the maximum quantity allowed is less than the maximum on the recipe. This quantity is noted in the column labeled "Max. lb (or oz in picklists)/ acre allowed". If maximum allowed is exceeded for these species, the message "too high" will appear in the Lb (or Oz in picklists)/acre column. If that message appears, lower the number you entered in the "Gross % of pick list seed count" until the message "too high" no longer appears in the "Lb (or oz in picklists) /acre" column.

Cost/acre
If you fill in unit costs for your vendor in column labeled “Cost per Lb” (highlighted in yellow), cost per acre will also automatically be calculated and provided in column labeled “Cost per Acre” (highlighted green).

B.3 Sample Seed Mix Design Worksheet

E. MESIC PRAIRIE SEED MIX DESIGN WORKSHEET

Overview:

• Worksheet below provides seed mix recipes needed for designing a site specific **Mesic Prairie** Seed Mix. See "Native Seed Mix Design for Roadsides" manual for full seed mix design methodology steps and concepts.
• See Manual Figure 3-1 for an example of where to use this worksheet in a Typical Roadside Section.
• See Manual Appendix B for abbreviations and description of columns.
• See Manual Appendix D for excel instructions for various helpful functions, such as, for example (1) how to hide columns or freeze panes to fit worksheet on your computer screen with just the columns you need, (2) how to filter the picklist to contain just species native to the ecosection in which your project is located.·

Core Species Recipe:

1. In column labeled "**gross % of total seed count**" (highlighted **yellow**), assign a gross % between **5% and 30%** of the core species seed count to each of the core species below; total must equal 100.
Note: maximum quantity allowed can be less than 30% for a few very aggressive species, as noted in the column labeled "Max. lb/ acre allowed". If maximum allowed is exceeded for these species, the message "too high" will appear in the Lb/acre column. If that message appears, lower the number you entered in the "gross % of pick list seed count" until the message "too high" no longer appears in the "Lb/acre" column.
2. Once you have entered gross % of seed mix, spreadsheet automatically calculates net seeds per s.f. (shown in column labeled, "**net seeds per s.f.",** highlighted **green**) and weight per acre needed for that species (shown in column labeled, "**lb per acre",** highlighted **green**).
3. If you fill in unit costs for your vendor in column labeled "**Cost per Lb**" (highlighted in **yellow**), cost per acre will also automatically be calculated and provided in column labeled "**Cost per Acre**" (highlighted **green**).
4. If a core species is not available, chose a substitute species that is native to the ecological section in which your project is located and from the same guild and successional stage as the unavailable species. Core species can only be substituted with proof of non-availability.

Core Species List: based on gross 55 seeds per s.f.

Species Selection Informants													Calculations Informants		Input		Output				
Guild	Scientific Name	Common Name	Sun Exposure	Soil	Height	Succes-sional stage	Hydro-logic Zone	Pollinator Value	Bloom Time	Soil Salt	Eco-sections	Notes	Seed Count Multi-plier	Seeds/ oz	Cost/ lb	Gross % of core list seed count	Gross # seeds/ s.f.	Net # seeds/ s.f.	Lb/ acre	Max. lb/ acre allowed	Cost/ acre
G	*Andropogon gerardii*	big bluestem	SU PS	CMF	36-96	L	M-D	Nests	8,9	M	23456789		0.6	10,000			0	0	0.00		$0.00
G	*Bouteloua curtipendula*	side-oats grama	SU PS	CMF	12-36	M	MZ,D	Nests	7,8,9	M	34789		0.5	6,000			0	0	0.00		$0.00
L	*Dalea purpurea*	purple prairie clover	SU	CMF	12-30	M	MZ,D	Very High	7,8	M	123456789		0.7	15,000			0	0	0.00	0.50	$0.00
G	*Elymus canadensis*	nodding wild rye	SU PS	CMF	36-60	E	MZ,D	None	7,8	M	123456789		0.4	5,200			0	0	0.00	2.00	$0.00
G	*Schizachyrium scoparium*	little bluestem	SU PS	CMF	12-30	L	MZ,D	None	8,9	M	23456789		0.7	15,000			0	0	0.00		$0.00
G	*Sorghastrum nutans*	Indian grass	SU	CMF	36-96	L	M	Nests	8,9,	M	34789		0.7	12,000			0	0	0.00		$0.00
	Total															**0**	**0**	**0**	**0.00**		**$0.00**

Pick List Recipe:

1. In column labeled "**gross % of pick list seed count**" (**yellow**), assign a gross % between **1% and 10%** of the pick list seed count to the following number of pick list species from each of the guilds below (guilds are shown in the first column, labeled "**guild**" and highlighted **purple**); adjust quantities until total equals 100%:
   - minimum **8** species from Guild **A**
   - minimum **10** species from Guild **F**
   - minimum **4** species from Guild **G**
   - minimum **4** species from Guild **L**

Note: maximum quantity allowed can be less than 10% for a few very aggressive species, as noted in the column labeled "Max. oz/ acre allowed". If maximum allowed is exceeded for these species, the message "too high" will appear in the oz/acre column. If that message appears, lower the number you entered in the "gross % of pick list seed count" until the message "too high" no longer appears in the "Oz/acre" column.

2. No more than 3 species per mix can be selected from the same genus.
3. Include total of at least **3 early or mid successional** and **3 late successional** pick list species. Successional stage is shown in column labeled "**successional stage**", highlighted **purple**.
4. For **wildlife habitat enhancement projects**, such as, for example, roadsides for wildlife:

a. Specify to cluster forbs of same species together during installation.
b. Include minimum 3 species that bloom in spring, 3 in summer, 3 in fall (see "**bloom time**" column)

5. For **beautification projects**, such as, for example, scenic byways:

a. Specify to cluster forbs of same species together during installation.
b. Total combined A, F, and L guild species seed count must equal minimum 30% of total seed mix count.

6. Once you have entered gross % of seed mix, worksheet automatically calculates net seeds per s.f. (shown in column labeled, "**net seeds per s.f.",** highlighted **green**) and weight per acre needed for that species (shown in column labeled, "**oz per acre",** highlighted **green**).

Pick List: based on gross 20 seeds per s.f.

Species Selection Informants													Calculations Informants		Input		Output				
Guild	Scientific Name	Common Name	Sun Exposure	Soil	Height	Succes-sional stage	Hydro-logic Zone	Pollinator Value	Bloom Time	Soil Salt	Eco-sections	Notes	Seed Count Multi-plier	seeds/ oz	cost / oz	Gross % of pick list seed count	Gross # seeds / s.f.	Net # seeds / s.f.	Oz/ acre	Max. oz/ acre allowed	Cost/ acre
A	*Achillea millefolium*	common yarrow	SU PS	CMF	12-30	E	MZ,D	Low	4,5,6,7,8,9	L	123456789		1.6	178,251			0	0	0.00	0.25	$0.00
A	*Artemisia ludoviciana*	prairie sage	SU PS	CMF	12-40	M	MZ,D	None	8,9	L	346789*		2	250,000			0	0	0.00		$0.00
A	*Aster ericoides*	heath aster	SU PS	CMF	12-36	M	MZ,D	High	8,9,10	M	1*2*345*6*789	Uncommon in 1,2,5,6	2	200,000			0	0	0.00		$0.00
A	*Aster laevis*	smooth aster	SU PS	CMF	31-54	L	MZ,D	High	8,9,10	M	3456789	Uncommon in 5	1	55,000			0	0	0.00		$0.00
A	*Aster novae-angliae*	New England aster	SU PS	CMF	36-54	L	S	Very High	9,10	M	34789		1.2	65,000			0	0	0.00		$0.00
A	*Aster oolentangiensis*	skyblue aster	SU PS	CMF	24-36	L	MZ,D	Low	8,9,10	M	678		1.4	80,000			0	0	0.00		$0.00
A	*Coreopsis palmata*	bird's foot coreopsis	SU PS	CM	12-30	L	MZ, D	Medium	7,8	M	6789		0.6	10,000			0	0	0.00		$0.00

Guild	Scientific Name	Common Name	Sun Exposure	Soil	Height	Succes-sional stage	Hydro-logic Zone	Pollinator Value	Bloom Time	Soil Salt	Eco-sections	Notes	Seed Count Multi-plier	seeds/ oz	cost / oz	Gross % of pick list seed count	Gross # seeds / s.f.	Net # seeds / s.f.	Oz/ acre	Max. oz/ acre allowed	Cost/ acre
A	*Echinacea pallida var. angustifolia*	narrow-leaved purple coneflower	SU	CMF	12-48	L	MZ,D	High	6,7	M	4*9	Not native in 4 north of Polk Co.	0.5	7,000			0	0	0.00		$0.00
A	*Helianthus giganteus*	giant sunflower	SU PS	CMF	84	E	M	High	7,8,9		123456789		0.5	10,000			0	0	0.00		$0.00
A	*Helianthus maximilianii*	Maximilian's sunflower	SU PS	CMF	48-60	E	M, MZ	High	9,10	L	123456789		0.6	13,000			0	0	0.00	0.25	$0.00
A	*Helianthus occidentalis*	western sunflower	SU PS	CM	36	M	MZ,D	High	7,8,9		67*	In 6 only in sandy soil at St. Croix St. Prk	0.7	14,000			0	0	0.00	0.50	$0.00
A	*Helianthus pauciflorus*	stiff sunflower	SU	CMF	12-48	M	MZ,D	High	7,8	M	123456789		0.3	4,000			0	0	0.00		$0.00
A	*Heliopsis helianthoides*	ox-eye	SU PS	CMF	24-60	M	MZ, D	Very Low	6,7,8	M	123456789		0.5	6,300			0	0	0.00		$0.00
A	*Heterotheca villosa*	hairy golden aster	SU	CM	6-18	L	D	Medium	7,8	H	345*6*789	uncommon and only in dry sandy soil in 5 & 6	1.2	70,000			0	0	0.00		$0.00
A	*Kuhnia eupatorioides*	false boneset	SU PS	CMF	36	M	D	Low	8,9		78*9	Not native to 8 north of Twin Cities	1	32,000			0	0	0.00		$0.00
A	*Liatris aspera*	rough blazing star	SU PS	CM	24-36	L	MZ,D	High	7,8,9	M	34789		0.8	16,000			0	0	0.00		$0.00
A	*Liatris ligulistylis*	northern plains blazing star	SU PS	CM	18-36	L	S-MZ	High	8,9	H	3456789		0.6	10,000			0	0	0.00		$0.00
A	*Liatris pycnostachya*	great blazing star	SU PS	CMF	24-48	L	M,MZ	High	7,8	M	4*5789	Not native north of Polk Co in 4	0.7	11,000			0	0	0.00		$0.00
A	*Prenanthes racemosa*	smooth rattlesnakeroot	SU	CMF	36	M	M,MZ	Medium	7,8,9,10		4789		0.8	20,000			0	0	0.00		$0.00
A	*Ratibida columnifera*	prairie coneflower	SU	CMF	24-36	M	MZ,D	Medium	7,8	M	4*9	Rare north of Polk Co. in 4	1	42,000			0	0	0.00		$0.00
A	*Ratibida pinnata*	gray-headed coneflower	SU PS	CMF	36-72	M	MZ	Medium	7,8,9	M	789	Not native north of Twin Cities in 8	1	30,000			0	0	0.00		$0.00