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NATIVE VEGETATION ESTABLISHMENT FOR IDOT EROSION CONTROL BEST MANAGEMENT PRACTICES

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16. Abstract

The objective of this report was to develop native roadside vegetation best management practices for the Illinois Department of Transportation. A review of current practices was undertaken, along with a review of those of other state departments of transportation that routinely use native vegetation for roadsides. Additionally, literature was reviewed for site preparation and desirable qualities, seed and species selection and quality control, application of seed, and management of vegetation. To better understand current practices, we performed a study to assess the performance of existing native seed mixes and practices along Illinois roadsides. Multiple sites were identified where native seed mixes were applied to roadsides. Vegetation sampling was performed to identify which species were present and in what quantities, and was compared to the seed mixes that were applied, to determine which species were successful. Based on the literature review and study results, numerous recommendations for native roadside vegetation best management practices were made.

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EXECUTIVE SUMMARY

The objective of this report was to develop native roadside vegetation best management practices for the Illinois Department of Transportation. A review of current practices was undertaken, along with a review of those of other state departments of transportation that routinely use native vegetation for roadsides. Additionally, literature was reviewed for site preparation and desirable qualities, seed and species selection and quality control, application of seed, and management of vegetation. To better understand current practices, we performed a study to assess the performance of existing native seed mixes and practices along Illinois roadsides. Multiple sites were identified where native seed mixes were applied to roadsides. Vegetation sampling was performed to identify which species were present and in what quantities, and was compared to the seed mixes that were applied, to determine which species were successful. Based on the literature review and study results, numerous recommendations for native roadside vegetation best management practices were made.

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INTRODUCTION

This report is divided into three sections. The first section presents a review of practices used by other departments of transportation for management of roadside vegetation and of applicable literature related to native roadside vegetation management. The section contains subsections for seedbed preparation, seed selection and quality, seed application, and management of established vegetation. The second section describes a study that was conducted to document the performance of existing native vegetation established on Illinois roadsides, using existing native seed mixes and practices. The third section contains recommendations for best management practices for using native vegetation on Illinois roadsides. The subsections correspond to those used in the review section and contain the current specifications for Illinois Department of Transportation.

CHAPTER 1 LITERATURE REVIEW

1.1 SEEDBED PREPARATION

1.1.1 Soil Physical Properties

1.1.1.1. Soil Structure

Missouri recommends that soil be loosened to a depth of 2 in. prior to any seeding (MO DOT 2012a), while Indiana and Minnesota both recommend a depth of 3 in. (IN DOT 2012; MN DOT 2007). In areas of excessive vehicular traffic, the soil should be loosened to a depth of 6 in. (IN DOT 2012). For light tillage seeding or when seeding prairie vegetation into temporary cover crops, the site should be disked so that 50% of the soil surface is visible through the mulch and plant debris (MN DOT 2007).

1.1.1.2. Topsoil

Topsoil is a valuable natural resource that is not readily renewable and should be conserved whenever possible (MN DOT 2006; WI DOT 2012). Stockpiling of topsoil should be required on all projects where topsoil currently exists and will be removed, and topsoil should not be used as a common fill material (MN DOT 2006). Topsoil should not be taken from a source known to contain any noxious weeds (IN DOT 2012). Topsoil should have a pH value of 6.2 to 7.4 (IN DOT 2012).

Topsoil should consist of loose, friable soil that is free of refuse, stumps, large roots, rocks over 2 in. in diameter, brush, weeds, or other material that would be detrimental to the proper development of vegetative growth (IN DOT 2012). Kentucky specifies that rock and dirt clods greater than 4 in. in diameter should be removed (KTC 2009). Ohio specifies that rocks or foreign material greater than 3 in. should be removed; but in front of residences or commercial properties and between curbs and sidewalks, rocks and foreign material greater than 1 in. should be removed (OH DOT 2010).

Many states specify that topsoil should be spread uniformly to a depth of 3 in. (MN DOT 2006; WI DOT 2009a), while Kentucky and Indiana require that topsoil be spread to a depth of 6 in. (KTC 2009; IN DOT *Design Manual* 2012). Ohio requires topsoil be applied to achieve a 4-in. compacted depth (OH DOT 2010). Minnesota requires a 6-in. topsoil depth in urban areas (MN DOT 2006). In Wisconsin, topsoil should be at least 4 in. deep in rural areas and 6 in. deep in urban areas (WI DOT 2012).

Areas to be covered with topsoil should first be loosened by disking or harrowing prior to receiving topsoil, to permit bonding with the topsoil when it is applied (WI DOT 2009a; IN DOT 2012; MO DOT 2012). When there is a significant difference in texture of topsoil and subsoil, such as clay over sand, the subsoil and topsoil should be blended (WI DOT 2009a). Topsoil should not be placed on slopes greater than 3:1 (KTC 2009).

1.1.2 Soil Chemical Properties

1.1.2.1. Soil Testing

Soil testing should be used to determine the topsoil's acceptability for use, including bioassay tests for the persistence of chemical residues; soluble salt tests; pH tests; phosphorus and potassium tests; mechanical analyses; and laboratory recommendations for nitrogen, phosphorus, potassium, and agricultural limestone or sulfur (IL THA 2012). Soil samples should consist of a series of subsamples collected to a depth of 6 to 8 in. at points evenly distributed across the sampling area, with a minimum of three subsamples per acre (IL THA 2012).

For sampling roadside soils, soil sampling frequency is one composite sample for every 10 acres (ac) per project side or one per project, whichever is greater (OH DOT 2010). Each composite sample consists of 15 soil cores in a random pattern spaced at a minimum of 500 ft from one another (OH DOT 2010). All changes in soil (i.e., color or texture changes) should be sampled (OH DOT 2010). To sample topsoil, obtain samples from at least three different locations (WI DOT

2009a). These samples should be composited into a single large sample (WI DOT 2009a). Thoroughly mix the sample for analysis (WI DOT 2009a). For stockpiled topsoil, do not collect from the surface but dig down to obtain a representative sample from the center of the pile (WI DOT 2009a).

1.1.2.2. pH

Quality requirements for limestone are highly variable among states. Missouri requires that agricultural lime have no less than 90% passing through a #8 sieve containing no less than 65% calcium carbonate equivalent (MO DOT 2012a). In Wisconsin, limestone should have a neutralizing value between 40 and 109 (WI DOT 2012). Ohio specifies that lime should have a total neutralizing power (TNP) of 90%, with at least 40% of the material passing through a #100 and 95% passing through a #8 sieve (OH DOT 2010). In Minnesota, lime should contain at least 80% TNP, ground so that 90% passes through a #8 sieve, 60% through a #20 sieve, and 50% through a #60 sieve; and have a maximum water content of 10% (MN DOT 2005). Samples must be submitted to the Minnesota Department of Agriculture or the University of Minnesota for analysis within 90 days of land application in Minnesota (MN DOT 2005).

Limestone application also varies by state, with some using a standard application rate (2 t/ac in Tennessee, 2.2 t/ac in Wisconsin) (TN DOT 2006; WI DOT 2009a), while others set soil pH limits for lime application (6.5 in Iowa, greater than 5.5 in Minnesota) (MN DOT 2007; OH DOT 2010).

Lime and fertilizer should be applied separately but may be incorporated into the soil together to a minimum depth of 2 in. no more than 48 hours prior to seeding (MO DOT 2012a). Dry lime should not be applied when it can create a traffic hazard (KTC 2009).

Soil textural differences have a large impact on liming requirements. For example, a clay–loam soil requires three times as much lime to raise the pH from 5 to 6, compared to a sandy soil (FHA 2007). Soil organic matter also influences liming, as higher organic matter content requires additional lime. Soil pH has a very strong influence on the availability of nutrients for plant uptake (Figure 1), and pH values above or below the acceptable range from 6 to 7 should be ameliorated. Lime application should be based on a target pH of 6.5. Thus, soil testing should be required, to ensure liming is adequate but not excessive. Lime should be of an acceptable quality (texture and neutralizing value), and application rates should be adjusted based on the neutralizing power.

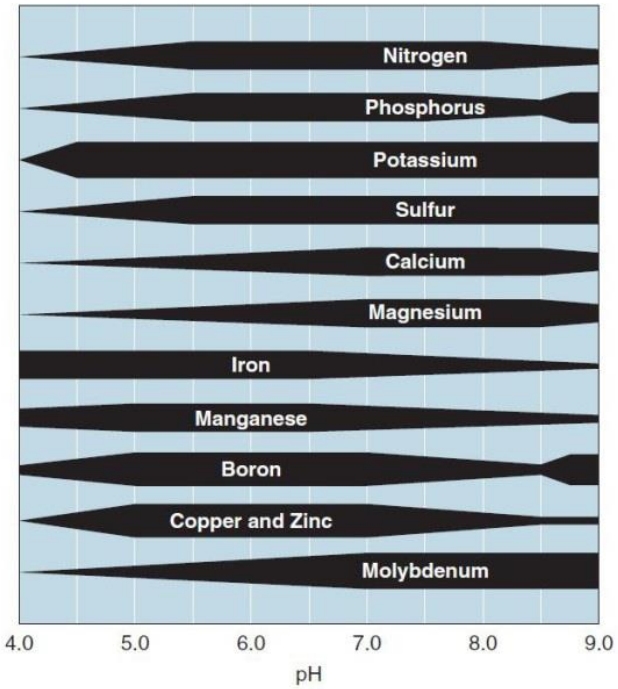


Figure 1. Relationship etween soil pH and plant nutrient availability. From Fernandez and Hoeft 2009.

1.1.2.3. Nutrients

Fertilizer requirements are highly variable between states surveyed. Soil testing is recommended to determine existing soil fertility (MN DOT 2007). Minnesota has very specific requirements for fertilizer type, but most other states do not. Minnesota guidelines direct one to select a fertilizer depending on the site and situation (proximity to ditches, surface water, etc.): (1) commercial fertilizer, (2) P-free fertilizer, (3) slow-release N fertilizer, or (4) organic fertilizer (MN DOT 2007).

Fertilizer should conform to one of the following types: commercial fertilizer should consist of dry granulated nutrients containing the three major plant nutrients (nitrogen, phosphorus, and potassium) (MN DOT 2005). Phosphorus-free fertilizer should meet the requirements of commercial fertilizer but contain no phosphorus (MN DOT 2005). Slow-release fertilizer should contain the three major plant nutrients and specifically be processed to release nitrogen at a slow rate over a growing season (MN DOT 2005). Nitrogen should be a coated, prilled urea form; and a minimum of 70% of the nitrogen should be a slow-release, water-insoluble nitrogen form (MN DOT 2005). Natural base fertilizer should have a minimum of 50% of the mass and 50% of the macronutrients derived from natural or organic material; be free of sewage sludge, raw manure, or uncomposted organic matter; and be a dry granulated product with no more than 10% moisture content, with the granules between 2.8 and 0.6 mm in size (MN DOT 2005).

Fertilizer rates are as variable as the requirements for fertilizer type. Some states have one standard application rate: 12-12-12 at 800 lb/ac (IN DOT 2012), or 10-10-10 at 870 lb/ac (TN DOT 2006). Others have very specific requirements.

When disking and mulching, 350 to 550 lb/ac of 19-19-19 are spread in Kentucky (KTC 2009). In Ohio, standard mixes are fertilized with 10-20-10 at a rate of 870 lb/ac (OH DOT 2010), and general seed mixes in Minnesota are fertilized with 200 lb/ac of 10-10-10 fertilizer (MN DOT 2007). For no-till seeding, 300 lb/ac of 19-19-19 are used in Kentucky (KTC 2009). For overseeding by hand, spreader, or hydroseeder in Kentucky, 275 to 450 lb/ac of 19-19-19 are used (KTC 2009); and in Minnesota 200 to 300 lb/ac of 10-10-10 are recommended (MN DOT 2007). For interseeding areas in Ohio, a 12-12-12 fertilizer at a rate of 870 lb/ac is recommended (OH DOT 2010); and 200 lb/ac of 10-10-10 are used in Minnesota (MN DOT 2007).

Once seeded vegetation has established in Kentucky, a topdressing of 500 lb/ac of 20-10-10 is applied (KTC 2009). When existing vegetation is topdressed in the fall, 150 lb/ac of 46-0-0 or 300 lb/ac of 19-19-19 are used (KTC 2009). For second fertilizer applications in Ohio, 12-12-12 is used at a rate of 435 lb/ac (OH DOT 2010). Second applications may not be applied until 3 months after seeding and then only if the seed has germinated (OH DOT 2010).

Nitrogen fertilizer is not recommended for native seedings, as it encourages weed growth (MN DOT 2007). However, adding 40 to 60 lb/ac nitrogen to established native plant stands is recommended (MN DOT 2007). Phosphorus and potassium fertilizers can be used if soil tests indicate a deficiency, with a 0-10-20 fertilizer recommended at a rate of 60 lb/ac (MN DOT 2007). For seeding prairie vegetation into bare soil or temporary cover crops, a 10-20-20 slow-release fertilizer should be applied at a rate of 300 lb/ac (MN DOT 2007). For broadcast seeding prairie species, fertilize on an as-needed basis with 100 lb/ac of 0-10-20 slow-release fertilizer (MN DOT 2007).

Soil amendments should be applied immediately prior to seeding, in separate operations (OH DOT 2010). Ohio recommends incorporating fertilizers to a depth of 2 to 4 in. (OH DOT 2010), and Minnesota recommends the top inch (MN DOT 2007). If applying fertilizers to areas without topsoil, incorporate fertilizer uniformly to a depth of 6 in. (WI DOT 2012).

1.1.2.4. Salinity

Soil salinity occurs along roadsides where salt runoff pools in low areas. Soil salinity is considered strong if electrical conductivity exceeds 16 dS m^{-1}. Gypsum applied to roadsides in Maine effectively reduced sodium levels in soils (Hutchinson 1971). Gypsum should be incorporated into soil prior to winter to a depth of 4 to 6 in., with rates up to 7 t/ac, depending on soil salinity (NRCS 2013).

1.1.3 Soil Biological Properties

1.1.3.1. Organic Carbon

Most states provide little guidance for management of soil carbon. However, Ohio has established guidelines for the amount of organic matter in topsoil (between 4 and 20%) and allows a mixture of 1 part approved compost and 2 parts topsoil to be treated as topsoil (OH DOT 2010). Requirements such as mulching and/or adding compost to seeded sites indirectly address the need for soil carbon by adding organic matter to the soil surface to prevent erosion. Adequate soil organic matter, comprised of carbon-based molecules, is essential to proper soil functioning for maintenance of desirable plant communities. Soil organic matter improves soil aggregation and structure, increases water infiltration and drainage, increases water-holding capacity, improves rooting depth, contains essential plant nutrients, and aids in binding and releasing nutrients for plant uptake (FHA 2007).

The most important aspect of carbon management in soils is ensuring that amendments contain a desirable amount of nitrogen to allow plant growth. The ratio of carbon to nitrogen (C:N) is a very important number, as it indicates whether nitrogen in the soil will be available for plant uptake or if it will be sequestered by soil microbes. As carbon is added to a soil, it is subjected to decomposition by soil microbes. These microbes need nitrogen just as plants do; and if the organic matter contains deficient levels of nitrogen, the microbes use whatever is available in the soil, making it unavailable for plants.

Compost and some commercial mulch products are the most widespread sources of organic matter, and temporary cover crops are effective at increasing organic matter in soils. However, many carbon sources can be used, including hay, straw, bark, leaves, and sugar. Any carbon amendment with a C:N ratio greater than 15:1 likely reduces availability of nitrogen in the soil (FHA 2007). For example, topsoil organic matter has a C:N ratio of around 10:1, and wheat straw has a C:N ratio of around 80:1. So, if wheat straw is added to a soil, additional nitrogen is required to overcome the increased C:N ratio in the soil. However, this reduction in C:N can be advantageous for establishing native prairie plants. Most native prairie plants have high nitrogen-use efficiency, meaning that they can grow in soils with less nitrogen than many weedy plant species. Increasing the C:N ratio in soils favors native plant establishment.

When composts are use, immature composts often fail to support desirable vegetation (Kirchhoff et al. 2002). For compost use, Texas requires that compost particle size is of a consistency such that 95% passes through a 5/8-in. screen and 70% passes through a 3/8-in. screen, salt content is less than 5.0 dS/m, organic matter content is between 25 and 65% on a dry weight basis, and stability is confirmed by carbon dioxide evolution (TX DOT 2004). Further, cured compost is defined as having a greater than 60% reduction in organic matter (TAC 1995). Sampling of composts for quality assurance is required for each stockpile, with one-third of all grabsamples taken from the base of the stockpile, one-third from the exposed surface, and one-third from a depth of 2 ft from the exposed surface (TAC 1995). A survey of compost use among states found that more than half use the U.S. Composting Council's Seal of Testing Assurance Program (WI DOT 2009b). Compost used as a mulch blanket is applied at highly variable depths (WI DOT 2009b). Texas successfully established native warm-season grasses using compost as mulch at a 3-in. depth (Storey et al. 1996). Some states also incorporate the bulk of the material into the underlying soil and place a small amount on the surface as a cover (WI DOT 2009b).

1.1.3.2. Inoculation

Inoculants for treating leguminous seeds should be standard pure cultures of nitrogen-fixing bacteria (IN DOT 2012). Inoculants for treating legumes should be from cultures approved for the specific legume species used (MO DOT 2012a). Inoculants should not be more than 1 year old at the time of use (OH DOT 2010; INDOT 2012). Inoculated legumes should not be exposed to direct sunlight, and any incidental exposure should not exceed 30 minutes (WI DOT 2012). All legume seeds are to be

treated with the proper amount of nitrogen-fixing bacteria mixed with sufficient water to wet the seed thoroughly (OH DOT 2010). The culture should be mixed with enough water to distribute it on the seed thoroughly (IN DOT 2012). Inoculant and sticking agent should be added immediately prior to seeding, and seed should be sown as soon as possible after inoculation (OH DOT 2010). The seed should be wetted thoroughly by the inoculant solution and allowed to dry thoroughly (IN DOT 2012). If inoculated seed is not seeded within 24 hours, it should be reinoculated (OH DOT 2010). For hydraulic seeding, the inoculants may be added to the water (IN DOT 2012). For hydraulic seeding, four times the specified inoculant rate should be used, or three times the rate for pre-inoculated seed (OH DOT 2010).

The relationship between legumes and nitrogen-fixing bacteria (Rhizobia) can be very specific, and the same inoculants cannot be used for all legumes (FHA 2007). While seeds of most introduced legumes are often provided with a suitable rhizobial inoculant, the same is not true for native legumes. Rhizobial legume inoculants are often already dead or do not contain the right Rhizobium species for the native plant species (MN DOT *Seeding Manual* 2007). Native legumes are often more selective in their associations with Rhizobia, compared with introduced legumes, and therefore require more specialized inoculants. However, Rhizobia are free-living soil organisms that do not require plant hosts for survival. In fact, Rhizobia inoculated onto nonhosts (including wheat, corn, barley, radish, and rape) formed stable populations, colonized neighboring nonlegumes, and colonized crops the following growing season (Wiehe and Hoflich 1995; Schloter et al. 1997; Hoflich 1999; Graham et al. 2008).

Although most states require rhizobial inoculation of introduced legume species, most provide no guidance for management of the soil microbial community in general. However, roadside construction may remove these important components of the plant–soil system; and reintroducing them is a key component of roadside vegetation management (FHA 2007). Most desirable native plant species associate with arbuscular mycorrhizal fungi (AMF). These soil fungi colonize host plant roots and, in exchange for carbon fixed by their plant hosts, provide the hosts with phosphorus, nitrogen, water, zinc, copper, and other essential micronutrients (Smith and Read 2002). Further, they provide protection from soil pathogens, drought, salinity, and toxins that may be present in the soil. Commercial inoculants exist that contain spores of AMF. However, the viability of these products can be questionable (Corkidi et al. 2004; Rowe et al. 2007; Tarbell and Koske 2007). No commercial sources are available for arbuscular mycorrhizal fungi for use on roadsides in Minnesota (MN DOT 2007).

Although many studies have identified the importance of returning soil microbes to disturbed sites, few have focused on the best way to do this. The best practice is to preserve topsoil that is removed from a site prior to construction, as it likely contains numerous desirable soil microbes. If topsoil is absent or cannot be salvaged, re-inoculation may be necessary. For seeding disturbed sites, collecting soil from nearby undisturbed sites that contain a similar plant community as the one being established has proven effective. However, the ideal amount of soil to collect is not known, nor does information exist for how best to incorporate the source soil at the new site. The amount of soil collected should not negatively impact the established source site and should be replaced with weed-free soil. Previous research with tallgrass prairie vegetation showing positive responses used between 4 and 50 tons per acre (Noyd et al. 1996; Johnson 1998; Smith et al. 1998; Bever and Schultz 2003). The inoculated source soil should be collected within 48 hours of use and stored in a cool, dry location out of sunlight. To be incorporated, the source soil needs to be placed so that germinating seeds can access it in a short amount of time. Placing the source soil on the seeding site prior to seedbed preparation should incorporate it into the site and allow for contact with seedlings.

1.2 SEED SELECTION AND QUALITY

For this report, all states bordering Illinois (Iowa, Indiana, Kentucky, Missouri, and Wisconsin), as well as states with environments similar to Illinois's (Michigan, Minnesota, Ohio, and Tennessee), were surveyed to compare seed mixes and identify improvements that could be made to mixes currently used in Illinois. Seed mix number and type are highly variable across the Midwest (Tables D1 to D8, E1 to E11).

1.2.1 Seed Labeling

Seed analyses should be conducted by a certified seed analyst accredited through the Association of Official Seed Analysts or a registered seed technologist accredited through the Society of Commercial Seed Technologists (IA DOT 2012b). Purity, percentage weed seeds, and percentage germination should be provided for all species, with the test date marked on each bag (OH DOT 2010). Labels should include percentages for inert materials, weed seed and noxious weed limits, germination, hard seed, and live seed purity (MN DOT 2010). All seed bags should be labeled with genus, species, common name, origin (where grown), bulk weight, percentage purity, percentage germination, percentage hard and dormant seed, and percentage pure live seed (PLS) (IA DOT 2012b). Purity should include percentage by weight of all weed seed, the name and weight of occurrence per unit weight of each kind of secondary noxious weed seed, the percentage by weight of agricultural seed (which may be designated as other crop seed), and the percentage inert matter (IA DOT 2012b).

Seed labels should contain the following information provided by seed tests conducted by a certified seed testing laboratory: **purity**—pure seeds of the desired species, seeds of other species, weed seeds, and inert matter (stems, chaff, scales, and small stones) expressed as a percentage of the total weight of the sample; **moisture content**—moisture content for long-term storage should be less than 10%; **seeds per pound**—10 random samples of 100 seeds of each of the desired species, converted to seeds per pound; **viability**—either a germination test under controlled conditions or tetrazolium staining, expressed as a percentage (FHA 2007). The analyses on the label should not be handwritten (IA DOT 2012b).

1.2.2 Seed Quality

Many states have set standards for individual species regarding minimum purity and germination percentages, although most states provide requirements for only the most commonly introduced grasses and forbs. For Iowa, most cool-season grasses require a minimum of 95% purity and 85% germination; legumes require a minimum of 98% purity and 90% germination; nurse and stabilizing crops require a minimum of 97% purity and 85% germination; and native species have widely variable PLS percentage requirements (IA DOT 2012a). Indiana has similar requirements for purity and germination of introduced grasses and legumes, and requires that many species contain no more than 25% hard seed (IN DOT 2012). Minnesota has a much more stringent requirement for quality of native plant species, with most native grasses requiring a minimum of 85% purity and 70% germination, and most native forbs requiring a minimum of 80% purity and 40% germination (MN DOT 2005). The test date for germination should be within 9 months of shipping (IA DOT 2012b). All seeds should be sown within 9 months of the testing date (OH DOT 2010).

1.2.3 Seed Sources

Seeds used by the Ohio Department of Transportation should be furnished from a registered or licensed dealer or grower by the Ohio Department of Agriculture or from an approved list on file with the DOT (OH DOT 2010). The Minnesota Crop Improvement Association certifies local origin through a "yellow tag" certification system (MN DOT 2007). Source-identified (yellow tag) seed is prioritized for use over seed lacking an identified source (MN DOT 2010). Original (generation 0)

seed sources should be identified for all native species, using the smallest known geographic location (township, county, preserve, etc.) (MN DOT 2010). Indiana DOT produces its own native seeds as part of the Hoosier Roadside Heritage Program (http://www.in.gov/indot/2583.htm). Seeds are produced at three IN DOT seed farms, with a fourth farm in development at an Indiana Department of Corrections facility. Inmates perform all maintenance and labor at the seed farms.

Local ecotypes of certain seed can be specified and are the only permitted source (MO DOT 2012a). Local ecotypes should be collected from the entire remnant population and not be selected based on plant traits such as height or seed size (MN DOT 2010). Sources of native vegetation should be prioritized, with the top priority being a source as close to the project site as possible, followed by a source within the ecozone, then within 75 mi of the project, and finally within 150 mi of the project (MN DOT 2010). If no seed are found within these criteria, then staff can approve substitutions of species or geographical sources (MN DOT 2010). Suggested maximum collection distances (i.e., distance between the collection site and the site where seed will be planted) include 100 mi in latitude (north–south distance) and 200 mi in longitude (east–west distance) (Packard and Mutel 1997).

Local ecotypes can be obtained from neighboring states for use by MN DOT: northern Iowa (zone 1) ecotypes are acceptable for use in southern Minnesota, eastern ND and SD ecotypes are acceptable for use in western Minnesota, and western Wisconsin ecotypes are acceptable for use in eastern Minnesota (MN DOT 2007). In Iowa, seed grown within the state are preferred over seed grown outside the state (IA DOT 2012b). Priority-source G0 seed from Iowa consists of seed from Iowa Ecotype Project zones 1, 2, or 3 or from any location in Iowa (IA DOT 2012b). For seed without an identified source, the growing location must be identified (IA DOT 2012b). For source-identified seed, a source-identified class yellow label should be provided by the certification agency, listing the G0 source and county and state where seed was grown (IA DOT 2012b).

Seed used by WI DOT should be grown in Wisconsin, northern Illinois (Boone, Bureau, Carroll, Cook, DeKalb, DuPage, Grundy, Henry, Jo Daviess, Kane, Kendall, Lake, La Salle, Lee, McHenry, Ogle, Putnam, Rock Island, Stephenson, Whiteside, Will, and Winnebago Counties), northeastern Iowa (Allamakee, Benton, Black Hawk, Bremer, Buchana, Cedar, Chickasaw, Clayton, Clinton, Delaware, Dubuque, Fayette, Floyd, Howard, Jackson, Johnson, Jones, Linn, Mitchell, Muscatine, Scott, and Winneshiek Counties), or eastern Minnesota (Aitkin, Anoka, Carlton, Carver, Chisago, Dakot, Dodge, Fillmore, Goodhue, Hennepin, Houston, Isanti, Kanabec, La Sueur, Mille Lacs, Mower, Olmsted, Pine, Ramsey, Rice, Scott, Sherburne, Steele, Wabasha, Washington, Winona, and Wright Counties) (WI DOT 2012).

Seed sources should be restricted to a 1/2-mi buffer around remnant prairies, where only local sources (preferably generation 0 seed directly from the remnant) are allowed (MN DOT 2010). These seed sources should be acquired directly from the agency or organization directly responsible for its protection, with involvement from natural resource professionals (MN DOT 2010). Native seeds are preferred to be of Minnesota origin or of regional origin if Minnesota source seed is unavailable, and from wild ecotype sources (MN DOT 2007).

1.2.4 Ecoregions

Only Iowa and Minnesota have established ecoregions for seed-source selection and use. Minnesota has four ecological provinces (Tall Aspen Parklands, Laurentian Mixed Forest, Prairie Parkland, and Eastern Broadleaf Forest) that guide selection of suitable plant materials (MN DOT 2010). Iowa has three provenance zones, divided latitudinally across the state to achieve roughly the same size for each zone (UNI 2012). Seed is donated from remnants across the state, and these donations are then pooled for each zone and increased commercially (UNI 2012). Only sources from the major landforms (Northwest Iowa Plains, Des Moines Lobe, Iowan Surface, Paleozoic Plateau,

and Southern Iowa Drift Plain) are included in the ecotype project; minor and unique landforms (Loess Hills, Missouri, and Mississippi Alluvial Plains) are excluded (UNI 2012).

1.2.5 Nonnative Seed Mixes

1.2.5.1. Temporary Seed Mixes

Across all states surveyed, oats are used the most frequently for temporary seed mixes (Table D1). However, some states (Indiana, Minnesota, and Wisconsin) use oats only in spring and summer (March 15 to June 15 in Indiana), with wheat used in the fall (after September 1). Annual ryegrass can also be used as a dormant-season cover crop (MN DOT 2007). Perennial ryegrass is used in Michigan and Minnesota for longer-term temporary stabilization (6 to 24 months in Michigan, 2 to 5 years in Minnesota). Cereal rye is used only in Iowa and Michigan, likely due to its aggressive nature. Tennessee uses Starr millet or Sudangrass as a temporary cover crop from May 1 to July 15, and Sudangrass is on Iowa's approved plant species list. Legumes were commonly used in temporary seed mixes, averaging 8.6% of all temporary seed mixes surveyed. Red clover was the legume most commonly used (in Iowa, Minnesota, and Wisconsin) (Table D1).

1.2.5.2. Turf Seed Mixes

Every state surveyed had some type of turf seed mix, with most states specifying many different turf-type seed mixes for specialty uses, including salt tolerance, urban, rural, sandy soil, etc. (Table D2). The most commonly used plant species are perennial ryegrass and Kentucky bluegrass, although Kentucky 31 fescue, creeping red fescue, red fescue, hard fescue, and turf-type tall fescue were common as well (Table D2). Of the 34 turf-type mixes surveyed, the average application rate was 169 lb/ac. Many states (Indiana, Minnesota, Missouri, Tennessee, and Wisconsin) added white clover to at least one turf-type mix. The white clover component ranged from 1 to 11% of the total mix, with an average of 6% (Table D2).

1.2.5.3. Salt-Tolerant Seed Mixes

Of the other states surveyed, only Michigan, Minnesota, and Wisconsin had specialized salt-tolerant seed mixes (Table D3). The components of these seed mixes are fairly consistent between the states. With the exception of Michigan (220 lb/ac), the states used a much lower application rate than Illinois (80 lb/ac in Indiana, 100 lb/ac in Minnesota, and 87 lb/ac in Wisconsin) (Table D3). Only Michigan had a salt-tolerant native seed mix, likely because most native prairie grasses have a moderate tolerance to salinity, and the same native grass mix is used regardless of salinity. Both Illinois and Michigan use little bluestem in their salt-tolerant native mixes, while only Michigan uses sideoats grama in the respective native mixes (Table D3). However, little bluestem is intolerant of and sideoats grama has a low tolerance to soil salinity (Table C2) (USDA, NRCS 2012). Of the native prairie grasses commonly used for roadside vegetation, only slender wheatgrass has a high tolerance to soil salinity; and Canada wildrye, big bluestem, indiangrass, switchgrass, and buffalograss have a medium tolerance (Table C2) (USDA, NRCS 2012).

1.2.5.4. Low-Grow Seed Mixes

Of the states surveyed, only Minnesota and Ohio had low-grow seed mixes (Table D4). Kentucky uses hard fescue exclusively for under and near guardrails, because of its low stature. Creeping red fescue, perennial ryegrass, and annual ryegrass are the most commonly used plant species (Table D4). Ohio also uses a native low-grow seed mix comprised of the same native grasses as IL 4A (little bluestem, sideoats grama, and prairie dropseed).

1.2.5.5. Slope-*Stabilization* Seed Mixes

Slope mixes are highly variable between states (Table D5). Iowa and Minnesota do not use dedicated slope mixes. Indiana and Kentucky use crown vetch exclusively for slopes (IN DOT 2011; KTC 2009). Tennessee uses sericea lespedeza almost exclusively (TN DOT 2006). Michigan and

Ohio use standard introduced grasses (perennial ryegrass, annual ryegrass, creeping red fescue, hard fescue, etc.) (MI DOT 2012; OH DOT 2010). The Illinois Toll Highway Authority and Wisconsin use mixes comprised primarily of native vegetation.

1.2.6 Native Seed Mixes

Many states have developed custom native prairie seed mixes for use on roadsides (Tables D6 to D8). Iowa has a native grass mix and a native wetland mix (IA DOT 2012a). Michigan has a native grass mix for environmental seeding, with it being used primarily for areas where native vegetation is necessary (MI DOT 2012). Minnesota uses blends of native and introduced plant species in many of its general mixes and has a variety of purely native mixes, including a native sedge/prairie meadow mix, two wet mixes, a short sandy/dry mix, a mid-height sandy/dry mix, and a roadside mix (MO DOT 2012b). Minnesota also has mesic, wet, and dry forb mixes that are composed of numerous forb species used as minor components in each of the standard native mixes that each is best suited for (for example, the mesic forb mix is added to the native roadside mix) (MODOT 2012b). Missouri has developed a very simple pair of seed mixes: one for urban settings and one for rural settings, with each comprised of a select assemblage of cosmopolitan native plants (MO DOT 2012b). Ohio has five native mixes for a variety of purposes, including a low-growing native grass mix, native grass mix, wildflower mix, annual and perennial wildflower mix, and native wildflower and grass mix (OH DOT 2010). Wisconsin has four native seed mixes: two native mixes for slopes and upland areas (one for sandy soils and one for loamy soils), a native grass mix for erosion control, and a salt-tolerant native mix for erosion control (WI DOT 2012).

Indiana has not developed a native seed mix but rather grows its own seed through three managed seed farms at IN DOT locations as part of the Hoosier Roadside Heritage Program (http://www.in.gov/indot/2583.htm). This partnership with the Federal Highway Administration, Indiana Department of Natural Resources, and Indiana Department of Environmental Management, produces wildflower and native grass seed at sites maintained by Indiana Department of Corrections inmates. This seed is then planted on roadsides where beautification and mowing reductions are prioritized. In Wisconsin, native seed mixes are not used for erosion control or large-scale plantings on roadsides because they are expensive, mowing may prevent flowering of wildflowers, establishment times are slow, and commitments of staff and resources would be required to ensure establishment and persistence (WI DOT 2009a). Kentucky and Tennessee do not have native mixes.

Native seed mixes should be comprised of plant species that are naturally widely distributed across the state, providing evidence that they are adapted to the environmental conditions that they will be exposed to on roadsides. Plant species need to be adapted to the area of roadside where they primarily will be used. Mixes should also contain diverse plant species, as functional diversity fills available niches and enhances resistance to invasion (Pokorny et al. 2005). Diverse plantings are more resistant to drought, floods, and pathogens, as compared with low-diversity plantings; and diverse forb mixes occupy niches that might otherwise be filled by invasive plant species (MN DOT 2007). Plant species used in mixes should be cosmopolitan in nature and not have such restricted growth requirements that they will not thrive where planted. Plant species should have tolerances to salt if they are to be used near road shoulders and where runoff accumulates and should have tolerances to commonly used herbicides when used on steep slopes and other areas where weed control by mechanical methods is problematic. Annual ryegrass, perennial ryegrass, oats, and wheat are typically used as cover crops for native seed mixes. Wheat and annual ryegrass are both considered allelopathic, although they have been used successfully as cover crops for native plant establishment.

1.2.7 Substituting Species in Seed Mixes

Wisconsin has a list of substitute species to choose from in the absence of one or more species in a mix (WI DOT 2012). Iowa has an extensive list of species that are approved for use on roadsides that can be used to alter mixes based on need (IA DOT 2012a). For each standard mix, Minnesota allows species to be selected from a list of alternate species that are native to the ecological section, belong to the same guild (aster family, legume, forb, and grasses and grasslike), and are components of the same successional stage (early, mid, and late seral) as the species being substituted for (MN DOT 2010). Minnesota has extensive information on all approved species, including height, pollinator value, successional status, salinity tolerance, etc., to guide selection of appropriate alternatives.

1.3 SEED APPLICATION

1.3.1 Landscape Position of Seed Mixes

Landscape position of seed mixes vary by state. Salt-tolerant seed mixes should be used in urban medians, between curbs and sidewalks, and within the first 5 ft of curbs on major roads (WI DOT 2012). However, some states do not use salt-tolerant mixes. Temporary seeding is applied to any disturbed area that will be inactive for more than 14 days and any other disturbed areas where quick vegetation establishment is desired (WI DOT 2012). However, Michigan does not temporarily seed slopes greater than 1:3 after topsoiling (MI DOT 2012). The position of native plantings is most variable, mostly due to the variation of specialty mixes. However, Missouri has a mow-area mix that is used for all vegetation on slopes less than 3:1 and within 30 ft of a road surface and plants one of two native seed mixes (Table E8) everywhere else (MO DOT 2011). Unmowed native grasses planted along the right-of-way can serve as living snow fences (MN DOT 2011).

1.3.2 Native Seed Application

1.3.2.1 Application

For new construction, imprints from all wheeled and tracked vehicles should be tilled out of the soil surface (MN DOT 2005). Seed should be installed with a drop seeder equipped with a cultipacker and mulched (MN DOT 2007). For seeding native vegetation, a native grass or rangeland drill should be used that is capable of metering the seed boxes and uniformly mixing the seed (MN DOT 2007). Rangeland drills should have three seed boxes: a grain box for large, non-bearded seeds of lawn-type grasses and cover crop species, a native seed box with pick fingers for adequate placement of bearded seeds such as native warm-season grasses, and a fine-seed box for small seeds such as wildflowers and other forbs (MN DOT 2007; WI DOT 2009a). Each box should be calibrated independently from others, and a press wheel should be mounted on the rear of each drop tube to firm soil over seed (WI DOT 2009a). As an alternative, each seed type may be seeded separately, with recalibration of the drill for each effort (WI DOT 2009a). Native grasses should be drilled with no less than two passes in different directions, with seed split evenly between passes (OH DOT 2010). Native seeds prefer a firm seedbed (MN DOT 2007).

In places inaccessible to mechanical equipment, a hand-operated cyclone seeder may be used (IN DOT 2012). Broadcast or hydroseeding creates a more aesthetically pleasing natural look that does not contain rows of vegetation (MN DOT 2007). For broadcast seeding, seed should be installed evenly with a cyclone seeder equipped with an effective agitator to ensure constant mixing of seed, or by hand, and mulched with weed-free mulch and disc-anchored (MN DOT 2007). For hydroseeding, site preparation and finishing are paramount to successful establishment, and are mostly used on steep slopes or inaccessible areas such as pond and wetland edges (MN DOT 2007). Seeding should be conducted with a fan-type nozzle with 500 gal of water/ac and 75 lb hydromulch per 500 gal of water (MN DOT 2007). If hydraulic soil stabilizers are used for mulch, the

stabilizer should be applied as a separate operation following seeding to ensure seed contacts soil directly (MN DOT 2007). Hydroseeding prairie plants is not recommended, as it does not meet the requirement for firm seed-to-soil contact (Diboll 2012b). However, hydroseeding prairie can be successful if done in the fall with a minimum amount of carrier and no tackifier (Diboll 2012b).

Following any seeding (including hydroseeding), sites should be harrowed or raked, cultipacked, mulched at a rate of 2 t/ac and disc-anchored (MN DOT 2007). Straw mulch should be spread at a rate of 2 t/ac; hay mulch shall be spread at a rate of 3 t/ac (TN DOT 2006). A mulch tiller should be used for crimping mulch into the topsoil (WI DOT 2009a). A disc is not a mulch tiller and will bury the mulch rather than pressing it into the soil (WI DOT 2009a). For native vegetation, seeded sites should be mulched with weed-free grain or prairie hay mulch at a rate of 2 t/ac and disc-anchored (MN DOT 2007).

Cultivation, fire, and/or herbicides can be used when restoring native prairie in introduced grasses and other roadside vegetation that is already established (MN DOT 2000). For cultivation, disking or plowing vegetation repeatedly, with adequate spacing between cycles, can effectively kill unwanted vegetation and newly germinated seedlings. A broad-spectrum herbicide can also be used to remove existing vegetation; after the herbicide is allowed time to kill vegetation, mowing or burning can be used to remove standing dead biomass. Fire alone can be used to remove standing biomass but allows resprouting of existing vegetation.

Staggered seeding can be used to increase plant diversity in remnant or planted prairies (MN BWSR 2012). Interseeding into existing prairie is most commonly conducted after burning, but can follow a spring application of glyphosate to control weeds and stunt prairie grasses (MN BWSR 2012). Dormant seedings are ideal for forbs and cool-season prairie grasses, but warm-season prairie grasses have lower germination rates (Diboll 2012b). Forbs are commonly broadcast in late fall or winter, and grasses are drilled in later winter or early spring (MN BWSR 2012).

For interseeding prairie vegetation into temporary cover crops, mow existing vegetation to a height of 4 to 6 in. if it has grown taller than 12 in. 2 to 4 weeks prior to seeding (MN DOT 2007; WI DOT 2012). Ten to 14 days after mowing, spray vegetation with a broad-spectrum herbicide if needed (WI DOT 2012).

For drill interseeding into existing vegetation other than cover crops, the site should be mowed in mid- to late spring or late summer to a height of 4 to 6 in. (MN DOT 2007). After regrowth is allowed for 1 to3 weeks, the site should be sprayed with a broad-spectrum herbicide (glyphosate) at a rate of 2 qt/ac, with 2,4-D added at 1 to 2 qt/ac as needed for broadleaf weeds (MN DOT 2007). If sites contain severe weed infestations, additional control efforts may be necessary to ensure successful prairie plant establishment (MN DOT 2007).

For fall interseeding into existing vegetation, mow existing vegetation to less than 4 in. in height 4 to 6 weeks before seeding (WI DOT 2012). Ten to 14 days after mowing, spray vegetation with a broad-spectrum herbicide (WI DOT 2012). Re-treat with an additional herbicide application if live vegetation persists 10 to 14 days after the initial application (WI DOT 2012).

After planting native vegetation, mow all seeded areas twice during the first growing season to a height of 12 in. once vegetation has reached a minimum height of 12 in. (WI DOT 2012). If any noxious weeds appear in native plantings, eradicate with hand-pulling or herbicide spot treatment (WI DOT 2012).

For interseeding native vegetation, use a native grass, or rangeland, drill with a maximum row spacing of 8 in., one that is capable of metering the seed boxes and uniformly mixing the seed (MN DOT 2007). When seeding into existing vegetation, the drill should be equipped with coulters that slice through existing vegetation in front of furrow openers (WI DOT 2009a) and a packer assembly to compact soil over the furrows (MN DOT 2007). Coulters should make a furrow 1 in.

wide by 1/2 to 1 in. deep that is directly in line with the disc opener (MN DOT 2007). As an alternative, each seed type may be seeded separately, with recalibration of the drill for each effort (WI DOT 2009a). Native grasses should be drilled with at least two passes in different directions, with seed split evenly between passes (OH DOT 2010). Soil should be cultipacked following interseeding and mulched as necessary to reduce bare ground visibility to 10% (MN DOT 2007).

1.3.2.2. Depth

General seed mixes should be planted to a depth of 1/4 in. (WI DOT 2012). Large and/or fluffy seeds should be planted at a depth of 1/4 to 1/2 in., lightly covered with soil through raking or harrowing; and small seeds should be scattered on the soil surface (MN DOT 2007). Seed of warm-season grasses, forbs, or aquatic species should not be covered more than 1/8 in. deep; all other seed should not be covered more than 1/2 in. deep (IN DOT 2012). Cover crops should be seeded with a grain drill at a depth of 1/4 to 1/2 in. or broadcast, harrowed or raked, and mulched using weed-free grain straw or prairie hay at a rate of 2 t/ac and disc-anchored (MN DOT 2007).

1.3.2.3. Timing

Don't seed in windy weather or when the ground is frozen, wet, or otherwise untillable (TN DOT 2006). In Minnesota, a temporary wheat mix (100) is planted August 1 to October 1, a temporary oats mix (110) is planted May 1 to August 1, and longer-term stabilization mixes (150 and 190) may be planted from April 1 to October 20 (MN DOT 2005). In Wisconsin, cover crop seed mixes may be planted anytime except from July 15 to October 15 (WI DOT 2009a). In Ohio, temporary seed may be applied between October 30 and March 1 but not on frozen ground (OH DOT 2010). Temporary mixes seeded between October 30 and March 1 are fertilized at half the normal rate (OH DOT 2008).

Minnesota general turf mixes (240, 250, 260, and 270) may be planted from April 1 to June 1 or July 20 to September 20, and agricultural roadside mix (280) may be planted from April 1 to September 1 (MN Dot 2005). Standard Ohio mixes are seeded between August 15 and October 30 (OH DOT 2010). Between March 1 and August 15, seeding rates are increased by 5% (OH DOT 2010). Standard and temporary mixes may be hydroseeded between March 1 and October 30 (OH DOT 2010). Wisconsin turf and general seed mixes may be planted anytime except midsummer and late fall (WI DOT 2009a). In Illinois, turf-type and other general cool-season grass and legume seed mixes should be planted between March 15 and June 1, or August 15 to October 15 (Morrison 2009). Spring seedings in the northern one-fourth of Illinois are more successful than fall seedings, spring and fall seedings are equally successful in the center one-half of Illinois, and late-summer seedings are more successful in the southern one-fourth of Illinois (Morrison 2009).

For late seeding, the following guidelines should be used: germination occurs only when soil temperatures and moisture are adequate; seed is most vulnerable to drought and freezing when it has just germinated; know when an area is prone to its first killing frost; weigh the risks of late-season planting; dormant seeding is acceptable in some cases and desirable with native mixes; fall seeding of permanent vegetation is risky; increasing mulch depths from 0.5 to 1.5 in. to 2 to 2.5 in. can aid establishment of late-seeded plants; and temporary seeding is more likely to germinate and establish in cold conditions and is so inexpensive that risks are minimal (WI DOT 2009a). Ohio wildflower mixes are seeded from September 1 to October 30, or from March 1 to May 31 with engineer approval (OH DOT 2010). In Ohio, native grass mixes should be seeded from March 1 to May 31 (OH DOT 2010). Minnesota native plant mixes (310 and higher) are planted from April 15 to July 20 or September 20 to October 20 (MN DOT 2005). Native plantings can be performed in the spring or fall (MN DOT 2007). In Wisconsin, native seed mixes may be planted anytime except from June 15 to October 15 (WI DOT 2009a).

Broadcast or hand-seeding should not be performed when wind is sufficient to blow the seeds (WI DOT 2012). Hydroseeding should not be used on dry, dusty soils or during hot, dry periods (MN DOT 2007). For hydroseeding, seed should not be added to the hydroseeder tank more than 1 hour prior to seeding (MN DOT 2007). Hydroseeders should be emptied within one hour of adding seed (MI DOT 2012). Broadcast or hydroseeding should not be performed when wind speed exceeds 15 mph or gusts affect seed placement (MN DOT 2005). Seed that remains mixed with the water for more than 1 hour should be disposed of (MI DOT 2012).

Because many native species have specific requirements to break dormancy (stratification, scarification, etc.), fall seeding naturally meets these requirements (MN DOT 2007). Further, if you are seeding over existing vegetation, fall seeding allows better seed–soil contact through the movement of soil during freeze–thaw cycles (MN DOT 2007). For seeding prairie vegetation into temporary cover crops, the cover crop is first established on disturbed soil as soon as possible (often during times of year unsuitable for prairie planting), with the native seed mixture installed the following fall or spring (MN DOT 2007). In Ohio, interseeding into existing vegetation may be performed only between March 15 and May 15 or September 1 to October 15 (OH DOT 2010). Nurse crops are more useful to prairie planting in the fall to stabilize soil and should be used at a higher rate in fall (15 lb/ac annual rye, 128 lb/ac oats) than in the spring (5 lb/ac annual rye, 64 lb/ac oats) (Diboll 2012b).

Cover crops should be selected to provide for maximum short-term cover immediately after they are sown. Minimum germination temperatures should aid in selection of cover crops for different seeding dates. Wheat and annual ryegrass germinate at a minimum temperature around 40°F, oats germinates at a minimum temperature around 45°F, and Sudangrass–sorghum germinates at a minimum temperature around 60°F (Undersander et al. 1990; Pathak et al. 2012). Sudangrass produces significant biomass in summer, achieving an average of 1 ft in height after 3 to 4 weeks, 2 ft around 7 weeks, and 3 ft around 9 to 10 weeks in plantings across Illinois (Maughan 2011). Soybean requires a minimum germination temperature around 60°F (Pathak et al. 2012). Ideal germination temperatures are usually around 10°F greater than the minimum germination temperatures. A potential alternative cover crop is cup plant (*Silphium perfoliatum*), a native forb that has shown potential as a forage crop in the Midwest (Stanford 1990; Albrecht and Goldstein 1997).

1.3.2.4. Dormant (Frost and Snow) Seeding

Because many native species have specific requirements to break dormancy (stratification, scarification, etc.), fall seeding naturally meets these requirements (MN DOT 2007). Frost seeding uses natural cold, moist cycles for stratification, and uses natural freeze–thaw cycles to provide good seed-soil contact (Morrison 2009). Because native plant species are most sensitive to drought and freezing temperatures when in the seedling stage, care must be taken not to conduct dormant seedings too early (WI DOT 2009a). Minimum germination temperatures for most native species are not available, but for both grass and forb species studied appears to be around 59°F (McGraw et al. 2003, Seepaul et al. 2011). In Wisconsin, dormant seeding is defined as occurring when soil temperatures are consistently below 53°F (WI DOT 2012). Dormant seeding is performed after October 20 in Minnesota when soil temperatures at a depth of 1 in. fall below 40°F (MN DOT 2005). In Michigan, dormant seeding may occur after November 15 but not on frozen ground; and seeded areas are to be mulched within 24 hours (MI DOT 2012). Soil should be prepared prior to soil freezing.

Snow seeding is performed during thawing days in February and March. Snow seeding works best on soft, thin snow, as hard, thick snow can allow seed to blow across it or can wash seed away if it melts rapidly (Diboll 2012b). Hand-seeding or a cyclone seeder should be used for frost or snow seeding (Morrison 2009). An inert material, such as dark-colored husks or sand, should be mixed with seed to identify where seed is spread and to quickly melt the snow around seeds so they

sink into the snow and are not visible to predators. Fertilizer should not be placed on frozen or snow covered soil (MN DOT 2005).

1.3.2.5. Adjusting for Delays

Temporary seeding should be used on disturbed soils that will not be brought to final grade for at least 30 days, where exposed soils are created and where areas will be exposed through the winter (WI DOT 2009a). In Ohio, when broadcast seeding nonnative standard mixes (1, 2, 3A, 3B), between March 1 and August 15 (as opposed to the normally allowed period from August 15 to October 30), increase seeding rates by 5% (OH DOT 2010). Tennessee uses three general roadside mixes (A, B, and C) almost year-round, with the same seeding rates throughout but with slight adjustments to the components for different times of year (TN DOT 2006). Mix A, which is used from February 1 to July 1, contains 80% Kentucky 31 fescue, 5% English rye, and 15% Korean lespedeza (TN DOT 2006). Mix B, which is used from June 1 to August 15, has altered levels of cool-season grasses (55% Kentucky 31 fescue, 20% English rye), adds a warm-season grass (10% German millet), and keeps 15% Korean lespedeza (TN DOT 2006). Mix C, which is used from August 1 to December 1, increases cool-season grass (70% Kentucky 31 fescue, 20% English rye), and replaces Korean lespedeza with 10% white clover (TN DOT 2006).

As much as 90% of seeding failures are due to dry soil (WI DOT 2009a). Once seeds germinate, the top inch of soil should be maintained with adequate moisture until vegetation is well established (WI DOT 2009a). Water should be considered as a bid item when turf is desired for a period of 30 days after planting (WI DOT 2009a). All permanently seeded areas should be watered after the seed has germinated, using 13,000 gal/ac split into at least 2 applications spread over 7 days, applied using a spray that will not dislodge mulch material (OH DOT 2010). A second application should occur between 7 and 10 days after the primary application (OH DOT 2010). If 1/2 in. of rainfall occurs within the initial 7-day period following germination, the second application may be omitted (OH DOT 2010).

1.4 MANAGEMENT OF ESTABLISHED VEGETATION

1.4.1 Mowing

1.4.1.1. Location

Mowing is expensive and can hinder utilization of roadside vegetation for native vegetation establishment and conservation objectives (AASHTO 2011). Native vegetation does not require frequent mowing and creates low-maintenance roadsides. Native roadside vegetation will most likely provide the most self-sustaining, low-maintenance vegetation (AASHTO 2011). Vegetation that requires minimal maintenance and inputs is most cost-effective over the long term (AASHTO 2001). Indiana DOT estimates savings from native vegetation on reduced mowing at $45/ac per year. Rights-of-way should use native plants wherever feasible and can be mowed, burned, or tilled for the establishment of native vegetation (MN DOT 2006). In Missouri, slopes greater than 3:1 and all other areas not requiring mowing are planted to native prairie vegetation (MO DOT 2011). Minnesota has adopted a minimalist approach to mowing, allowing only the first 8 ft along the road surface to be mowed at any time (MN DOT 2006). Warm-season tallgrass prairie grasses (big bluestem, indiangrass, and switchgrass) allowed to remain standing over the winter can serve as snow fences (MN DOT 2007). To help defray costs of native plant establishment, encourage partnerships with entities such as local municipalities and civic organizations for the development and maintenance of native plant communities, similar to the Adopt-A-Highway Program (WI DOT1999).

Minnesota has developed roadside management categories: (1) **minimal mowing:** no full-width mowing, natural vegetation-height shoulder cuts only; (2) **50/50 mowing:** areas next to homes and businesses mowed; and (3) **high-frequency mowing** (MN DOT 2000). Clear zones for mowing

are calculated based on vehicle speed, road curvature, and slope, as well as intersections (MN DOT 2006). Clear zone calculations and guidance follow AASHTO's *Roadside Design Guide* and "A Policy on Geometric Design of Highways and Streets." In rural areas of Minnesota, roadsides can be mowed if the adjacent land is maintained turf (park, cemetery, church, roadside business, home, or farmstead) or if noxious weed infestations are present (MN DOT 2006). Outside of these exceptions, rural rights-of-way may be mowed only if necessary for safety reasons (MN DOT 2006). In urban areas, roadsides are maintained similarly to adjacent properties; and mowing entire rights-of-way are permitted on slopes less than 3:1 (MN DOT 2006). Where roadsides abut private lawns or businesses and are conspicuous from these properties, the vegetation is maintained at a height of 4 to 6 in. (MN DOT 2006). Where roadsides abut residential or commercial areas but are separated by a retaining wall, extensive landscaping, or frontage road, the vegetation is maintained to a height of 4 to 12 in. (MN DOT 2006).

Kentucky has roadside environmental district managers who develop annual vegetation management programs for each district for mowing, seeding, weed control, etc. (KTC 2009). For type 2 mowing in Kentucky, areas are mowed in a 10-ft strip along shoulders and medians, and all areas able to be mowed inside the ramps of interchanges (KTC 2009). For type 3 mowing in Kentucky, the complete roadside is mowed from the pavement to the right-of-way (KTC 2009). Mowing is not performed in scenic areas, native plantings, or newly seeded areas. Iowa mows all roadsides to a distance of 15 ft from shoulders, with medians mowed entirely (IA DOT 2012a). Minor roads in Missouri are mowed in 15-ft strips along the shoulder in even years, and 30-ft strips in odd years (MO DOT 2011). On major roads, shoulders are mowed in 15-ft widths in spring and summer, and 30-ft widths in fall (MO DOT 2011). Medians less than 60 ft wide are mowed entirely, while medians less than 100 ft wide are mowed entirely only in fall, and greater than 100 ft wide are mowed in 30-ft widths in fall (MO DOT 2011). Interchanges are mowed 15 ft from the road (MO DOT 2011).

1.4.1.2. Frequency

Mowing established prairie vegetation can be used to maintain quality (Diboll 1984; Collins et al. 1998). Spring mowing and haying most closely mimics prescribed burning, by removing litter that keeps soils moist and cool (Tix et al. 2003). Mowing in late June in KS maintained diversity similar to burning (Collins et al. 1998). However, July mowing provides the greatest reduction in cool-season grasses (Diboll 1984). For first-year maintenance of spring-planted native seedings, mow to a height of 6 to 8 in. every 30 days following planting through September 30 (MN DOT 2007). For fall-planted native seedlings, mow to a height of 6 to 8 in. the following year—once in May, June, and July (MN DOT 2007). For year-2 maintenance of native seedings, mow to a height of 6 to 8 in. once between June 1 and August 15 before weeds set seed (MN DOT 2007). For long-term maintenance of native seedings, mow only if necessary to control weeds (MN DOT 2007).

Minor roads in Missouri are mowed in 15-ft strips along the shoulder in even years and 30-ft strips in odd years (MO DOT 2011). On major roads, shoulders are mowed in 15-ft widths in spring and summer and 30-ft widths in fall (MO DOT 2011). Outside of these exceptions, rural rights-of-way may be mowed only if necessary for safety reasons (MN DOT 2006).

1.4.1.3. Timing

For Iowa metropolitan areas, three to four mowings are performed annually, beginning with the first mowing prior to Memorial Day, the second in late June or early July, the third (in four-pass locations) in early to mid-August, and a final mowing after Labor Day (IA DOT 2012a). Medians are mowed entirely (IA DOT 2012a). Major roads in Missouri are mowed prior to Memorial Day, July 4th, and Labor Day, with an additional pass in the fall (MO DOT 2011). In Missouri, minor roads are mowed when 50% of the vegetation reaches a height of 18 in. (MO DOT 2011).

In Minnesota, first-year maintenance of general roadside mixes after spring or early summer seeding includes mowing during early fall if weed infestations or shading becomes a problem (MN DOT 2007). For fall or dormant seeding, first-year management includes mowing in May or June for weed infestations (MN DOT 2007). For long-term maintenance, mowing in May or June may be necessary for weed infestations (MN DOT 2007).

For first-year maintenance of spring-planted native seedings, mow to a height of 6 to 8 in. every 30 days following planting through September 30 (MN DOT 2007). For fall-planted native seedlings, mow to a height of 6 to 8 in. the following year—once in May, June, and July (MN DOT 2007). For year-2 maintenance of native seedings, mow to a height of 6 to 8 in. once between June 1 and August 15 before weeds set seed (MN DOT 2007).

1.4.1.4. Chemical Mowing

An alternative to mechanical mowing is the use of plant growth regulators (PGRs) to reduce growth of vegetation. Application of PGRs is sometimes referred to as chemical mowing. Areas for PGR application include vegetated shoulder areas between pavement and guardrails, behind guardrails and other sloped areas where mowing is difficult or unsafe, and narrow vegetated raised medians (KTC 2009). Timing of PGR application is critical to success, and they are often applied after mowing (AASHTO 2011). Repeated use of PGRs can stress and weaken plants (AASHTO 2011). In Kentucky, PGRs are applied only in the spring at one application per season to grasses to control height prior to seed head emergence (KTC 2009). PGR's are not used on newly planted grasses (KTC 2009).

Journey herbicide can be used for seed head suppression of grasses (without methylated seed oil or adjuvants) although the effects of application rates on grass species will vary (BASF 2008a). For suppression, Journey applied at 6 to 10 oz/ac suppresses tall fescue seed head development, while an application of 8 to 12 oz/ac suppresses smooth brome and reed canarygrass (BASF 2008a).

Michigan began using PGRs in 2009 to reduce roadside maintenance costs. Milestone VM, Escort XP, and Plateau, all in mixture, were applied to large spans of the Lower Peninsula at a significantly reduced cost (Melzer 2009). However, many concerns were raised about public safety and potential groundwater contamination.

1.4.1.5. Nesting and Habitat Considerations

Little information exists for roadside vegetation practices to protect nesting birds, with the exception of Minnesota's restrictions on mowing entire rights-of-way outside cities. However, Wisconsin allows mowing beyond the 15-ft shoulder zone only from mid-July through the end of March to protect grassland- and ground-nesting birds (MN DOT 2000). These zones are mowed once every 2 to 3 years to control weeds and woody growth during the specified time interval.

1.4.1.6. Limiting Spread of Weeds

The best method to control invasive plants is to establish and maintain a healthy native plant community (MN DOT 2000). Noxious weed infestations should not be allowed to cover an area larger than 11 sq ft (MN DOT 2006). Mowing may prevent the production of seeds but will not destroy perennial plants or prevent vegetative spread (MN DOT 2006). Mow weed patches before they go to seed, skip mowing heavily infested areas when seed is mature or mature enough to ripen even when cut, and clean mower decks and other seed collection areas on equipment before mowing uninfested areas (MN DOT 2006). All equipment (vehicles, mowers, tillage implements) should be thoroughly cleaned after operation in known weed-infested areas (FEIS 2012).

1.4.1.7. Record Keeping
Geographic information systems (GIS) and global positioning systems (GPS) are powerful tools for managing spatial data. Forty-one percent of transportation agencies use GPS and GIS in their vegetation management programs, most often to improve herbicide spraying and invasive species mapping (AASHTO 2011). However, all facets of roadside management can be incorporated into GIS platforms, and all activities could benefit from such data management. Construction activities, seeding, mowing, weed populations, herbicide use, hazards, and restricted or special management areas can all be mapped and managed through GIS. The conditions of any roadside asset, including vegetation, can be recorded and mapped with GPS (AASHTO 2011).

1.4.2 Burning

Controlled burning has been very successful as a roadside vegetation management aid in CA, CO, Iowa, Texas, and Utah (AASHTO 2011). Fire can be a useful tool to manage roadside vegetation, especially native prairie plantings. Controlled burns can be used in place of low-maintenance vegetation mowing, as well as to remove weeds and woody vegetation, stimulate growth of desirable plants, and eliminate roadside litter (AASHTO 2011).

Burning of native vegetation should occur as soon as enough litter accumulates to carry a fire, usually in the second or third season following planting. Burning should be conducted every 3 to 5 years to control weeds and woody vegetation but can be increased to accommodate localized problematic vegetation. For long-term management of native plant mixes, burn on a 3-to-5-year rotation with alternating spring and fall burns, hay on a 3-to-5-year rotation alternating with or substituting for burning in late summer or early fall (MN DOT 2007). Burning at different times of year minimizes effects on individual species (MN DOT 2000). Consecutive burning 2 years in a row can be used for sites overrun with noninvasive weeds such as foxtail (MN DOT 2007). Burns are primarily conducted in late winter or early spring (February to April), and are usually most effective for controlling undesirable vegetation soon after cool-season grasses have begun to green.

1.4.3 Control of Weeds

1.4.3.1. Common/Cutleaf Teasel (Dipsacus fullonum (sylvestris)/laciniatus)
Teasel can become very dense along roadsides and dominate desirable vegetation. Mowing alone does not control teasel but aids in its spread and dominance. A combination of herbicide and mowing can be successful if conducted at the appropriate times and maintained for the necessary period of time, likely up to 5 or 6 years (MODOC 2013). Teasel is spread easily through improper cleaning of equipment and mowing at inappropriate times. Mowing should never occur in teasel-infested areas after the population has gone to seed. Further, if the flower stalks are mowed prior to flowering, a new stalk (and seed) likely will be produced that can cause teasel to increase (INHS 2011b). Cut seed stalks should be removed completely from a site and destroyed, as seeds may mature after cutting (INHS 2011b). Fire is ineffective for teasel control but removes litter and exposes rosettes, making chemical control much more effective (MODOC 2013). Dense teasel stands do not carry fire (INHS 2011b).

Early-spring or late-fall application of broad-spectrum herbicides may allow better targeting of teasel growing in desirable native vegetation, as it retains activity after many native plants go dormant in the fall and becomes active before they break dormancy in the spring (FEIS 2012). Postemergence application of Plateau at 8 to 12 oz/ac (BASF 2008b), Journey at 21.3 to 32 oz/ac (BASF 2008a), or Milestone at 4 to 7 oz/ac (Dow AgroSciences 2005) controls common teasel. Glyphosate, triclopyr, and 2,4-D are all effective for controlling teasel (MODOC 2013).

1.4.3.2. Musk/Canada/Bull Thistles (Carduus nutans, Cirsium arvense, vulgare)
Prevention of seed production in existing thistle populations and maintaining healthy native plant communities are key to managing thistles, as they are shade-intolerant (INHS 2011a; FEIS 2012). Repeated mowing may require mowing every 1 to 4 weeks for 4 years to kill existing plants (FEIS 2012). Mowing new seedlings within 17 days of emergence can kill them, but mowing established plants before they flower is not effective, as plants resprout (FEIS 2012). Mowing thistles in full bloom as close to the ground as possible can reduce seed production, but cut flower heads should be removed (INHS 2011a).

Fires are effective at controlling thistles but can also contribute to post-fire dominance, as fires can create bare spaces that allow thistles to establish (FEIS 2012). Late-spring burns are the preferred method of Canada thistle control but damages desirable vegetation and wildlife (INHS 2011a), while early-spring burns are not effective and increase sprouting (INHS 2011a). Fall application of herbicides is a preferred method, as all live plants (seedlings and rosettes) are active, and control is most effective during these stages (FEIS 2012). Postemergence application of Plateau at 8 to 12 oz/ac (BASF 2008b) or Journey at 21.3 to 32 oz/ac (BASF 2008a) controls bull and musk thistles, while preemergence application of Journey at the same rate suppresses these weeds in native vegetation (BASF 2008a). Postemergence application of Milestone at 3 to 5 oz/ac controls bull and musk thistles, while 5 to 7 oz/ac controls Canada thistle in native vegetation (Dow AgroSciences 2005).

1.4.3.3. Sweetclover (Melilotus alba/officinalis)
Sweetclover is common along roadsides, and repeated mowing seems to favor its dominance (FEIS 2012). However, excessive mowing (7 to 8 times per growing season) may be effective for control (FEIS 2012). Dormant-season fires stimulate sweetclover (FEIS 2012). Late-spring or growing-season fires can control sweetclover, but these late fires can reduce desirable plant species and negatively affect wildlife such as nesting birds (FEIS 2012). Dormant-season fires can be used to clean existing biomass and encourage early germination of sweetclover seedlings. These seedlings can be controlled the following year with a late-season burn (TNC 2010), or seedlings can be controlled following a dormant-season fire with 2,4-D early in the spring before desirable forbs break dormancy (Schwegman and McClain 1985).

1.4.3.4. Common Reed (Phragmites australis)
Phragmites is a difficult plant to control and requires several years of management and monitoring to reduce populations effectively. Creating multiple stresses over an extended period most effectively controls phragmites. Herbicide use is effective but must be properly conducted due to phragmites' growth in aquatic environments. Glyphosate and imazapyr can be used to control phragmites, with imazapyr most effective when foliage is green and actively growing, while glyphosate or a combination of the two is most effective in late summer after plants are in full bloom prior to the first killing frost (MI DEQ 2012). Wick application of herbicides can protect nearby shorter, desirable plants. Prescribed burning should be used in conjunction with herbicide application, as burning alone is not effective and stimulates vigorous regrowth in plants (FEIS 2012).

Phragmites treated with herbicides should be treated the following year with fire, either in late summer or winter, although late summer is ideal as it destroys seed (MI DEQ 2012). If burning is not an option, mowing phragmites following herbicide application can be effective but should occur at least 2 weeks after herbicide treatment (MI DEQ 2012). Nearby native vegetation should not be disturbed, and wet sites can be mowed in winter after soil has frozen sufficiently. In the spring following burning or mowing, remaining phragmites should be spot-treated. Mowing low-density phragmites invasions without herbicides can also be effective during late summer or fall.

1.4.3.5. Johnsongrass (Sorghum halepense)
Johnsongrass control requires controlling seed production, preventing new seedlings from establishing, and killing existing rhizomes. Fire alone does not control johnsongrass and may promote growth (FEIS 2012). However, fire can be used to prevent johnsongrass invasion in fire-adapted native vegetation (FEIS 2012). Seedlings mowed within 2 weeks after emergence can be killed by mowing, while two clippings each within 2 weeks of new growth can reduce rhizomes (Newman 2012). After this initial period, however, repeated mowing is necessary.

Herbicides can be used to control johnsongrass in native prairies. Pre- or postemergence application of Plateau at 8 to 12 oz/ac or Journey at 21.3 to 32 oz/ac controls johnsongrass seedlings less than 12 in. in height, while postemergence application of either herbicide is effective for rhizomes (BASF 2008a, b). Plateau and Journey are most effective on johnsongrass rhizomes after it has reached 18 to 24 in. in height at the whorl (BASF 2008a, b). Postemergence application of Outrider at a rate of 0.75 to 2 oz/ac can be applied to native warm-season grasses for the control of johnsongrass (Monsanto 2006).

1.4.3.6. Tall Fescue (Schedonorus phoenix (Festuca arundinacea))
Tall fescue invasion in native prairie plantings can be reduced by spring mowing after tall fescue has greened up but before warm-season grasses have begun active growth. However, mowing prior to herbicide application can reduce effectiveness by shielding tall fescue under litter (Darrow 2009). Like other cool-season grasses, tall fescue is susceptible to fall or spring burns (FEIS 2012). However, a combination of burning and herbicides provides the greatest control. Mid-to late-summer burns can be used in conjunction with herbicide application to remove litter and encourage new growth for herbicide application (Darrow 2009). Burning prior to herbicide application is more effective at controlling tall fescue with imazapic (Barnes 2004).

Applying herbicides to control tall fescue in native vegetation is most effective in late fall after three or four hard frosts when temperatures reach 50°F or more (Darrow 2009). Repeated herbicide applications (such as fall and spring) may be required to ensure total control of tall fescue (Darrow 2009). Glyphosate (2.0 lb ai/ac) application followed by imazapic (0.06 lb ai/ac) application at seeding is also effective (Barnes 2004). Clethodim (0.21 lb ai/ac) and imazapic (0.19 lb ai/ac) can control tall fescue and increase native plant abundance (Ruffner and Barnes 2010). Glyphosate, imazapic, and clethodim—alone and in combination—can effectively control tall fescue (Barnes 2004). Postemergence application of Outrider at a rate of 1.33 to 2 oz/ac can be applied to native warm-season grasses for the control of tall fescue (Monsanto 2006).

Pre- or postemergence application of Plateau at 8 to 12 oz/ac controls tall fescue (BASF 2008b). For established tall fescue, Plateau at 12 oz/ac plus methylated seed oil at 2 pt/ac is effective but only when it is actively growing; and the addition of Accord, glyphosate, or Roundup Pro and/or nitrogen fertilizer aids control (BASF 2008b). For best control of established tall fescue stands, a fall application of Plateau at 8 to 12 oz/ac plus Accord or Roundup Pro at 24 to 64 oz/ac controls mature plants and seedlings (BASF 2008b). If the lower 8-oz rate is used, it is recommended that an additional application of 4 oz/ac of Plateau be applied the following spring for control of annual weeds and tall fescue seedlings (BASF 2008b). Prior to fall application, repeated mowing is recommended to increase susceptibility of tall fescue to herbicide application, as long as at least 10 in. of regrowth is allowed prior to fall spraying (BASF 2008a, b). A late-winter burn followed by imazapic application at 0.18 lb ai/ac a month later provides control of tall fescue (Barnes 2004). For spring applications in native vegetation, Plateau at 6 to 12 oz/ac plus Accord or Roundup Pro at 32 to 64 oz/ac is effective; but the higher rate should be used for mature stands, and the lower rate should be used if seeding forbs (BASF 2008b).

Pre- or postemergence application of Journey at 21.3 to 32 oz/ac controls tall fescue (BASF 2008a). Journey applied at a rate of 32 oz/ac plus methylated seed oil is best for controlling actively

growing tall fescue, and the addition of nitrogen fertilizer aids control (BASF 2008a). For best control of established tall fescue stands, a fall application of Journey at 21.3 to 32 oz/ac plus Accord or Roundup Pro at 16 to 48 oz/ac controls mature plants and seedlings (BASF 2008b). For spring applications, Journey at 16 to 32 oz/ac plus Accord or Roundup Pro at 16 to 48 oz/ac is effective (BASF 2008b).

1.4.3.7. Smooth Brome (Bromus inermis)

Smooth brome invasion in native prairie plantings can be reduced by spring mowing after brome has greened up but before warm-season grasses have begun active growth. Repeated mowing up to four times during a growing season may provide control of smooth brome (Sather 2012). However, a single mowing in the boot stage (approximately 18 in. in height) may be a more effective means of control (Sather 2012). Late-spring fires, after introduced cool-season grasses have greened up, can be used to suppress smooth brome (FEIS 2012). However, fire does not kill smooth brome but only reduces its density and spread (Sather 2012). Spring and fall applications of imazapy (0.3 lb ai/ac) or imazapyr (0.09 lb ai/ac) plus imazapic (0.14 lb ai/ac) effectively reduced smooth brome and increased native plants (Bahm et al. 2011b). Treatments using imazapyr and sulfosulfuron plus glyphosate have also shown effectiveness (Bahm et al. 2011c).

CHAPTER 2 PERFORMANCE OF NATIVE SEED MIXES ON ILLINOIS ROADSIDES

2.1 OVERVIEW

The goal of this study was to evaluate native seed mixes across Illinois to determine the most effective species to help guide revisions to the native seed mixes.

2.1.1 Sampling Design

Sites seeded with native seed mixes (4 or 4A and 5 or 5A) were identified from contracts awarded by IDOT (Figure 2). Sites were chosen to be in the range of 4 to 5 years old so that native vegetation had time to establish. At each site, a tape measure was strung in a line 50 m long. Every 2.5 m, a 1/4 m^2 quadrat was placed; and each plant species was recorded, along with its estimated cover, in each of 20 quadrat plots per site. To obtain total relative cover (TRC), each cover estimate for each species was divided by the total cover for all plant species in each plot. This standardization allows individual plant (or group) cover data to be presented as a percentage of the total vegetative cover.

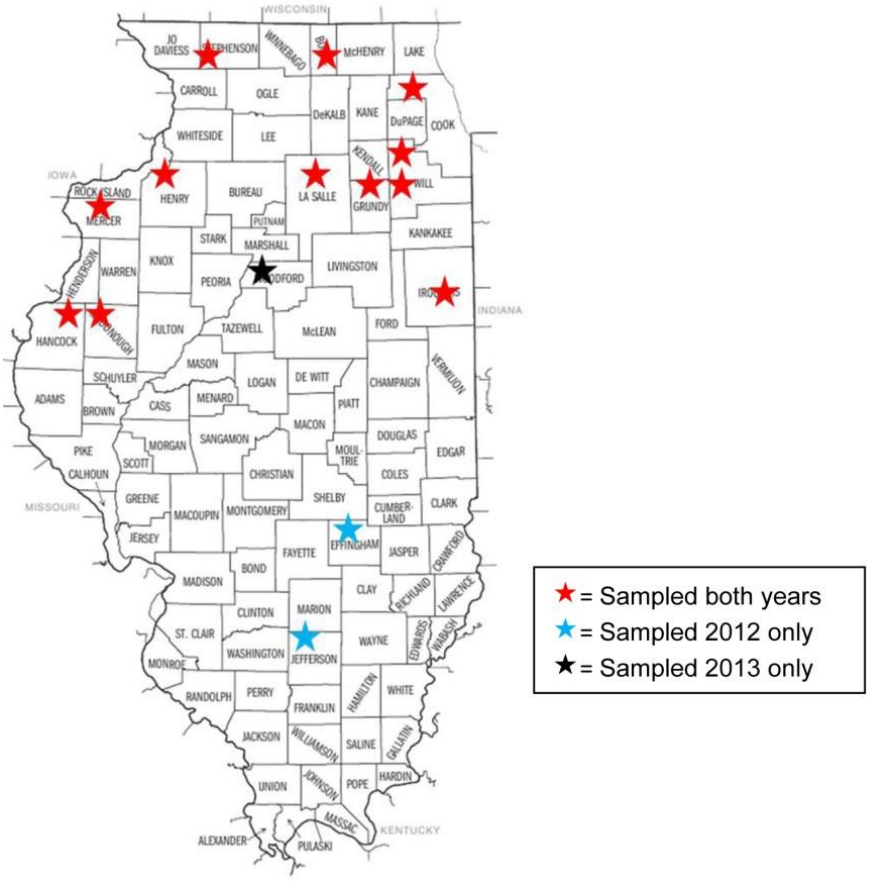


Figure 2. Sampling locations.

2.1.2 Summary of Sites

A total of 14 sites across Illinois were sampled in late-summer 2012 and 13 sites in late-summer 2013 (Table 1). Most sites (11) were seeded in 2008, with two in 2007 and one in 2009. Other sites were visited but either they were not seeded or another seed mix was used. Two sites sampled in 2012 were not sampled in 2013 because of new construction, so an additional site was identified that was not sampled the previous year. Sites were selected that were seeded to native grass mix 4 or 4A, and some were also seeded to native forb mix 5 or 5A. Sites were selected from contract seeding dates around 2007, to allow adequate time for establishment of slow-growing species. Two sites (62269 in Will County and 66000 in LaSalle County) were sampled twice in 2012, as seeded areas sometimes had very distinct plant communities across the seeded areas for unknown reasons. Only one of the locations was resampled in 2013 at each site because recent mowing had removed all biomass and made plant identification impossible.

Table 1. Site Locations and Descriptions

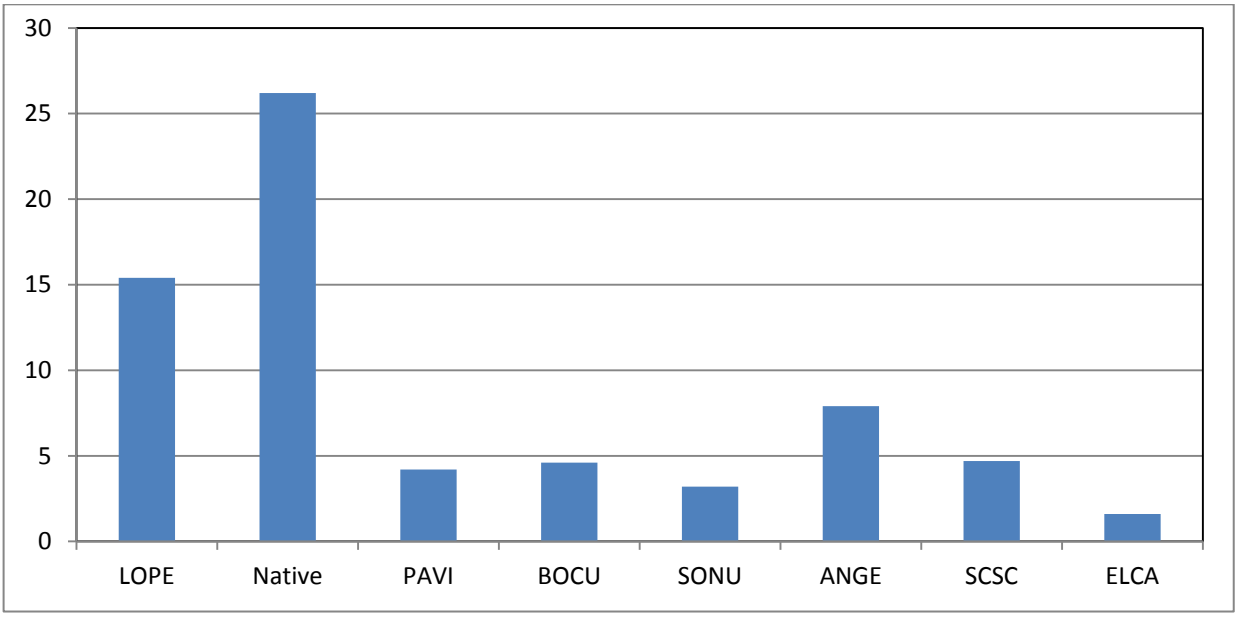
Contract	Description	District	County	Grass Mix	Forb Mix	Letting Date	Mowed In 2012	Sample Years
62269	IL 53 over Prairie Creek center median	1	Will	4	None	11/16/2007	No	2012
62269	IL 53 over Prairie Creek SE	1	Will	4	None	11/16/2007	No	Both
62895	IL 52/53 over I-80	1	Will	4	None	6/15/2007	No	Both
62897	Dundee Road and IL 68	1	Cook	4	None	3/9/2007	No	Both
64800	IL Rt. 173 over Beaver Creek	2	Boone	4	5	4/27/2007	Yes	Both
64602	Poppy Road over I-80	2	Henry	4	None	1/19/2007	No	Both
64B48	IL 20 culvert replacement	2	Stephenson	4	None	4/27/2007	Yes	Both
66412	I-80 Exit 105	3	Grundy	4A	None	1/20/2006	No	Both
66000	I-80 Exit 97 SE turnout	3	LaSalle	4A	5A	1/18/2008	No	2012
66000	I-80 Exit 97 NW onramp	3	LaSalle	4A	5A	1/18/2008	No	Both
66411	US 45 over Louis Creek	3	Iroquois	4	5A	3/9/2007	No	Both
68085	IL 94 over Edwards River	4	Mercer	4	None	9/21/2007	No	Both
68206	IL 336	4	McDonough	4A	5A	1/19/2007	Yes	Both
68206	IL 336 over LaMoine River	6	Hancock	4A	5A	1/19/2007	No	Both
74131	IL 32/33 over Green Creek	7	Effingham	4A	5	6/16/2006	No	2012
98963	I-64 Mt. Vernon Veteran Memorial	9	Jefferson	4	None	9/21/2007	No	2012
—	US 24 W of Cruger	4	Tazewell	4A	5	—	—	2013

The McDonough County site had no prairie grasses present in 2012, but seeded forbs were present and perennial ryegrass was abundant. The SE turnout of Exit 97 on I-80 had no prairie grasses in 2012 but had abundant seeded forbs and perennial ryegrass. At that same exit, the NW onramp had abundant Canada wildrye, little bluestem, and big bluestem present with some seeded forbs. IL 32/33 over Green Creek had no seeded grasses or forbs. It was in a floodplain and dominated by Canada goldenrod and Virginia wildrye. It is unknown if the Virginia wildrye was substituted in the seed mix or if it occurred naturally. This area was recently mowed in 2013 and was

not sampled. IL 52/53 at I-80 had saltgrass present, along with switchgrass and sideoats grama. IL 53 at Prairie Creek had a thick layer of compost on the SE side, with very few native grasses and an abundance of perennial ryegrass. Some sites that did not have forbs seeded had very high native forbs present. One such site, Exit 105 on I-80, had an abundance of prairie dock, with New England aster present in 2012. Other sites had blends of species, often with one or two seeded native grasses having much higher cover than the other seeded species, and often with one or more seeded native species absent. The pattern of presence and absence differed greatly between sites. Of the seeded forbs, several were quite common, several were rarely encountered, and many were never encountered. For individual site data, see Sectdion 2.2.5, Results by Site.

2.2 RESULTS

Seeded grasses (seven species sampled) comprised 26.1% of total relative cover (TRC) across all sampled sites in 2012 and 34.1% in 2013. Prairie dropseed (*Sporobolus heterolepis*) was never sampled or seen at any site in 2012 but was present and sampled at the US 24 site in 2013. Big bluestem was most common (7.9% TRC in 2012, 9.4% in 2013), occurring in 11 sampled sites in 2012 and 8 in 2013 (Figures 3 and 4). Little bluestem (6 sites in 2012, 5 in 2013) comprised 4.7% of TRC in 2012 and 7.5% in 2013, sideoats grama (7 sites in 2012, 4 sites in 2013) comprised 4.6% of TRC in 2012 and 2.7% in 2013, switchgrass (10 sites in both years) comprised 4.2% of TRC in 2012 and 8.0% in 2013, indiangrass (8 sites in 2012, 6 sites in 2013) comprised 3.2% of TRC in 2012 and 3.5% in 2013, and Canada wildrye (4 sites in 2012, 7 sites in 2013) comprised 1.6% of TRC in 2012 and 2.4% in 2013. Perennial ryegrass (13 sites in 2012, 11 in 2013) comprised 15.4% of TRC in 2012 and 11.3% in 2013. Only 15 species of seeded forbs were encountered across all sites, with a TRC of 10.0% in 2012 and 3.6% in 2013 (not all sites had forbs planted, so cover at planted sites is higher than percentages presented) (Figures 5 and 6). Of these species, yellow coneflower (2.1% TRC) was most common in 2012 and oxeye sunflower most common in 2013 (1.0% TRC).



LOPE = Perennial Ryegrass; Native = Total Seeded Native Grasses; PAVI = Switchgrass; BOCU = Sideoats Grama; SONU = Indiangrass; ANGE = Big Bluestem; SCSC = Little Bluestem; ELCA = Canada Wildrye

Figure 3. Total relative cover (%) of seeded grasses across all sites in 2012.

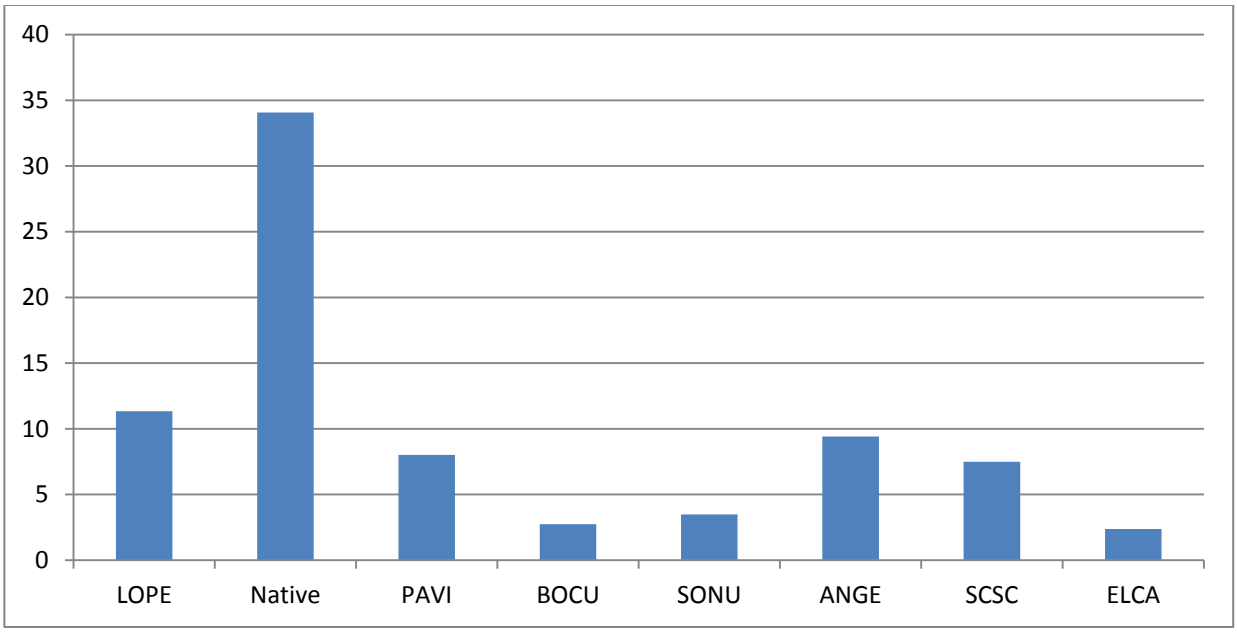


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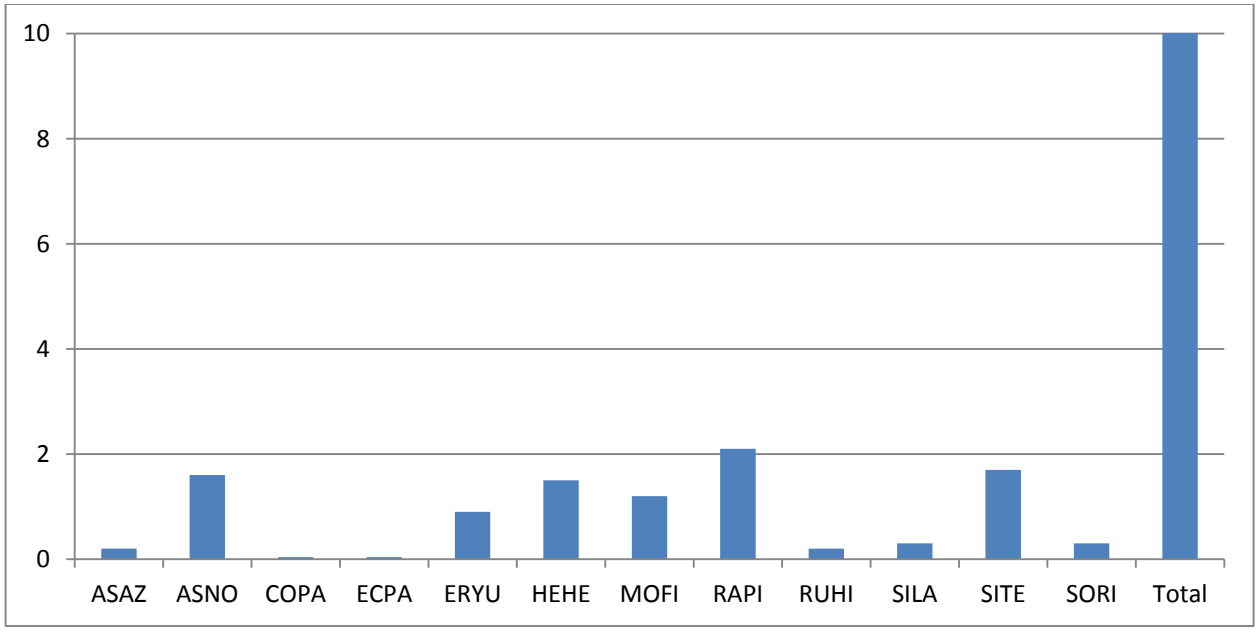
Figure 4. Total relative cover (%) of seeded grasses across all sites in 2013.



ASAZ = Sky Blue Aster; ASNO = New England Aster; COPA = Prairie Coreopsis; ECPA = Pale Purple Coneflower; ERYU = Rattlesnake Master; HEHE = Oxeye Sunflower; MOFI = Wild Bergamont; RAPI = Yellow Coneflower; RUHI = Black-Eyed Susan; SILA = Compass Plant; SITE = Prairie Dock; SORI = Rigid Goldenrod

Figure 5. Total relative cover (%) of seeded forbs across all sites in 2012.

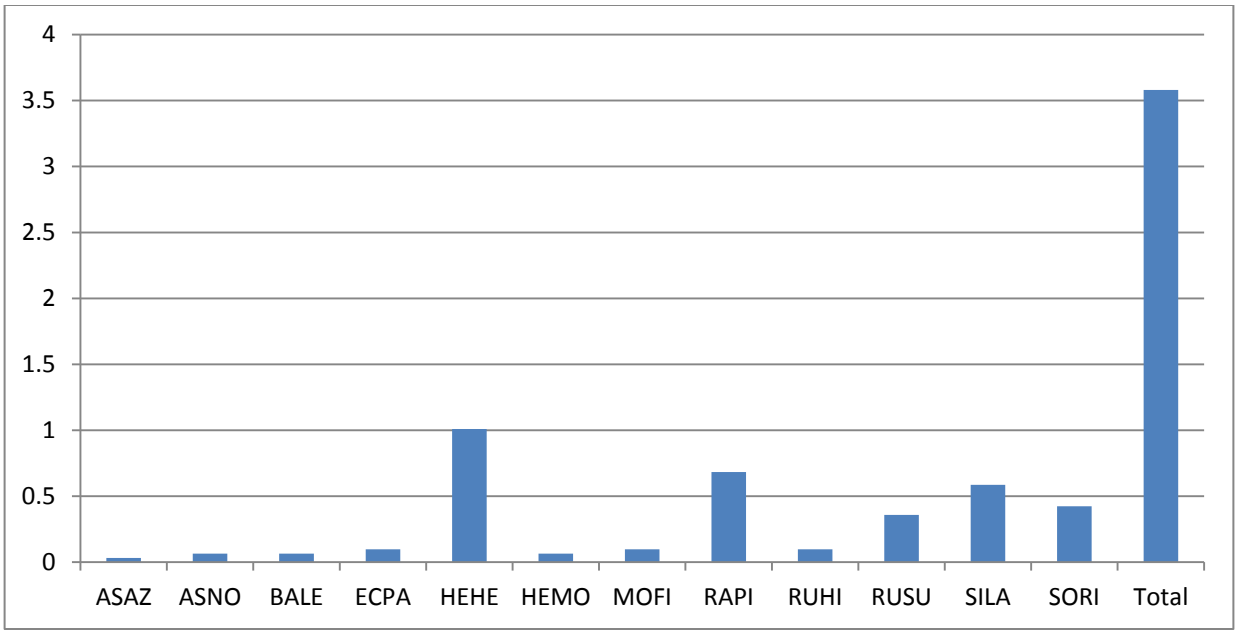


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Figure 6. Total relative cover (%) of seeded forbs across all sites in 2013.

In 2012, 12 species of introduced non-seeded grasses were sampled, with a TRC of 19.3%. In 2013, 9 species were sampled, with a TRC of 23.9%. Tall fescue (13 sites, 9.8% TRC in 2012; 10 sites, 9.8% TRC in 2013) and reed canarygrass (10 sites, 4.2% TRC in 2012; 11 sites, 12.2% TRC in 2013) were the most common. Non-planted native forbs comprised 12.9% of TRC across all sites in 2012 and 16.1% in 2013, with 45 total species sampled. The dominant species were Canada goldenrod (4.7% TRC, 9 sites in 2012; 4.9% TRC, 9 sites in 2013) and heath aster (4.2% TRC, 7 sites in 2012; 4.3% TRC, 5 sites in 2013). Other notable native forbs sampled include tall green milkweed (*Asclepias hirtella*), whorled milkweed (*Asclepias verticillata*), false boneset (*Brickellia eupatorioides*), partridge pea (*Chamaechrista fasciculata*), tall coreposis (*Coreopsis tripteris*), tall boneset (*Eupatorium altissimum*), boneset (*Eupatorium perfoliatum*), Joe Pye weed (*Eupatorium purpureum*), annual sunflower (*Helianthus annuus*), sawtooth sunflower (*Helianthus grosseserratus*), Jerusalem artichoke (*Helianthus tuberosus*), common evening primrose (*Oenothera biennis*), foxglove beardtongue (*Penstemon digitalis*), brown-eyed susan (*Rudbeckia triloba*), wild petunia (Ruellia humilis), rosinweed (*Silphium integrifolium*), cup plant (*Silphium perfoliatum*), and prairie ironweed (*Vernonia fasciculata*). Introduced forbs comprised 10.4% of TRC across all sites in 2012 and 7.8% in 2013, with a total of 27 species sampled. The most common introduced forbs were crown vetch (2.5% TRC, 6 sites total in 2012; 2.7% TRC, 4 sites total in 2013) and white clover (2.0% TRC, 5 sites total in 2012; 0.9% TRC, 4 sites in 2013). Teasels were sampled at only 2 sites, comprising only 0.3% TRC across all sites in 2012 and 0.03% in 2013. Thistles and knapweeds (*Cirsium* spp., *Centaurea maculata*) were sampled at 4 sites, comprising 0.4% TRC across all sites in 2012 and .8% in 2013. Sweetclover was sampled in 6 sites, comprising 0.8% of TRC across all sites in both years. Trees and shrubs comprised 1.0% of TRC across all sites in 2012 and 0.4% in 2013, with a total of 10 species sampled.

2.2.1 Results by District

A total of four sites were sampled in district 1, three sites in district 2, four sites in district 3, two sites in district 4, one site in district 6, one site in district 7, and one site in district 9 in 2012 (Figures 7 and 9). Three sites each in districts 1, 2, 3, and 4 were sampled in 2013 and one in district 6 (Figures 8, 10). However, these are far too few sites to draw any conclusions about district-level differences.

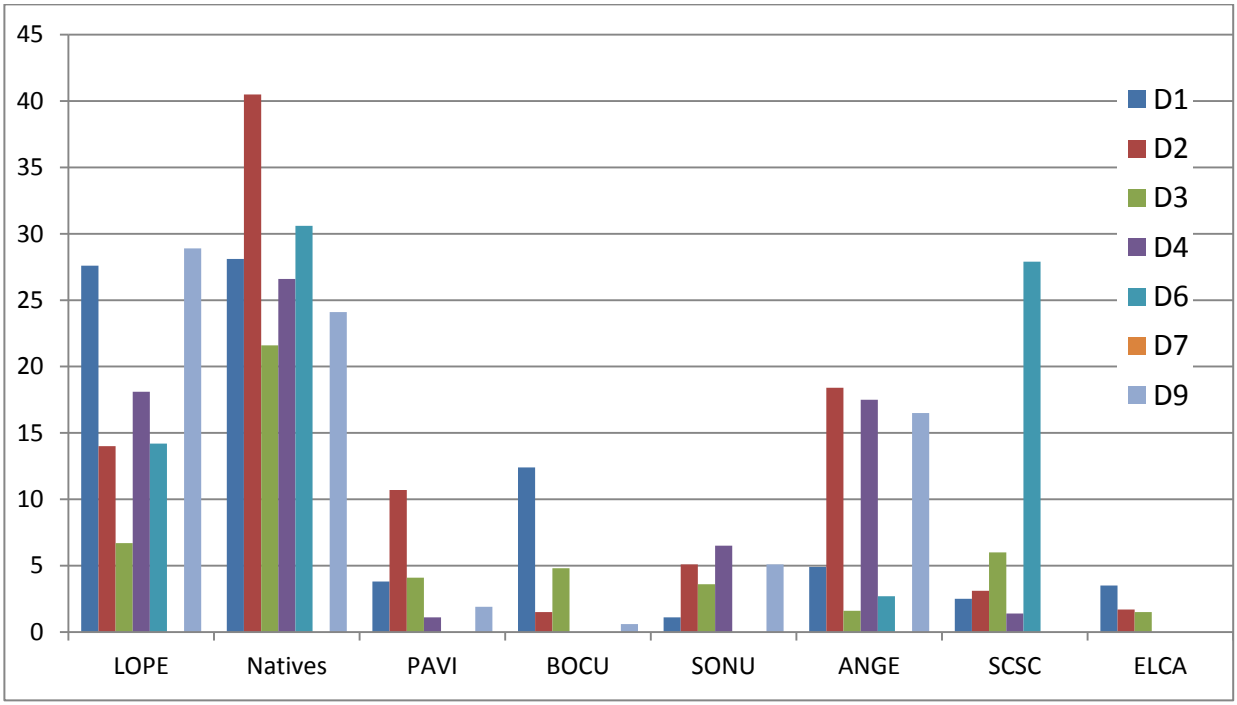

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Figure 7. Total relative cover (%) of planted grass species by district in 2012.

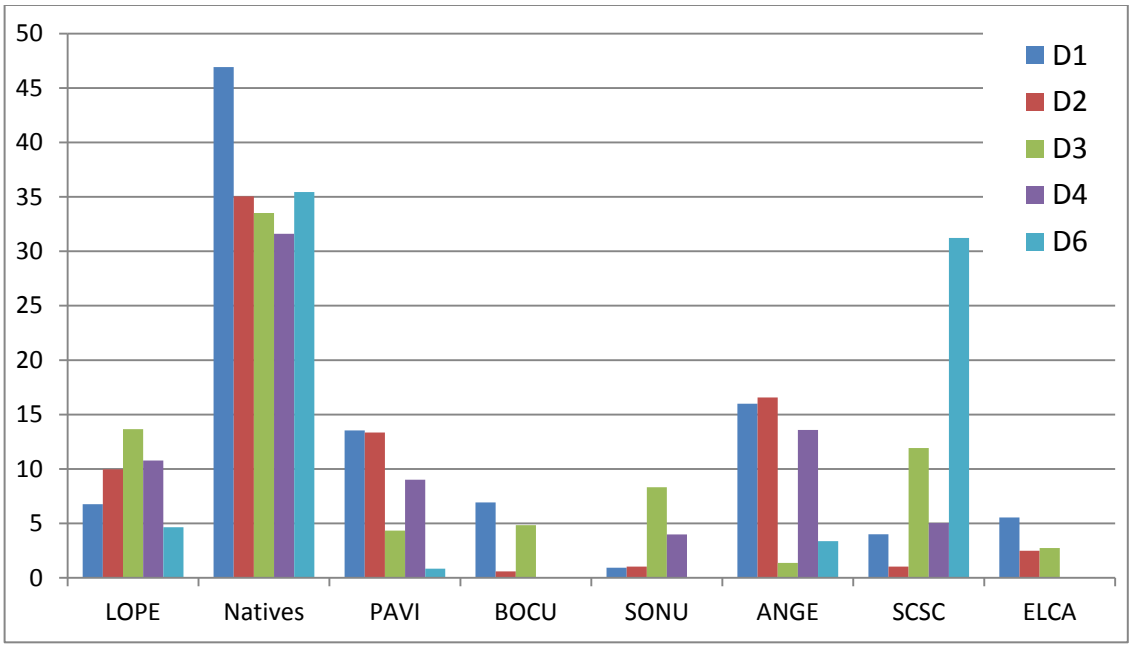

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Figure 8. Total relative cover (%) of planted grass species by district in 2013.

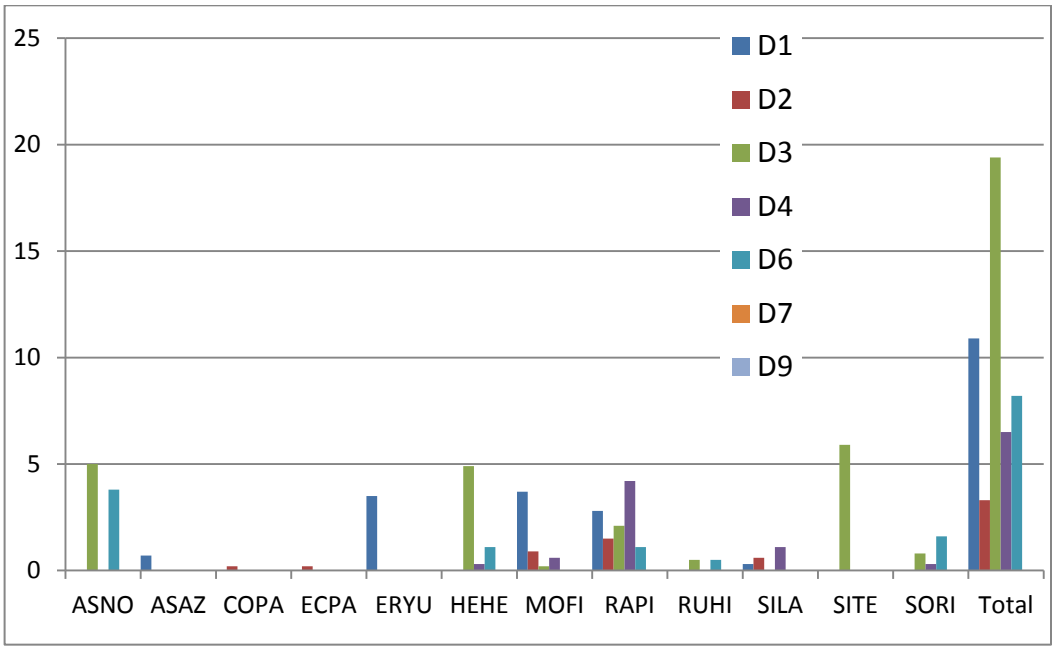

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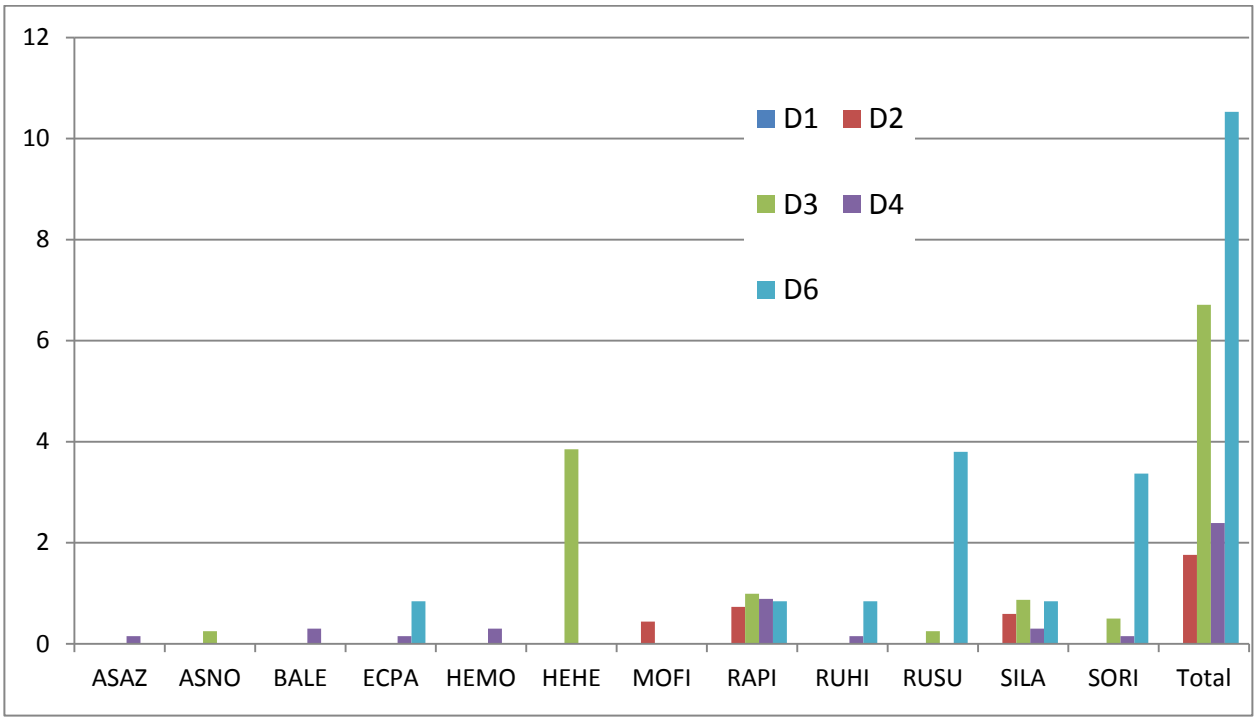
Figure 9. Total relative cover (%) of seeded forb species by district in 2012.

Yellow coneflower (RAPI) and wild bergamont (MOFI) occurred in the most districts in 2012.

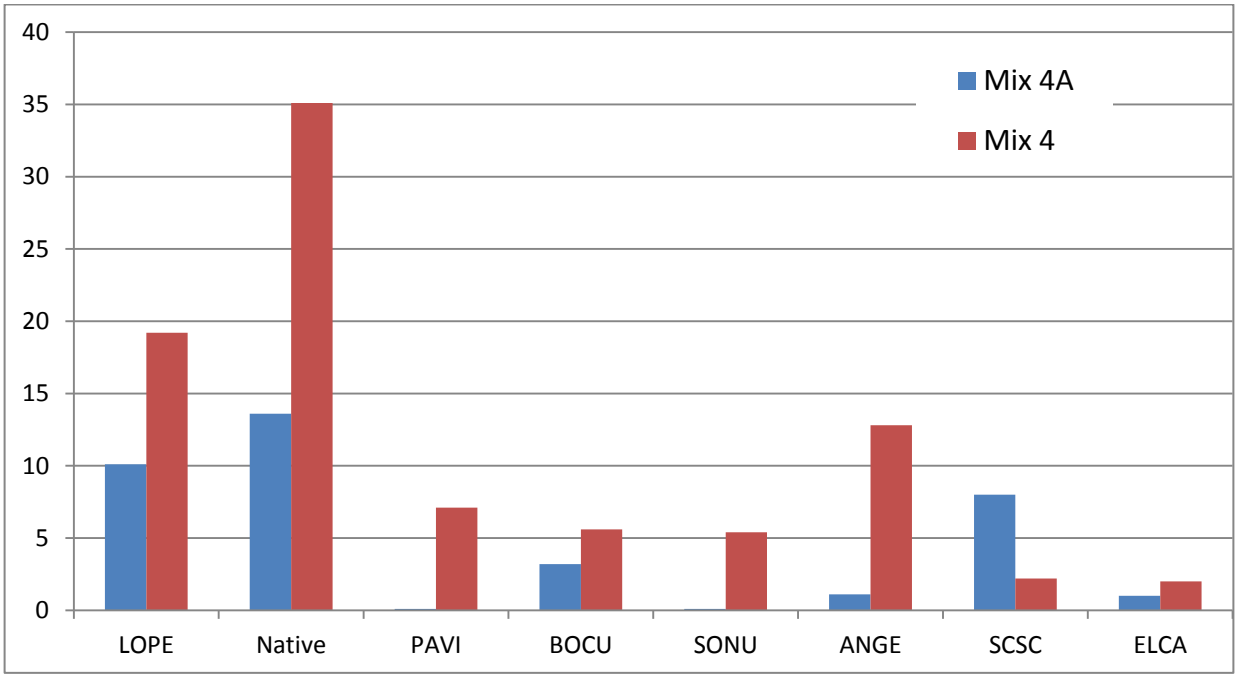


ASAZ = Sky Blue Aster; ASNO = New England Aster; COPA = Prairie Coreopsis; ECPA = Pale Purple Coneflower; ERYU = Rattlesnake Master; HEHE = Oxeye Sunflower; MOFI = Wild Bergamont; RAPI = Yellow Coneflower; RUHI = Black-Eyed Susan; SILA = Compass Plant; SITE = Prairie Dock; SORI = Rigid Goldenrod

Figure 10. Total relative cover (%) of seeded forb species by district in 2013.

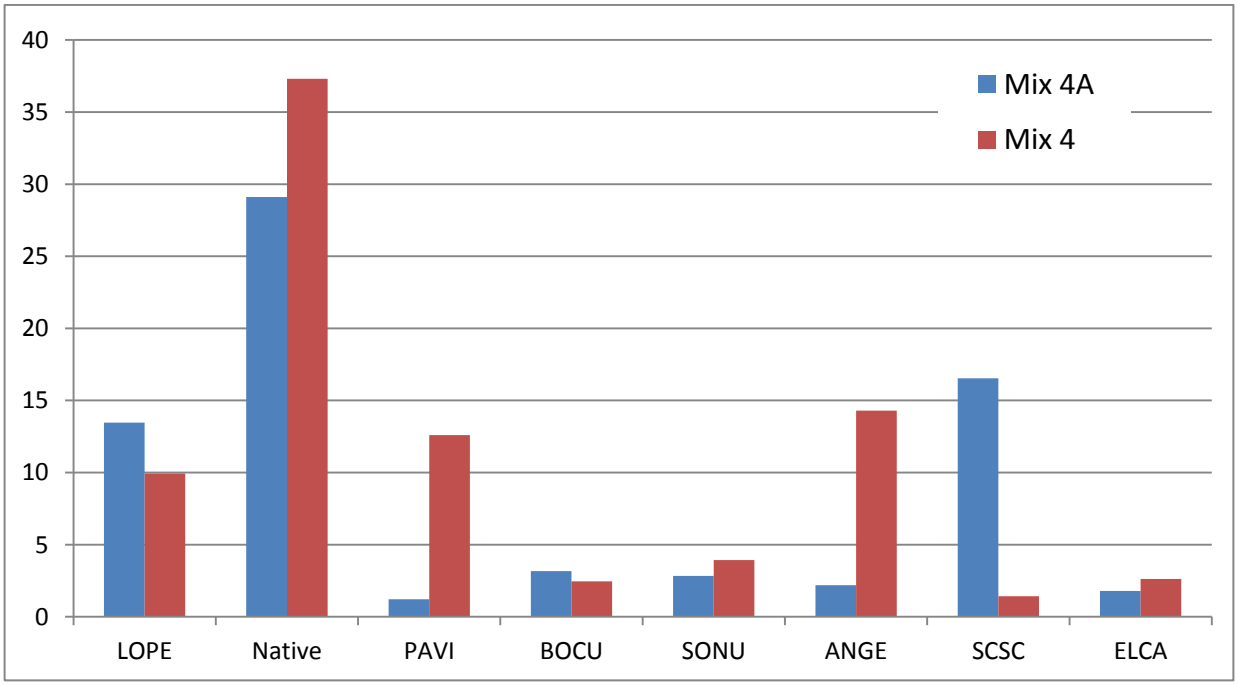
Yellow coneflower (RAPI) and compass plant (SILA) occurred in the most districts in 2013.

2.2.2 Results by Grass Mix



LOPE = Perennial Ryegrass; Native = Total Seeded Native Grasses; PAVI = Switchgrass; BOCU = Sideoats Grama; SONU = Indiangrass; ANGE = Big Bluestem; SCSC = Little Bluestem; ELCA = Canada Wildrye

Figure 11. Total relative cover (%) of seeded grass species by seed mix in 2012.



LOPE = Perennial Ryegrass; Native = Total Seeded Native Grasses; PAVI = Switchgrass; BOCU = Sideoats Grama; SONU = Indiangrass; ANGE = Big Bluestem; SCSC = Little Bluestem; ELCA = Canada Wildrye

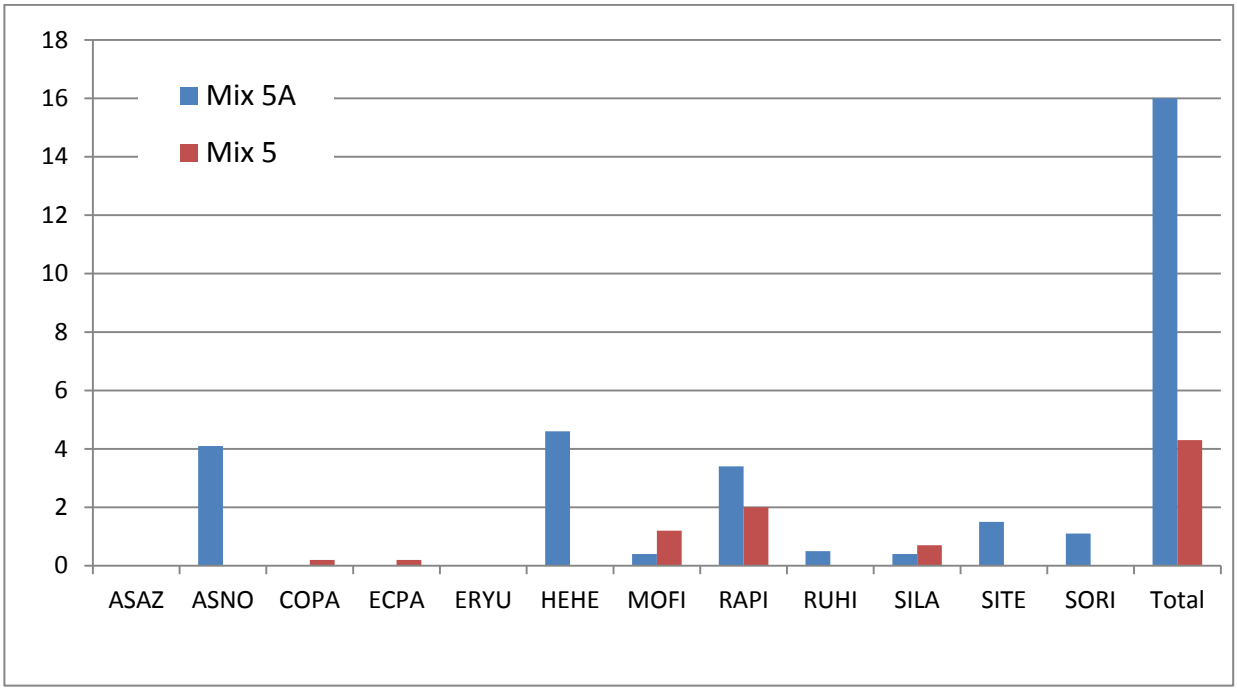
Figure 12. Total relative cover (%) of seeded grass species by seed mix in 2013.

Nine of the sites were seeded with mix 4, and five were seeded with 4A in 2012 (Figure 11). In 2013, eight sites were seeded with mix 4, and five were seeded with 4A (Figure 12).

Mix 4 appeared to perform better than 4A in both years, likely because the taller species were better able to compete with non-seeded plant species, although perennial ryegrass had much higher relative cover in mix 4 compared to 4A in 2012.

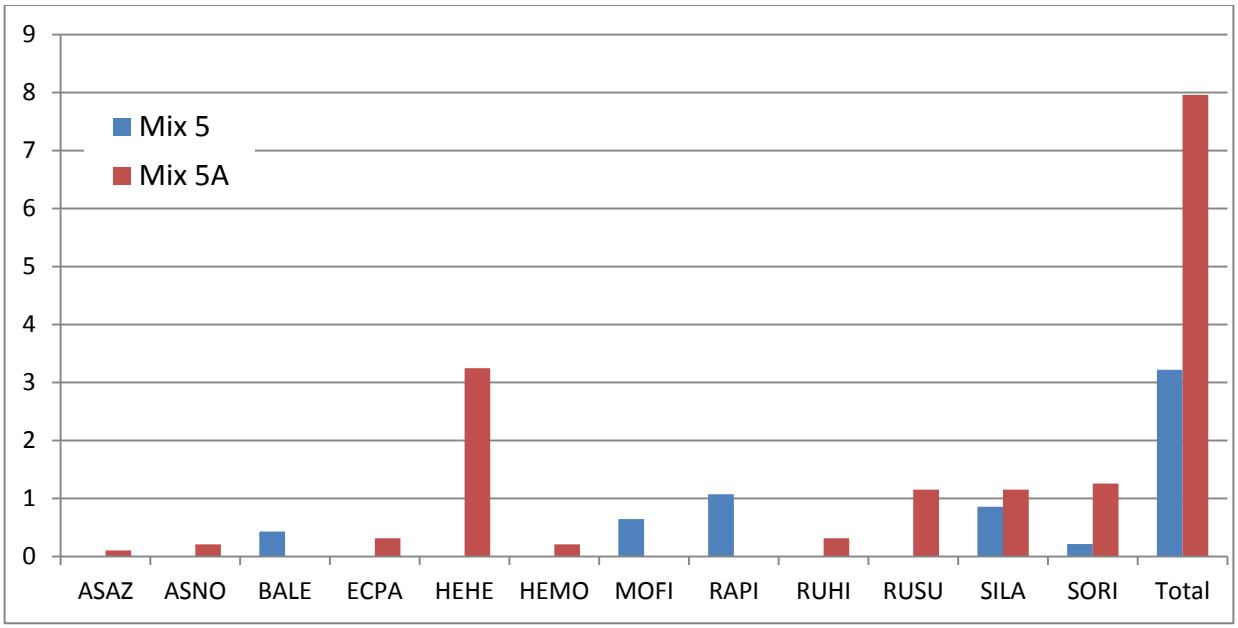
2.2.3 Results by Forb Mix

Two of the sites were seeded with mix 5, while four were seeded with 5A in both years (Figures 13 and 14).



ASAZ = Sky Blue Aster; ASNO = New England Aster; COPA = Prairie Coreopsis; ECPA = Pale Purple Coneflower; ERYU = Rattlesnake Master; HEHE = Oxeye Sunflower; MOFI = Wild Bergamont; RAPI = Yellow Coneflower; RUHI = Black-Eyed Susan; SILA = Compass Plant; SITE = Prairie Dock; SORI = Rigid Goldenrod

Figure 13. Total relative cover (%) of seeded forb species by seed mix in 2012.



ASAZ = Sky Blue Aster; ASNO = New England Aster; COPA = Prairie Coreopsis; ECPA = Pale Purple Coneflower; ERYU = Rattlesnake Master; HEHE = Oxeye Sunflower; MOFI = Wild Bergamont; RAPI = Yellow Coneflower; RUHI = Black-Eyed Susan; SILA = Compass Plant; SITE = Prairie Dock; SORI = Rigid Goldenrod

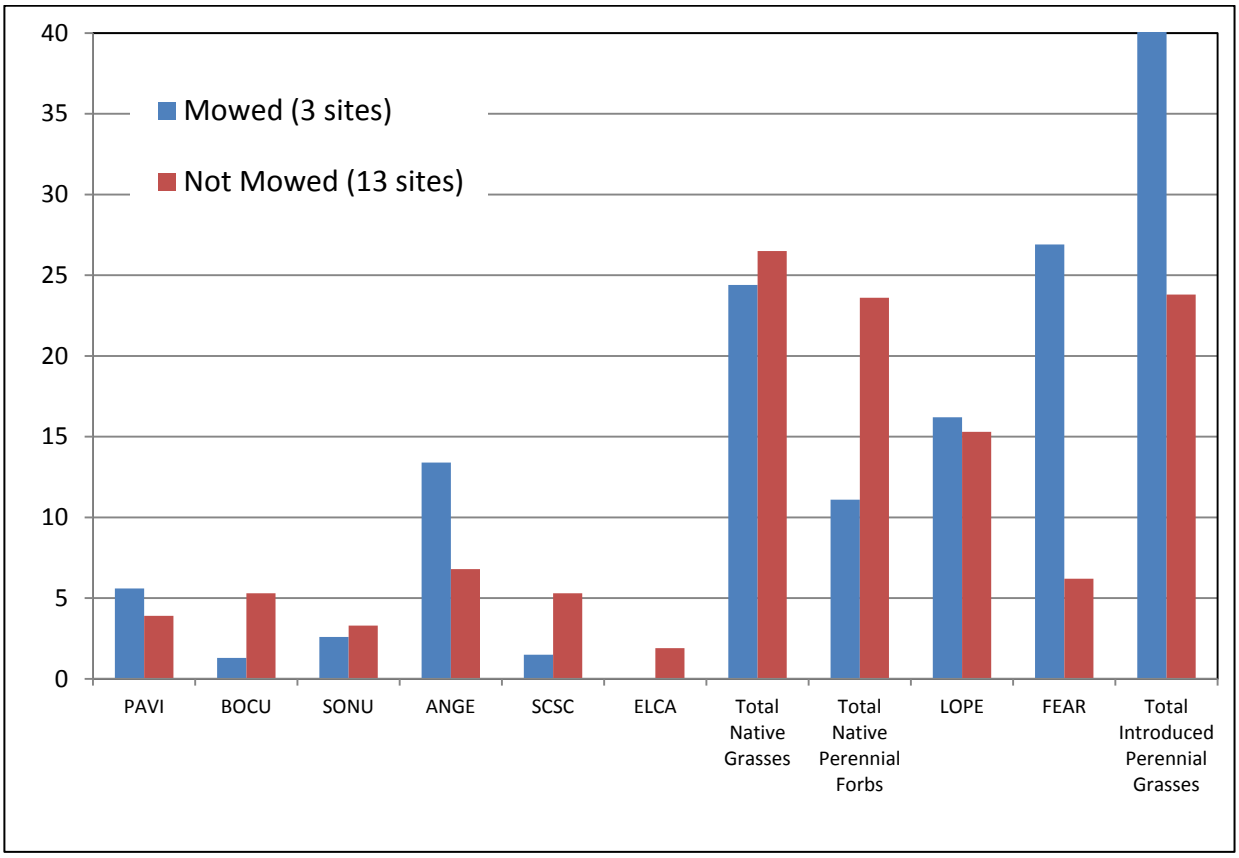
Figure 14. Total relative cover (%) of seeded forb species by seed mix in 2013.

Numerous native forb species listed in the mixes were never encountered (Figures 13 and 14). From mix 5, *Amorpha canescens, Anemone cylindrica, Asclepias tuberosa, Aster laevis, Liatris aspera, Liatris pycnostachya, Parthenium integrifolium, Petalostemum candidum, Petalostemum purpureum, Physostegia virginiana, Potentilla arguta, Rudbeckia subtomentosa, Tradescantia ohiensis,* and *Veronicastrum virginicum* were all absent, either because they were not included in the seed mix, they failed to establish, or senescence occurred prior to sampling (e.g., Tradescantia). *Aster laevis, Liatris pycnostachya,* and *Physostegia virginiana* were seen at least one site, although they were not present in large amounts, were not sampled, and could have been present from natural nearby populations.

Liatris pycnostachya was the only species from mix 5A absent from all sites. *Helianthus mollis* was present at only one site in 1 year.

Species used in mix 5A seemed to have a much higher establishment success rate, with 9 of 10 seeded species measured. In mix 5, only 13 of 27 (48%) species were measured (14 of 32 including annuals).

2.2.4 Results by Recent Mowing History



PAVI = Switchgrass; BOCU = Sideoats Grama; SONU = Indiangrass; ANGE = Big Bluestem; SCSC = Little Bluestem; ELCA = Canada Wildrye; LOPE=Perennial Ryegrass; FEAR=Tall Fescue

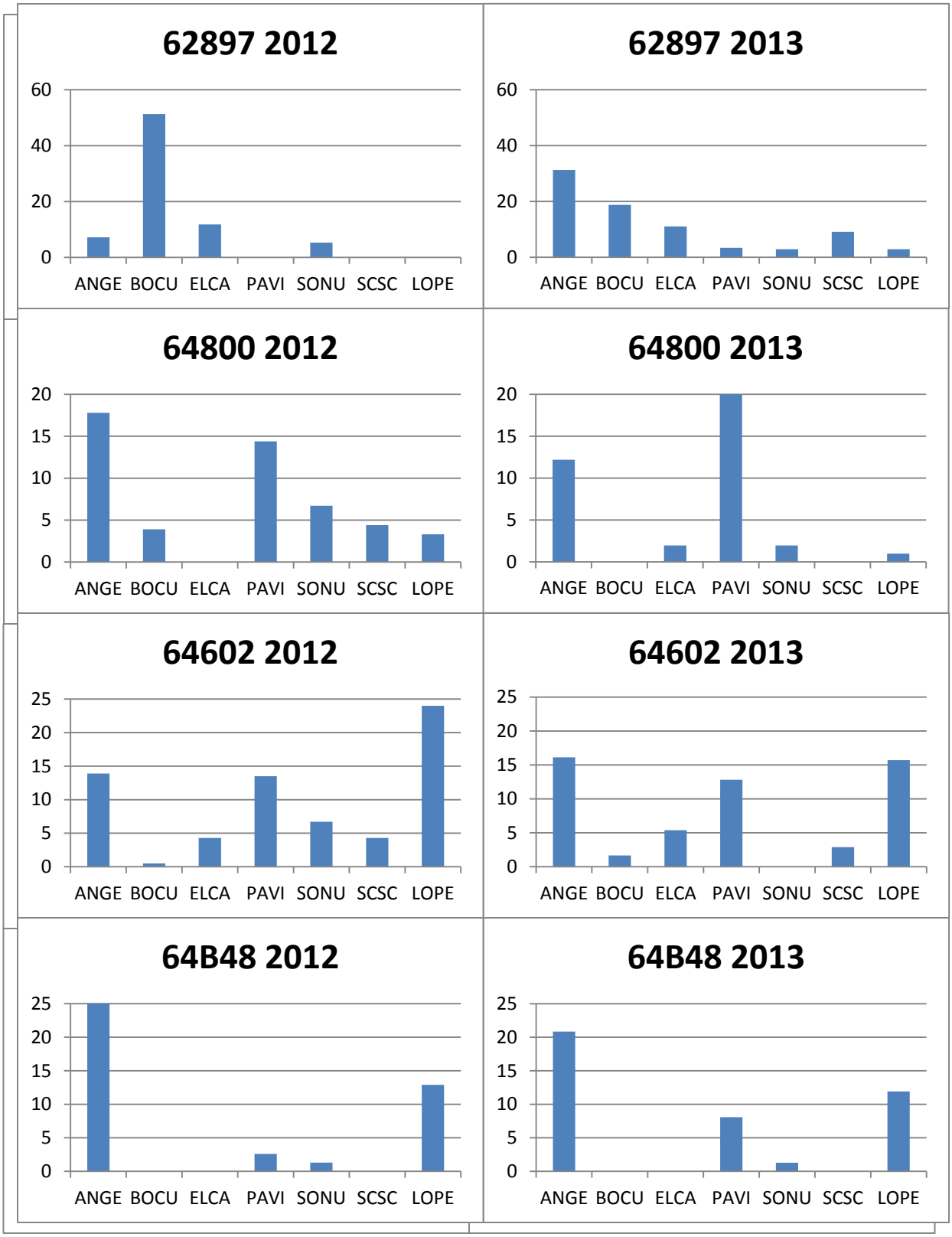
Figure 15. Relative percent cover by mowing in 2012.

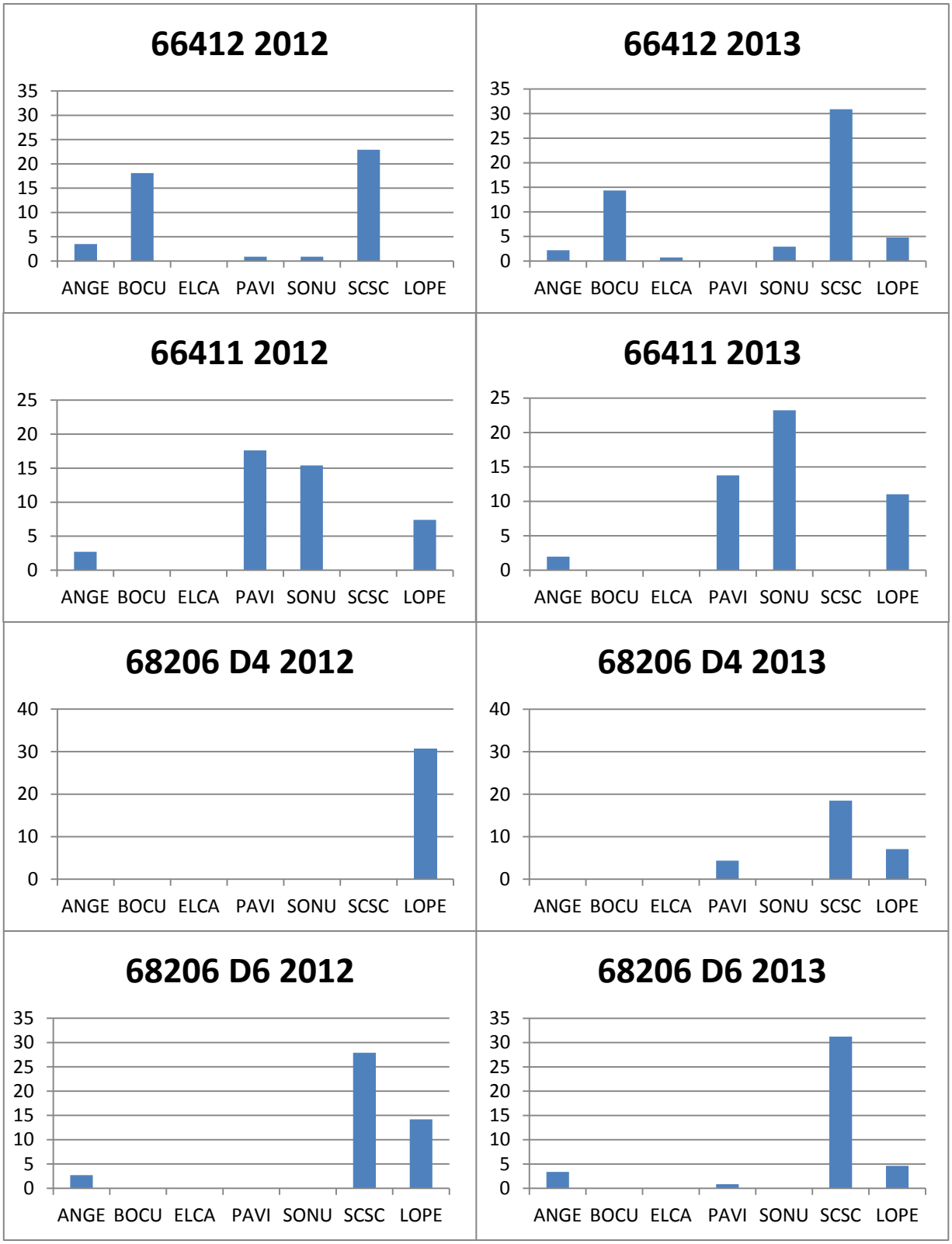
Three sites had been recently mowed. Although mowing history was not known, and the number of sites sampled is too few to draw any significant conclusions, comparing areas that were mowed prior to sampling shows several interesting differences (Figure 15). First, switchgrass and big bluestem had higher relative cover in mowed than unmowed areas; and sideoats grama, little bluestem, and Canada wildrye had higher relative cover in unmowed areas. Total native perennial forbs had much higher relative cover in unmowed areas. Total introduced perennial grass relative cover was much higher in mowed areas than in unmowed areas, primarily because of a very large increase in tall fescue in mowed areas. Mowed areas were not sampled in 2013, as areas that were recently mowed retained too little biomass for accurate identification of vegetation.

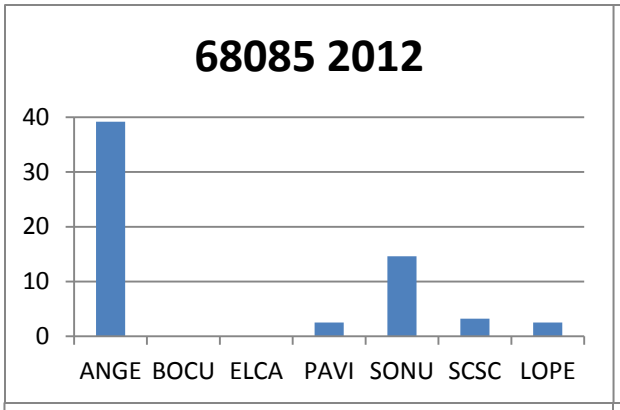
2.2.5 Results by Site

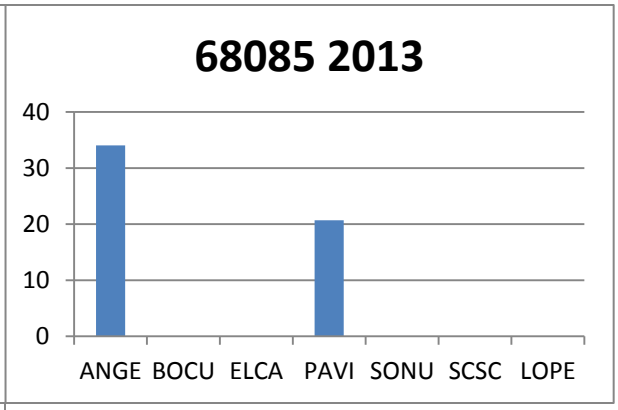
The charts on the following four pages show percent relative cover of seeded grass species by site. The grass species are as follow:

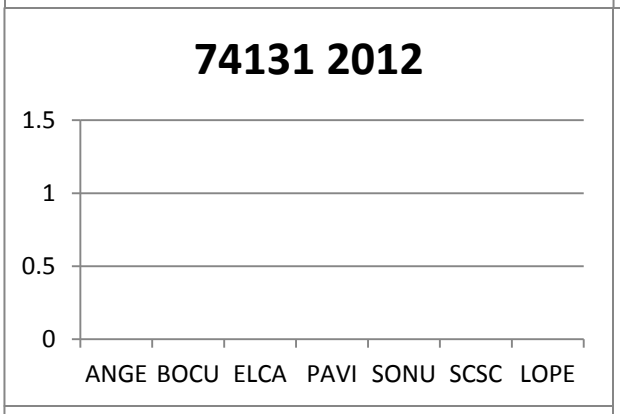
ANGE = big bluestem
BOCU = sideoats grama
ELCA = Canada wildrye
PAVI = switchgrass
SONU = indiangrass
SCSC = little bluestem
LOPE = perennial ryegrass


62897 2012
60
40
20
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE
62897 2013
60
40
20
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE
64800 2012
20
15
10
5
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE
64800 2013
20
15
10
5
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE
64602 2012
25
20
15
10
5
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE
64602 2013
25
20
15
10
5
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE
64B48 2012
25
20
15
10
5
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE
64B48 2013
25
20
15
10
5
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE


66412 2012
35
30
25
20
15
10
5
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE
66412 2013
35
30
25
20
15
10
5
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE
66411 2012
25
20
15
10
5
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE
66411 2013
25
20
15
10
5
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE
68206 D4 2012
40
30
20
10
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE
68206 D4 2013
40
30
20
10
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE
68206 D6 2012
35
30
25
20
15
10
5
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE
68206 D6 2013
35
30
25
20
15
10
5
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE


68085 2012
40
30
20
10
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE


68085 2013
40
30
20
10
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE


74131 2012
1.5
1
0.5
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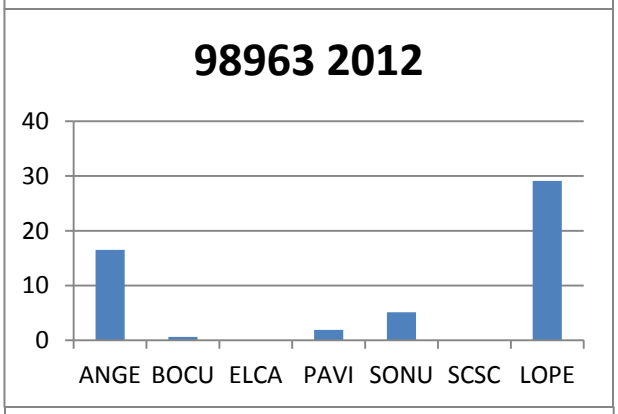
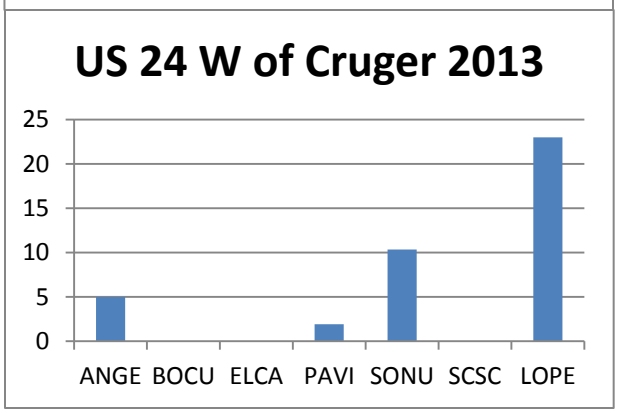
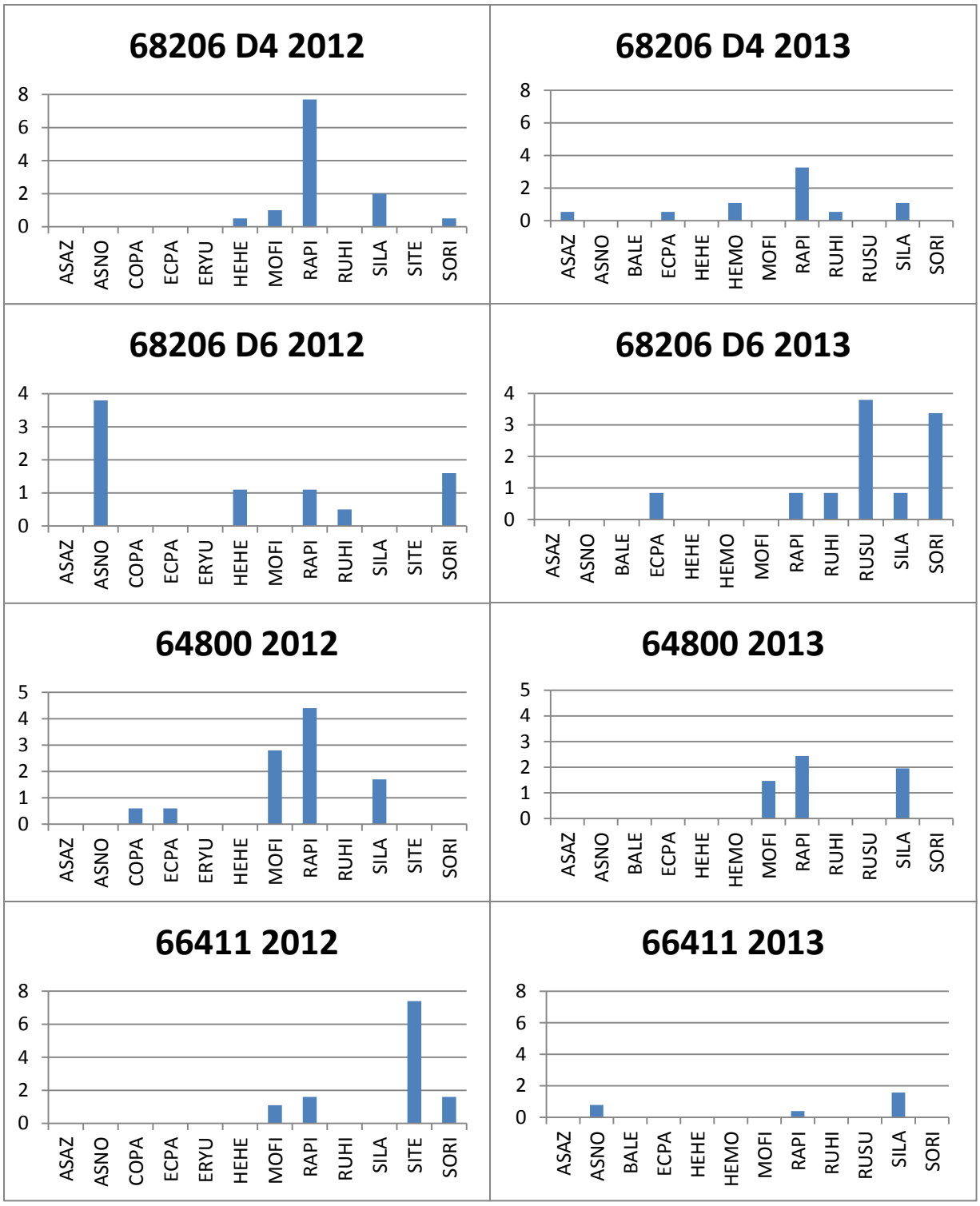
ANGE BOCU ELCA PAVI SONU SCSC LOPE

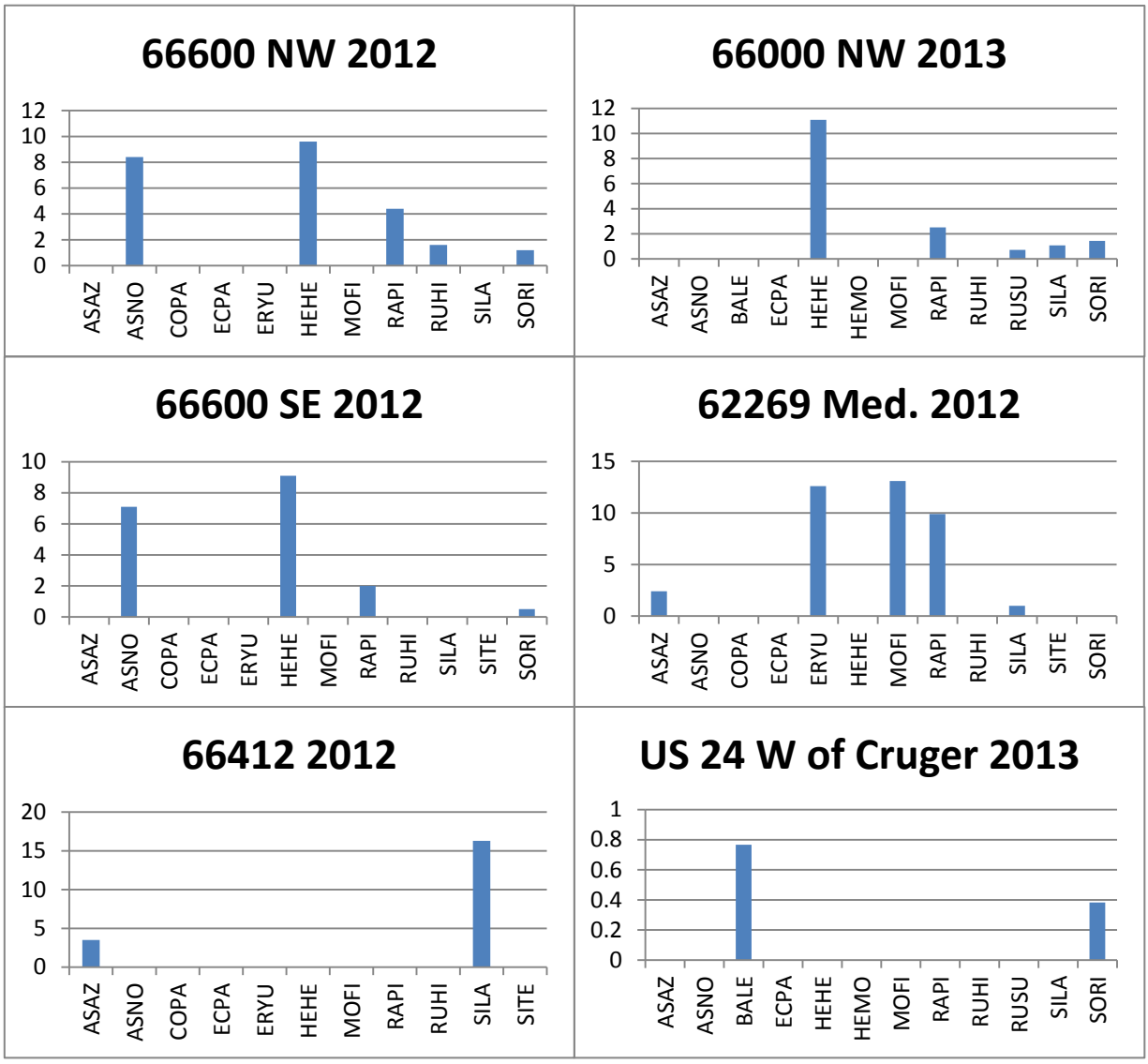

98963 2012
40
30
20
10
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE


US 24 W of Cruger 2013
25
20
15
10
5
0
ANGE BOCU ELCA PAVI SONU SCSC LOPE

The charts on the following two pages show percent relative cover of seeded forb species by site. The forb species are as follows:

ASAZ = sky blue aster
ASNO = New England aster
BALE = white wild indigo
COPA = prairie coreopsis
ECPA = pale purple coneflower
ERYU = rattlesnake master
HEHE = oxeye sunflower
HEMO = downy sunflower
MOFI = wild bergamont
RAPI = yellow coneflower
RUHI = black-eyed susan
RUSU = fragrant coneflower
SILA = compass plant
SITE = prairie dock
SORI = rigid goldenrod


68206 D4 2012
0 2 4 6 8
ASAZ ASNO COPA ECPA ERYU HEHE MOFI RAPI RUHI SILA SITE SORI
68206 D4 2013
0 2 4 6 8
ASAZ ASNO BALE ECPA HEHE HEMO MOFI RAPI RUHI RUSU SILA SORI
68206 D6 2012
0 1 2 3 4
ASAZ ASNO COPA ECPA ERYU HEHE MOFI RAPI RUHI SILA SITE SORI
68206 D6 2013
0 1 2 3 4
ASAZ ASNO BALE ECPA HEHE HEMO MOFI RAPI RUHI RUSU SILA SORI
64800 2012
0 1 2 3 4 5
ASAZ ASNO COPA ECPA ERYU HEHE MOFI RAPI RUHI SILA SITE SORI
64800 2013
0 1 2 3 4 5
ASAZ ASNO BALE ECPA HEHE HEMO MOFI RAPI RUHI RUSU SILA SORI
66411 2012
0 2 4 6 8
ASAZ ASNO COPA ECPA ERYU HEHE MOFI RAPI RUHI SILA SITE SORI
66411 2013
0 2 4 6 8
ASAZ ASNO BALE ECPA HEHE HEMO MOFI RAPI RUHI RUSU SILA SORI


66600 NW 2012
12
10
8
6
4
2
0
ASAZ
ASNO
COPA
ECPA
ERYU
HEHE
MOFI
RAPI
RUHI
SILA
SORI
66000 NW 2013
12
10
8
6
4
2
0
ASAZ
ASNO
BALE
ECPA
HEHE
HEMO
MOFI
RAPI
RUHI
RUSU
SILA
SORI
66600 SE 2012
10
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ASAZ
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COPA
ECPA
ERYU
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MOFI
RAPI
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62269 Med. 2012
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COPA
ECPA
ERYU
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RAPI
RUHI
SILA
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RAPI
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US 24 W of Cruger 2013
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ASAZ
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ECPA
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HEMO
MOFI
RAPI
RUHI
RUSU
SILA
SORI

CHAPTER 3 RECOMMENDATIONS FOR BEST MANAGEMENT PRACTICES

3.1 SEEDBED PREPARATION

3.1.1 Soil Physical Properties

Illinois currently requires that areas to be seeded are to be worked to a minimum depth of 3 in. with a disk tiller or other engineer-approved method that reduces all soil particles to a size no larger than 2 in. in the largest dimension (IL DOT 2012, Section 250.05). The prepared surface should be relatively free from weeds, clods, stones, roots, sticks, rivulets, gullies, crusting, and caking; and no seeds should be sown until the engineer approves the site.

Illinois currently requires that topsoil be loamy soil from the A horizon of local soils as defined in the *Geotechnical Manual;* be relatively free from large roots, sticks, weeds, brush, or stones larger than 1 in. in diameter, or other litter and waste products; at least 90 percent should pass a 2-mm sieve (IL DOT 2012, Section 1081.05). Topsoil should be obtained within the limits of the right-of-way at the locations and to the depths designated on the plans or approved by the engineer, but additional topsoil furnished outside the limits of the right-of-way may be approved by the engineer prior to its use (IL DOT 2012, Section 211.03). Topsoil should be stockpiled at approved locations; and when special types of topsoil are specified, each type should be handled separately and not be allowed to mix with other materials (IL DOT 2012, Section 211.03). When special types of topsoil (hydric, prairie, or woodland) are specified, the seeds and plants within these topsoils are desirable to maintain and should be placed as directed by the engineer to maintain viability (IL DOT 2012, Section 211.03). If the existing soil surface has become hardened or crusted, it should be disked or raked or otherwise broken up to provide a bond with the topsoil being applied (IL DOT 2012, Section 211.04).

Prior to any seeding, soil should be loosened by disking to a depth of 3 in., except in areas where excessive traffic has compacted the soil. In these areas, the soil should be loosened to a depth of 6 in. When seeding into existing vegetation, disking should be conducted so that 50% of the soil surface becomes visible. Soil loosening should not be conducted when soil contains sufficient moisture that restricts breaking up of soil particles or passage of tillage equipment compacts soil excessively or when a no-till drill is used.

Topsoil is necessary to support a healthy plant community that stabilizes soil and resists invasion. If at all possible, topsoil existing at a construction site should be stockpiled and conserved. However, if it must be imported from off-site, certain guidelines are required to ensure quality. Sources of topsoil should be areas with known histories, that are free from noxious weeds [common ragweed (*Ambrosia artemisiifolia*) if used within corporate limits, giant ragweed (*Ambrosia trifida*) if used within corporate limits, marijuana (*Cannabis sativa*), musk thistle (*Carduus nutans*), Canada thistle (*Cirsium arvense*), kudzu (*Pueraria montana*), perennial sowthistle (*Sonchus arvensis*), Columbus grass (*Sorghum almum*), and johnsongrass (*Sorghum halepense*)] and other undesirable species; herbicide residues; or other contaminants that could restrict plant growth, leach into groundwater, or otherwise harm the environment. Testing should be conducted to ensure quality (see Section 1.1.2.1, Soil Testing). Undesirable weeds, in addition to noxious weeds, that should not be tolerated include spotted knapweed (*Centaurea stoebe*), teasel (*Dipsacus fullonum* and *D. sylvestris*), leafy spurge (*Euphorbia esula*), Sericia lespedeza (*Lespedeza cuneata*), Japanese stiltgrass (*Microstegium vimineum*), reed canarygrass (*Phalaris canariensis*), and giant reed (*Phragmites australis*). Areas containing these species should not be used, as removal of weeds does not remove the seed bank. Areas should be surveyed extensively prior to excavation, and equipment should be properly cleaned prior to excavation, transportation, and placement of topsoil to ensure weed seed contamination is minimized.

Topsoil should consist of soil material containing adequate nutrients and organic matter and with a pH between 5 and 8. Topsoil should be free of rocks and other debris over 2 in. in diameter, except in front of residences or commercial properties and between curbs and sidewalks, where it should be free of rocks and foreign debris greater than 1 in. in diameter. Transported topsoil should closely match the texture of the original topsoil.

Topsoil shall be spread to a depth of 3 in. for seedbed preparation. Slopes greater than 3:1 should be benched or ripped prior to topsoil placement. Topsoil should be minimally compacted based on Proctor density measurements, with final depth determined by the designer. Prior to topsoil placement, surfaces should be loosened mechanically to aid in bonding of the topsoil to the existing soil material. For granular subsoils, a transition zone should be created where up to half of the desired topsoil is placed and incorporated into the subsoil prior to final placement of the remaining topsoil. A nongranular topsoil material should be used for creating a transition zone. This transition zone improves root penetration and reduces shearing.

3.1.2 Soil Chemical Properties

Illinois currently has no specification for soil testing of topsoil for use in seeding areas. Illinois currently requires that pH of topsoil be between 5.0 and 8.0 (IL DOT 2012, Section 1081.05). Agricultural ground limestone should contain particles of a size such that all material pass through a #4 sieve and is graded relatively uniformly through #8, #30, and #60 sieves (IL DOT 2012, Section 1081.06).

Illinois currently requires that fertilizer be ready-mixed of an analysis specified in the plans, with the name and address of the manufacturer; the name, brand, or trademark; the number of net pounds of material; chemical composition; and guarantee of analysis on the package (IL DOT 2012, Section 1081.08).

Although soil testing may require better planning to collect soils, have them analyzed, interpret the results, and use the information when needed for roadside-management activities, the increased cost for soil sampling should be recouped easily through reductions in excessive and unnecessary application of soil amendments and improved quality of vegetation. A soil probe is the most accurate equipment for obtaining soil samples, although an auger or spade can be used if carefully operated to obtain a consistent depth and volume of samples (Fernandez and Hoeft 2009). For each soil sample collected, five subsamples 1 in. in diameter and 7 in. deep should be collected (Fernandez and Hoeft 2009). For roadsides, the samples should be evenly placed along the area to be sampled, with samples collected 500 ft from one another. Sample placement should be reduced if visible changes in soil are encountered, to ensure inclusion of these differences. Samples should be labeled in such a way as to denote where each sample was taken for future application of results. For intact topsoil sources, three samples are to be collected from each acre in the same manner as for roadsides. For stockpiled topsoils, three samples representative of the entire pile should be taken from the interior of the pile (greater than 6 in. deep). Soil testing should be conducted on all topsoil sources to identify herbicide residues, texture, pH, plant macronutrients (NPK), and total organic carbon—to provide recommendations to alleviate pH deficiencies that are outside the range of 6 to 7, with a target pH of 6.5.

Lime application should be based on a target pH of 6.5. Soil testing should be required to ensure liming is adequate but not excessive. Lime should be of an acceptable quality (texture and neutralizing value), and application rates should be adjusted based on the neutralizing power.

Fertilizing introduced seed mixes should be adequate to support a healthy plant population but not excessive to the point that it is easily lost from the topsoil. Application rates should be based on soil testing and likely in the range of 50 to 100 lb/ac nitrogen. Lower amounts should be applied if seed-mix components contain legumes, with no nitrogen recommended for introduced grass

pastures in Illinois if legumes comprise at least 30% of the total mix or 50 lb/ac nitrogen if legumes comprise 20 to 30% of the mixture (Fernandez et al. 2009). Following establishment, plantings should be fertilized as needed in subsequent years if visual signs of deficiency are present. A single fertilizer application of 50 to 100 lb/ac nitrogen, with similar phosphorus and potassium content, should be performed during the growing season.

Fertilizer additions should be restricted in areas to be seeded to native plant species. Native grassland soil nitrogen levels should be around 20 to 40 lb/ac, phospohorus levels should be around 10 to15 ppm, and potassium levels should be around 100 to 150 ppm (Munshower 1994). High phosphorus levels negatively affect arbuscular mycorrhizal fungi, which many native prairie plants are dependent on (see Section 3.1.3, Soil Biological Properties) (Hoeksema et al. 2010; Wilson and Hartnett 1998). Once plants are established (no earlier than the second growing season), low-level fertilizer additions can improve prairie plant health and reduce invasions. A single application of 40 to 60 lb/ac nitrogen to existing prairies should be performed in the second, third, or fourth growing season once adequate establishment has been attained. This fertilizer should also include potassium at a similar content to nitrogen but include little or no phosphorus. A slow-release fertilizer is preferred over highly available forms to reduce nitrogen losses from the soil and use by weeds.

For saline soils, salinity should be determined with a soil test, and gypsum applied in the fall at a rate dependent on the soil salinity. Gypsum should be incorporated into the soil to a depth of 4 to 6 in.

3.1.3 Soil Biological Properties

Illinois currently requires that topsoils have an organic content between 1 and 10%(IL DOT 2012, Section 1081.05). Compost should be thoroughly decomposed organic waste produced at an Illinois EPA-registered compost facilty, should have no glass or metal shards present, should have no plastic or other synthetic material larger than 1/4 in. or greater than 1%of total dry weight, should be capable of supporting and germinating vegetation; test results complying with Illinois EPA standards should be provided to the engineer with each shipment (IL DOT 2012, Section 1081.05). Illinois EPA standards require that compost also have a pH between 6.5 and 8.5, reach stability as demonstrated by either a temperature stability test or a germination test, meet pathogen density requirements, and meet limits for heavy metals (IAC Title 35 Part 830, 1994).

Illinois currently requires that all legumes (with only clover and alfalfa specified) be inoculated with the proper bacteria in the amounts and manner recommended by the manufacturer of the inoculants before sowing or being mixed with other seeds for sowing (IL DOT 2012, Section 250.06). Inoculated seed should be sown as soon as possible after inoculation, and any seed standing more than 24 hours after inoculation should be reinoculated prior to sowing (IL DOT 2012, Section 250.06). If legumes are applied by a hydraulic seeder, three times the normal amount of inoculants should be used (IL DOT 2012, Section 250.06).

Organic carbon is important for healthy soils that support healthy plant communities. Topsoil should contain at least 4% total organic carbon. Adding carbon amendments, such as composts, to soils lacking topsoil can improve numerous soil traits. Compost quality guidelines should be improved (see http://compostingcouncil.org/tmecc/) and should include salt content, particle size, pathogen density, organic matter and moisture content, heavy metals, inert material, nutrients, and two measures of compost maturity (one that tests biological stability—Dewar self-heating, oxygen uptake, or carbon respiration; and one that tests phytotoxicity—ammonia, ammonia:nitrate ratio, volatile organic acids, or root elongation). Because root elongation is much more sensitive to phytotoxic substances than germination, a germination test should not be utilized (Woods End 2000). Samples for analyses should be taken from each stockpile equally from the base, surface, and interior and combined into a composite sample. C:N ratio would also be useful for determining

the amount of fertilization required. Compost used as mulch for native vegetation should not be added above a maximum depth that restricts growth of seedlings. If compost is incorporated, greater volumes should be used and incorporated into the top 4 to 6 in. of existing soil, with a lesser amount reserved for the mulch.

Amendments with a high C:N ratio (straw, wood chips, sugar, etc.) can be effectively added to nutrient rich soils to decrease nitrogen availability. This technique, known as soil impoverishment, can be used to improve native prairie establishment by reducing weed growth.

All legume seeds, native and introduced, require rhizobial inoculants. Inoculants must be of proper nodule-forming, nitrogen-fixing bacterial species for each legume species planted. Label directions should be followed for all inoculant products, and products should not be more than 1 year old. Inoculants should be applied to seed no more than 24 hours prior to use, and inoculated seeds should not be exposed to direct sunlight for more than 30 minutes. Legumes should not be applied using a hydroseeder but rather packaged, blended, and seeded separately using other means. When dormant- or interseeding legumes, inoculant survival might be improved by inoculating the cover crop that is established prior to legume seeding (i.e., wheat, annual ryegrass, or other), as inoculants are free-living soil organisms that can colonize the root surfaces of nonlegumes. Further, because both cover crops and inocula require burial, no conflicts will arise due to requirements to minimize sunlight exposure in inocula while ensuring legumes are seeded at or near the soil surface. This practice might also allow for increased use of legumes in dormant seedings or other seedings without concerns over proper inoculant treatment where seed burial is not possible.

Other components of the soil microbial community are important to plant establishment, especially native plant species, but may be absent from disturbed soils. Many native plant species depend on arbuscular mycorrhizal fungi and require these soil microbes for successful establishment. However, commercial inoculants may not be effective. Collecting soils from existing native plant communities and applying this soil to the new site can add these and other beneficial soil microbes to seeded prairie sites. Exact quantities of soil to collect are not known, but any amount could be beneficial. The amount collected should minimize disturbance to the source site but provide as much inoculum as possible. Inoculated soils should be collected within 48 hours of placement and be placed on the new site prior to seedbed preparation to allow mixing of the source soil with the upper inches of the existing soil prior to seeding. Stockpiled soils should be maintained in such a way as to preserve microbial diversity. Stockpiled topsoil to be used for native plant establishment should be seeded with a cover crop if final seeding will not occur for more than 3 months. Cover crops should include grasses and a legume (such as soybean) to provide a suitable suite of host plant species to maintain soil microbial diversity.

3.2 SEED SELECTION AND QUALITY

3.2.1 Seed Labeling

Illinois currently requires that each seed bag be tagged or labeled (IL DOT 2012, Section 1081.04).

Seed labels for Illinois should provide genus, species, and common name, as well as the state of origin and bulk weight of material. For special mixes, the genetic origin of seed should be required. Labels should not be handwritten. Seed analyses should be conducted by a certified seed analyst or a registered seed technologist, with the date of testing marked on the label. Testing should include purity, moisture, seed weight, and viability. Purity should be expressed as a percentage of the entire sample and also include weight by percentage of inert matter, other seeds, and noxious weeds by weed species (for Illinois noxious weeds, see www.agr.state.il.us/Laws/Regs/8iac220.pdf.) Noxious weeds in Illinois whose presence should not be tolerated in any quantity include common ragweed (*Ambrosia artemisiifolia*) if used within corporate limits, giant ragweed (*Ambrosia trifida*) if used within corporate limits, marijuana (*Cannabis*

sativa), musk thistle (*Carduus nutans*), Canada thistle (*Cirsium arvense*), kudzu (*Pueraria montana*), perennial sowthistle (*Sonchus arvensis*), Columbus grass (*Sorghum almum*), and johnsongrass (*Sorghum halepense*). Other weeds whose presence should not be tolerated in any quantity include spotted knapweed (*Centaurea stoebe*), teasel (*Dipsacus fullonum* and *D. sylvestris*), leafy spurge (*Euphorbia esula*), Sericia lespedeza (*Lespedeza cuneata*), Japanese stiltgrass (*Microstegium vimineum*), reed canarygrass (*Phalaris canariensis*), and giant reed (*Phragmites australis*). Moisture should be expressed as a percentage. Seed weight should be expressed as seeds per pound. Viability should be expressed as a percentage and include percentage dormant and hard seeds. Seed labels should also contain pure live seed ratings, which are calculated by multiplying the percentage purity of the desired seed times the percentage viability of the desired seed.

3.2.2 Seed Quality

Illinois currently requires that each lot of seed, except prairie forbs, be tested by a state agricultural department or land-grant college or university agricultural section or by a registered seed technologist (IL DOT 2012, Section 1081.04). Seed should be packed in suitable bags and stored in an approved weatherproof building to protect it from deterioration (IL DOT 2012, Section 1081.04). Seeds should be guaranteed to be true to name and variety, to be from the origin specified, to be free of primary noxious weeds, and to contain no more than the maximum number per ounce of secondary noxious weeds (IL DOT 2012, Section 1081.04). Seeds having a purity below that specified (at least 90%, varies by species) and any sample containing more than 5% by weight of seed of other cultivated plants will be rejected (IL DOT 2012, Section 1081.04). For prairie forbs, a description will be provided that includes the name and location of the seed supplier, the origin and date of harvest, a statement of purity and germination, and the estimated seeds per pound (IL DOT 2012, Section 1081.04).

Illinois should develop a set of standards similar to other states' for every plant species approved for use on Illinois roadsides, including minimum purity and germination requirements and limits on dormant seed composition for species with excessive dormancy. Testing of all seed should be required (see Section 3.2.1, Seed Labeling.). A requirement that all seeds be tested for viability and be used within 1 year after seed testing is performed would ensure that new seed is used or that older seed is still of an acceptable quality.

3.2.3 Seed Sources

Illinois currently requires that alfalfa shall be grown in Kansas or farther north (IL DOT 2012, Section 1081.04).

Seed should be purchased only from suppliers registered or certified by the State of Illinois, with preference given to suppliers located in Illinois. A yellow tag source–certification system should be implemented to identify local origins of native seed and the location where the seed was grown. Seed sources for each native species used on IDOT projects should be identified in Illinois using this type of certification, with generation 0 locations identified at the county level and one level lower (specific location within the county). A database of native plant species and generation 0 source locations should be developed with a list of all commercially available in-state sources. Gaps should be filled in by commercial seed producers to increase availability of ecotypes, and priority should be given to these seed sources to promote availability of local ecotypes. Local sources of native seed should be sought from private landowners, government agencies, nonprofit conservation organizations, and other environmental stewards to increase availability of local ecotypes for commercial growers. Generation 0 seed from protected nature preserves should not be accepted unless a permit has been issued.

If ecoregions are developed for Illinois, priority seed sources should be from generation 0 collections from remnant populations in each ecoregion. In the absence of these sources, or if

ecoregions are not developed, generation 0 collections from Illinois should be prioritized, with preference given to sources within 50 mi of the seeding site. In the absence of these sources, collections from within 50 mi of Illinois should be prioritized. In the absence of these sources, other sources should require approval for use and be restricted to within 100 mi north of the northern border or south of the southern border, and within 200 mi east of the eastern border or west of the western border.

For remnant prairies and other critical areas, a 1/2-mi buffer should be established around the area. Inside the buffer, the only authorized native vegetation should be seed collected directly from the remnant by qualified natural resources personnel, or from a source authorized by a qualified expert (i.e., Illinois Nature Preserves Commission, Illinois Department of Natural Resources, or other entity).

3.2.4 Ecoregions

Ecoregions were developed for Illinois using criteria similar to those for developing ecoregions for Iowa and Minnesota (Figure B5). Level III ecoregions developed by the USEPA (Figure B1) served as the basis for the ecoregions. Additional factors that were considered in developing the ecoregions were soils (Figure B2), IDOT districts (Figure B3), and plant hardiness (Figure B4). From these criteria, four ecoregions are proposed (Figure B5).

The first, Northern Illinois Drift Plains, includes all of IDOT district 1 and portions of districts 2 and 3. This ecoregion encompasses the Driftless Area of northwestern Illinois, the Southeastern Wisconsin Till Plains of extreme northern Illinois, the Rock River Hills, the Chicago Lake Plain, the Kankakee Marsh, and portions of Illinois/Indiana Prairies. Soils in this ecoregion contain numerous areas developed from glacial drift. This ecoregion contains the entire area of Illinois in plant hardiness zone 5a.

The second, the Western Illinois Till Plain, includes portions of IDOT districts 2, 4, 6, and 8. This ecoregion encompasses the Upper Mississippi Alluvial Plain, River Hills, and Western Dissected Illinoian Till Plain. Soils in this ecoregion are comprised primarily of loess.

The third, the Eastern Illinois Prairies, includes all of IDOT district 5, and portions of districts 3, 4, 6, and 7. Soils in this ecoregion are highly variable, with large areas of glacial drift, outwash, loess, and sands.

The fourth ecoregion, the Southern Illinois Till Plain, includes all of IDOT district 9, and portions of districts 7 and 8. Soils in this ecoregion are comprised primarily of loess. This ecoregion contains the entire area of Illinois in plant hardiness zones 6b and 7a.

Ecoregions were developed in such a way that distances between ecoregions would allow use of plant materials in neighboring ecoregions. Source material from ecoregions 2 and 3 are usable in all ecoregions of the state, while ecoregions 1 and 4 should not use source seed from the other respective ecoregion, as their closest boundaries are approximately 100 mi apart latitudinally.

3.2.5 Native Seed Mixes

Illinois currently uses two distinct slope mixtures (3 and 3A), a native grass mix (4), a low-profile native grass mix (4A), a wetland grass and sedge mix (4B), a forb with annuals mix (5), a large-flower native forb mix (5A), a wetland forb mix (5B), a conservation mix (6), and a salt-tolerant conservation mix (6A) (IL DOT 2012, Section 250.07). The composition of these mixes is provided in Appendix E.

As each state has developed native mixes unique to its specific environmental conditions and needs, the same has been done for Illinois. Some states (including Illinois) have very numerous, complex mixes that likely create difficulties in determining where each is to be placed on the

landscape. Further, availability of seed could become an issue with numerous specialty forbs, sedges, and other native species that are not commonly commercially available. Other states have developed simplistic native mixes that are universally applicable to the roadside environment. A list of the traits for Illinois native plants is provided in Tables C1 toC3. County distribution information was obtained to determine which species are already most common across Illinois (Mohlenbrock and Ladd 1978). Wetland status information was obtained from Taft et al. (1997) and USDA, NRCS (2012). Habitat information was obtained from *Guide to the Vascular Flora of Illinois* (Mohlenbrock 1986). For determining growth requirements, coefficients of conservatism were obtained (Taft et al. 1997). Coefficients of conservatism rank species on a scale from 0 to 10, with 0 being a weedy colonizer of bare soil and 10 being a rare plant with very specific environmental requirements (Taft et al. 1997). Plant taxonomic information, lifespan, and salinity tolerances were obtained from the PLANTS Database (USDA, NRCS 2012). Plant height and flower color information were obtained from plant taxonomic literature (Hitchcock 1971; Great Plains Flora Association 1986). Herbicide resistance to the most commonly used broad-spectrum herbicides was compiled through a literature review, summarized in Table C3.

Illinois currently has a complex assemblage of 10 native plant mixes. Some of these appear redundant and unnecessary. The two slope mixtures and two conservation mixes are likely unnecessary, as they could easily be combined to create two or three widely applicable mixes. The only difference between conservation mix 6 and salt-tolerant conservation mix 6A is the inclusion of saltgrass, an obligate wetland plant not native to Illinois. As many native grasses are tolerant to soil salinity, a conservation mix comprised of these species would negate the need for 6A. Further, as many of these same species are present in both mix 6 and the slope mixes (3 and 3A), they could be combined as well. Because slopes are difficult to maintain mechanically, herbicide use is the preferred method to control undesirable vegetation. As most of the grasses already in use in these mixes are tolerant of some of the most commonly used herbicides for weed control in prairie vegetation, simply combining species with these traits and those with salt tolerance makes simplifying seed mixes much easier. As pure grass plantings often leave niche openings for weedy forbs to occupy and do not provide nitrogen fixation to keep the planting healthy, these mixes will require a component of forbs and legumes (or routine herbicide application) to perform these services.

Native plants tolerant to aminopyralid are all perennial native grasses, pale purple coneflower, showy goldenrod, and sky blue aster. Native grasses tolerant to imazapic throughout their lifespans are big bluestem, broomsedge, buffalograss, slender wheatgrass, little bluestem, and indiangrass. Native grasses that can be suppressed during the seedling stage, but that otherwise appear tolerant, are sideoats grama, switchgrass, and threeawn species. Native grasses that appear intolerant of imazapic are the wildryes (Canada, Virginia, silky), bottlebrush grass, prairie cordgrass, prairie dropseed, and Junegrass (Diboll 2012a). Legumes tolerant to imazapic include partridge pea, Illinois bundleflower, prairieclovers, leadplant, and wild senna. Legumes that can be suppressed during the seedling stage, but that otherwise appear tolerant, are tick trefoils and bushclovers. Forbs that appear tolerant to imazapic include lanceleaf coreopsis, black-eyed susan, and purple coneflower. Many forbs have information on tolerance to imazapic once established but no information about tolerance as seedlings (Barnes 2007). The forb species exhibiting tolerance once established include butterflyweed, New England aster, bonesets, false boneset, sneezeweed, woodland sunflower, spotted St. John’s wort, prairie blazingstar, palespike lobelia, wild bergamot, evening primrose, wild quinine, downy phlox, false dragonhead, slender mountain mint, yellow coneflower, brown-eyed susan, prairie dock, gray goldenrod, showy goldenrod, sky blue aster, wingstem, and tall ironweed.

Plants tolerant to imazapic and salt are big bluestem, broomsedge, buffalograss, indiangrass, slender wheatgrass, white prairieclover, and purple coneflower. Plants tolerant to

imazapic and salt when established are sideoats grama, switchgrass, sneezeweed, and prairie blazingstar. Plants tolerant to imazapic but intolerant to salt are little bluestem, purple prairieclover, wild senna, Illinois bundleflower, lanceleaf coreopsis, and black-eyed susan. Plants tolerant to salt but intolerant to imazapic are Canada wildrye and prairie cordgrass. Plants tolerant to salt but lacking imazapic tolerance data are false aster, pale purple coneflower, Missouri goldenrod, foxglove beardtongue, and white sage. Plants tolerant to imazapic with no salt data are partridge pea and leadplant. Plants tolerant to imazapic when established, but with no salt data, are tick trefoils, bushclovers, false boneset, palespike lobelia, evening primrose, wild quinine, false dragonhead, slender mountain mint, prairie dock, and wingstem.

The following changes are recommended to IDOT's existing native seed mixes, based on comparisons of existing seed mix components to the species listed in Tables C1 to C3 for factors such as distribution, habitat, conservatism, phylogeny, height, lifespan, and herbicide and salt tolerance:

3.2.5.1. Recommendations for All Native Seed Mixes

The primary drawback to using native seed mixes is the slow establishment time and requirement that roadsides achieve 70% vegetative cover in the short term. This condition necessitates the need for cover crops, but these cover crops must not reduce the establishment of seeded native species. Several cover crops currently in use are too competitive.

3.2.5.2. Mixes 3, 3A, 6, and 6A

Combine these mixes into two or three widely applicable mixes, based on height, salt and herbicide tolerance, and phylogeny. **Slope mix** (wide distribution, phylogenetically diverse, tolerance to imazapic): big bluestem, indiangrass, little bluestem, switchgrass, broomsedge, white prairieclover, partridge pea, prairie blazingstar, butterflyweed, black-eyed susan, and wild bergamont. Canada wildrye should be added to this mix (although tolerance to imazapic is questionable) to include a widely adapted native cool-season grass to the mix. **Low-grow slope mix** (short stature, wide distribution, phylogenetically diverse, tolerance to imazapic): little bluestem, broomsedge, buffalograss, sideoats grama, white prairieclover, partridge pea, black-eyed susan, and slender mountain mint. Junegrass should be added to this mix (although tolerance to imazapic is questionable) as it is the only native short-statured cool-season bunchgrass that is distributed across Illinois. **Low-grow, salt-tolerant mix** (short stature, wide distribution, phylogenetically diverse, salt-tolerant): broomsedge, buffalograss, sideoats grama, partridge pea, white prairieclover, white sage, foxglove beardtongue, and pale purple coneflower. No native cool-season grass worthy of consideration is short-statured, widely distributed in Illinois, and has salt tolerance. Because most roadside areas receiving road salt are in areas that are normally mowed for safety, a low-grow native salt-tolerant mix may be unnecessary. A regular salt-tolerant mix could easily be created as well if desired or needed. Any of these mixes could be used for a variety of conservation purposes and (because grass composition comprises the majority of these mixes) could be used where predominantly native grasses are desired.

Another potential mix could be specifically designed for areas near airports to reduce habitat for birds and safety risks associated with bird–aircraft strike hazards. Little bluestem is tolerant to both imazapic and aminopyralid, does not achieve the heights of other widely used native grasses, and lacks shoot strength to support most bird nests.

3.2.5.3. Mixes 4, 4A, and 4B

For all native seed mixes, increase annual ryegrass to 50 lb/ac and remove oats and/or wheat for fall seeding. Sideoats grama could also be used as a component of seed mixes for fall seeding to aid in establishment of cover. Another alternative for fall seeding could be Regreen, a sterile wheat–wheatgrass hybrid, although its costs are higher than for other cover crops. For spring seeding,

annual rye should be reduced to 10 lb/ac; and oats should be increased to 50 to 60 lb/ac. Perennial ryegrass should be removed completely from all native seed mixes, as it is too competitive and often inhibits native grass establishment. An alternative is to use red top (*Agrostis alba*) at a rate of 1 to 4 lb/ac and one or more of Canada wildrye (*Elymus canadensis*), slender wheatgrass (*Elymus trachycaulus*), and Virginia wildrye (*Elymus virginicus*) at a total rate of 2 to 3 lb/ac.

3.2.5.3.1. Mix 4

No changes are recommended to this seed mix, with the exception of the previously noted alterations to the cover crop species.

3.2.5.3.2. Mix 4A

Sporobolus heterolepis should be removed from the mix and replaced with purpletop (*Tridens flavus*) and buffalograss (*Buchloe dactyloides*). *Tridens flavus* should be added at a rate of 0.5 lb/ac, and *Buchloe dactyloides* should be added at a rate of 1 lb/ac. These species will not become dominant but rather fluctuate in density to become more or less prevalent during wet and dry years, respectively. An alternative to *Tridens flavus* in southern Illinois could be *Paspalum floridanum*, a mesic warm-season perennial grass native to the south.

3.2.5.3.3. Mix 4B

Many species currently in this mix have restricted distributions across Illinois. Further, phylogenetic diversity is low, as the same genera are repeatedly used. *Sparganium eurycarpum* and *Acorus calamus* should be moved from 5B to this mix, as they are not forbs, fit in the grass and sedge mix better, and increase phylogenetic diversity in this mix.

3.2.5.4. Mixes 5, 5A, and 5B

3.2.5.4.1. Mix 5

Several species in this mix are poor performing, including *Liatris* and *Petalostemum* species, due to vole predation. *Liatris aspera* and *L. pycnostachya* should be removed entirely.

Annuals: *Chrysanthemum maximum* (shasta daisy), *Gaillardia pulchella* (blanketflower), and *Ratibida columnifera* (long-headed coneflower) should be replaced with *Chamaecrista fasciculata* (partridge pea) and *Oenothera biennis* (evening primrose).

Perennials: Several existing species are expensive (based on a survey of current midwestern prices at five large growers) and can easily be replaced with cheaper species. *Anemone cylindrica* (thimble weed), *Physostegia virginiana* (false dragonhead), and *Veronicastrum virginicum* (Culver's root) were consistently much more expensive than the other species, while *Asclepias tuberosa* (butterflyweed), *Baptisia leucantha* (white wild indigo), and *Helianthus mollis* (downy sunflower) had highly variable prices. Potential substitutes *Eupatorium altissimum* (tall boneset), *Penstemon digitalis* (foxglove beardtongue), *Vernonia missurica* (Missouri ironweed), and *Zizia aurea* (golden alexanders) are much more cost-effective as substitutes. *Dodecatheon meadia* (shooting star) was recommended as a possible alternative but was consistently the most expensive seed (> $1,200 per lb) that was observed. Table 2 presents the recommended species, sorted by seed size.

3.2.5.4.2. Mix 5A

The goal of this mix is to provide a cost-effective and large-flowered mix. Recommendations are to remove *Liatris pycnostachya* and *Helianthus mollis* because of establishment failures and to add *Chamaecrista fasciculata* (partridge pea)*, Penstemon digitalis* (foxglove beardtongue), *Vernonia missurica* (Missouri ironweed), and *Zizia aurea* (golden alexanders).

The new recommended mix: *Chamaecrista fasciculata* (partridge pea) (5%), *Echinacea pallida* (pale purple coneflower) (10%), *Heliopsis helianthoides* (oxeye sunflower) (10%), *Penstemon digitalis* (foxglove beardtongue) (10%), *Ratibida pinnata* (yellow coneflower) (5%), *Rudbeckia hirta* (black-eyed susan) (10%), *Silphium laciniatum* (compass plant) (10%), *Silphium terebinthinaceum* (prairie dock) (15%), *Symphyotrichum novae-angliae* (New England aster) (5%), *Vernonia missurica* (Missouri ironweed) (10%), and *Zizia aurea* (golden alexanders) (10%).

3.2.5.4.3. Mix 5B

Acorus calamus and *Sparganium eurycarpum* are more grasslike, and suitable for the wetland grass and sedge mix (4B). *Polygonum pensylvanicum* and *lapathifolium* are weeds that are most likely already in the seed bank and constitute species that are normally reduced through planting of desirable vegetation. Several species are restricted geographically in Illinois or just uncommon.

Table 2. Recommended Mix 5

Large-Seeded Species (< 300 Seeds g^{-1})		**Small-Seeded Species (800–2,000 Seeds g^{-1})**	
Silphium laciniatum	23[a]	*Vernonia missurica*[b]	832
Silphium terebinthinaceum	35	*Ratibida pinnata*	991
Baptisia leucantha	70	*Rudbeckia subtomentosa*	1515
Chamaechrista fasciculata[b]	132	*Eupatorium altissimum*[b]	1762
Asclepias tuberosa	152		
Echinacea pallida	209	**Very-Small-Seeded Species (> 2,000 Seeds g^{-1})**	
Heliopsis helianthoides	222	*Aster laevis*	2200
Helianthus mollis	247	*Solidago rigida*	2222
Parthenium integrifolium	247	*Aster novae-angliae*	2325
Eryngium yuccifolium	264	*Monarda fistulosa*	2643
Tradescantia ohiensis	282	*Aster azureus*	2800
		Oenothera biennis[b]	3083
Medium-Seeded Species (300–800 Seeds g^{-1})		*Rudbeckia hirta*	3304
Coreopsis palmata	352	*Penstemon digitalis*[b]	4400
Zizia aurea	388	*Potentilla arguta*	9700
Amorpha canescens	497		
Petalostemum purpureum	528		
Coreopsis lanceolata	660		
Petalostemum candida	670		

[a]Estimated seeds g^{-1}
[b]Denotes recommended species

3.2.6 Substituting Species in Seed Mixes

Illinois currently allows variation in the class 4 and 5 mixes with the approval of the engineer, providing the changes, reasons for change, and name of the seed supplier are provided (IL DOT 2012, Section 250.07).

With Illinois's extensive list of native forbs and sedges used in seed mixes, it would be useful to provide an alternative species list for use when specified seed is unavailable. To ensure proper composition of seed mixes, each species used in mixes with uncertain availability should be assigned to a group, with each group having acceptable alternates of similar function. For example,

species in *Asteraceae* used in standard native plantings could be grouped with alternative species in this family that grow in the same type of environment; and wetland sedges and rushes in the family *Cyperaceae* could be grouped in a similar fashion with alternative wetland species in *Cyperaceae*. Useful information for native species common in Illinois for development of alternatives is provided in Table C1. Alternatives could be pulled from this list, matched to species in mixes, and provided as alternatives to specific species or groups of species for each individual native seed mix or as substitutes as a whole.

3.2.7 Landscape Position of Seed Mixes

Illinois does not currently specify where placement of specific native seed mixes should occur. An 8-to-5-ft safety zone should be common to all roadsides, medians, and interchanges. Along rural roadsides and interchanges, all areas with greater than 2.5:1 slopes and areas that lie outside the 8-ft strip should be planted to native vegetation (prairie, wetland, or forest as desired) unless additional mowing is necessary for safety or if adjacent property is maintained as turf. Areas outside the 8-ft strip requiring additional maintenance should be maintained in a similar fashion to the shoulder strip. Slope mixes should be placed on all slopes greater than 3:1. Temporary mixes should be used on any disturbed soils that will not be permanently seeded for at least 2 weeks. Salt-tolerant vegetation should be planted near road surfaces and ditches and other low-lying areas where road runoff accumulates. Turf-type or other mowing-tolerant mixes should be used in areas where mowing is necessary for safety or aesthetics. Most turf-type mixes should also be salt-tolerant because of their proximity to road surfaces. Because the goal of using native vegetation is to reduce maintenance requirements, any areas that do not require mowing for safety or aesthetic purposes should be planted to some type of native seed mix. To improve aesthetic value, all native mixes should include a native wildflower component to the extent possible. Native wetland mixes should be used in and around ditches and other low-lying areas. Native low-growing mixes should be used in areas where tall vegetation is not desired but where mowing is not easily or safely performed. For aesthetic blending of roadsides, the area just outside the mow area should be planted to low-growing native vegetation, with taller native vegetation planted between this mix and the right-of-way. Tall native vegetation planted along the right-of-way can also serve as snowbreaks if left standing through the winter.

3.3 SEED APPLICATION

3.3.1 New Construction

Illinois currently requires that seeding class 3 (slope mixes) may be sown with a hydraulic seeder, class 4 (grass mixes) with a rangeland-type grass drill, class 5 (forb mixes) with a hydraulic seeder or rangeland-type grass drill, and class 6 (conservation mixes) with a machine that mechanically places the seed in direct contact with the soil, packs, and covers the seed in one continuous operation, unless otherwise specified by the engineer (IL DOT 2012, Section 250.06). Broadcast or hydraulic seeding will be allowed as approved by the engineer on steep slopes (over 1:3) or in inaccessible areas (IL DOT 2012, Section 250.06). When broadcast seeding is used for classes 3 or 4, the species comprising the mix will be sown separately (IL DOT 2012, Section 250.06). All equipment should be approved by the engineer prior to use, and prior to any work all seeders should be calibrated and adjusted to sow seeds at the required seeding rate (IL DOT 2012, Section 250.07). The engineer must be notified 48 hours prior to seeding so that trial runs can be used to determine if calibration of the seeder will provide uniform distribution at the specified rate (IL DOT 2012, Section 250.07). When seed is applied using a hydraulic seeder, the application rate should be not less than 1,000 gal/ac, and fertilizer and seed should be applied in separate operations (IL DOT 2012, Section 250.07).

Illinois currently does not specify depth for native plant seedings.

Illinois currently specifies that for slope mixes (class 3), the planting time should be April 1 to June 15 and August 1 to November 1 in districts 1 through 6, and March 1 to June 1 and August 1 to November 15 in districts 7 through 9 (IL DOT 2012, Section 250.07). For grass (class 4) and forb (class 5) mixes, the planting time should be May 15 to June 30 and October 15 to December 1 (IL DOT 2012, Section 250.07). Class 6 (conservation mixes) have no timing specification. No seed should be sown during high winds or when the ground is not in a proper condition for seeding (IL DOT 2012, Section 250.07).

Compaction from equipment operations should be tilled prior to seeding. For seeding nonnative seed mixes, a seed drill, cyclone seeder, or hydroseeder should be used. Seed drills should contain two separate boxes, one for large seeds and one for legumes and other smaller seeds; each box should be independently calibrated. Drills should plant seeds at the proper depth, with a maximum row spacing of 8 in., and should smooth the soil over the seeds. Cyclone seeders for broadcast seeding should have an agitator to keep seed properly mixed. Hydroseeders should be used only for steep slopes or areas inaccessible to seeders and should use at least 500 gal of water/ac with 75 lb/ac of hydromulch. Hydroseeding should not be conducted when conditions are hot and dry. Seed should not be added to the hydroseeder more than 1 hour prior to seeding, and the hydroseeder should be emptied within an hour of adding seed. Hydroseeding should not be used for seeding native vegetation unless areas are inaccessible to other methods. If native vegetation must be hydroseeded, fall seeding will be required, and no tackifier is to be used. The preferred method for seeding native vegetation is with a rangeland drill. Rangeland drills should have a maximum row spacing of 8 in. and must have three seed boxes: a grain box for larger seeds, a native-seed box with picks fingers for bearded and fluffy seeds, and a fine-seed box for wildflowers and other small seeds. Each box should be independently calibrated. Rangeland drills must have a press wheel mounted directly behind each drop tube to firm the soil over planted seeds. Native vegetation should be drilled in two different directions to attain proper seed coverage and minimize rows in established vegetation. Fertilization should not be used with native plant seedings.

Following seed placement, sites should be harrowed or lightly raked, cultipacked, mulched at a rate of 2 t/ac and anchored. A disc does not properly anchor mulch, and requires a mulch tiller.

Introduced species should be planted at a maximum depth of 1/2 in. and minimum depth of 1/4 in. Large and/or fluffy seeds of native plant species should be planted at a maximum depth of 1/4 in. Small seeds of native wildflowers and other species should be planted at a maximum depth of 1/8 in. or applied to the surface. Switchgrass and purpletop seeds, because of their much smaller seed size, should be kept separate from other grasses and should be broadcast on the surface prior to drilling other species.

No seeding should be performed in windy weather. Only broadcast dormant seeding should be performed when soil is frozen, wet, or otherwise unsuitable for other seeding operations. Dormant seeding should be the preferred method for native wildflower establishment. For temporary mixes, wheat should be used from August 15 to November 1, oats from April 1 to July 1, and a warm-season temporary species such as Sudangrass should be used from May 15 to August 15. Dates could be altered to incorporate soil temperatures or frost dates. Annual rye or wheat should be used as a temporary mix on exposed, highly erodible soils even in late fall and throughout winter when conditions are suitable because of the low cost of seed and the importance of reducing erosion. Native plant species should be planted between March 15 and June 15 or dormant-seeded in the fall after soil temperatures at a 1 in. depth fall to 40°F or less. Soil should be prepared in the fall when conditions are suitable prior to dormant seeding.

3.3.2 Interseeding

Illinois currently specifies that prior to interseeding all areas of existing turf should be mowed one or more times to a height no more than 3 in., using equipment that is capable of completely severing all

growth at the cutting height, distributing it evenly over the mowed area, and not windrowing it or leaving it in a lumpy or bunched condition (IL DOT 2012, Section 250.06). Additional mowing may be required by the engineer on certain areas to disperse mowed material and allow seed penetration, but mowing will not be required within 1 ft of the right-of-way fence, in continuously wet ditches and drainage ways, on slopes greater than 1:3, or areas designated as not mowable by the engineer (IL DOT 2012, Section 250.06). Debris encountered that hamper the operation should be removed, and damage such as ruts or wheel tracks more than 2 in. deep should shall be repaired to the satisfaction of the engineer prior to seeding (IL DOT 2012, Section 250.06). All seeding classes should be interseeded using a rangeland-type grass drill with an interseeding attachment, except broadcast or hydraulic seeding will be allowed on steep slopes (1:3 or greater) or inaccessible areas (IL DOT 2012, Section 250.06). When broadcast seeders are used for classes 3 and 4, the individual species should be sown separately (IL DOT 2012, Section 250.06).

Managing existing vegetation depends on the type of vegetation and the seeding objectives. When existing vegetation is undesirable, broad-spectrum herbicide application with mowing or repeated disking is recommended. A combination of mowing and herbicide application will kill existing vegetation and newly germinated seedlings if enough time is allowed (10 to 14 days) between the initial treatment and follow-up treatments. If vegetation persists, another herbicide application can be made after an additional 10 to 14 days. When seeding into temporary seed mixes, mow the existing vegetation to a maximum height of 4 in., with herbicide applied if the vegetation is too dense to allow proper interseeding. Interseeding into existing vegetation without soil tillage should be used only when seeding with a rangeland drill or for dormant broadcast seeding.

If you are seeding into existing native vegetation, the site should be mowed to a height of 4 to 6 in. in the fall if you are performing a dormant seeding. If you are seeding in the spring, the site should be burned prior to seeding. In the absence of fire, the site should be mowed prior to seeding to a height of 4 to 6 in.

If you are seeding native vegetation into existing vegetation, a rangeland drill should be used. The drill should be equipped with coulters that slice through existing vegetation in front of furrow openers and with a packer assembly to compact soil over the furrows. Coulters should make furrows 1 in. wide by 1/2 to 1 in. deep that are directly in line with disc openers. Seed should be drilled with at least two passes in two different directions to reduce drill rows and improve seed coverage. In areas inaccessible to seeding equipment, broadcast seed with a cyclone spreader equipped with an agitator to properly mix seed. Following any seeding, sites should be harrowed or lightly raked, cultipacked, mulched, and anchored.

No seeding should be performed in windy weather. Only broadcast dormant seeding should be performed when soil is frozen, wet, or otherwise unsuitable for other seeding operations. Native plant species should be planted between March 15 and June 15 (or based on soil temperatures) or dormant-seeded in the fall after soil temperatures at a 1 in. depth falls to 40°F or less. Soil should be prepared in the fall when conditions are suitable prior to dormant seeding.

Timing native plant seeding to soil temperature would be more effective at limiting failures from adverse conditions while allowing greater flexibility throughout the year. The ideal temperature range for most native vegetation is 65° to 75°F, with lower germination also occurring in most species in the 55°-to-65°F range. Spring seeding should begin only when temperatures reach a desirable minimum level (likely in the 55°-to-65° range). Figures F1 and F2 provide average dates for 50° and 60°F spring soil temperatures at a depth of 4 in. Summer seeding should not be permitted after soil temperatures reach a maximum allowed, likely above 75°F, and should be resumed only once soil temperatures fall back into the desirable range similar to spring requirements. Fall seeding should cease before an adequate establishment window has closed.

Figure F3 provides the average first-frost dates in Illinois. Fall seeding cutoff dates should be a minimum of 2 to 4 weeks before these dates and well before soils reach temperatures at which germination is hindered. Figures F4 and F5 provide average dates for 50°F and 60°F fall soil temperatures at a depth of 4 in. Because legumes require an additional 2 to 4 weeks to establish compared to most other native vegetation, the cutoff date for seeding forb mixes that include legumes should be 2 to 4 weeks earlier than for grass mixes.

Seeding over existing vegetation in fall allows better seed–soil contact through the movement of soil during freeze–thaw cycles and removes dormancy in many species. Cover crops should be used for fall native seedings to stabilize soil. For seeding prairie vegetation into temporary cover crops, the cover crop is first established on disturbed soil as soon as possible (often during times of year unsuitable for prairie planting), with the native seed mixture installed the following fall or spring. For staggered seeding, forbs should be broadcast seeded in late fall or winter, native cool-season grasses should be drilled in late fall or winter, and native warm-season grasses should be drilled in later winter or early spring.

Cover crops should be selected based on the germination requirements suitable at the time of seeding to provide the quickest cover. Soybeans, prairie clover, or a *Desmodium* species should be added to provide an alternative host for soil microbes. Sudangrass can be used during the warmest periods of the growing season but if planted early can produce large amounts of biomass that can outcompete desirable vegetation and should be mowed regularly if heights exceed 2 ft. A possible alternative cover crop could be cup plant (*Silphium perfoliatum*). Brassicas should not be used as they are a preferred food source for deer and other wildlife.

3.3.3 Dormant (Frost and Snow) Seeding

Illinois does not currently specify requirements for dormant seeding, other than to allow slope mixes (class 3) to be planted until November 1 in districts 1 through 6, until November 15 in districts 7 through 9, and until December 1 for grass (class 4) and forb (class 5) mixes (IL DOT 2012, Section 250.07). Class 6 (conservation mixes) has no timing specification.

Any seedbed preparation should be conducted prior to soil freezing when conditions are appropriate. No fertilization should be used for dormant seedings. Dormant seeding should not be conducted before the soil temperature at a depth of 1 in. is consistently at or below 40°F in late fall or winter. Snow seeding should be conducted with a cyclone seeder or by hand. Snow seeding should be conducted only in areas where less than 4 in. of snow has accumulated, the snow has not formed a crust over the surface, and temperatures are above freezing or will be within 48 hours of seeding to allow seed to sink into melting snow. A dark-colored, inert material, such as grain husks or sand, should be added to seed when spreading to allow identification of seeded areas and increase snow melting around seed.

Minimum and maximum germination temperatures are lacking for most native vegetation. However, known minimum germination temperatures for desirable native species is around 60°F. Because some native plant seeds can germinate at temperatures in the 50s, using a 40°F rule for soil temperature should minimize any undesirable germination but could be adjusted upward.

3.3.4 Adjusting for Delays

Illinois does not currently specify what adjustments are required for planting delays.

Some of the required seeding dates should be revised to improve establishment. Limits accepted for fall end dates and spring start dates should be related to soil temperature or average frost date. However, seeding date restrictions for summer and early fall could be altered to compensate for hot, dry conditions by increasing the seed application rate, requiring contractors to remedy establishment failures, or through watering requirements. For a specific mix, the approved dates should be

identified, along with approved dates with increased application (and amount of increase) or watering required. For watering, water should be applied at a rate of 6,000 gal/ac within 24 hours of seeding, with an additional watering at the same rate within 7 to 10 days following the initial watering. A third application 7 to 10 days after the second should be applied as necessary. The second watering can be omitted if at least 1/2 in. of rain falls on the site at least 5 days after the initial watering, and the third watering omitted if at least 1/2 in. of rain falls on the site between 14 and 20 days after the initial watering. Watering should be applied to attain even coverage over the seeded site without dislodging seed.

3.4 MANAGEMENT OF ESTABLISHED VEGETATION

3.4.1 Mowing

Illinois currently specifies that selective mowing stakes be installed to delineate areas to be seeded or interseeded with class 4 (native grass) and 5 (native forb) mixes (IL DOT 2012, Section 250.08).

Random, uncontrolled mowing is likely the most destructive practice used to manage native vegetation. Not only does unnecessary mowing weaken desirable vegetation by removing biomass and exposing the soil surface to sunlight that encourages weed growth but it also actively spreads the weeds that overtake the native vegetation weakened by mowing. Mowing can be used effectively to promote native vegetation but can just as easily damage desirable vegetation and promote invasive plant growth. Mowing must be carefully controlled to avoid spreading weeds and damaging desirable vegetation. Compared to other Midwestern states' mowing guidelines, Illinois has a comprehensive policy. However, the lack of native prairie vegetation outside the roadside safety zone allows interpretation of guidelines to include excessive mowing of these areas. The Illinois Department of Transportation *Maintenance Policy Manual* repeatedly provides guidance, allowing mowing outside the shoulder area unless the area is planted with prairies, wildflowers, or seedlings (IL DOT 2002). As long as robust native plant communities are lacking in these areas (or delineations are ignored), mowing will continue to be used for control of unwanted vegetation. Established native vegetation provides numerous benefits, including reduced mowing requirements, reduced weed management and herbicide use, habitat for migratory birds and other wildlife, improved aesthetics, and living snow fences (MN DOT 2010). Therefore, a priority for the Illinois Department of Transportation should be to convert these areas into high-quality native prairie plantings to minimize the need for managing the entire right-of-way with excessive mowing. To help defray costs of native plant establishment, partnerships with local entities should be encouraged to assist with establishing and managing native vegetation.

Outside the safety strip, established native areas should be mowed or burned once every 2 to 3 years to manage weeds and woody vegetation. In areas where migratory bird impacts are to be kept to a minimum, mowing should occur only between July 15 and March 15, and only one shoulder on a given road should be mowed in any given year, to maintain adequate habitat corridors.

Newly planted native vegetation should be mowed repeatedly the first growing season to a minimum height of 6 in. to reduce weed competition. This guideline could require mowing every 30 days if growing conditions are suitable for vigorous weed growth but could be limited to three times during the growing season. The goal of mowing is not to achieve the look of turf but to remove aggressive weed biomass that has overtaken the smaller native seedlings. Mowing should be conducted as necessary when the height of weedy vegetation reaches a level that negatively impacts native seedling establishment (8 to12 in.). Do not mow at the end of the growing season. This does not provide any benefit and will likely spread weed seeds. No other weed treatments should be performed the first year, as they will be detrimental to establishing vegetation.

In the second growing season following planting, mow to a height of 8 in. prior to Memorial Day and to a height of 12 in. prior to July 4 (as needed) to remove weeds and promote native vegetation. If vegetation growth is too vigorous, mowing can kill vegetation if clippings form a thick cover of the site. If mowed vegetation is more than 2 ft in height, baling should be used to remove the clippings. In the third year, burn in midspring if possible. Otherwise, mow to a height of 6 in. once cool-season grasses green up. Spot treatment of weed infestations can be performed; however, care must be taken not to kill establishing native vegetation.

In the third year, burning or mowing should be conducted in midspring. When used as a substitute for fire, mowing should be performed once during the growing season in midspring and is most effective when combined with baling of the mowed biomass. In following years, burning should be conducted every 2 to 3 years. In the absence of burning, mowing should be conducted only as necessary to control weed outbreaks or as a substitute for fire. A schedule where one-third of a seeded area is burned or mowed per spring on a rotation should be implemented for a variety of reasons, including improved aesthetics, habitat for birds and insects, and disrupting life cycles of undesirable vegetation. When used to control weeds, mowing should be used only to minimize seed set, depending on the specific types of weeds present and required timing. To distinguish between new, year-old, 2-year-old, and established prairie plantings, a color coding for signs marking prairie plantings could be useful to prevent overmowing areas and indicate which areas require which management activities without the requirement that employees know the site history.

All equipment (vehicles, mowers, tillage implements) should be thoroughly cleaned before transporting to and after operation in a site (sites should be clearly defined, to include construction sites as well as boundaries for mowing activities, such as township, specific station boundaries, etc.). Knowledge of weeds should be improved, so that employees engaged in mowing operations are familiar with weed identification, biology, and factors affecting spread and control. Weed patches should be mowed before they go to seed, and mowing should be avoided in heavily infested areas when seed is mature or mature enough to ripen even when cut. Noxious weed infestations should be controlled as soon as their presence is known.

An alternative to mechanical mowing in established (>3-year-old) vegetation is chemical mowing, which is the use of plant growth regulators (PGRs) to reduce growth of vegetation. Application of PGRs should be restricted to one application to established grasses each growing season after the first spring mowing. Application of PGRs should be restricted to shoulder areas between pavement and guardrails, and behind guardrails and other sloped areas where mowing is difficult or unsafe. Application of PGRs should be treated as herbicide application, with applicable laws, restrictions, and safety policies followed.

Use of GIS and GPS should be a primary component of roadside vegetation management, particularly for monitoring and managing native plantings and for weed management. GPS systems should be mounted in every roadside maintenance vehicle and display appropriate maps created to indicate where activities should occur, as well as allow activities in each vehicle to be monitored, recorded, and managed. To begin creating maps and compiling data, GPS navigators carried by workers could be used to map hazards, boundaries, and other noteworthy landmarks to create low-level maps and attribute tables. GPS locations for weed populations, threatened and endangered species, remnant prairies, and other special considerations could be provided by a variety of sources, including IDOT and Illinois Natural History Survey staff to create district-level and statewide asset inventories of roadside vegetation. Wording of new construction contracts to delineate construction activity boundaries in attribute tables with predetermined information that is linked to GPS points and polygons (i.e., volume and source of soil removed/added, soil amendments added and type, erosion-control structures location and type, and seed-mix type, source, and deviations, and dates for each activity) could be added to bids to add an increasing level of detail to IDOT GIS assets. Management of GPS and other data using GIS will be necessary at the district and state

level to maintain records, create maps, and compile new data to ensure that information provided to field workers contains uniform, accurate, and up-to-date information.

The most important factor determining success and failure of native vegetation is knowing what is desirable and what is undesirable. Roadside managers and operators need to be able to identify native vegetation and weeds, as well as understand the traits of these species, such as flowering time, lifespan, and proper management. Native vegetation requires several growing seasons to fully establish, and declaring failure prematurely often ensures that failure will result.

3.4.2 Burning

Burning is a very important management tool for maintaining healthy stands of native vegetation by controlling unwanted vegetation and removing litter that restricts vegetation growth and provides a soil environment favorable to unwanted vegetation. Burning native prairie on a 3-to-5-year rotation controls weeds and woody vegetation, often starting with the third growing season after planting. Burns can be conducted in spring or fall, and alternating burns minimizes effects on individual species. Spring burns should be conducted prior to mid-March to minimize effects on nesting birds and are most effective at controlling undesirable vegetation after early-growing vegetation has begun to green. Controlled burns should be conducted only by qualified personnel and only during ideal weather conditions to minimize risks.

3.4.3 Control of Weeds

Along with uncontrolled mowing, invasive plants are a significant cause of native plant failure. Any activity that brings invasive plant seeds to a site, reduces the ability of native vegetation to compete with invasive plants, or encourages invasive plant growth should be avoided. This activity includes unnecessary disturbance to the vegetation or soil, mowing unnecessarily or at inappropriate times, and improper cleaning of equipment. Controlling weeds often requires several activities to be conducted simultaneously at appropriate times to be effective. Rarely does a single treatment result in control. The most effective strategy to manage weeds is to find, document, control, monitor, and restore the infestations. Finding weed outbreaks is very important, as it allows measures to be taken to limit spread and begin treatment. The weeds listed in the review of weed control, as well as the proper control strategies, should be identifiable to all roadside managers and operators. When these species are encountered at high densities, patches should be flagged or otherwise marked. When equipment is located in these patches, careful cleaning should take place within the patch before the equipment is moved to a new location. This information needs to be shared with any other personnel that might be working in the patch as well, to limit spread of seeds. A control strategy should be developed for each identified patch depending on the type of vegetation present, the age and density of the weed, the latest information that exists regarding effective control, and the long-term goal of the vegetation within the patch. Control should also include managing invasive plant outbreaks on adjacent properties to prevent spread. Right-of-way entry permits should be used to treat infestations on adjacent properties if the landowner is not managing infestations properly. Once control is started, the entire strategy needs to be maintained regardless of how the site looks, as seeds in the bank can cause reinfestations if control is believed to have been achieved too early. Monitoring of sites during and after control strategies are implemented will ensure that the strategy is working and will indicate when site restoration can begin. Monitoring will need to be maintained during and after restoration to ensure that control was actually achieved.

Innovative weed management equipment should also be considered. Batwing mowers with covered tops should be required to prevent seed transport. Baling contracts not only improve native plant communities in the absence of fire but also can be used to manage weeds. Silage chopping could be used for removing seeds from infestations. Additionally, seed pulverizers are being

developed in Australia for production agriculture, and a similar technology for managing weed infestation in natural areas could be developed.

Cooperative weed management areas could be implemented (see http://invasiveplantcenters.org/cwmas.html and http://mipn.org/cwma_resources.html). Illinois had four cooperative weed management areas in 2008 (McFarland 2008). These include the River to River CWMA (http://www.rtrcwma.org/) and the Northeast Illinois Invasive Plant Partnership (http://niipp.net/).

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APPENDIX A SPECIES LIST

Table A1. Common and Scientific Names of All Species in Seed Mixes Surveyed

Common Name	Scientific Name	Family
Sweet Flag	Acorus americanus	Acoraceae
Water Plantain	Alisma triviale	Alismataceae
Broad-Leaved Arrowhead	Sagittaria latifolia	Alismataceae
Purple Angelica	Angelica atropurpurea	Apiaceae
Rattlesnake Master	Eryngium yuccifolium	Apiaceae
Heart-Leaved Alexanders	Zizia aptera	Apiaceae
Golden Alexanders	Zizia aurea	Apiaceae
Swamp Milkweed	Asclepias incarnata	Asclepiadaceae
Butterflyweed	Asclepias tuberosa	Asclepiadaceae
Yarrow	Achillea millefolium	Asteraceae
Beggarticks	Bidens cernua	Asteraceae
Cornflower	Centaurea cyanus	Asteraceae
Shasta Daisy	Chrysanthemum maximum	Asteraceae
Lance-Leaved Coreopsis	Coreopsis lanceolata	Asteraceae
Prairie Coreopsis	Coreopsis palmata	Asteraceae
Cosmos	Cosmos bipinnatus	Asteraceae
Yellow Cosmos	Cosmos sulphureus	Asteraceae
Flat-Topped Aster	Doellingeria (Aster) umbellata	Asteraceae
Narrow-Leaved Coneflower	Echinacea angustifolia	Asteraceae
Pale Purple Coneflower	Echinacea pallida	Asteraceae
Purple Coneflower	Echinacea purpurea	Asteraceae
Boneset	Eupatorium perfoliatum	Asteraceae
Joe Pye Weed	Eupatorum maculatum	Asteraceae
Blanketflower	Gaillardia pulchella	Asteraceae
Sneezeweed	Helenium autmnale	Asteraceae
Giant Sunflower	Helianthus giganteus	Asteraceae
Downy Sunflower	Helianthus mollis	Asteraceae
Western Sunflower	Helianthus occidentalis	Asteraceae
Oxeye Sunflower	Heliopsis helianthoides	Asteraceae
Rough Blazingstar	Liatris aspera	Asteraceae
Dotted Blazingstar	Liatris punctata	Asteraceae
Prairie Blazingstar	Liatris pycnostachya	Asteraceae
Wild Quinine	Parthenium integrifolium	Asteraceae
Long-Headed Coneflower	Ratibida columnifera	Asteraceae
Yellow Coneflower	Ratibida pinnata	Asteraceae
Orange Coneflower	Rudbeckia fulgida	Asteraceae
Black-Eyed Susan	Rudbeckia hirta	Asteraceae
Cutleaf Coneflower	Rudbeckia laciniata	Asteraceae
Fragrant Coneflower	Rudbeckia subtomentosa	Asteraceae
Compass Plant	Silphium laciniatum	Asteraceae
Prairie Dock	Silphium terebinthinaceum	Asteraceae
Whorled Rosinweed	Silphium trifoliatum	Asteraceae
Grass-Leaved Goldenrod	Euthamia (Solidago) graminifolia	Asteraceae
Gray Goldenrod	Solidago nemoralis	Asteraceae
Upland Goldenrod	Solidago ptarmicoides	Asteraceae
Riddell Goldenrod	Solidago riddellii	Asteraceae
Stiff Goldenrod	Solidago rigida	Asteraceae
Showy Goldenrod	Solidago speciosa	Asteraceae
Heath Aster	Symphyotrichum (Aster) ericoides	Asteraceae

Table A1 (continued). Common and Scientific Names of All Species in Seed Mixes Surveyed

Common Name	Scientific Name	Family
Smooth Aster	Symphyotrichum (Aster) laeve	Asteraceae
New England Aster	Symphyotrichum (Aster) novae-angliae	Asteraceae
Red-Stalked Aster	Symphyotrichum (Aster) puniceum	Asteraceae
Panicled Aster	Symphyotrichum lanceolatum (Aster simplex)	Asteraceae
Sky Blue Aster	Symphyotrichum oolentangiense (Aster azureus)	Asteraceae
Ironweed	Vernonia fasciculata	Asteraceae
Cardinal Flower	Lobelia cardinalis	Campanulaceae
Great Blue Lobelia	Lobelia siphilatica	Campanulaceae
Great St. Johnswort	Hypericum ascyron (pyramidatum)	Clusiaceae
Ohio Spiderwort	Tradescantia ohiensis	Commelinaceae
Bottlebrush Sedge	Carex comosa	Cyperaceae
Lake Bank Sedge	Carex lacustris	Cyperaceae
Broom Sedge	Carex scoparia	Cyperaceae
Awl-Fruited Sedge	Carex stipata	Cyperaceae
Tussock Sedge	Carex stricta	Cyperaceae
Fox Sedge	Carex vulpinoidea	Cyperaceae
Needle Spike Rush	Eleocharis acicularis	Cyperaceae
Blunt Spike Rush	Eleocharis obtusa	Cyperaceae
Common Spikerush	Eleocharis palustris	Cyperaceae
Hard-Stemmed Bulrush	Schoenoplectus (Scirpus) acutus	Cyperaceae
Green Bulrush	Scirpus atrovirens	Cyperaceae
Woolgrass	Scirpus cyperinus	Cyperaceae
River Bulrush	Schoenoplectus (Scirpus) fluviatilis	Cyperaceae
Softstem Bulrush	Schoenoplectus tabernaemontani (Scirpus validus)	Cyperaceae
Flowering Spurge	Euphorbia corollata	Euphorbiaceae
Leadplant	Amorpha canescens	Fabaceae
Canada Milkvetch	Astragalus canadensis	Fabaceae
White Wild Indigo	Baptisia lactea	Fabaceae
Partridge Pea	Chamaecrista (Cassia) fasciculata	Fabaceae
Crown Vetch	Coronilla varia	Fabaceae
White Prairieclover	Dalea candida	Fabaceae
Purple Prairieclover	Dalea purpurea	Fabaceae
Illinois Bundleflower	Desmanthus illinoensis	Fabaceae
Showy Tick Trefoil	Desmodium canadense	Fabaceae
Pointed Tick Trefoil	Desmodium glutinosum	Fabaceae
Annual Lespedeza	Kummerowia stipulacea	Fabaceae
Korean Lespedeza	Kummerowia stipulacea	Fabaceae
Roundhead Bushclover	Lespedeza capitata	Fabaceae
Sericea Lespedeza	Lespedeza cuneata	Fabaceae
Birdsfoot Trefoil	Lotus corniculatus	Fabaceae
Wild Lupine	Lupinus perennis	Fabaceae
Creeping Alfalfa	Madicago sativa	Fabaceae
Vernal Alfalfa	Medicago sativa	Fabaceae
Annual Alfalfa	Medicago sativa	Fabaceae
Yellow Sweetclover	Melilotus officinalis	Fabaceae
Alsike Clover	Trifolium hybridum	Fabaceae
Red Clover	Trifolium pratense	Fabaceae
White Clover	Trifolium repens	Fabaceae
Hairy Vetch	Vicia villosa	Fabaceae
Wild Geranium	Geranium maculatum	Geraniaceae

Table A1 (continued). Common and Scientific Names of All Species in Seed Mixes Surveyed.

Common Name	Scientific Name	Family
Wild Iris	Iris versicolor	Iridaceae
Blue Flag	Iris virginica var. shrevei	Iridaceae
Common Rush	Juncus effusus	Juncaceae
Slender Rush	Juncus tenuis	Juncaceae
Torrey's Rush	Juncus torreyi	Juncaceae
Fragrant Giant Hyssop	Agastache foeniculum	Lamiaceae
Wild Bergamont	Monarda fistulosa	Lamiaceae
Horse Mint	Monarda punctata	Lamiaceae
False Dragonhead	Physostegia virginiana	Lamiaceae
Mountain Mint	Pycnanthemum virginianum	Lamiaceae
Meadow Garlic	Allium canadense	Liliaceae
Corn Poppy	Papaver rhoeas	Papaveraceae
Red Top	Agrostis gigantea	Poaceae
Big Bluestem	Andropogon gerardii	Poaceae
Oats	Avena sativa	Poaceae
Sideoats Grama	Bouteloua curtipendula	Poaceae
Blue Grama	Bouteloua gracilis	Poaceae
Fringed Brome	Bromus ciliata	Poaceae
Smooth Brome	Bromus inermis	Poaceae
Buffalograss	Buchloe dactyloides	Poaceae
Bluejoint Grass	Calamagrostis canadensis	Poaceae
Bermudagrass	Cynodon dactylon	Poaceae
Orchardgrass	Dactylis glomerata	Poaceae
Barnyard Grass	Echinochloa crus-galli	Poaceae
Japanese Millet	Echinochloa esculenta	Poaceae
Canada Wildrye	Elymus canadensis	Poaceae
Slender Wheatgrass	Elymus trachycaulus	Poaceae
Virginia Wildrye	Elymus virginicus	Poaceae
Weeping Lovegrass	Eragrostis curvula	Poaceae
Hard Fescue	Festuca ovina	Poaceae
Red Fescue	Festuca rubra	Poaceae
Creeping Red Fescue	Festuca rubra ssp. Arenaria	Poaceae
Jasper Red Fescue	Festuca rubra var. Jasper	Poaceae
Fineleaf Turf Fescue	Festuca spp.	Poaceae
Reed Mannagrass	Glyceria grandis	Poaceae
Fowl Mannagrass	Glyceria striata	Poaceae
Junegrass	Koeleria macrantha	Poaceae
Rice Cutgrass	Leersia oryzoides	Poaceae
Sprangletop	Leptochloa fascicularis	Poaceae
Annual Ryegrass	Lolium multiflorum	Poaceae
English Rye	Lolium perenne	Poaceae
Fineleaf Perennial Ryegrass	Lolium perenne	Poaceae
Italian Rye	Lolium perenne	Poaceae
Perennial Ryegrass	Lolium perenne	Poaceae
Switchgrass	Panicum virgatum	Poaceae
Starr Millet	Pennisetum glaucum	Poaceae
Timothy	Phleum pratense	Poaceae
Canada Bluegrass	Poa compressa	Poaceae
Fowl Bluegrass	Poa palustris	Poaceae
98/85 Bluegrass	Poa pratensis	Poaceae

Table A1 (continued). Common and Scientific Names of All Species in Seed Mixes Surveyed

Common Name	Scientific Name	Family
Common Bluegrass	Poa pratensis	Poaceae
Kentucky Bluegrass	Poa pratensis	Poaceae
Fults Saltgrass	Puccinellia distans	Poaceae
Tall Fescue	Schedonorus phoenix (Festuca arundinacea)	Poaceae
Fawn Fescue	Schedonorus phoenix (Festuca arundinacea) var. Fawn	Poaceae
Kentucky 31 Fescue	Schedonorus phoenix (Festuca arundinacea) var. KY 31	Poaceae
Little Bluestem	Schizachyrium scoparium	Poaceae
Cereal Rye	Secale cereale	Poaceae
Balboa Rye	Secale cereale var. Balboa	Poaceae
German Millet	Setaria italica	Poaceae
Indiangrass	Sorghastrum nutans	Poaceae
Sudangrass	Sorghum bicolor ssp. Drummondii	Poaceae
Prairie Cordgrass	Spartina pectinata	Poaceae
Tall Dropseed	Sporobolus asper	Poaceae
Sand Dropseed	Sporobolus cryptandrus	Poaceae
Prairie Dropseed	Sporobolus heterolepis	Poaceae
Wheat	Triticum aestivum	Poaceae
Curlytop Knotweed	Polygonum lapathifolium	Polygonaceae
PA Smartweed	Polygonum pensylvanicum	Polygonaceae
Winged Loosestrife	Lythrum alatum	Primulaceae
Canada anemone	Anemone canadensis	Ranunculaceae
Thimbleweed	Anemone cylindrica	Ranunculaceae
Rocket Larkspur	Delphinium ajacis	Ranunculaceae
Tall Meadow Rue	Thalictrum dasycarpum	Ranunculaceae
Prairie Cinquefoil	Potentilla arguta	Rosaceae
Prairie Rose	Rosa arkansana	Rosaceae
Long-Leaved Bluets	Hedyotis longifolia	Rubiaceae
Showy Penstemon	Penstemon grandiflorus	Scrophulariaceae
Culver's Root	Veronicastrum virginicum	Scrophulariaceae
Giant Bur Reed	Sparganium eurycarpum	Sparganiaceae
Blue Vervain	Verbena hastata	Verbenaceae
Hoary Vervain	Verbena stricta	Verbenaceae

APPENDIX B FACTORS USED FOR ECOSYSTEM DEVELOPMENT

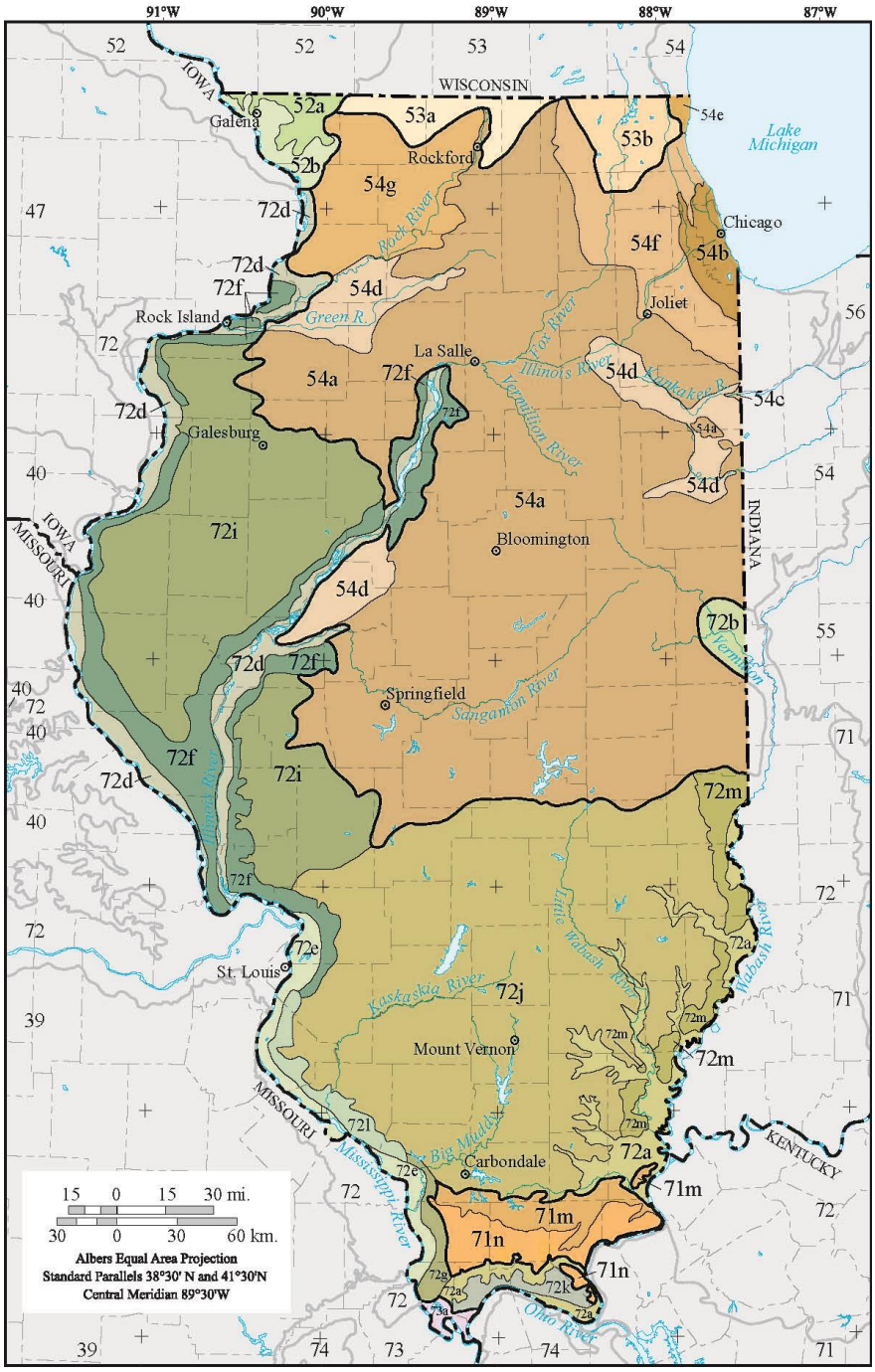

Figure B1. Illinois level III and level IV ecoregions
(see next page for legend, key, and credits).

ILLINOIS LEVEL III AND LEVEL IV ECOREGIONS

LEGEND, KEY, AND CREDITS

52 Driftless Area
52a Savanna Section
52b Paleozoic Plateau/Coulee Section

53 Southeastern Wisconsin Till Plains
53a Rock River Drift Plain
53b Kettle Moraines

54 Central Corn Belt Plains
54a Illinois/Indiana Prairies
54b Chicago Lake Plain
54c Kankakee Marsh
54d Sand Area
54e Chiwaukee Prairie Region
54f Valparaiso-Wheaton Morainal Complex
54g Rock River Hills

71 Interior Plateau
71m Northern Shawnee Hills
71n Southern Shawnee Hills

72 Interior River Valleys and Hills
72a Wabash-Ohio Bottomlands
72b Glaciated Wabash Lowlands
72d Upper Mississippi Alluvial Plain
72e Middle Mississippi Alluvial Plain
72f River Hills
72g Southern Ozarkian River Bluffs
72i Western Dissected Illinoian Till Plain
72j Southern Illinoian Till Plain
72k Cretaceous Hills
72l Karstic Northern Ozarkian River Bluffs
72m Wabash River Bluffs and Low Hills

73 Mississippi Alluvial Plain
73a Northern Holocene Meander Belts

Level III ecoregion boundary
Level IV ecoregion boundary
State boundary
County boundary

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This project to refine and subdivide EPA level III ecoregions in Illinois was partly conducted under the auspices of the Program for Cooperative Research on Aquatic Indicators Award # CR-831682-01.

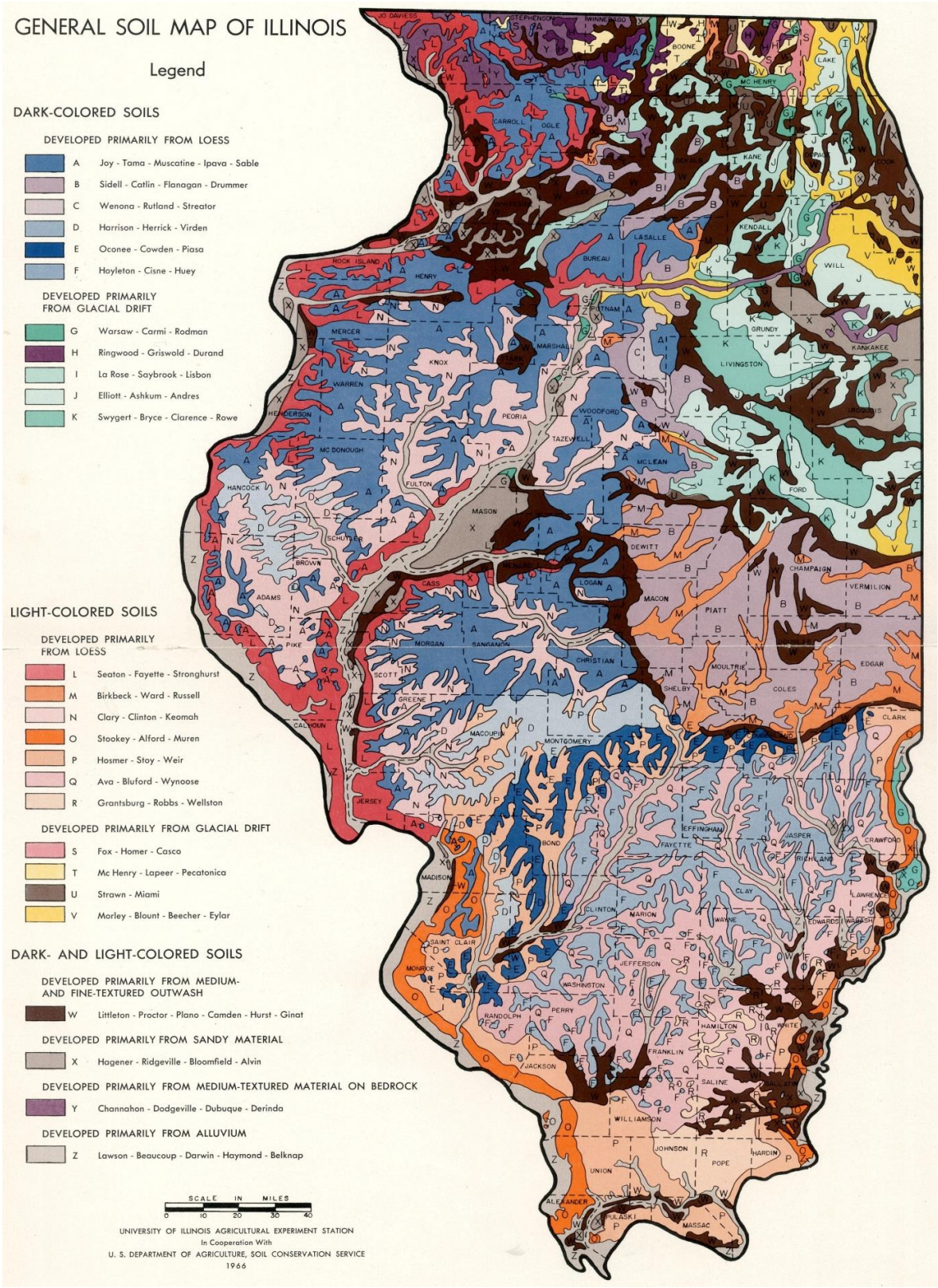

Figure B2. General soil map of Illinois.

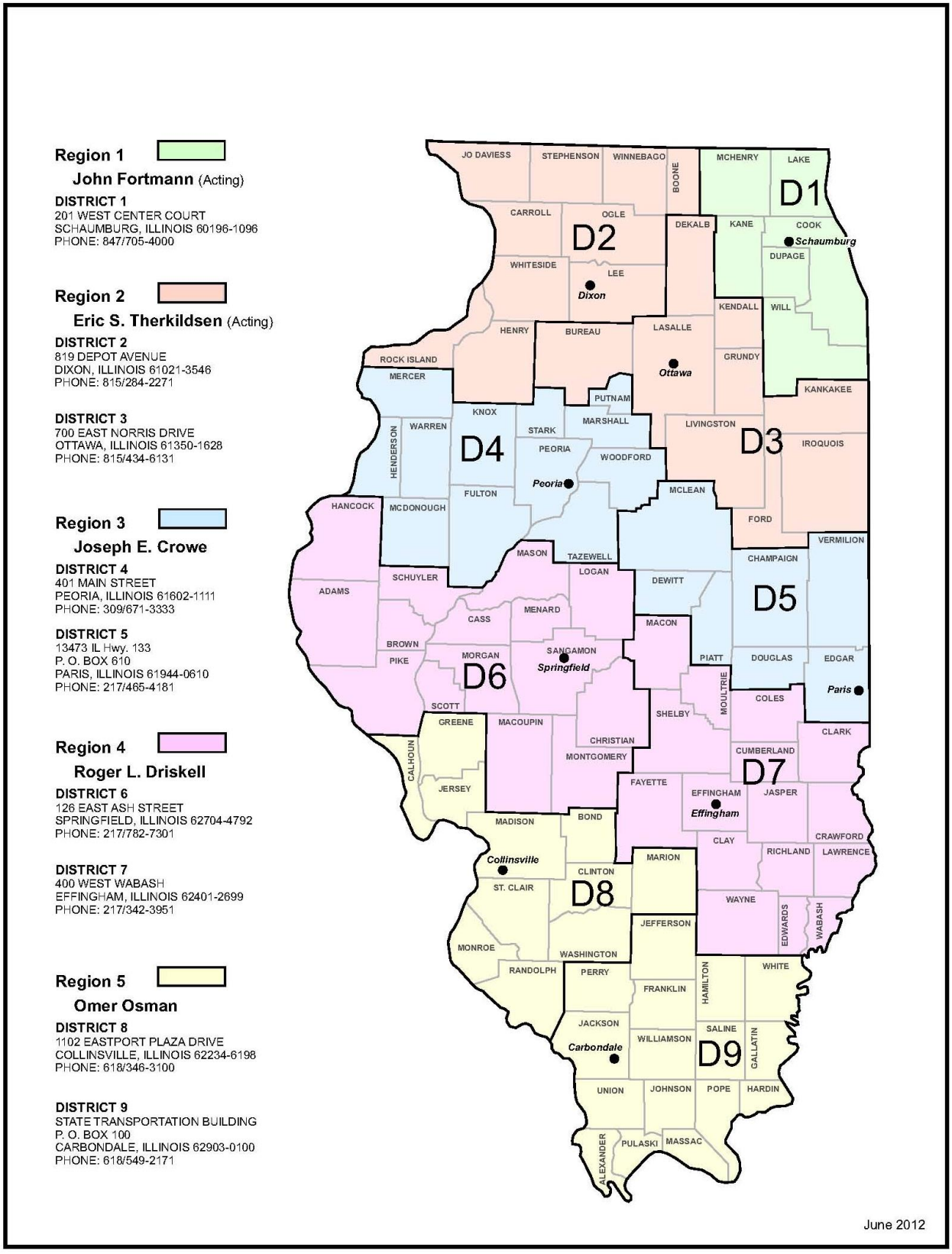

Figure B3. Illinois Department of Transportation region and district boundaries.

Figure B4. USDA plant hardiness zone map for Illinois.

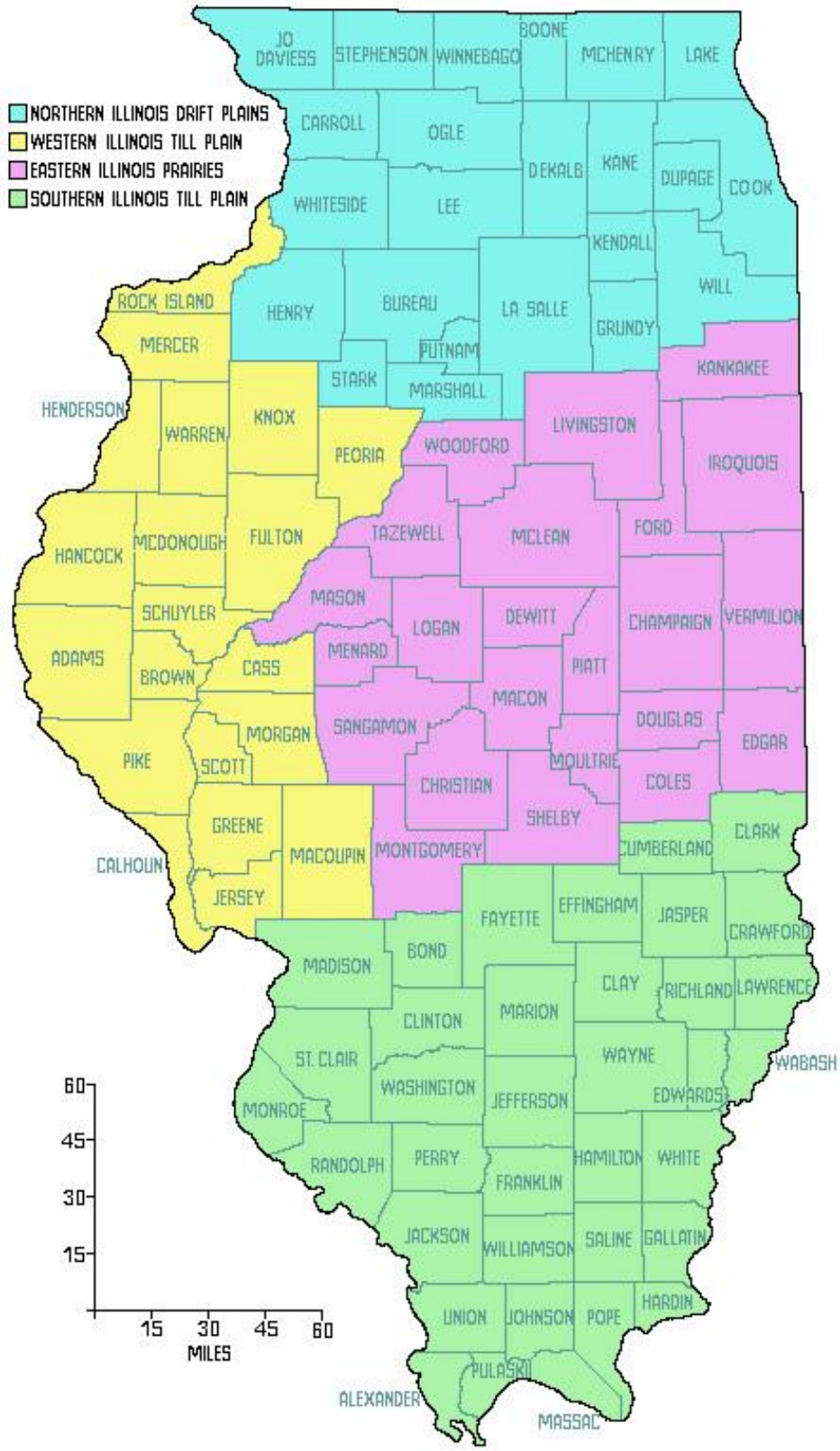

Figure B5. Proposed ecoregion map for Illinois.

APPENDIX C ATTRIBUTES OF NATIVE PLANT SPECIES OF ILLINOIS

Table C1. Attributes of Common Illinois Plant Species Suitable for Roadside Seed Mixes

Common[1]	Scientific[2]	Counties[3]	CC[1]	Wetland[1]	Habitat[4]	Lifespan[2]	Family[2]	Flower Color[5,6]	Height (m)[7,8]
Sweet Flag	Acorus americanus (calamus)	61	4	OBL	marshes	Perennial	Acoraceae	brown	1.5
Purple Angelica	Angelica atropurpurea	29 (N 1/3)	6	OBL	marshes	Perennial	Apiaceae	white	2.0
Rattlesnake Master	Eryngium yuccifolium	82	7	FAC+	prairies	Perennial	Apiaceae	green	1.5
Golden Alexanders	Zizia aurea	78	6	FAC+	prairies	Perennial	Apiaceae	yellow	1.0
Green Milkweed	Asclepias hirtella	72	6	UPL	prairies	Perennial	Asclepiadaceae	green	1.1
Swamp Milkweed	Asclepias incarnata	102	4	OBL	marshes	Perennial	Asclepiadaceae	pink	2.0
Butterflyweed	Asclepias tuberosa	89	5	UPL	prairies	Perennial	Asclepiadaceae	orange	0.9
White Sage	Artemisia ludoviciana	48	2	UPL	disturbed soil	Perennial	Asteraceae	tiny	1.0
Swamp Marigold	Bidens aristosa	99	1	FACW	wet soil	Annual	Asteraceae	yellow	1.5
Nodding Beggarticks	Bidens cernua	85	2	OBL	wet soil	Annual	Asteraceae	yellow	0.8
Common Beggarticks	Bidens frondosa	82	1	FACW	moist soil	Annual	Asteraceae	yellow	1.0
False Aster	Boltonia asteroides	79	5	FACW	moist soil	Perennial	Asteraceae	white	1.2
False Boneset	Brickellia eupatorioides	72	6	UPL	prairies	Perennial	Asteraceae	white	1.0
Pale Indian Plantain	Cacalia atriplicifolia	68	5	UPL	prairies	Perennial	Asteraceae	white	2.0
Lance-Leaved Coreopsis	Coreopsis lanceolata	33	5	FACU	sandy soil	Perennial	Asteraceae	yellow	0.7
Prairie Coreopsis	Coreopsis palmata	66	6	UPL	prairies	Perennial	Asteraceae	yellow	0.9
Golden Coreopsis	Coreopsis tinctoria	26	*	FAC-	disturbed soil	Annual	Asteraceae	yellow	1.2
Tall Coreopsis	Coreopsis tripteris	80	4	FAC	open woods	Perennial	Asteraceae	yellow	2.0
Pale Purple Coneflower	Echinacea pallida	76	7	UPL	prairies	Perennial	Asteraceae	pink	0.9
Purple Coneflower	Echinacea purpurea	41	6	UPL	prairies	Perennial	Asteraceae	purple	1.8
Marsh Fleabane	Erigeron philadelphicus	99	3	FACW	fields	Perennial	Asteraceae	white	0.7
Robin's Plantain	Erigeron pulchellus	53	5	FACU	open woods	Perennial	Asteraceae	white	0.6
Daisy Fleabane	Erigeron strigosus	92	2	FAC-	fields	Perennial	Asteraceae	white	0.7
Tall Boneset	Eupatorium altissimum	87	2	FACU	prairies	Perennial	Asteraceae	white	2.0
Mistflower	Eupatorium coelestinum	58 (S 1/2)	3	FAC+	moist soil	Perennial	Asteraceae	purple	0.9
Joe Pye Weed	Eupatorium maculatum	40 (N 1/2)	5	OBL	moist soil	Perennial	Asteraceae	purple	1.5
Boneset	Eupatorium perfoliatum	94	4	FACW+	wet soil	Perennial	Asteraceae	white	1.5
Purple Joe Pye Weed	Eupatorium pupureum	93	5	FAC	open woods	Perennial	Asteraceae	purple	2.0
White Snakeroot	Eupatorium rugosum	103	2	FACU	woods	Perennial	Asteraceae	white	1.5
Late Boneset	Eupatorium serotinum	102	1	FAC+	open woods	Perennial	Asteraceae	white	1.5
Grass-Leaved Goldenrod	Euthamia (Solidago) graminifolia	95	3	FACW-	moist soil	Perennial	Asteraceae	yellow	1.2
Sneezeweed	Helenium autumnale	81	3	FACW+	wet soil	Perennial	Asteraceae	yellow	1.0
Annual Sunflower	Helianthus annuus	73	*	FAC-	fields	Annual	Asteraceae	yellow	2.5
Woodland Sunflower	Helianthus divaricatus	86	5	UPL	open woods	Perennial	Asteraceae	yellow	2.0
Sawtooth Sunflower	Helianthus grosseserratus	98	2	FACW-	prairies	Perennial	Asteraceae	yellow	3.0
Bristly Sunflower	Helianthus hirsutus	63	5	UPL	fields	Perennial	Asteraceae	yellow	1.5
Downy Sunflower	Helianthus mollis	65 (S 3/4)	7	UPL	prairies	Perennial	Asteraceae	yellow	1.2

Table C1 (continued). Attributes of Common Illinois Plant Species Suitable for Roadside Seed Mixes

Common	Scientific	Counties	CC	Wetland	Habitat	Lifespan	Family	Flower Color	Height (m)
Prairie Sunflower	Helianthus rigidus	75	6	UPL	prairies	Perennial	Asteraceae	yellow	2.0
Pale-Leaved Sunflower	Helianthus strumosus	94	3	UPL	open woods	Perennial	Asteraceae	yellow	2.0
Jerusalem Artichoke	Helianthus tuberosus	91	3	FAC	moist soil	Perennial	Asteraceae	yellow	3.0
Oxeye Sunflower	**Heliopsis helianthoides**	94	4	UPL	prairies	Perennial	Asteraceae	yellow	1.5
Hairy Hawkweed	Hieracium longipilum	58	6	UPL	fields	Perennial	Asteraceae	yellow	2.0
Rough Hawkweed	Hieracium scabrum	51	5	UPL	dry woods	Perennial	Asteraceae	yellow	1.2
Rough Blazingstar	Liatris aspera	83	7	UPL	prairies	Perennial	Asteraceae	purple	1.2
Prairie Blazingstar	Liatris pycnostachya	73	6	FAC-	prairies	Perennial	Asteraceae	purple	1.5
Wild Quinine	Parthenium integrifolium	70	8	UPL	prairies	Perennial	Asteraceae	white	1.0
Long-Headed Coneflower	Ratibida columnifera	10	*	UPL	railroads	Perennial	Asteraceae	yellow	1.0
Yellow Coneflower	Ratibida pinnata	81	4	UPL	prairies	Perennial	Asteraceae	yellow	1.2
Black-Eyed Susan	Rudbeckia hirta	105	2	FACU	fields	Annual	Asteraceae	yellow	1.0
Cutleaf Coneflower	Rudbeckia laciniata	78	3	FACW+	moist soil	Perennial	Asteraceae	yellow	3.0
Fragrant Coneflower	Rudbeckia subtomentosa	68	5	FACW	prairies	Perennial	Asteraceae	yellow	2.0
Brown-Eyed Susan	Rudbeckia triloba	84	3	FAC-	woods	Perennial	Asteraceae	yellow	1.5
Rosinweed	Silphium integrifolium	96	5	UPL	prairies	Perennial	Asteraceae	yellow	1.5
Compass Plant	Silphium laciniatum	90	5	FACU-	prairies	Perennial	Asteraceae	yellow	3.0
Cup Plant	Silphium perfoliatum	92	4	FACW-	open woods	Perennial	Asteraceae	yellow	2.0
Prairie Dock	Silphium terebinthinaceum	94	4	FAC-	prairies	Perennial	Asteraceae	yellow	2.0
Canada Goldenrod	Solidago canadensis	103	1	FACU	fields	Perennial	Asteraceae	yellow	2.0
Giant Goldenrod	Solidago gigantea	96	3	FACW	moist soil	Perennial	Asteraceae	yellow	1.5
Early Goldenrod	Solidago juncea	89	4	UPL	fields	Perennial	Asteraceae	yellow	1.2
Missouri Goldenrod	Solidago missouriensis	89	4	UPL	prairies	Perennial	Asteraceae	yellow	1.0
Gray Goldenrod	Solidago nemoralis	101	3	UPL	fields	Perennial	Asteraceae	yellow	1.3
Riddell Goldenrod	Solidago riddellii	23	7	OBL	moist soil	Perennial	Asteraceae	yellow	1.0
Stiff Goldenrod	Solidago rigida	88	4	FACU-	prairies	Perennial	Asteraceae	yellow	1.6
Showy Goldenrod	Solidago speciosa	67	7	UPL	prairies	Perennial	Asteraceae	yellow	2.0
Elm Leaved Goldenrod	Solidago ulmifolia	103	5	UPL	woods	Perennial	Asteraceae	yellow	1.5
Sky Blue Aster	Symphyotrichum (Aster) azureus	57	7	UPL	prairies	Perennial	Asteraceae	blue	1.5
Heath Aster	Symphyotrichum (Aster) ericoides	86	4	FACU-	prairies	Perennial	Asteraceae	white	1.0
Smooth Aster	Symphyotrichum (Aster) laeve	52	8	UPL	moist soil	Perennial	Asteraceae	blue	1.0
Calico Aster	Symphyotrichum (Aster) lateriflorum	86	2	FACW-	woods	Perennial	Asteraceae	white	1.5
New England Aster	Symphyotrichum (Aster) novae-angliae	89	4	FACW	moist soil	Perennial	Asteraceae	purple	1.2
Hairy Aster	Symphyotrichum (Aster) pilosum	105	0	FACU	disturbed soil	Perennial	Asteraceae	white	1.5
Willow Aster	Symphyotrichum (Aster) praealtus	77	4	OBL	moist soil	Perennial	Asteraceae	purple	1.2
Red-Stalked Aster	Symphyotrichum (Aster) puniceum	35	7	OBL	moist soil	Perennial	Asteraceae	white	2.5
Arrow-Leaved Aster	Symphyotrichum cordifolium (Aster sagittifolius)	93	4	UPL	dry woods	Perennial	Asteraceae	white	2.0

Table C1 (continued). Attributes of Common Illinois Plant Species Suitable for Roadside Seed Mixes

Common	Scientific	Counties	CC	Wetland	Habitat	Lifespan	Family	Flower Color	Height (m)
Panicled Aster	Symphyotrichum lanceolatum (Aster simplex)	84	3	OBL	moist soil	Perennial	Asteraceae	white	2.0
Wingstem	Verbesina alternifolia	78	4	FACW	moist soil	Perennial	Asteraceae	yellow	2.0
Ironweed	Vernonia fasciculata	66	5	FACW	prairies	Perennial	Asteraceae	purple	1.2
Tall Ironweed	Vernonia gigantea	68	4	FAC	open woods	Perennial	Asteraceae	purple	2.0
Missouri Ironweed	Vernonia missurica	94	4	FAC+	prairies	Perennial	Asteraceae	purple	2.0
Cardinal Flower	Lobelia cardinalis	82	6	OBL	wet soil	Perennial	Campanulaceae	red	1.5
Indian Tobacco	Lobelia inflata	89	4	FACU-	fields	Perennial	Campanulaceae	pink	0.8
Great Blue Lobelia	Lobelia siphilatica	93	4	FACW+	wet soil	Perennial	Campanulaceae	purple	1.5
Palespike Lobelia	Lobelia spicata	78	4	FAC	prairies	Perennial	Campanulaceae	pink	1.0
Feverwort	Triosteum perfoliatum	74	5	UPL	dry woods	Perennial	Caprifoliaceae	tiny	1.3
Sleepy Catchfly	Silene antirrhina	92	1	UPL	fields	Annual	Caryophyllaceae	tiny	0.8
Starry Campion	Silene stellata	91	6	UPL	woods	Perennial	Caryophyllaceae	white	1.2
Dwarf St. John's Wort	Hypericum mutilum	62	5	FACW	moist soil	Perennial	Clusiaceae	yellow	0.3
Spotted St. John's Wort	Hypericum punctatum	105	3	FAC+	roadsides	Perennial	Clusiaceae	yellow	1.0
Roundseed St. John's Wort	Hypericum sphaerocarpum	73	5	FACU	roadsides	Perennial	Clusiaceae	yellow	0.6
Ohio Spiderwort	Tradescantia ohiensis	94	3	FACU+	prairies	Perennial	Commelinaceae	purple	1.0
Crested Sedge	Carex cristatella	84	3	FACW+	wet soil	Perennial	Cyperaceae	NA	1.0
Davis' Sedge	Carex davisii	74	3	FAC+	moist soil	Perennial	Cyperaceae	NA	0.9
Fescue Sedge	Carex festucacea	57	6	FAC	wet soil	Perennial	Cyperaceae	NA	1.0
Pale Sedge	Carex granularis	64	2	FACW+	wet soil	Perennial	Cyperaceae	NA	0.9
Common Bur Sedge	Carex grayi	57	6	FACW+	wet soil	Perennial	Cyperaceae	NA	0.8
Lake Bank Sedge	Carex lacustris	37	6	OBL	wet soil	Perennial	Cyperaceae	NA	1.3
Wooly Sedge	Carex lanuginosa	53	4	OBL	wet soil	Perennial	Cyperaceae	NA	1.0
Hop Sedge	Carex lupulina	68	5	OBL	wet soil	Perennial	Cyperaceae	NA	1.2
Broom Sedge	Carex scoparia	58	5	FACW	marshes	Perennial	Cyperaceae	NA	1.0
Short's Sedge	Carex shortiana	68	4	FACW+	moist soil	Perennial	Cyperaceae	NA	0.8
Squarrose Sedge	Carex squarrosa	58	5	OBL	wet soil	Perennial	Cyperaceae	NA	0.8
Awl-Fruited Sedge	Carex stipata	58	2	OBL	swamps	Perennial	Cyperaceae	NA	1.2
Tussock Sedge	Carex stricta	38 (N 3/4)	5	OBL	swamps	Perennial	Cyperaceae	NA	0.8
Blunt Broom Sedge	Carex tribuloides	69	3	FACW+	marshes	Perennial	Cyperaceae	NA	0.9
Fox Sedge	Carex vulpinoidea	105	3	OBL	wet soil	Perennial	Cyperaceae	NA	0.9
Short Pointed Flat Sedge	Cyperus acuminatus	56	2	OBL	wet soil	Annual	Cyperaceae	NA	1.2
Fragrant Flat Sedge	Cyperus odoratus (ferruginescens)	59	1	OBL	moist soil	Annual	Cyperaceae	NA	1.0
Bearded Flat Sedge	Cyperus squarrosus (aristatus)	68	2	OBL	moist soil	Annual	Cyperaceae	NA	0.2
Needle Spike Rush	Eleocharis acicularis	47	3	OBL	wet soil	Perennial	Cyperaceae	NA	0.2
Slender Spike Rush	Eleocharis elliptica	44	7	OBL	wet soil	Perennial	Cyperaceae	NA	1.0
Blunt Spike Rush	Eleocharis obtusa	72	2	OBL	wet soil	Annual	Cyperaceae	NA	0.5

Table C1 (continued). Attributes of Common Illinois Plant Species Suitable for Roadside Seed Mixes

Common	Scientific	Counties	CC	Wetland	Habitat	Lifespan	Family	Flower Color	Height (m)
Hard-Stemmed Bulrush	Schoenoplectus (Scirpus) acutus	30	6	OBL	shallow water	Perennial	Cyperaceae	NA	3.0
River Bulrush	Schoenoplectus (Scirpus) fluviatilis	47	3	OBL	stream margins	Perennial	Cyperaceae	NA	1.5
Softstem Bulrush	Schoenoplectus tabernaemontani (Scirpus validus)	66	4	OBL	marshes	Perennial	Cyperaceae	NA	4.0
Green Bulrush	Scirpus atrovirens	105	4	OBL	wet soil	Perennial	Cyperaceae	NA	1.5
Woolgrass	Scirpus cyperinus	51	5	OBL	marshes	Perennial	Cyperaceae	NA	2.0
Red Bulrush	Scirpus pendulus	89	3	OBL	stream margins	Perennial	Cyperaceae	NA	1.4
Tall Scouring Rush	Equisetum hyemale affine	105	2	FACW-	roadsides	Perennial	Equisetaceae	NA	2.0
Smooth Scouring Rush	Equisetum laevigatum	71	4	FACW	moist sandy soil	Perennial	Equisetaceae	NA	1.0
Leadplant	Amorpha canescens	70	8	UPL	prairies	Perennial	Fabaceae	purple	1.2
False Indigo Bush	Amorpha fruticosa	84	6	FACW	moist soil	Perennial	Fabaceae	purple	3.5
White Wild Indigo	Baptisia lactea	100	6	UPL	prairies	Perennial	Fabaceae	white	2.0
Maryland Senna	Cassia marilandica	58	4	FACW	roadsides	Perennial	Fabaceae	yellow	2.0
Partridge Pea	Chamaecrista (Cassia) fasciculata	100	1	FACU-	prairies	Annual	Fabaceae	yellow	1.2
White Prairieclover	Dalea candida	61	9	UPL	prairies	Perennial	Fabaceae	white	1.0
Purple Prairieclover	Dalea purpurea	74	8	UPL	prairies	Perennial	Fabaceae	purple	0.9
Illinois Bundleflower	Desmanthus illinoensis	42	4	FAC-	prairies	Perennial	Fabaceae	white	2.0
Showy Tick Trefoil	Desmodium canadense	76	5	FAC-	prairies	Perennial	Fabaceae	purple	2.0
Bracted Tick Trefoil	Desmodium cuspidatum	72	6	UPL	dry woods	Perennial	Fabaceae	pink	2.0
Smooth Tick Trefoil	Desmodium glabellum (dillenii)	68	3	FACU	dry woods	Perennial	Fabaceae	pink	1.5
Pointed Tick Trefoil	Desmodium glutinosum	82	3	UPL	woods	Perennial	Fabaceae	pink	1.0
Prairie Tick Trefoil	Desmodium illinoense	80	5	UPL	prairies	Perennial	Fabaceae	pink	2.0
Roundhead Bushclover	Lespedeza capitata	91	4	FACU	prairies	Perennial	Fabaceae	white	2.0
Violet Bushclover	Lespedeza violacea	66	5	UPL	dry woods	Perennial	Fabaceae	purple	0.7
Slender Bushclover	Lespedeza virginica	68 absent NW	5	UPL	dry woods	Perennial	Fabaceae	pink	1.0
Carolina Cranesbill	Geranium carolinianum	84	2	UPL	fields	Annual	Geraniaceae	tiny	0.7
Wild Geranium	Geranium maculatum	105	4	FACU	woods	Perennial	Geraniaceae	pink	0.5
Blue Flag	Iris virginica var. shrevei	82	5	OBL	wet soil	Perennial	Iridaceae	purple	0.8
Sharp-Fruited Rush	Juncus acuminatus	63	4	OBL	wet soil	Perennial	Juncaceae	NA	0.8
Dudley's Rush	Juncus dudleyi	71	4	FAC	moist soil	Perennial	Juncaceae	NA	1.0
Common Rush	Juncus effusus	38	4	OBL	swamps	Perennial	Juncaceae	NA	1.2
Inland Rush	Juncus interior	90	3	FAC+	wet soil	Perennial	Juncaceae	NA	0.9
Slender Rush	Juncus tenuis	105	0	FAC	disturbed soil	Perennial	Juncaceae	NA	0.5
Torrey's Rush	Juncus torreyi	81	3	FACW	wet soil	Perennial	Juncaceae	NA	0.8
Yellow Giant Hyssop	Agastache nepetoides	81	4	FACU	open woods	Perennial	Lamiaceae	yellow	2.5
Wild Bergamont	Monarda fistulosa	99	4	FACU	prairies	Perennial	Lamiaceae	pink	1.2
False Dragonhead	Physostegia virginiana	70	6	FACW	moist soil	Perennial	Lamiaceae	pink	1.5
Hairy Mountain Mint	Pycnanthemum pilosum	69	6	UPL	prairies	Perennial	Lamiaceae	pink	1.2

Table C1 (continued). Attributes of Common Illinois Plant Species Suitable for Roadside Seed Mixes

Common	Scientific	Counties	CC	Wetland	Habitat	Lifespan	Family	Flower Color	Height (m)
Slender Mountain Mint	Pycnanthemum tenuifolium	96	4	FAC	fields	Perennial	Lamiaceae	pink	1.1
Mountain Mint	Pycnanthemum virginianum	74	5	FACW+	prairies	Perennial	Lamiaceae	pink	0.9
Blue Skullcap	Scutellaria lateriflora	76	4	OBL	marshes	Perennial	Lamiaceae	purple	1.0
Heartleaf Skullcap	Scutellaria ovata	87	5	FACU	rocky woods	Perennial	Lamiaceae	purple	1.0
Michigan Lily	Lilium michiganense	74	6	FAC+	moist soil	Perennial	Liliaceae	orange	2.0
Blue Waxweed	Cuphea viscosissima	66 absent NW	4	FACU	dry soil	Annual	Lythraceae	purple	0.6
Winged Loosestrife	Lythrum alatum	97	5	OBL	moist soil	Perennial	Lythraceae	purple	1.2
Halberd-Leaved Rosemallow	Hibiscus laevis (militaris)	68	4	OBL	wet soil	Perennial	Malvaceae	pink	2.5
Seedbox	Ludwigia alternifolia	70	5	OBL	wet soil	Perennial	Onagraceae	yellow	1.0
Marsh Seedbox	Ludwigia palustris americana	76	4	OBL	wet soil	Perennial	Onagraceae	tiny	0.5
False Loosestrife	Ludwigia polycarpa	68	5	OBL	wet soil	Perennial	Onagraceae	tiny	0.9
Evening Primrose	Oenothera biennis	105	1	FACU	fields	Biennial	Onagraceae	yellow	2.0
Cutleaf Evening Primrose	Oenothera laciniata	65	2	FACU	prairies	Annual	Onagraceae	yellow	0.8
Big Bluestem	Andropogon gerardii	105	5	FAC-	prairies	Perennial	Poaceae	NA	2.0
Broomsedge	Andropogon virginicus	68 absent NW	1	FAC-	fields	Perennial	Poaceae	NA	1.0
Three Awn	Aristida longespica	46	2	FACU-	sandy soil	Annual	Poaceae	NA	0.4
Prairie Three Awn	Aristida oligantha	93	0	UPL	fields	Annual	Poaceae	NA	0.5
Sideoats Grama	Bouteloua curtipendula	49 (W, N)	7	UPL	prairies	Perennial	Poaceae	NA	0.8
Buffalograss	Buchloe dactyloides	5	*	FACU-	prairies	Perennial	Poaceae	NA	0.2
Bluejoint Grass	Calamagrostis canadensis	52 (N 3/4)	3	OBL	moist soil	Perennial	Poaceae	NA	1.3
Sandbur	Cenchrus longispinus	84	0	UPL	sandy soil	Annual	Poaceae	NA	0.9
Slender Wheatgrass	Elymus (Agropyron) trachycaulus	6 (N 1/4)	8	FAC	disturbed soil	Perennial	Poaceae	NA	1.2
Canada Wildrye	Elymus canadensis	105	4	FAC-	prairies	Perennial	Poaceae	NA	1.5
Bottlebrush	Elymus hystrix	105	5	UPL	woods	Perennial	Poaceae	NA	1.5
Silky Wildrye	Elymus villosus	105	4	FACU	woods	Perennial	Poaceae	NA	1.2
Virginia Wildrye	Elymus virginicus	105	4	FACW-	fields	Perennial	Poaceae	NA	1.0
Fowl Mannagrass	Glyceria striata	105	4	OBL	moist soil	Perennial	Poaceae	NA	1.5
Junegrass	Koeleria macrantha	49 (rare E)	7	UPL	prairies	Perennial	Poaceae	NA	0.6
Rice Cutgrass	Leersia oryzoides	81	3	OBL	moist soil	Perennial	Poaceae	NA	1.1
Whitegrass	Leersia virginica	83	4	FACW	moist soil	Perennial	Poaceae	NA	1.2
Switchgrass	Panicum virgatum	88	4	FAC+	prairies	Perennial	Poaceae	NA	1.4
Little Bluestem	Schizachyrium scoparium	85	5	FACU-	prairies	Perennial	Poaceae	NA	1.0
Indiangrass	Sorghastrum nutans	105	4	FACU+	prairies	Perennial	Poaceae	NA	2.0
Prairie Cordgrass	Spartina pectinata	91	4	FACW+	marshes	Perennial	Poaceae	NA	2.0
Tall Dropseed	Sporobolus asper	77	3	UPL	sandy soil	Perennial	Poaceae	NA	1.3
Prairie Dropseed	Sporobolus heterolepis	41	9	FACU-	prairies	Perennial	Poaceae	NA	1.0

Table C1 (continued). Attributes of Common Illinois Plant Species Suitable for Roadside Seed Mixes

Common	Scientific	Counties	CC	Wetland	Habitat	Lifespan	Family	Flower Color	Height (m)
Blue Phlox	Phlox divaricata laphamii	101	5	FACU	woods	Perennial	Polemoniaceae	blue	0.5
Smooth Phlox	Phlox glaberrima interior	71	6	FACW	prairies	Perennial	Polemoniaceae	purple	0.6
Garden Phlox	Phlox paniculata	74	3	FACU	woods	Perennial	Polemoniaceae	purple	2.0
Downy Phlox	Phlox pilosa	82	7	FAC-	prairies	Perennial	Polemoniaceae	pink	0.8
Curlytop Knotweed	Polygonum lapathifolium	89	0	FACW+	wet soil	Annual	Polygonaceae	NA	0.8
PA Smartweed	Polygonum pensylvanicum	105	1	FACW+	wet soil	Annual	Polygonaceae	NA	1.5
Fringed Loosestrife	Lysimachia ciliata	86	4	FACW	moist woods	Perennial	Primulaceae	yellow	1.0
Lance-Leaved Loosestrife	Lysimachia lanceolata	75	6	FAC	moist woods	Perennial	Primulaceae	yellow	0.6
Thimbleweed	Anemone cylindrica	47	8	UPL	prairies	Perennial	Ranunculaceae	green	0.7
Tall Anemone	Anemone virginiana	100	4	UPL	open woods	Perennial	Ranunculaceae	green	1.1
Leather Flower	Clematis pitcheri	62	4	FACU	woods	Perennial	Ranunculaceae	purple	4.0
White Avens	Geum canadense	105	2	FAC	woods	Perennial	Rosaceae	tiny	1.0
Rough Avens	Geum laciniatum	64 (N 2/3)	2	FACW	meadows and thickets	Perennial	Rosaceae	green	1.0
Prairie Cinquefoil	Potentilla arguta	39 (N 1/2)	10	FACU-	prairies	Perennial	Rosaceae	yellow	1.0
Common Cinquefoil	Potentilla simplex	105	3	FACU-	prairies	Perennial	Rosaceae	yellow	1.2
Pasture Rose	Rosa carolina	100	4	FACU-	prairies	Perennial	Rosaceae	pink	1.0
Climbing Rose	Rosa setigera	76	5	FACU+	woods	Perennial	Rosaceae	pink	1.0
Slender False Foxglove	Agalinis tenuifolia	87	5	FACW	moist soil	Annual	Scrophulariaceae	purple	0.5
Foxglove Beardtongue	Penstemon digitalis	86	4	FAC-	woods	Perennial	Scrophulariaceae	white	0.9
Pale Beardtongue	Penstemon pallidus	77	6	UPL	prairies	Perennial	Scrophulariaceae	white	0.7
Purslane Speedwell	Veronica peregrina	105	0	FACW+	fields	Annual	Scrophulariaceae	tiny	0.3
Culver's Root	Veronicastrum virginicum	100	6	FAC	prairies	Perennial	Scrophulariaceae	white	1.5
Giant Bur Reed	Sparganium eurycarpum	46	5	OBL	shallow water	Perennial	Sparganiaceae	NA	1.0
Creeping Vervain	Verbena bracteata	80	1	FACU	disturbed soil	Annual	Verbenaceae	purple	0.7
Blue Vervain	Verbena hastata	105	3	FACW+	wet soil	Perennial	Verbenaceae	purple	2.3
Hoary Vervain	Verbena stricta	102	2	UPL	prairies	Perennial	Verbenaceae	purple	1.8
White Vervain	Verbena urticifolia	105	3	FAC+	fields	Perennial	Verbenaceae	purple	2.5

[1] Taft et al. 1997
[2] USDA, NRCS 2012
[3] Mohlenbrock and Ladd 1978
[4] Mohlenbrock 1986
[5] Kurz 2004
[6] Peterson and McKenny 1968
[7] Great Plains Flora Association 1986
[8] Hitchcock 1971

Table C2. Salt Tolerance of Illinois Prairie Plants (from USDA, NRCS 2012)

Common	Scientific	Family	Salt Tolerance
Slender Wheatgrass	Elymus trachycaulus	Poaceae	High
Big Bluestem	Andropogon gerardii	Poaceae	Med
Buffalograss	Buchloe dactyloides	Poaceae	Med
Canada Wildrye	Elymus canadensis	Poaceae	Med
Switchgrass	Panicum virgatum	Poaceae	Med
Indiangrass	Sorghastrum nutans	Poaceae	Med
Broomsedge	Andropogon virginicus	Poaceae	Low
Sideoats Grama	Bouteloua curtipendula	Poaceae	Low
Prairie Cordgrass	Spartina pectinata	Poaceae	Low
Virginia Wildrye	Elymus virginicus	Poaceae	None
Fowl Mannagrass	Glyceria striata	Poaceae	None
Junegrass	Koeleria macrantha	Poaceae	None
Rice Cutgrass	Leersia oryzoides	Poaceae	None
Whitegrass	Leersia virginica	Poaceae	None
Little Bluestem	Schizachyrium scoparium	Poaceae	None
Prairie Dropseed	Sporobolus heterolepis	Poaceae	None
Fragrant Flat Sedge	Cyperus odoratus	Cyperaceae	Med
Needle Spike Rush	Eleocharis acicularis	Cyperaceae	Med
Broom Sedge	Carex scoparia	Cyperaceae	Low
Awl-Fruited Sedge	Carex stipata	Cyperaceae	Low
Hard-Stemmed Bulrush	Schoenoplectus acutus	Cyperaceae	Low
Softstem Bulrush	Schoenoplectus tabernaemontani	Cyperaceae	Low
Red Bulrush	Scirpus pendulus	Cyperaceae	Low
Crested Sedge	Carex cristatella	Cyperaceae	None
Pale Sedge	Carex granularis	Cyperaceae	None
Common Bur Sedge	Carex grayi	Cyperaceae	None
Lake Bank Sedge	Carex lacustris	Cyperaceae	None
Hop Sedge	Carex lupulina	Cyperaceae	None
Short's Sedge	Carex shortiana	Cyperaceae	None
Squarrose Sedge	Carex squarrosa	Cyperaceae	None
Tussock Sedge	Carex stricta	Cyperaceae	None
Blunt Broom Sedge	Carex tribuloides	Cyperaceae	None
Fox Sedge	Carex vulpinoidea	Cyperaceae	None
Short Pointed Flat Sedge	Cyperus acuminatus	Cyperaceae	None
Blunt Spike Rush	Eleocharis obtusa	Cyperaceae	None
River Bulrush	Schoenoplectus fluviatilis	Cyperaceae	None
Green Bulrush	Scirpus atrovirens	Cyperaceae	None
Woolgrass	Scirpus cyperinus	Cyperaceae	None
Swamp Milkweed	Asclepias incarnata	Asclepiadaceae	None
Butterflyweed	Asclepias tuberosa	Asclepiadaceae	None
White Sage	Artemisia ludoviciana	Asteraceae	High
False Aster	Boltonia asteroides	Asteraceae	Low
Pale Purple Coneflower	Echinacea pallida	Asteraceae	Low
Sneezeweed	Helenium autumnale	Asteraceae	Low

Table C2 (continued). Salt Tolerance of Illinois Prairie Plants (from USDA, NRCS 2012)

Common	Scientific	Family	Salt Tolerance
Purple Coneflower	Echinacea purpurea	Asteraceae	Low
Prairie Blazingstar	Liatris pycnostachya	Asteraceae	Low
Long-Headed Coneflower	Ratibida columnifera	Asteraceae	Low
Missouri Goldenrod	Solidago missouriensis	Asteraceae	Low
Lance-Leaved Coreopsis	Coreopsis lanceolata	Asteraceae	None
Golden Coreopsis	Coreopsis tinctoria	Asteraceae	None
Marsh Fleabane	Erigeron philadelphicus	Asteraceae	None
Daisy Fleabane	Erigeron strigosus	Asteraceae	None
Joe Pye Weed	Eupatorium maculatum	Asteraceae	None
Sawtooth Sunflower	Helianthus grosseserratus	Asteraceae	None
Jerusalem Artichoke	Helianthus tuberosus	Asteraceae	None
Oxeye Sunflower	Heliopsis helianthoides	Asteraceae	None
Yellow Coneflower	Ratibida pinnata	Asteraceae	None
Black-Eyed Susan	Rudbeckia hirta	Asteraceae	None
Cutleaf Coneflower	Rudbeckia laciniata	Asteraceae	None
Canada Goldenrod	Solidago canadensis	Asteraceae	None
Giant Goldenrod	Solidago gigantea	Asteraceae	None
Gray Goldenrod	Solidago nemoralis	Asteraceae	None
Smooth Aster	Symphyotrichum laeve	Asteraceae	None
Hairy Aster	Symphyotrichum pilosum	Asteraceae	None
Red-Stalked Aster	Symphyotrichum puniceum	Asteraceae	None
Missouri Ironweed	Vernonia missurica	Asteraceae	None
Cardinal Flower	Lobelia cardinalis	Campanulaceae	None
Dwarf St. John's Wort	Hypericum mutilum	Clusiaceae	None
Spotted St. John's Wort	Hypericum punctatum	Clusiaceae	None
White Prairieclover	Dalea candida	Fabaceae	Low
Purple Prairieclover	Dalea purpurea	Fabaceae	None
Illinois Bundleflower	Desmanthus illinoensis	Fabaceae	None
Roundhead Bushclover	Lespedeza capitata	Fabaceae	None
Maryland Senna	Senna (Cassia) marilandica	Fabaceae	None
Blue Flag	Iris virginica var. shrevei	Iridaceae	None
Common Rush	Juncus effusus	Juncaceae	Low
Slender Rush	Juncus tenuis	Juncaceae	Low
Torrey's Rush	Juncus torreyi	Juncaceae	Low
Inland Rush	Juncus interior	Juncaceae	None
Wild Bergamont	Monarda fistulosa	Lamiaceae	None
Halberd-Leaved Rosemallow	Hibiscus laevis	Malvaceae	None
Marsh Seedbox	Ludwigia palustris americana	Onagraceae	None
Blue Phlox	Phlox divaricata laphamii	Polemoniaceae	None
Smooth Phlox	Phlox glaberrima interior	Polemoniaceae	None
Lance-Leaved Loosestrife	Lysimachia lanceolata	Primulaceae	None
White Avens	Geum canadense	Rosaceae	None
Rough Avens	Geum laciniatum	Rosaceae	None
Prairie Cinquefoil	Potentilla arguta	Rosaceae	None
Foxglove Beardtongue	Penstemon digitalis	Scrophulariaceae	Med
Giant Bur Reed	Sparganium eurycarpum	Sparganiaceae	None

Scientific Name	Type	Application[a]	Herbicide	Rate	Effect
Anemone virginiana	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Asclepias tuberosa	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Asclepias tuberosa	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Bidens aristosa	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Bidens frondosa	Forb	Post, S	Imazapic	0.9 oz ai/ac[4]	Tolerant
Bidens frondosa	Forb	Pre, S	Imazapic	0.9 oz ai/ac[4]	Intolerant
Brickellia eupatorioides	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Brickellia eupatorioides	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Coreopsis lanceolata	Forb	Post, S	Imazapic	3 oz ai/ac[14]	Tolerant
Coreopsis lanceolata	Forb	Pre, Post, S	Imazapic	0.9 oz ai/ac[4]	Tolerant
Coreopsis lanceolata	Forb	Pre, S	Imazapic	1 oz ai/ac[2]	Tolerant
Coreopsis lanceolata	Forb	Pre, S	Imazapic	1 oz ai/ac[9]	Tolerant
Coreopsis lanceolata	Forb	Pre, S	Imazapic	4 oz ai/ac[14]	Tolerant
Coreopsis lanceolata	Forb	Pre, S	Journey	10.7 oz/ac[5]	Tolerant
Coreopsis tinctoria	Forb	Post, S	Imazapic	1.5 oz ai/ac[14]	Tolerant
Coreopsis tinctoria	Forb	Post, S	Imazapic	2 oz ai/ac[14]	Suppressed
Coreopsis tinctoria	Forb	Pre, Post, S	Imazapic	0.9 oz ai/ac[4]	Tolerant
Coreopsis tinctoria	Forb	Pre, S	Imazapic	1.5 oz ai/ac[14]	Tolerant
Coreopsis tinctoria	Forb	Pre, S	Imazapic	2 oz ai/ac[14]	Suppressed
Coreopsis tinctoria	Forb	Pre, S	Journey	10.7 oz/ac[5]	Tolerant
Coreopsis tripteris	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Coreopsis tripteris	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Echinacea purpurea	Forb	E	Aminopyralid	2.8 oz ai/ac[7]	Tolerant
Echinacea purpurea	Forb	Post, S	Imazapic	3 oz ai/ac[14]	Tolerant
Echinacea purpurea	Forb	Pre, Post, S	Imazapic	0.9 oz ai/ac[4]	Tolerant
Echinacea purpurea	Forb	Pre, S	Imazapic	1 oz ai/ac[2]	Suppressed
Echinacea purpurea	Forb	Pre, S	Imazapic	2 oz ai/ac[14]	Tolerant
Echinacea purpurea	Forb	Pre, S	Imazapic	4 oz ai/ac[14]	Suppressed
Echinacea purpurea	Forb	Pre, S	Journey	10.7 oz/ac[5]	Tolerant
Eupatorium altissimum	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Eupatorium altissimum	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Eupatorium coelestinum	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Eupatorium coelestinum	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Eupatorium serotinum	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Gaillardia pulchella	Forb	Post, S	Imazapic	0.9 oz ai/ac[4]	Tolerant
Gaillardia pulchella	Forb	Post, S	Imazapic	2 oz ai/ac[14]	Tolerant
Gaillardia pulchella	Forb	Post, S	Imazapic	3 oz ai/ac[14]	Suppressed
Gaillardia pulchella	Forb	Pre, S	Imazapic	0.9 oz ai/ac[4]	Intolerant
Gaillardia pulchella	Forb	Pre, S	Imazapic	1 oz ai/ac[14]	Suppressed
Gaillardia pulchella	Forb	Pre, S	Imazapic	4 oz ai/ac[14]	Suppressed
Geranium carolinianum	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Helenium autumnale	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant

Table C3. Responses of Native Illinois Plant Species to Common Rangeland Herbicides

Scientific Name	Type	Application[a]	Herbicide	Rate	Effect
Helianthus annus	Forb	Pre, S	Imazapic	1 oz ai/ac[14]	Suppressed
Helianthus annus	Forb	Pre, S	Journey	10.7 oz/ac[5]	Tolerant
Helianthus annuus	Forb	Post	Aminopyralid	1.6–2.4 oz ai/ac[8]	Intolerant
Helianthus annuus	Forb	Post, S	Imazapic	1 oz ai/ac[14]	Intolerant
Helianthus divaricatus	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Helianthus divaricatus	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Hypericum punctatum	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Liatris pycnostachya	Forb	Pre, S	Journey	10.7 oz/ac[5]	Tolerant
Lobelia siphilatica	Forb	E	Aminopyralid	2.8 oz ai/ac[7]	Suppressed
Lobelia spicata	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Lobelia spicata	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Ludwigia alternifolia	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Ludwigia alternifolia	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Monarda fistulosa	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Monarda fistulosa	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Oenothera biennis	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Oenothera biennis	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Oenothera laciniata	Forb	Post	Aminopyralid	1.6–2.8 oz ai/ac[8]	Intolerant
Parthenium integrifolium	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Parthenium integrifolium	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Phlox pilosa	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Phlox pilosa	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Physostegia virginiana	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Physostegia virginiana	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Pycnanthemum tenuifolium	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Pycnanthemum tenuifolium	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Ratibida columnifera	Forb	E	Aminopyralid	2.8 oz ai/ac[7]	Intolerant
Ratibida columnifera	Forb	Post, S	Halosulfuron	0.67 oz ai/ac[1]	Injury
Ratibida columnifera	Forb	Post, S	Imazapic	2 oz ai/ac[1]	Intolerant
Ratibida columnifera	Forb	Pre, Post, S	Imazapic	0.9 oz ai/ac[4]	Tolerant
Ratibida columnifera	Forb	Pre, S	Journey	10.7 oz/ac[5]	Tolerant
Ratibida pinnata	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Ratibida pinnata	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Rudbeckia hirta	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Rudbeckia hirta	Forb	Post, S	Imazapic	3 oz ai/ac[14]	Tolerant
Rudbeckia hirta	Forb	Pre, Post, S	Imazapic	0.9 oz ai/ac[4]	Tolerant
Rudbeckia hirta	Forb	Pre, S	Imazapic	1 oz ai/ac[9]	Suppressed
Rudbeckia hirta	Forb	Pre, S	Imazapic	4 oz ai/ac[14]	Tolerant
Rudbeckia hirta	Forb	Pre, S	Journey	10.7 oz /ac[3]	Tolerant
Rudbeckia hirta	Forb	Pre, S	Journey	10.7 oz/ac[5]	Tolerant
Rudbeckia hirta	Forb	Pre, S	Journey	21.4 oz ac[3]	Intolerant
Rudbeckia hirta	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Rudbeckia triloba	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant

Table C3 (continued). Responses of Native Illinois Plant Species to Common Rangeland Herbicides

Scientific Name	Type	Application[a]	Herbicide	Rate	Effect
Silphium terebinthinaceum	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Silphium terebinthinaceum	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Solidago nemoralis	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Solidago nemoralis	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Solidago speciosa	Forb	E	Aminopyralid	2.8 oz ai/ac[7]	Tolerant
Solidago speciosa	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Symphyotrichum laeve	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Symphyotrichum laeve	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Symphyotrichum novae-angliae	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Symphyotrichum novae-angliae	Forb	Post, S	Imazapic	0.9 oz ai/ac[4]	Tolerant
Symphyotrichum novae-angliae	Forb	Pre, S	Imazapic	0.9 oz ai/ac[4]	Intolerant
Symphyotrichum novae-angliae	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Symphyotrichum oolentangiensis	Forb	E	Aminopyralid	2.8 oz ai/ac[7]	Tolerant
Symphyotrichum pilosum	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Symphyotrichum pilosum	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Verbena urticifolia	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Verbesina alternifolia	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Vernonia gigantea	Forb	Post	Aminopyralid	2–2.8 oz ai/ac[8]	Intolerant
Vernonia gigantea	Forb	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Vernonia gigantea	Forb	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Andropogon gerardii	Grass	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Andropogon gerardii	Grass	Pre, Post, S	Imazapic	3 oz ai/ac[14]	Tolerant
Andropogon gerardii	Grass	Pre, S	Imazapic	1 oz ai/ac[2]	Tolerant
Andropogon gerardii	Grass	Pre, S	Imazapic	2 oz ai/ac[12]	Tolerant
Andropogon gerardii	Grass	S,E	Imazapic	0.4–2.7 oz ai/ac[4]	Tolerant
Andropogon gerardii	Grass	Pre, S	Journey	10.7 oz /ac[3]	Tolerant
Andropogon gerardii	Grass	Pre, S	Journey	10.7–32 oz/ac[5]	Tolerant
Andropogon gerardii	Grass	Pre, S	Journey	21.4 oz ac[3]	Tolerant
Andropogon gerardii	Grass	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Andropogon gerardii	Grass	Post, E	Sulfosulfuron	0.6–1.5 oz ai/ac[13]	Tolerant
Andropogon virginicus	Grass	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Andropogon virginicus	Grass	S,E	Imazapic	0.4–2.7 oz ai/ac[4]	Tolerant
Andropogon virginicus	Grass	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Aristida longespica	Grass	E	Imazapic	0.4–2.7 oz ai/ac[4]	Tolerant
Aristida oligantha	Grass	E	Imazapic	0.4–2.7 oz ai/ac[4]	Tolerant
Bouteloua curtipendula	Grass	E	Imazapic	0.4–1.8 oz ai/ac[4]	Tolerant
Bouteloua curtipendula	Grass	Pre, Post, S	Imazapic	2.5 oz ai/ac[14]	Tolerant
Bouteloua curtipendula	Grass	Pre, Post, S	Imazapic	3 oz ai/ac[14]	Suppressed
Bouteloua curtipendula	Grass	Pre, S	Imazapic	2 oz ai/ac[12]	Tolerant
Bouteloua curtipendula	Grass	S	Imazapic	0.4–1.8 oz ai/ac[4]	Suppressed
Bouteloua curtipendula	Grass	Pre, S	Journey	10.7–21.3 oz/ac[5]	Tolerant
Bouteloua curtipendula	Grass	Post, E	Sulfosulfuron	0.6–1.5 oz ai/ac[13]	Tolerant
Buchloe dactyloides	Grass	Post, E	Sulfosulfuron	0.6–1.5 oz ai/ac[13]	Tolerant

Table C3 (continued). Responses of Native Illinois Plant Species to Common Rangeland Herbicides

Scientific Name	Type	Application[a]	Herbicide	Rate	Effect
Buchloe dactyloides	Grass	E	Imazapic	0.4–1.8 oz ai/ac[4]	Tolerant
Buchloe dactyloides	Grass	S	Imazapic	0.4–0.9 oz ai/ac[4]	Tolerant
Buchloe dactyloides	Grass	Pre, S	Journey	10.7 oz/ac[5]	Tolerant
Elymus trachycaulus	Grass	Pre, S	Imazapic	1 oz ai/ac[10]	Tolerant
Panicum virgatum	Grass	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Panicum virgatum	Grass	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Panicum virgatum	Grass	Post, E	Sulfosulfuron	0.6–1.5 oz ai/ac[13]	Tolerant
Schizachyrium scoparium	Grass	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Schizachyrium scoparium	Grass	Pre, Post, S	Imazapic	3 oz ai/ac[14]	Tolerant
Schizachyrium scoparium	Grass	Pre, S	Imazapic	1 oz ai/ac[2]	Tolerant
Schizachyrium scoparium	Grass	Pre, S	Imazapic	2 oz ai/ac[12]	Tolerant
Schizachyrium scoparium	Grass	S,E	Imazapic	0.4–2.7 oz ai/ac[4]	Tolerant
Schizachyrium scoparium	Grass	Pre, S	Journey	10.7 oz /ac[3]	Tolerant
Schizachyrium scoparium	Grass	Pre, S	Journey	10.7–32 oz/ac[5]	Tolerant
Schizachyrium scoparium	Grass	Pre, S	Journey	21.4 oz ac[3]	Tolerant
Schizachyrium scoparium	Grass	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Schizachyrium scoparium	Grass	Post, E	Sulfosulfuron	0.6-1.5 oz ai/ac[13]	Tolerant
Sorghastrum nutans	Grass	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Sorghastrum nutans	Grass	Pre, Post, S	Imazapic	3 oz ai/ac[14]	Tolerant
Sorghastrum nutans	Grass	Pre, S	Imazapic	1 oz ai/ac[2]	Tolerant
Sorghastrum nutans	Grass	Pre, S	Imazapic	2 oz ai/ac[12]	Tolerant
Sorghastrum nutans	Grass	S,E	Imazapic	0.4–2.7 oz ai/ac[4]	Tolerant
Sorghastrum nutans	Grass	Pre, S	Journey	10.7 oz /ac[3]	Tolerant
Sorghastrum nutans	Grass	Pre, S	Journey	10.7–32 oz/ac[5]	Tolerant
Sorghastrum nutans	Grass	Pre, S	Journey	21.4 oz ac[3]	Tolerant
Sorghastrum nutans	Grass	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Sorghastrum nutans	Grass	Post, E	Sulfosulfuron	0.6–1.5 oz ai/ac[13]	Tolerant
Amorpha canescens	Legume	Pre, Post, S	Imazapic	1.8 oz ai/ac[4]	Tolerant
Amorpha canescens	Legume	Pre, S	Imazapic	1 oz ai/ac[11]	Suppressed
Chamaecrista fasciculata	Legume	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Chamaecrista fasciculata	Legume	Post, S	Imazapic	3 oz ai/ac[14]	Tolerant
Chamaecrista fasciculata	Legume	Pre, Post, S	Imazapic	0.9 oz ai/ac[4]	Tolerant
Chamaecrista fasciculata	Legume	Pre, S	Imazapic	1 oz ai/ac[11]	Tolerant
Chamaecrista fasciculata	Legume	Pre, S	Imazapic	4 oz ai/ac[14]	Tolerant
Chamaecrista fasciculata	Legume	Pre, S	Journey	10.7 oz /ac[3]	Tolerant
Chamaecrista fasciculata	Legume	Pre, S	Journey	10.7 oz/ac[5]	Tolerant
Chamaecrista fasciculata	Legume	Pre, S	Journey	21.4 oz ac[3]	Tolerant
Chamaecrista fasciculata	Legume	E	Sulfosulfuron	0.4 oz ai/ac[6]	Tolerant
Dalea candida	Legume	E	Aminopyralid	2.8 oz ai/ac[7]	Intolerant
Dalea candida	Legume	Post, S	Halosulfuron	0.67 oz ai/ac[1]	Injury
Dalea candida	Legume	Post, S	Imazapic	2 oz ai/ac[1]	Intolerant
Dalea candida	Legume	Pre, Post, S	Imazapic	0.9 oz ai/ac[4]	Tolerant

Table C3 (continued). Responses of Native Illinois Plant Species to Common Rangeland Herbicides

Scientific Name	Type	Application[a]	Herbicide	Rate	Effect
Dalea purpurea	Legume	Post, S	Imazapic	3 oz ai/ac[14]	Tolerant
Dalea purpurea	Legume	Pre, Post, S	Imazapic	0.9 oz ai/ac[4]	Tolerant
Dalea purpurea	Legume	Pre, S	Imazapic	1 oz ai/ac[11]	Tolerant
Dalea purpurea	Legume	Pre, S	Imazapic	1 oz ai/ac[14]	Intolerant
Dalea purpurea	Legume	Pre, S	Imazapic	1 oz ai/ac[2]	Tolerant
Dalea purpurea	Legume	Pre, S	Journey	10.7 oz/ac[5]	Tolerant
Desmanthus illinoensis	Legume	Post, S	Imazapic	3 oz ai/ac[14]	Tolerant
Desmanthus illinoensis	Legume	Pre, Post, S	Imazapic	0.9 oz ai/ac[4]	Tolerant
Desmanthus illinoensis	Legume	Pre, S	Imazapic	1 oz ai/ac[11]	Tolerant
Desmanthus illinoensis	Legume	Pre, S	Imazapic	1 oz ai/ac[2]	Tolerant
Desmanthus illinoensis	Legume	Pre, S	Imazapic	4 oz ai/ac[14]	Tolerant
Desmanthus illinoensis	Legume	Pre, S	Journey	10.7 oz/ac[5]	Tolerant
Desmodium canadense	Legume	Post, S	Imazapic	0.9 oz ai/ac[4]	Tolerant
Desmodium canadense	Legume	Pre, S	Imazapic	0.5 oz ai/ac[10]	Tolerant
Desmodium canadense	Legume	Pre, S	Imazapic	0.9 oz ai/ac[4]	Intolerant
Desmodium canadense	Legume	Pre, S	Imazapic	1 oz ai/ac[10]	Suppressed
Desmodium canadense	Legume	Pre, S	Imazapic	1 oz ai/ac[11]	Suppressed
Desmodium spp.	Legume	Pre, S	Journey	10.7 oz/ac[5]	Tolerant
Lespedeza capitata	Legume	Pre, S	Imazapic	0.5 oz ai/ac[10]	Suppressed
Lespedeza capitata	Legume	Pre, S	Imazapic	1 oz ai/ac[10]	Intolerant
Lespedeza capitata	Legume	Pre, S	Imazapic	1 oz ai/ac[11]	Suppressed
Lespedeza violacea	Legume	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Lespedeza virginica	Legume	E	Imazapic	2.9 oz ai/ac[6]	Tolerant
Senna marilandica	Legume	E	Imazapic	2.9 oz ai/ac[6]	Tolerant

[a] E = Established, S = Seedling, Pre = Preemergence Application, Post = Postemergence Application.

[1] Wiese et al. 2011

[2] Washburn and Barnes 2000

[3] Riffell et al. 2009

[4] BASF 2008b

[5] BASF 2008a

[6] Barnes 2007

[7] Mikkelson and Lym 2012

[8] Dow AgroSciences 2005

[9] Norcini et al. 2003

[10] Bahm and Barnes 2011a

[11] Beran et al. 1999

[12] Mittelhauser et al. 2011

[13] Monsanto 2006

[14] Vollmer and Vollmer 1999

APPENDIX D COMPOSITION OF SEED MIXES BY MIX TYPE FOR ALL STATES

Table D1. Temporary Mix Composition for All States Surveyed. Values are application rates in lb/ac

	Seed Mixes									
Species	**IL 7**	**IL THA 7**	**IN T**	**IA Spring**	**IA Summer**	**IA Fall**	**MI CR**	**MI TSM 6/24**	**MI TSM 24+**	**MN 100**
Wheat			150 (9-1 to 11-30)							100
Oats	64		150 (3-15 to 6-15)	65	97	65		50	100	
Perennial Ryegrass	50							50	100	
Cereal Rye				25	35	35	70			
Annual Ryegrass		30								
Timothy				5	5	5				
Slender Wheatgrass										
Sudangrass or Starr Millet										
Italian Rye										
Balboa Rye										
Japanese Millet										
Smooth Brome										
Canada Wildrye										
Red Clover				5	5	5				
Alsike Clover										
Korean Lespedeza										
Hairy Vetch										
Vernal Alfalfa										
Creeping Alfalfa										
Annual Alfalfa										
Total	114	30	150	100	142	110	70	100	200	100

Table D1 (continued). Temporary Mix Composition for All States Surveyed. Values are application rates in lb/ac.

	Seed Mixes									
Species	**MN 110**	**MN 130**	**MN 150**	**MN 190**	**TN D**	**TN E**	**TN F**	**WI 60**	**WI Temp**	**WI Nurse**
Wheat		40							130 (after 9-1)	35 (after 9-1)
Oats	100	40			21			13	130 (Sp, Su)	35 (Sp, Su)
Perennial Ryegrass			15	15						
Cereal Rye										
Annual Ryegrass		10						19.5		
Timothy								8		
Slender Wheatgrass			5	3						
Sudangrass or Starr Millet						65				
Italian Rye					22		22			
Balboa Rye							43			
Japanese Millet								13		
Smooth Brome				7.2						
Canada Wildrye								6.5		
Red Clover			10	6				2.5		
Alsike Clover				4.2				2.5		
Korean Lespedeza					22					
Hairy Vetch				15						
Vernal Alfalfa			10							
Creeping Alfalfa				9.6						
Annual Alfalfa		10								
Total	100	100	40	60	65	65	65	65	130	35

Table D2. Turf Mix Composition for All States Surveyed. Values are application rates in lb/ac.

	Seed Mixes														
Species	**IL 1**	**IL 1A**	**IL 1B**	**IL 2**	**IL 2A**	**IL THA 2E**	**IL THA 2F**	**IN R**	**IN U**	**IN P**	**IN 1**	**IN 2**	**IA Rural**	**IA Urban**	**KY 1**
Perennial Ryegrass	60	20	20	50	20	50	50	65		20	65	15	45		25
Kentucky Bluegrass	100	60				20	50					40		122.5	
Kentucky 31 Fescue								95			95				188
Creeping Red Fescue	40		20	40			50					30		35	
Hard Fescue		20			30	40									
Red Fescue		20			30	50	20	10	20	30	10				
Tall Fescue				100	60	80	110		95						
Red Top			10	10			10								25
Fults Saltgrass		60			60	60				30					
Fineleaf Perennial Ryegrass									35					17.5	
Canada Bluegrass															
Fowl Bluegrass															
98/85 Bluegrass															
Fawn Fescue													55		
Fineleaf Turf Fescue			150												
Alkalili Grass															
Smooth Brome											15	15			
Orchardgrass											40	10			
Bermudagrass															
Annual Ryegrass															
Oats															
German Millet															
White Clover															12
Birdsfoot Trefoil													5		
Korean Lespedeza															
Annual Lespedeza															
Total	200	180	200	200	200	300	290	170	150	80	225	110	105	175	250

Table D2 (continued). Turf Mix Composition for All States Surveyed. Values are application rates in lb/ac.

	Seed Mixes											
Species	**MI TDS**	**MI THV**	**MI TUF**	**MI TGM**	**MI THM**	**MN 60A**	**MN 260**	**MN 270**	**MO Mow**	**OH 1**	**OH 2**	**TN A**
Perennial Ryegrass	55	66	44	44	44	14	20	20.4	5	87	65	5.5
Kentucky Bluegrass	11	33	22	22	66	22	62	90		130	65	
Kentucky 31 Fescue											88	87
Creeping Red Fescue	99	99	88	88	110	10		9.6		130		
Hard Fescue	55		44	66			8					
Red Fescue												
Tall Fescue									80			
Red Top												
Fults Saltgrass		22	22									
Fineleaf Perennial Ryegrass												
Canada Bluegrass						12	10					
Fowl Bluegrass						10						
98/85 Bluegrass						12						
Fawn Fescue												
Fineleaf Turf Fescue												
Alkalili Grass						19						
Smooth Brome												
Orchardgrass												
Bermudagrass												
Annual Ryegrass									10	87		
Oats									10			
German Millet												
White Clover						1			5			
Birdsfoot Trefoil												
Korean Lespedeza												16.5
Annual Lespedeza												
Total	220	220	220	220	220	100	100	120	110	434	218	109

Table D2 (continued). Turf Mix Composition for All States Surveyed. Values are application rates in lb/ac.

	Seed Mixes						
Species	**TN B**	**TN B1**	**TN C**	**WI 10**	**WI 20**	**WI 30**	**WI 40**
Perennial Ryegrass	22		22	13	39		
Kentucky Bluegrass				26	8	9	31
Kentucky 31 Fescue	60		76				
Creeping Red Fescue							
Hard Fescue					31	21	17
Red Fescue				16		26	17
Tall Fescue					52		
Red Top				3			
Fults Saltgrass						9	
Fineleaf Perennial Ryegrass						13	22
Canada Bluegrass							
Fowl Bluegrass							
98/85 Bluegrass							
Fawn Fescue							
Fineleaf Turf Fescue							
Alkalili Grass							
Smooth Brome							
Orchardgrass							
Bermudagrass		18					
Annual Ryegrass							
Oats							
German Millet	11						
White Clover			11	7			
Birdsfoot Trefoil						9	
Korean Lespedeza	16						
Annual Lespedeza		8					
Total	109	26	109	65	130	87	87

Table D3. Salt-Tolerant Mix Composition for All States Surveyed. Values are application rates in lb/ac.

	Seed Mixes									
Species	**IL 1A**	**IL 2A**	**IL 6A**	**IL THA 2E**	**IN P**	**MI THV**	**MN 60A**	**MN 60A Alternates**	**WI 30**	**WI 80**
Saltgrass	60	60	20	60	30	22	19		9	0.7
Red Fescue	20	30		50	30	99			26	
Perennial Ryegrass	20	20		50	20	66	14			
Bluegrass	60			20		33	22		9	
Hard Fescue	20	30		40					21	
Tall Fescue		60		80						
Little Bluestem			5					X		3.5
Canada Wildrye			2					X		8
Buffalograss			5							
Vernal Alfalfa			15							
Oats			48							
Fine-Leaved Ryegrass									13	
Birdsfoot Trefoil									9	
Sieoats Grama								X		8.8
Slender Wheatgrass										7
Annual Ryegrass										3.5
Switchgrass										3.5
Creeping Red Fescue							10			
Canada Bluegrass							12			
Fowl Bluegrass							10			
Common Bluegrass							12			
White Clover							1			
Indiangrass								X		
Blue Grama								X		
Total	180	200	95	300	80	220	100	X	87	35

Table D4. Low-Grow Mix Composition for All States Surveyed. Values are application rates in lb/ac.

	Seed Mixes					
Species	**IL 1B**	**IL 4A**	**KY Guardrail**	**MN 60A**	**OH 3B**	**OH 4B**
Perennial Ryegrass	20	15		14		
Creeping Red Fescue	20			10	35	
Annual Ryegrass		25			10	10
Little Bluestem		5				8
Sideoats Grama		5				1.5
Prairie Dropseed		0.5				1.5
Hard Fescue			150		56	
Fineleaf Turf Fescue	150					
Red Top	10					
Canada Wildrye		1				
Oats		25				
Canada Bluegrass				12		
Fowl Bluegrass				10		
Common Bluegrass				12		
KentuckyY Bluegrass				22		
Alkaligrass				19		
White Clover				1		
Total	200	76.5	150	100	101	21

Table D5. Slope Mix Composition for All States Surveyed. Values are application rates in lb/ac.

	Seed Mixes														
Species	**IL 3**	**IL 3A**	**IL THA 3E**	**IN CV**	**KY CV**	**MI TDS**	**MI TGM**	**MI THM**	**OH 3B**	**OH 3C**	**TN Slope (+ Mix A, B, or C)**	**TN Slope (2-1 to 7-1) (+ A, B, or C)**	**WI 70[1]**	**WI 70A[1]**	**WI 75**
Perennial Ryegrass	20	20	40			55	44	44		78					
Little Bluestem	12	12	25										2.6	3.5	3
Sideoats Grama	10	10	20										2.6	3.5	6
Canada Wildrye	5	20	10										2.6	2.6	10.5
Creeping Red Fescue			15			99	88	110	35						
Kentucky Bluegrass			10			11	22	66							
Annual Ryegrass			30						10	13					3
Hard Fescue						55	66		56						
Oats	50	50	50												
Tall Fescue			50												
Switchgrass		10													
Big Bluestem													2.6	2.6	3
Indiangrass													2.6		3
Slender Wheatgrass	15		15												
Buffalograss	5		5												
Weeping Lovegrass												2			
Fults Saltgrass	30		30												
Junegrass														0.9	
White Prairieclover		5													
Purple Prairieclover													0.35	0.35	1.2
Sericea Lespedeza											15	15			
Alsike Clover	5		2												
Illinois Bundleflower	2		1												
Crown Vetch				10	10					39					
Black-Eyed Susan		5													0.3
Other Native Forbs[1]													4	4	
TotalE	154	132	303	10	10	220	220	220	101	130	124	126	17.4	17.5	30

[1] See Table E11 for native forb species and application rate information.

Table D6. Native Mix Composition for All States Surveyed.
Values are application rates in lb/ac.

	Seed Mixes										
Common Name	**Family**	**IL 3**	**IL 3A**	**IL 4**	**IL 4A**	**IL 6**	**IL 6A**	**IL THA 4E**	**IL THA 4F**	**IA Native Grass**	**MI ES**
Oats	Poaceae	50	50	25	25	48	48	40	40		
Wheat	Poaceae										
Little Bluestem	Poaceae	12	12	5	5	5	5	15	20		3
Canada Wildrye	Poaceae	5	20	1	1	2	2	2	3	12	
Annual Ryegrass	Poaceae			25	25			30	50		
Sideoats Grama	Poaceae	10	10	5	5					3	
Big Bluestem	Poaceae			4						8	9
Indiangrass	Poaceae			2				2		8	3
Switchgrass	Poaceae		10	1				2		2	4
Perennial Ryegrass	Poaceae	20	20	15	15			25	40		11
Slender Wheatgrass	Poaceae	15							5		
Virginia Wildrye	Poaceae										
Buffalograss	Poaceae	5				5	5				
Junegrass	Poaceae										
Fults Saltgrass	Poaceae	30					20				
Cereal Rye	Poaceae							10	15	22.5	
Prairie Dropseed	Poaceae				0.5						
Blue Grama	Poaceae									3	
Red Fescue	Poaceae								10		
Tall Fescue	Poaceae							20	45		
Tall Dropseed	Poaceae										
Sand Dropseed	Poaceae										
Fringed Brome	Poaceae										
Fowl Bluegrass	Poaceae										
Red Top	Poaceae										
Timothy	Poaceae										24
Canada Bluegrass	Poaceae										
Kentucky Bluegrass	Poaceae								20		

Table D6 (continued). Native Mix Composition for All States Surveyed.
Values are application rates in lb/ac.

		Seed Mixes													
Common Name	**Family**	**MN 328**	**MN 330**	**MN 340**	**MN 350**	**MO Urban**	**MO Rural**	**OH 4B**	**OH 5B**	**OH 6**	**OH 7**	**WI 70**	**WI 75**	**WI 70A**	**WI 80**
Oats	Poaceae	56[a]	56[a]	56[a]	56[a]	10	20								
Wheat	Poaceae	56[b]	56[b]	56[b]	56[b]										
Little Bluestem	Poaceae		3.5	2.5	2.5	6	6	8	3	8		2.6	3	3.5	3.5
Canada Wildrye	Poaceae		3	2	2	1	1					2.6	11	2.6	8
Annual Ryegrass	Poaceae	11.2	11.2	11.2	11.2	10	10	10	40	10	10		3		3.5
Sideoats Grama	Poaceae		3	2	3	6	4	1.5				2.6	6	3.5	8.8
Big Bluestem	Poaceae	2		3	3		4		2	5.5	3	2.6	3	2.6	
Indiangrass	Poaceae	2			2.5		8		1	5.5	4	2.6	3		
Switchgrass	Poaceae	1		0.5	1		2				1				3.5
Perennial Ryegrass	Poaceae					10	5								
Slender Wheatgrass	Poaceae	2.8	2.8	2.8	2.8										7
Virginia Wildrye	Poaceae	4				1	1								
Buffalograss	Poaceae														
Junegrass	Poaceae		1	0.5										0.9	
Fults Saltgrass	Poaceae														0.7
Cereal Rye	Poaceae														
Prairie Dropseed	Poaceae					0.3		1.5							
Blue Grama	Poaceae		2.5												
Red Fescue	Poaceae						10								
Tall Fescue	Poaceae														
Tall Dropseed	Poaceae					0.3	0.5								
Sand Dropseed	Poaceae		1	0.5											
Fringed Brome	Poaceae	2													
Fowl Bluegrass	Poaceae	5													
Red Top	Poaceae						0.5								
Timothy	Poaceae														
Canada Bluegrass	Poaceae			3											
Kentucky Bluegrass	Poaceae														

[a] When sown in spring.

[b] When sown in fall.

Table D6 (continued). Native Mix Composition for All States Surveyed.
Values are application rates in lb/ac.

	Seed Mixes										
Common Name	**Family**	**IL 3**	**IL 3A**	**IL 4**	**IL 4A**	**IL 6**	**IL 6A**	**IL THA 4E**	**IL THA 4F**	**IA Native Grass**	**MI ES**
New England Aster	Asteraceae									0.2	
Yellow Coneflower	Asteraceae									0.3	
Oxeye Sunflower	Asteraceae										
Prairie Blazingstar	Asteraceae									0.3	
Prairie Dock	Asteraceae										
Purple Coneflower	Asteraceae										
Showy Goldenrod	Asteraceae										
Western Sunflower	Asteraceae										
Whorled Rosinweed	Asteraceae										
Stiff Goldenrod	Asteraceae										
Rough Blazingstar	Asteraceae										
Lance-Leaved Coreopsis	Asteraceae										
Showy Tick Trefoil	Asteraceae										
Downy Sunflower	Asteraceae										
Orange Coneflower	Asteraceae										
Purple Prairieclover	Fabaceae									0.3	
Partridge Pea	Fabaceae										
Vernal Alfalfa	Fabaceae					15	15				
White Clover	Fabaceae										
White Prairieclover	Fabaceae		5								
Wild Lupine	Fabaceae										
Illinois Bundleflower	Fabaceae	2									
Canada Tick Trefoil	Fabaceae										
Alsike Clover	Fabaceae	5									
Golden Alexanders	Apiaceae										
Rattlesnake Master	Apiaceae										
Butterflyweed	Asclepiadaceae									0.3	
Swamp Milkweed	Asclepiadaceae										
Black-Eyed Susan	Asteraceae		5							0.3	
Ohio Spiderwort	Commelinaceae										
Flowering Spurge	Euphorbiaceae										
Wild Geranium	Geraniaceae										
Wild Bergamont	Lamiaceae									0.3	
Horse Mint	Lamiaceae										
Canada anemone	Ranunculaceae										
Blue Vervain	Verbenaceae										
Total		154	132	83	76.5	75	95	146	248	60.5	54

Table D6 (continued). Native Mix Composition for All States Surveyed.
Values are application rates in lb/ac.

		Seed Mixes													
Common Name	**Family**	**MN 328**	**MN 330**	**MN 340**	**MN 350**	**MO Urban**	**MO Rural**	**OH 4B**	**OH 5B**	**OH 6**	**OH 7**	**WI 70**	**WI 75**	**WI 70A**	**WI 80**
New England Aster	Asteraceae								1.5	3		0.4		0.4	
Yellow Coneflower	Asteraceae						0.3		1.5			0.4		0.4	
Oxeye Sunflower	Asteraceae	0.3							1.5	8					
Prairie Blazingstar	Asteraceae											0.4			
Prairie Dock	Asteraceae								1.5	8					
Purple Coneflower	Asteraceae								1.5	8					
Showy Goldenrod	Asteraceae											0.4		0.4	
Western Sunflower	Asteraceae											0.5		0.5	
Whorled Rosinweed	Asteraceae								1.5	5					
Stiff Goldenrod	Asteraceae								1.5						
Rough Blazingstar	Asteraceae													0.4	
Lance-Leaved Coreopsis	Asteraceae					0.3									
Showy Tick Trefoil	Asteraceae	0.3													
Downy Sunflower	Asteraceae									3					
Orange Coneflower	Asteraceae								1.5						
Purple Prairieclover	Fabaceae	0.3					0.5					0.4	1.2	0.4	
Partridge Pea	Fabaceae						2		1.5					0.4	
Vernal Alfalfa	Fabaceae														
White Clover	Fabaceae					5	5								
White Prairieclover	Fabaceae														
Wild Lupine	Fabaceae													0.4	
Illinois Bundleflower	Fabaceae														
Canada Tick Trefoil	Fabaceae											0.4			
Alsike Clover	Fabaceae														
Golden Alexanders	Apiaceae											0.4			
Rattlesnake Master	Apiaceae								1.5						
Butterflyweed	Asclepiadaceae								1.5					0.4	
Swamp Milkweed	Asclepiadaceae	0.3													
Black-Eyed Susan	Asteraceae	0.5				0.3	0.3						0.3		
Ohio Spiderwort	Commelinaceae											0.4		0.4	
Flowering Spurge	Euphorbiaceae													0.4	
Wild Geranium	Geraniaceae											0.4			
Wild Bergamont	Lamiaceae								1.5			0.4			
Horse Mint	Lamiaceae													0.4	
Canada anemone	Ranunculaceae											0.4			
Blue Vervain	Verbenaceae	0.3													
Total		88	84	84	84	50.2	80.1	21	64	64	18	18	30	18	35

Table D7. Native Forb Mix Composition for All States Surveyed.
Values are application rates in lb/ac.

		Seed Mix						
Common Name	**Family**	**IL 5**	**IL 5A**	**IL 5B**	**MN Mesic Forb**	**MN Dry Forb**	**MN Wet Forb**	**OH 5A**
Black-Eyed Susan	Asteraceae	0.25	0.5		0.03	0.09	0.12	4
Stiff Goldenrod	Asteraceae	0.5	0.5		0.03	0.02	0.04	
Oxeye Sunflower	Asteraceae	0.5	0.5		0.03		0.02	
Prairie Blazingstar	Asteraceae	0.5	0.5		0.03		0.16	
New England Aster	Asteraceae	0.5	0.25				0.06	
Yellow Coneflower	Asteraceae	0.5	0.25		0.03			
Rough Blazingstar	Asteraceae	0.5			0.03	0.02		
Prairie Dock	Asteraceae	0.5	1					
Lance-Leaved Coreopsis	Asteraceae	0.25						4
Boneset	Asteraceae			0.14			0.2	
Sneezeweed	Asteraceae			0.04			0.02	
Prairie Coreopsis	Asteraceae	0.5				0.01		
Pale Purple Coneflower	Asteraceae	0.5	0.5					
Joe Pye Weed	Asteraceae			0.14			0.34	
Blanketflower	Asteraceae	0.25						0.5
Long-Headed Coneflower	Asteraceae	0.25			0.03			
Compass Plant	Asteraceae	0.5	0.5					
Smooth Aster	Asteraceae	0.5			0.03			
Red-Stalked Aster	Asteraceae			0.2			0.06	
Purple Coneflower	Asteraceae							4
Showy Goldenrod	Asteraceae					0.01		
Showy Tick Trefoil	Asteraceae				0.03			
Downy Sunflower	Asteraceae	0.5						
Beggarticks	Asteraceae			0.14				
Yarrow	Asteraceae					0.01		
Cornflower	Asteraceae							0.5
Shasta Daisy	Asteraceae	0.25						
Cosmos	Asteraceae							0.5
Yellow Cosmos	Asteraceae							0.5
Flat-Topped Aster	Asteraceae						0.02	
Narrow-Leaved Coneflower	Asteraceae				0.03			
Giant Sunflower	Asteraceae						0.04	
Dotted Blazingstar	Asteraceae					0.015		
Wild Quinine	Asteraceae	0.5						
Cutleaf Coneflower	Asteraceae			0.1				
Fragrant Coneflower	Asteraceae	0.5						
Grass-Leaved Goldenrod	Asteraceae						0.04	
Gray Goldenrod	Asteraceae					0.015		
Upland Goldenrod	Asteraceae					0.005		
Riddell Goldenrod	Asteraceae			0.04				
Heath Aster	Asteraceae					0.02		
Panicled Aster	Asteraceae						0.06	

Table D7 (continued). Native Forb Mix Composition for All States Surveyed.
Values are application rates in lb/ac.

		Seed Mix						
Common Name	**Family**	**IL 5**	**IL 5A**	**IL 5B**	**MN Mesic Forb**	**MN Dry Forb**	**MN Wet Forb**	**OH 5A**
Sky Blue Aster	Asteraceae	0.5						
Ironweed	Asteraceae						0.02	
Purple Prairieclover	Fabaceae	0.5			0.03	0.08	0.04	
White Prairieclover	Fabaceae	0.5			0.03	0.025	0.02	
Leadplant	Fabaceae	0.5				0.05		
Wild Lupine	Fabaceae					0.025		
Canada Milkvetch	Fabaceae				0.03			
White Wild Indigo	Fabaceae	0.5						
Canada Tick Trefoil	Fabaceae						0.02	
Roundhead Bushclover	Fabaceae					0.015		
Sweet Flag	Acoraceae			0.06				
Water Plantain	Alismataceae						0.08	
Golden Alexanders	Apiaceae				0.03	0.01	0.02	
Rattlesnake Master	Apiaceae	0.5						
Purple Angelica	Apiaceae			0.12				
Heart-Leaved Alexanders	Apiaceae				0.03			
Butterflyweed	Asclepiadaceae	0.5				0.01		
Swamp Milkweed	Asclepiadaceae			0.04			0.04	
Cardinal Flower	Campanulaceae			0.1				
Great Blue Lobelia	Campanulaceae			0.1				
Great St. Johnswort	Clusiaceae						0.04	
Ohio Spiderwort	Commelinaceae	0.5						
Wild Iris	Iridaceae						0.02	
Blue Flag	Iridaceae			0.04				
Wild Bergamont	Lamiaceae	0.5			0.03		0.02	
Mountain Mint	Lamiaceae			0.1	0.03		0.02	
False Dragonhead	Lamiaceae	0.5		0.1				
Fragrant Giant Hyssop	Lamiaceae						0.04	
Meadow Garlic	Liliaceae						0.02	
Corn Poppy	Papaveraceae							0.5
Curlytop Knotweed	Polygonaceae			0.2				
PA Smartweed	Polygonaceae			0.2				
Winged Loosestrife	Primulaceae			0.04				
Canada anemone	Ranunculaceae						0.02	
Thimbleweed	Ranunculaceae	0.5						
Rocket Larkspur	Ranunculaceae							0.5
Tall Meadow Rue	Ranunculaceae						0.04	
Prairie Cinquefoil	Rosaceae	0.5						
Prairie Rose	Rosaceae					0.005		
Long-Leaved Bluets	Rubiaceae					0.005		
Culver's Root	Scrophulariaceae	0.5					0.06	
Showy Penstemon	Scrophulariaceae				0.03			
Giant Bur Reed	Sparganiaceae			0.1				

Table D7 (continued). Native Forb Mix Composition for All States Surveyed.
Values are application rates in lb/ac.

		Seed Mix						
Common Name	**Family**	**IL 5**	**IL 5A**	**IL 5B**	**MN Mesic Forb**	**MN Dry**	**MN Wet Forb**	**OH 5A**
Blue Vervain	Verbenaceae				0.03		0.28	
Hoary Vervain	Verbenaceae				0.03	0.07		
Total		14.8	4.5	2	0.6	0.5	2	15

Table D8. Native Wetland Mix Composition for All States Surveyed.
Values are application rates in lb/ac.

		Seed Mixes			
Common Name	**Family**	**IL 4B**	**IA Wetland Grass**	**MN 310**	**MN 325**
Green Bulrush	Cyperaceae	0.18	0.1	0.3	0.2
Bluejoint Grass	Poaceae	0.72	0.1	0.3	0.2
Prairie Cordgrass	Poaceae	0.24	1	1.5	0.5
Tussock Sedge	Cyperaceae	0.36	0.1		0.2
Fox Sedge	Cyperaceae	0.36	0.3		0.2
Softstem Bulrush	Cyperaceae	0.18	0.5		0.3
Annual Ryegrass	Poaceae	25		11.2	11.2
Big Bluestem	Poaceae		1	2.5	1.5
Switchgrass	Poaceae		0.5	0.5	0.5
Virginia Wildrye	Poaceae		5	2	1.5
Bottlebrush Sedge	Cyperaceae		0.5		0.3
Woolgrass	Cyperaceae			0.3	0.2
Indiangrass	Poaceae			2.5	1.5
Slender Wheatgrass	Poaceae			2.8	2.8
Fowl Mannagrass	Poaceae	0.84			0.2
Rice Cutgrass	Poaceae	0.6	0.3		
Wheat	Poaceae			56 (fall)	56 (fall)
Oats	Poaceae	25		56	56 (spring)
New England Aster	Asteraceae		0.1		
Boneset	Asteraceae		0.1		
Sneezeweed	Asteraceae		0.1		
Beggarticks	Asteraceae		0.5		
Swamp Milkweed	Asclepiadaceae		1		
Blue Vervain	Verbenaceae		0.1		
Water Plantain	Alismataceae		0.3		
Broad-Leaved Arrowhead	Alismataceae		0.3		
Giant Bur Reed	Sparganiaceae			0.3	
Lake Bank Sedge	Cyperaceae	0.36			
Broom Sedge	Cyperaceae		0.1		
Awl-Fruited Sedge	Cyperaceae	0.36			
Needle Spike Rush	Cyperaceae	0.18			
Blunt Spike Rush	Cyperaceae	0.18			
Common Spikerush	Cyperaceae		0.3		
Hard-Stemmed Bulrush	Cyperaceae	0.18			
River Bulrush	Cyperaceae	0.18			
Common Rush	Juncaceae	0.36			
Slender Rush	Juncaceae	0.36			
Torrey's Rush	Juncaceae	0.36			
Fringed Brome	Poaceae				1.5
Fowl Bluegrass	Poaceae				1.5
Reed Mannagrass	Poaceae				0.2
Total		56	12.3	80	80

APPENDIX E COMPOSITION OF SEED MIXES BY STATE

Table E1. Illinois Department of Transportation Seed Mixes

Lawn Mixture 1	
Kentucky Bluegrass	100
Perennial Ryegrass	60
Creeping Red Fescue	40
Total	**200 lb/ac**

Salt -Tolerant Lawn Mix 1A	
Bluegrass	60
Perennial Ryegrass	20
Audubon Red Fescue	20
Rescue 911 Hard Fescue	20
Fults Saltgrass	60
Total	**180 lb/ac**

Low-Maintenance Lawn Mix 1B	
Fineleaf Turf-Type Fescue	150
Perennial Ryegrass	20
Red Top	10
Creeping Red Fescue	20
Total	**200 lb/ac**

Roadside Mixture 2	
Inferno or Tarheel II Tall Fescue	100
Perennial Ryegrass	50
Creeping Red Fescue	40
Red Top	10
Total	**200 lb/ac**

Salt-Tolerant Roadside Mixture 2A	
Inferno or Tarheel II Tall Fescue	60
Perennial Ryegrass	20
Audubon Red Fescue	30
Rescue 911 Hard Fescue	30
Fults Saltgrass	60
Total	**200 lb/ac**

Northern Illinois Slope Mix 3	
Canada Wildrye	5
Perennial Ryegrass	20
Alsike Clover	5
Illinois Bundleflower	2
Little Bluestem	12
Sideoats Grama	10
Fults Saltgrass	30
Oats	50
Slender Wheatgrass	15
Cody or Bowie Buffalograss	5
Total	**154 lb/ac**

Native Grass 4	
Big Bluestem	4
Little Bluestem	5
Sideoats Grama	5
Canada Wildrye	1
Switchgrass	1
Indiangrass	2
Annual Ryegrass	25
Oats	25
Perennial Ryegrass	15
Total	**83 lb/ac**

Low-Profile Native Grass 4A	
Little Bluestem	5
Sideoats Grama	5
Canada Wildrye	1
Prairie Dropseed	0.5
Annual Ryegrass	25
Oats	25
Perennial Ryegrass	15
Total	**76.5 lb/ac**

Table E1 (continued). Illinois Department of Transportation Seed Mixes

Wetland Grass and Sedge Mixture 4B	
Annual Ryegrass	25
Oats	25
Wetland Grasses (below)	6
Total	**56 lb/ac**
Wetland Grasses	% by Wt.
Bluejoint Grass	12
Lake Bank Sedge	6
Awl-Fruited Sedge	6
Tussock Sedge	6
Fox Sedge	6
Needle Spike Rush	3
Blunt Spike Rush	3
Fowl Mannagrass	14
Common Rush	6
Slender Rush	6
Torrey's Rush	6
Rice Cutgrass	10
Hard-Stemmed Bulrush	3
Dark Green Rush	3
River Bulrush	3
Softstem Bulrush	3
Cordgrass	4

Forbs with Annuals Mix 5	
Annuals	1
Do not exceed 25% by wt. for any species:	
Sand Coreopsis	
Shasta Daisy	
Blanketflower	
Long-Headed Coneflower	
Black-Eyed Susan	
Forbs	10
Do not exceed 5% by PLS wt. for any species:	
Leadplant	
Thimble Weed	
Butterflyweed	
Sky Blue Aster	
Smooth Aster	
New England Aster	
White Wild Indigo	
Prairie Coreopsis	
Pale Purple Coneflower	
Rattlesnake Master	
Downy Sunflower	
Oxeye	
Rough Blazingstar	
Prairie Blazingstar	
Prairie Bergamont	
Wild Quinine	
White Prairieclover	
Purple Prairieclover	
False Dragonhead	
Prairie Cinquefoil	
Yellow Coneflower	
Fragrant Coneflower	
Compass Plant	
Prairie Dock	
Rigid Goldenrod	
Spiderwort	
Culver's Root	
Total	**11 lb/ac**

Table E1 (continued). Illinois Department of Transportation Seed Mixes

Large-Flower Forb Mix 5A	
New England Aster	0.25
Pale Purple Coneflower	0.5
Downy Sunflower	0.5
Oxeye	0.5
Prairie Blazingstar	0.5
Yellow Coneflower	0.25
Black-Eyed Susan	0.5
Compass Plant	0.5
Prairie Dock	1
Rigid Goldenrod	0.5
Total	**5 lb/ac**

Wetland Forb Mix 5B	
Sweet Flag	0.06
Angelica	0.12
Swamp Milkweed	0.04
Purple-Stemmed Aster	0.2
Beggarticks	0.14
Spotted Joe Pye Weed	0.14
Boneset	0.14
Autumn Sneezeweed	0.04
Blue Flag	0.04
Cardinal Flower	0.1
Great Blue Lobelia	0.1
Winged Loosestrife	0.04
False Dragonhead	0.1
PA Smartweed	0.2
Curlytop Knotweed	0.2
Mountain Mint	0.1
Cutleaf Coneflower	0.1
Riddell Goldenrod	0.04
Giant Burreed	0.1
Total	**2 lb/ac**

Conservation Mix 6	
Little Bluestem	5
Canada Wildrye	2
Cody or Bowie Buffalograss	5
Vernal Alfalfa	15
Oats	48
Total	**75 lb/ac**

Salt-Tolerant Conservation Mix 6A	
Little Bluestem	5
Canada Wildrye	2
Cody or Bowie Buffalograss	5
Vernal Alfalfa	15
Oats	48
Fults Saltgrass	20
Total	**95 lb/ac**

Temporary Turf Cover Mix 7	
Perennial Ryegrass	50
Oats	64
Total	**114 lb/ac**

Table E2. Illinois Toll Highway Authority Seed Mixes

Salt Mix 2E	
Tall Fescue	80
Kentucky Bluegrass	20
Perennial Ryegrass	50
Red Fescue	30
Hard Fescue	40
Fults Saltgrass	60
Dawson Red Fescue	20
Total	**300 lb/ac**

Roadside Mix 2F	
Tall Fescue	110
Kentucky Bluegrass	50
Perennial Ryegrass	50
Creeping Red Fescue	50
Red Top	10
Dawson Red Fescue	20
Total	**290 lb/ac**

Slope Mix 3E	
Canada Wildrye	10
Perennial Ryegrass	40
Alsike Clover	2
Illinois Bundleflower	1
Little Bluestem	25
Sideoats Grama	20
Fults Saltgrass	30
Oats	50
Slender Wheatgrass	15
Buffalograss	5
Alta or K31 Fescue	50
Kentucky Bluegrass	10
Annual Ryegrass	30
Creeping Red Fescue	15
Total	**303 lb/ac**

Native Grass 4E	
Little Bluestem	15
Sideoats Grama	10
Canada Wildrye	2
Switchgrass	2
Indiangrass	2
Annual Ryegrass	30
Oats	40
Perennial Ryegrass	25
Alta Fescue	20
Total	**146 lb/ac**

Lo-Gro Native Grass 4F	
Little Bluestem	20
Sideoats Grama	15
Canada Wildrye	3
Prairie Dropseed	1
Annual Ryegrass	50
Oats	40
Perennial Ryegrass	40
Alta Fescue	45
Kentucky Bluegrass	20
Creeping Red Fescue	10
Slender Wheatgrass	5
Total	**249 lb/ac**

Changes from IL Mixes

4B Wetland Grass and Sedge Mix

Wetland Grasses 12 lb/ac

5 Forbs with Annuals Mix

Annuals Mixture	2 lb/ac
Forbs Mixture	18 lb/ac

5A Large-Flower Native Forb Mix

Forb Mix 12 lb/ac

5B Wetland Forb Mix

Forb Mixture 5 lb/ac

7 Temporary Turf Cover Mix

Annual Ryegrass 30 lb/ac

Table E3. Iowa Department of Transportation Seed Mixes

Rural Mix	
Fawn Fescue	55
Perennial Ryegrass	45
Birdsfoot Trefoil	5
Total	**105 lb/ac**

Urban Mix	
Kentucky Bluegrass	122.5
Fineleaf Perennial Ryegrass	17.5
Creeping Red Fescue	35
Total	**175 lb/ac**

Native Grass Mix	
Grain Rye	22.5
Canada Wildrye	12
Switchgrass	2
Big Bluestem	8
Indiangrass	8
Little Bluestem	4
Sideoats Grama	3
Blue Grama	3
Purple Prairieclover	4 oz/ac
Black-Eyed Susan	4 oz/ac
Prairie Blazingstar	4 oz/ac
Butterflyweed	4 oz/ac
Wild Bergamont	4 oz/ac
Gray Headed Coneflower	4 oz/ac
New England Aster	2 oz/ac
Total	**64 lb/ac**

Temporary Mix Spring (March 1–May 20)	
Oats	65
Rye	25
Red Clover	5
Timothy	5
Total	**100 lb/ac**

Summer (May 21–July 20)	
Oats	97
Rye	35
Red Clover	5
Timothy	5
Total	**142 lb/ac**

Fall (July 21–September 30)	
Oats	65
Rye	35
Red Clover	5
Timothy	5
Total	**110 lb/ac**

Wetland Grass Mix	
Verbena hastata	1 oz/ac
Eupatorium perfoliatum	1 oz/ac
Bidens cernua	8 oz/ac
Asclepias incarnata	1 lb/ac
Helenium autumnale	2 oz/ac
Alisma plantago-aquatica	4 oz/ac
Sagittaria latifolia	4 oz/ac
Symphyottrichum novae-angliae	2 oz/ac
Andropogon gerardii	1 lb/ac
Panicum virgatum	8 oz/ac
Spartina pectinata	1 lb/ac
Elymus virginicus	5 lb/ac
Calamagrostis	1 oz/ac
Leersia oryzoides	4 oz/ac
Scirpus atrovirens	1 oz/ac
Carex vulpinoidea	4 oz/ac
Schoenoplectus tabernaemontani	8 oz/ac
Eleocharis palustris	4 oz/ac
Carex hystericina	8 oz/ac
Broom Sedge	2 oz/ac
Tussock Sedge	2 oz/ac
Total	**12 lb/ac**

Table E3 (continued). Iowa Department of Transportation Seed Mixes

APPROVED SPECIES FOR MIXES

Domestic Grasses
Kentucky Bluegrass
Kentucky Bluegrass Ram-1
Kentucky Bluegrass Park
Smooth Brome Lincoln
Tall Fescue Fawn
Red Fescue Chewings
Red Fescue Creeping
Red Fescue Pennlawn
Tall Fescue Olympic Fineleaf
Tall Fescue Rebel Fineleaf
Sheep Fescue
Orchardgrass
Red Top
Reed Canarygrass
Canada Wildrye
Russian Wildrye
Perennial Ryegrass
Timothy

Legumes
Alfalfa Ranger and Vernal
Alfalfa Travois
Birdsfoot Trefoil Empire
Crownvetch Emerald
Hairy Vetch
Korean Lespedeza
Red Clover
Alsike Clover
White clover

Native Grasses
Big Bluestem
Little Bluestem
Switchgrass
Indiangrass
Sideoats Grama
Western Wheatgrass
Buffalograss
Sand Bluestem

Blue Grama
Intermediate Wheatgrass
Slender Wheatgrass
Prairie Dropseed
Sand Dropseed
Sand Lovegrass
Weeping Lovegrass
Hairy Wood Chess
Bluejoint Grass
Bottlebrush Sedge
Tussock Sedge
Fox Sedge
Virginia Wildrye
Reed Mannagrass
Fowl Mannagrass
Common Rush
Rice Cutgrass
Annual Ryegrass
Fowl Bluegrass
Green Bulrush
Woolgrass
Softstem Bulrush
Indiangrass
Spike Rush

Forbs
Canada Anemone
Marsh Milkweed
New England Aster
Swamp Aster
Showy Tick Trefoil
Joe Pye Weed
Boneset
Oxeye Sunflower

Blue Flag Iris
Meadow Blazingstar
Tall Blazingstar
Great Blue Lobelia
Reed Mannagrass
Fowl Mannagrass
Common Rush
Rice Cutgrass

Nurse or Stabilizing Crop
Oats
Rye
Sudangrass Piper

Table E4. Indiana Department of Transportation Seed Mixes

Seed Mix R (Rural)	
Kentucky 31 Fescue	95
Perennial Ryegrass	65
Jasper Red Fescue	10
Total	**170 lb/ac**

Seed Mix U (Urban)	
4-way blend of turf-type tall fescues	95
Jasper Red Fescue	20
Fine bladed Perennial Ryegrass	35
Total	**150 lb/ac**

Seed Mix P (Salt)	
"Fults" Puccinella distans	30
Jasper Red Fescue	30
Perennial Ryegrass	20
Total	**80 lb/ac**

Seed Mix D (Ditches) for saturated soils	
Fowl Manna Grass	1 oz/ac
Wetland Carex spp.	3 oz/ac
Rice Cut Grass	2 oz/ac
Bullrush	2 oz/ac
Leptochloa fascicularis	2 oz/ac
Barnyard Grass	2 oz/ac
Prairie Wildrye	2 oz/ac
Perennial Ryegrass	10 lb/ac
Jasper Red Fescue	2 lb/ac
"Fults" Puccinella distans	2 oz/ac
Redtop	1 lb/ac
Total	**14 lb/ac**

Seed Mix T (Temporary)	
Spring Mix (March 15–June15	
Oats	**150 lb/ac**
Fall Mix (September 1–November 30)	
Wheat	**150 lb/ac**

Seed Mix Grass	
Type 1	
Smooth Brome	15
Orchardgrass	40
Kentucky 31 Fescue	95
Perennial Ryegrass	65
Jasper Red Fescue	10
Total	**195 lb/ac**

Seed Mix Grass	
Type 2	
Smooth Brome	15 lb/ac
Orchardgrass	10
Certified Common KY Bluegrass	40
Creeping Red Fescue	30
Perennial Ryegrass	15
Total	**110 lb/ac**

Seed Mix Legume	
Type 1	
Sericea or Korean Lespedeza	10
Red or Alsike Clover	10
Kentucky 31 Fescue	95
Perennial Ryegrass	65
Jasper Red Fescue	10
Total	**190 lb/ac**

Seed Mix Legume	
Type 2	
Sericea or Korean Lespedeza	10
Med. Red or Alsike Clover	10
Birdsfoot Trefoil	10
Certified KY Bluegrass	40
Creeping Red Fescue	30
Annual Rye Grass	10
Total	**100 lb/ac**

Seed Mix CV (Crown Vetch)	
Crown Vetch	**10 lb/ac**

Table E5. Kentucky Transportation Cabinet Seed Mixes

Seed Mix 1	Complete	No-Till	Hydroseed	Overseed
Kentucky 31 Fescue	188	75	112.5	112.5
Red Top	25	10	15	15
White Clover	12	5	7.5	7.5
Perennial Ryegrass	25	10	15	15
Total	**250 lb/ac**	**100 lb/ac**	**150 lb/ac**	**150 lb/ac**

Seed Mix 2	Complete	No-Till	Hydroseed	Overseed
Kentucky 31 Fescue	75	30	45	45
Red Top	37.5	15	22.5	22.5
Partridge Pea	37.5	15	22.5	22.5
Sericea Lespedeza	50	20	30	30
Yellow Sweetclover	25	10	15	15
Perennial Ryegrass	25	10	15	15
Total	**250 lb/ac**	**100 lb/ac**	**150 lb/ac**	**150 lb/ac**

Crown Vetch (>= 3:1 slope)	
Crown Vetch	**10 lb/ac**

Under Guardrail	
Hard Fescue	**150 lb/ac**

Table E6. Michigan Department of Transportation Seed Mixes

TDS (Turf Dry Sandy)	
Kentucky Bluegrass	11
Perennial Ryegrass	55
Hard Fescue	55
Creeping Red Fescue	99
Total	**220 lb/ac**

THV (Turf Heavy Soil) (Salt-Tolerant)	
Kentucky Bluegrass	33
Perennial Ryegrass	66
Creeping Red Fescue	99
Fults Salt Grass	22
Total	**220 lb/ac**

TUF (Turf Urban Freeway)	
Kentucky Bluegrass	22
Perennial Ryegrass	44
Hard Fescue	44
Creeping Red Fescue	88
Fults Salt Grass	22
Total	**220 lb/ac**

TGM (Turf Medium to Heavy Soil)	
Kentucky Bluegrass	22
Perennial Ryegrass	44
Hard Fescue	66
Creeping Red Fescue	88
Total	**220 lb/ac**

THM (Turf Loamy to Heavy)	
Kentucky Bluegrass	66
Perennial Ryegrass	44
Creeping Red Fescue	110
Total	**220 lb/ac**

ES (Environmental Seeding)	
Perennial Ryegrass	11
Timothy	24
Little Bluestem	3
Switchgrass	4
Indiangrass	3
Big Bluestem	9
Total	**54 lb/ac**

CR (Temporary)	
Cereal Rye	70
Total	**70 lb/ac**

TSM 6/24	
Perennial Rye	50
Spring Oats	50
Total	**100 lb/ac**

TSM 24+	
Perennial Rye	100
Spring Oats	100
Total	**200 lb/ac**

Table E7. Minnesota Department of Transportation Seed Mixes

Low-Maintenance Salt-Tolerant Turf	
Creeping Red Fescue “Cindy”	10
Perennial Ryegrass “Elf”	14
Canada Bluegrass “Reubens”	12
Fowl Bluegrass	10
Common Bluegrass “98/85”	12
Kentucky Bluegrass “Park”	12
Kentucky Bluegrass “Caliber”	10
Alkali Grass “Salty”	19
White Clover	1
Total	**100 lb/ac**

Native Salt-Tolerant:
Canada Wildrye, Indiangrass, Little Bluestem, Blue Grama, Black-Eyed Susan, Yarrow Purple Prairieclover

Temporary Mix 100	
Wheat	**100 lb/ac**

Temporary Mix 110	
Oats	**100 lb/ac**

Temporary Mix 130	
Oats	40
Wheat	40
Rye Grass	10
Annual Alfalfa	10
Total	**100 lb/ac**

1–2 Year Stabilization Mix 150	
Perennial Ryegrass	15
Slender Wheatgrass	5
Red Clover	10
Vernal Alfalfa	10
Total	**40 lb/ac**

2–5 Year Stabilization Mix 190	
Red Clover	6
Alsike Clover	4.2
Creeping Alfalfa	9.6
Smooth Brome	7.2
Perennial Ryegrass	15
Slender Wheatgrass	3
Hairy Vetch	15
Total	**60 lb/ac**

General Roadside Mix 250	
Smooth Brome	9.8
KY Bluegrass “Certified Park”	20.3
Canada Bluegrass	9.8
Switchgrass	2.1
Slender Wheatgrass	2.8
Perennial Ryegrass	14.7
Timothy	2.1
Redtop	2.1
Creeping Alfalfa	4.2
White Clover	2.1
Total	**70 lb/ac**

Sandy Roadside Mix 240	
Smooth Brome	9.7
KY Bluegrass “Certified Park”	20.2
Canada Bluegrass	9.7
Switchgrass	1.9
Slender Wheatgrass	3
Hard Fescue “Reliant II”	5.3
Perennial Ryegrass	15
Sand Dropsed	1.9
Little Bluestem	2.6
Red Clover	5.3
Purple Prairieclover	0.4
Total	**75 lb/ac**

Commercial Turf 260	
KY Bluegrass “Certified Park”	32
Canada Bluegrass	10
KY Bluegrass—Low Maintenance	30
Hard Fescue	8
Perennial Ryegrass	20
Total	**100 lb/ac**

Residential Turf 270	
KY Bluegrass “Elite”	30
KY Bluegrass—Improved	30
KY Bluegrass—Low Maintenance	30
Creeping Red Fescue	9.6
Perennial Ryegrass	20.4
Total	**120 lb/ac**

Table E7 (continued). Minnesota Department of Transportation Seed Mixes

Agricultural Roadside Mix 280	
Creeping Alfalfa	15
Smooth Brome	10
Redtop	3
Perennial Ryegrass	15
Switchgrass	2
Timothy	2
Slender Wheatgrass	3
Total	**50 lb/ac**

Native Wet Mix 310	
Big Bluestem	2.5
Indiangrass	2.5
Virginia Wildrye	2
Switchgrass	0.5
Bluejoint Grass	0.25
Green Bulrush	0.25
Woolgrass	0.25
Giant Bur Reed	0.25
Prairie Cordgrass	1.5
Wheat (fall)/Oats (spring)	56
Annual Ryegrass	11.2
Slender Wheatgrass	2.8
Wet Forbs Mix	2
Total	**82 lb/ac**

Native Wet Mix 310	
Big Bluestem	2.5
Indiangrass	2.5
Virginia Wildrye	2
Switchgrass	0.5
Bluejoint Grass	0.25
Green Bulrush	0.25
Woolgrass	0.25
Giant Bur Reed	0.25
Prairie Cordgrass	1.5
Wheat (fall)/Oats (spring)	56
Annual Ryegrass	11.2
Slender Wheatgrass	2.8
Wet Forbs Mix	2
Total	**82 lb/ac**

Native Sedge/Prairie Meadow Mix 325	
Big Bluestem	1.5
Fringed Brome	1.5
Slender Wheatgrass	1.5
Virginia Wildrye	1.5
Switchgrass	0.5
Fowl Bluegrass	1.5
Indiangrass	1.5
Prairie Cordgrass	0.5
Bluejoint Grass	0.2
Bottlebrush Sedge	0.3
Tussock Sedge	0.2
Fox Sedge	0.2
Reed Mannagrass	0.2
Fowl Mannagrass	0.2
Green Bulrush	0.2
Woolgrass	0.2
Softstem Bulrush	0.3
Wheat (fall)/Oats (spring)	56
Annual Ryegrass	11.2
Slender Wheatgrass	2.8
Wet Forbs Mix	2
Total	**84 lb/ac**

Table E7 (continued). Minnesota Department of Transportation Seed Mixes

Native Wet Mix 328	
Big Bluestem	2
Fringed Brome	2
Virginia Wildrye	4
Switchgrass	1
Fowl Bluegrass	5
Indiangrass	2
Wheat (fall) Oats (spring)	56
Annual Ryegrass	11.2
Slender Wheatgrass	2.8
March Milkweed	0.3
Purple Prairieclover	0.3
Showy Tick Trefoil	0.3
Early Sunflower	0.3
Black-Eyed Susan	0.5
Blue Vervain	0.3
Total	**88 lb/ac**

Short Native Sandy/ Dry Mix 330	
Sideoats Grama	3
Blue Grama	2.5
Little Bluestem	3.5
Junegrass	1
Sand Dropseed	1
Canada Wildrye	3
Wheat (fall) Oats (spring)	56
Annual Ryegrass	11.2
Slender Wheatgrass	2.8
Dry Forbs Mix	0.5
Total	**84.5 lb/ac**

Mid-Height Native Sandy/ Dry Mix 340	
Big Bluestem	3
Little Bluestem	2.5
Canada Wildrye	2
Sideoats Grama	2
Switchgrass	0.5
Sand Dropseed	0.5
Canada Bluegrass	3
Junegrass	0.5
Wheat (fall) Oats (spring)	56
Annual Ryegrass	11.2
Slender Wheatgrass	2.8
Dry Forbs Mix	0.5
Total	**84.5 lb/ac**

General Native Roadside Mix 350	
Big Bluestem	3
Indiangrass	2.5
Little Bluestem	2.5
Sideoats Grama	3
Canada Wildrye	2
Switchgrass	1
Wheat (fall) Oats (spring)	56
Annual Ryegrass	11.2
Slender Wheatgrass	2.8
Mesic Forbs Mix	0.5
Total	**84.5 lb/ac**

Mesic Forb Mix	% of Mix
Smooth Blue Aster	5
Canada Milkvetch	5
White Prairieclover	5
Purple Prairieclover	5
Showy Tick Trefoil	5
Narrow-Leaved Coneflower	5
Common Oxeye	5
Gray Headed Coneflower	5
Rough Blazingstar	5
Tall Blazingstar	5
Wild Bergamont	5
Showy Penstemon	5
Mountain Mint	5
Columnar Coneflower	5
Black-Eyed Susan	5
Stiff Goldenrod	5
Blue Vervain	5
Hoary Vervain	5
Heart-Leaved Alexanders	5
Golden Alexanders	5
Total	**100%**

Table E7 (continued). Minnesota Department of Transportation Seed Mixes

Dry Forb Mix	% of Mix
Leadplant	10
Butterflyweed	2
Heath Aster	4
Stiff Tickseed	2
Yarrow	2
Long-Leaved Bluets	1
Roundhead Bushclover	3
Rough Blazingstar	4
Dotted Blazingstar	3
Wild Lupine	5
White Prairieclover	5
Purple Prairieclover	16
Prairie Rose	1
Black-Eyed Susan	18
Gray Goldenrod	3
Upland Goldenrod	1
Stiff Goldenrod	2
Showy Goldenrod	2
Hoary Vervain	14
Golden Alexanders	2
Total	**100%**

Wet Forb Mix	% of Mix
Fragrant Giant Hyssop	2
Water Plantain	4
Meadow Garlic	1
Canada Anemone	1
Marsh Milkweed	2
Panicled Aster	3
Ew England Aster	3
Red-Stalked Aster	3
Flat-Topped Aster	1
Canada Tick Trefoil	1
Joe Pye Weed	17
Boneset	10
Grass-Leaved Goldenrod	2
Sneezeweed	1
Giant Sunflower	2
Common Oxeye	1
Great St. Johnswort	2
Wild Iris	1
Tall Blazingstar	8
Wild Bergamont	1
White Prairieclover	1
Purple Prairieclover	2
Mountain Mint	1
Black-Eyed Susan	6
Stiff Goldenrod	2
Tall Meadow Rue	2
Blue Vervain	14
Ironweed	1
Culver's Root	3
Golden Alexanders	2
Total	**100%**

Table E8. Missouri Department of Transportation Seed Mixes

Mow Area Mix (within 30' of shoulder)	
Tall Fescue	80
Annual Ryegrass	10
Perennial Ryegrass	5
White Clover	5
Oats	10
Total	**110 lb/ac**

Urban Mix (outside mow area and >3:1 slopes)	
Little Bluestem	6
Sideoats Grama	6
Canada or Virginia Wildrye	2
Prairie or Tall Dropseed	0.5
Annual Ryegrass	10
Oats	10
Perennial Rye	10
White Clover	5
Lanceleaf Coreopsis	0.25
Black-Eyed Susan	0.25
Total	**50 lb/ac**

Rural Mix (outside mow area and >3:1 slopes)	
Indiangrass	8
Big Bluestem	4
Little Bluestem	6
Sideoats Grama	4
Switchgrass	2
Virginia or Canada Wildrye	2
Tall Dropseed	0.5
Purple Prairieclover	0.5
Annual Ryegrass	10
Perennial Ryegrass	5
Red Fescue	10
Redtop	0.5
Partridge Pea	2
White Clover	5
Grayheaded Coneflower	0.25
Black-Eyed Susan	0.25
Oats	20
Total	**80 lb/ac**

Table E9. Ohio Department of Transportation Seed Mixes

Lawn Mix (1)	
Kentucky Bluegrass	130
Creeping Red Fescue	130
Annual Ryegrass	87
Perennial Ryegrass	87
Total	**434 lb/ac**

Roadside Mix (2)	
Kentucky Bluegrass	65
Kentucky 31 Fescue	88
Perennial Ryegrass	65
Total	**218 lb/ac**

Slope Mix (3A)
Use 2, 3B, 3C, or 4B <3:1

Low-Growing Slope Mix (3B)	
Hard Fescue	56
Creeping Red Fescue	35
Annual Ryegrass	10
Total	**101 lb/ac**

Crown Vetch Mix (3C)	
Crown Vetch	39
Perennial Ryegrass	78
Annual Ryegrass	13
Total	**130 lb/ac**

Low-Growing Native Grass Mix (4B)	
Little Bluestem	8
Sideoats Grama	1.5
Prairie Dropseed	1.5
Annual Ryegrass (spring)	5
Annual Ryegrass (fall)	15
Total (spring)	**16**
Total (fall)	**26**

Annual and Perennial Wildflower Mix (5A)	
Total Annuals	3 lb/ac
Do not exceed 25% by wt. for any species:	
Corn Poppy	
Cosmos	
Yellow Cosmos	
Cornflower	
Rocket Larkspur	
Indian Blanket	
Total Perennials	12 lb/ac
Do not exceed 50% by PLS wt. for any species:	
Black-Eyed Susan	
Purple Coneflower	
Lance-Leaved Coreopsis	
Total	**15 lb/ac**

Table E9 (continued). Ohio Department of Transportation Seed Mixes

Native Wildflower and Grass Mix (5B)	
Total Wildflowers	15 lb/ac
Do not exceed 10% by PLS wt. for any species:	
Butterflyweed	
New England Aster	
Partridge Pea	
Purple Coneflower	
Rattlesnake Master	
Oxeye Sunflower	
Wild Bergamont	
Grey Headed Coneflower	
Orange Coneflower	
Prairie Dock	
Whorled Rosinweed	
Stiff Goldenrod	
Big Bluestem	2
Little Bluestem	3
Indiangrass	1
Annual Ryegrass	40
Total	**51 lb/ac**

Wildlife Mix (6)	
Big Bluestem	5.5
Little Bluestem	8
Indiangrass	5.5
Oxeye Sunflower	8
Prairie Dock	8
Purple Coneflower	8
Whorled Rosinweed	5
Downy Sunflower	3
New England Aster	3
Annual Ryegrass (spring)	5
Annual Ryegrass (fall)	15
Total (spring)	**59 lb/ac**
Total (fall)	**69 lb/ac**

Temporary Mix (7)	
Annual Ryegrass	**88 lb/ac**

Native Grass Mixture (4A)	
Big Bluestem	3
Indiangrass	4
Switchgrass	1
Annual Ryegrass (spring)	5
Annual Ryegrass (fall)	15
Total (spring)	**13 lb/ac**
Total (fall)	**23 lb/ac**

Table E10. Tennessee Department of Transportation Seed Mixes

Seed Group A (February 1–July 1)	
Kentucky 31 Fescue	87
English Rye	5.5
Korean Lespedeza	16.5
Total	**109 lb/ac**

Seed Group B (June 1–August 15)	
Kentucky 31 Fescue	60
English Rye	22
Korean Lespedeza	16
German Millet	11
Total	**109 lb/ac**

Seed Group B1 (April 15–August 15)	
Bermudagrass (Hulled)	18
Annual Lespedeza	8
Total	**26 lb/ac**

Seed Group C (August 1–December 1)	
Kentucky 31 Fescue	76
English Rye	22
White Clover	11
Total	**109 lb/ac**

Seed Group C1 (February 1–December 1)	
Crown Vetch	16
Kentucky 31 Fescue	46
English Rye	3
Total	**65 lb/ac**

Temporary Seed Group D (Jan 1–May 1)	
Italian Rye	22
Korean Lespedeza	22
Summer Oats	21
Total	**65 lb/ac**

Temporary Seed Group E (May 1–July 15)	
Sudan-Sorghum Crosses	65 lb/ac
OR Starr Millet	65 lb/ac
Total	**65 lb/ac**

Temporary Seed Group F (July 15–January 1)	
Balboa Rye	43
Italian Rye	22
Total	**65 lb/ac**

Slope Mix (>= 3:1 slopes)	
Mix A, B, or C	109 lb/ac
Sericea Lespedeza	15 lb/ac
Total	**124 lb/ac**

Slope Mix (February 1–July 1)	
Mix A, B, or C	109 lb/ac
Sericea Lespedeza (Scarified)	15 lb/ac
Weeping Lovegrass	2 lb/ac
Total	**126 lb/ac**

Slope Mix (July 1–December 1)	
Mix A, B, or C	109 lb/ac
Sericea Lespedeza (Unhulled)	15 lb/ac
Total	**124 lb/ac**

Table E11. Wisconsin Department of Transportation Seed Mixes

Seed Mix 10	
(loamy, clay or moist soils)	
Kentucky Bluegrass	26
Red Fescue	16
Redtop	3
Perennial Ryegrass	13
White Clover	7
Total	**65 lb/ac**

Seed Mix 20	
(dry sandy or gravelly soils and high slopes)	
Kentucky Bluegrass	8
Hard Fescue	31
Tall Fescue	52
Perennial Ryegrass	39
Total	**130 lb/ac**

Seed Mix 30	
(salt-tolerant turf within 15' of shoulder)	
Kentucky Bluegrass	9
Red Fescue	26
Hard Fescue	21
Salt Grass	9
Improved Fine Perennial Ryegrass	13
Birdsfoot Trefoil	9
Total	**87 lb/ac**

Seed Mix 40 (urban lawn turf)	
KY Bluegrass	31
Red Fescue	17
Hard Fescue	17
Improved Fine Perennial Ryegrass	22
Total	**87 lb/ac**

Seed Mix 60	
(cover or nurse seeding for wet areas)	
Timothy	8
Canada Wildrye	6.5
Annual Ryegrass	19.5
Alsike Clover	2.5
Red Clover	2.5
Japanese Millet	13
Annual Oats	13
Total	**65 lb/ac**

Seed Mix 70	
(native mix for loamy slopes and upland areas)	
Anemone canadensis	5.6 oz/ac
Aster novae-angliae	5.6 oz/ac
Dalea purpurea	5.6 oz/ac
Desmodium canadense	5.6 oz/ac
Geranium maculatum	5.6 oz/ac
Helianthus occidentalis	8.5 oz/ac
Liatris pycnostachya	5.6 oz/ac
Monarda fistulosa	5.6 oz/ac
Ratibida pinnata	5.6 oz/ac
Solidago speciosa	5.6 oz/ac
Tradescantia ohiensis	5.6 oz/ac
Zizia aurea	5.6 oz/ac
Andropogon gerardii	2.6 lb/ac
Bouteloua curtipendula	2.6 lb/ac
Elymus canadensis	2.6 lb/ac
Schizachyrium scoparium	2.6 lb/ac
Sorghastrum nutans	2.6 lb/ac
Total	**17.5 lb/ac**

Table E11 (continued). Wisconsin Department of Transportation Seed Mixes

Substitute Species for 70 and 70A	
Aster azureus	5.6 oz/ac
Baptisia leucantha	5.6 oz/ac
Echinacea pallida	5.6 oz/ac
Petalostemum candidum	5.6 oz/ac
Solidago rigida	5.6 oz/ac
Verbena stricta	5.6 oz/ac

Temporary Seed Mix	
Oats (spring and summer)	**130 lb/ac**
Winter wheat or rye (after September 1)	**130 lb/ac**

Nurse Crop Mix	
Oats (spring and summer)	**35 lb/ac**
Wheat (after September 1)	**35 lb/ac**

Seed Mix 75 (native grasses for erosion control)	
Dalea purpurea	1.2 lb/ac
Rudbeckia hirta	4.8 oz/ac
Andropogon gerardii	3 lb/ac
Bouteloua curtipendula	6 lb/ac
Elymus canadensis	10.5 lb/ac
Lolium multiflorum	3lb/ac
Schizachyrium scoparium	3 lb/ac
Sorghastrum nutans	3 lb/ac
Total	**30 lb/ac**

Seed Mix 70 A (native mix for sandy slopes and upland areas)	
Asclepias tuberosa	5.6 oz/ac
Aster novae-angliae	5.6 oz/ac
Chamaecrista fasciculata	5.6 oz/ac
Dalea purpurea	5.6 oz/ac
Euphorbia corollata	5.6 oz/ac
Helianthus occidentalis	8.5 oz/ac
Liatris aspera	5.6 oz/ac
Lupinus perennis	5.6 oz/ac
Monarda punctata	5.6 oz/ac
Ratibida pinnata	5.6 oz/ac
Solidago speciosa	5.6 oz/ac
Tradescantia ohiensis	5.6 oz/ac
Andropogon gerardii	2.6 lb/ac
Bouteloua curtipendula	3.5 lb/ac
Elymus canadensis	2.6 lb/ac
Koeleria macrantha	0.9 lb/ac
Schizachyrium scoparium	3.5 lb/ac
Total	**17.5 lb/ac**

Seed Mix 80 (salt-tolerant native mix for inslopes)	
Bouteloua curtipendula	8.8 lb/ac
Elymus canadensis	8 lb/ac
Elymus trachycaulus	7 lb/ac
Lolium multiflorum	3.5 lb/ac
Panicum virgatum	3.5 lb/ac
Puccinella distans	0.7 lb/ac
Schizachyrium scoparium	3.5 lb/ac
Total	**35 lb/ac**

APPENDIX F CLIMATE DATA FOR ILLINOIS

Figure F1. Average dates for 50° soil temperatures in spring across Illinois (from Illinois State Water Survey).

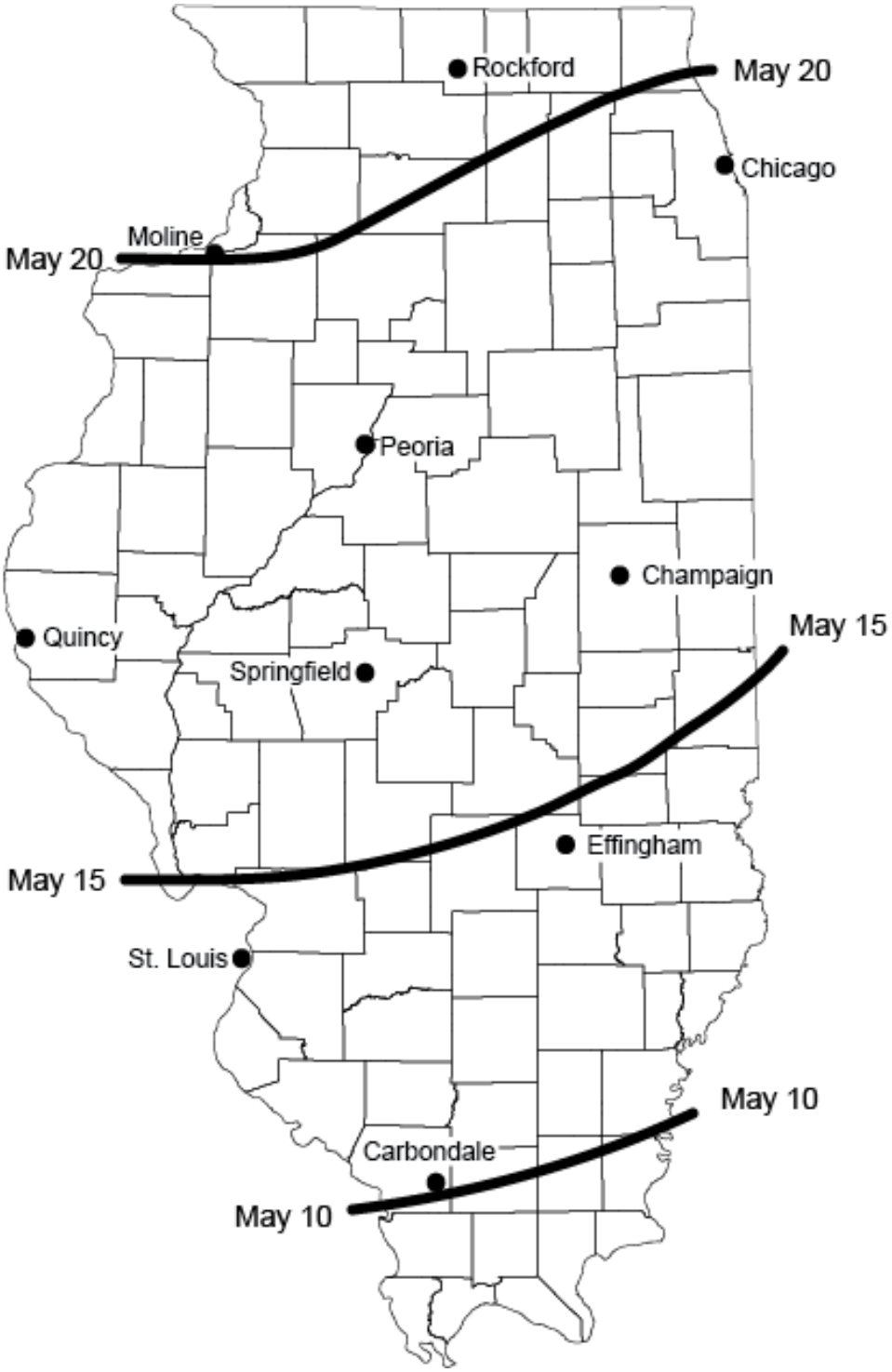

Figure F2. Average dates for 60° soil temperatures in spring across Illinois (from Illinois State Water Survey).

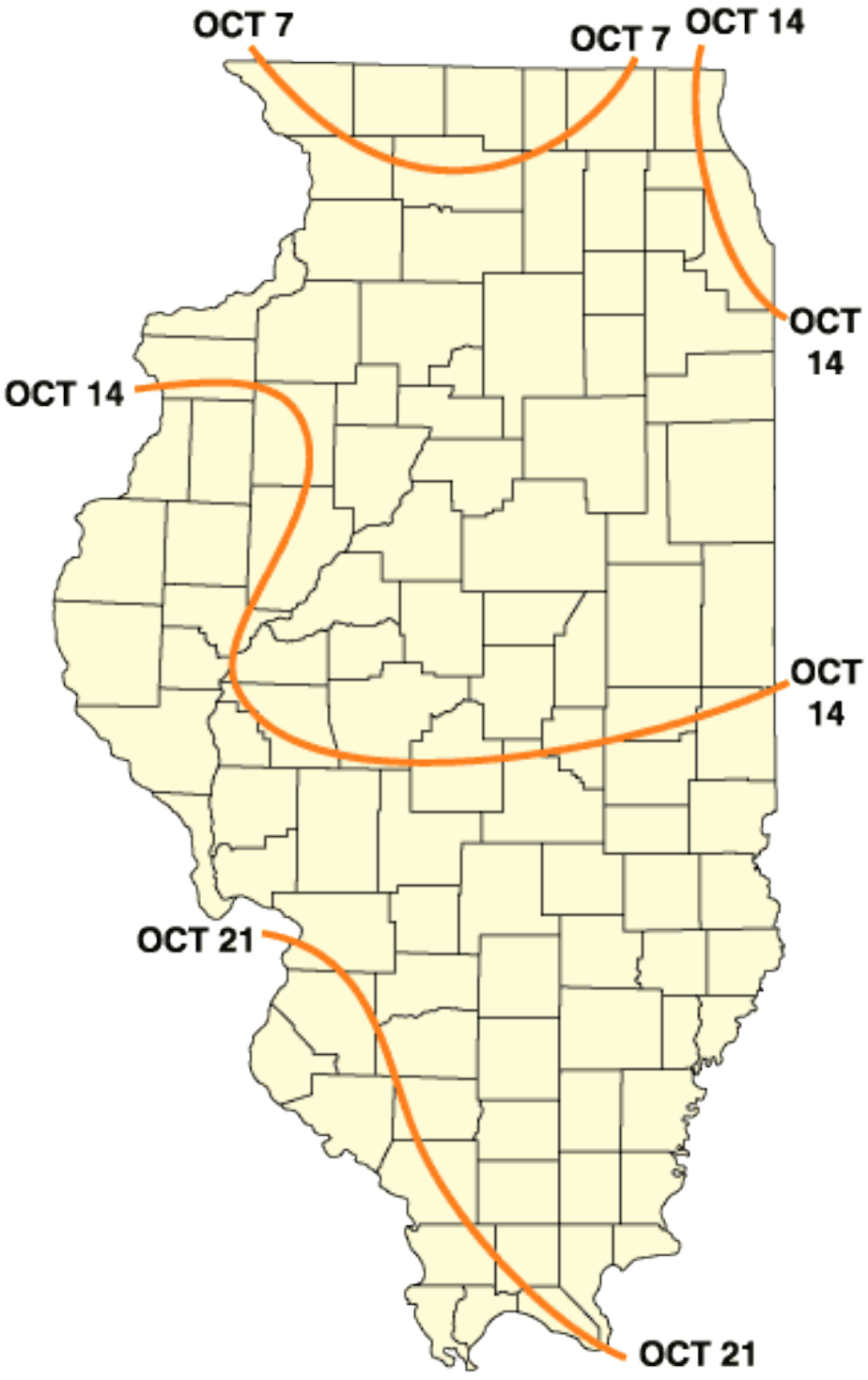

Figure F3. Average first-frost date in Illinois (from Illinois State Water Survey).

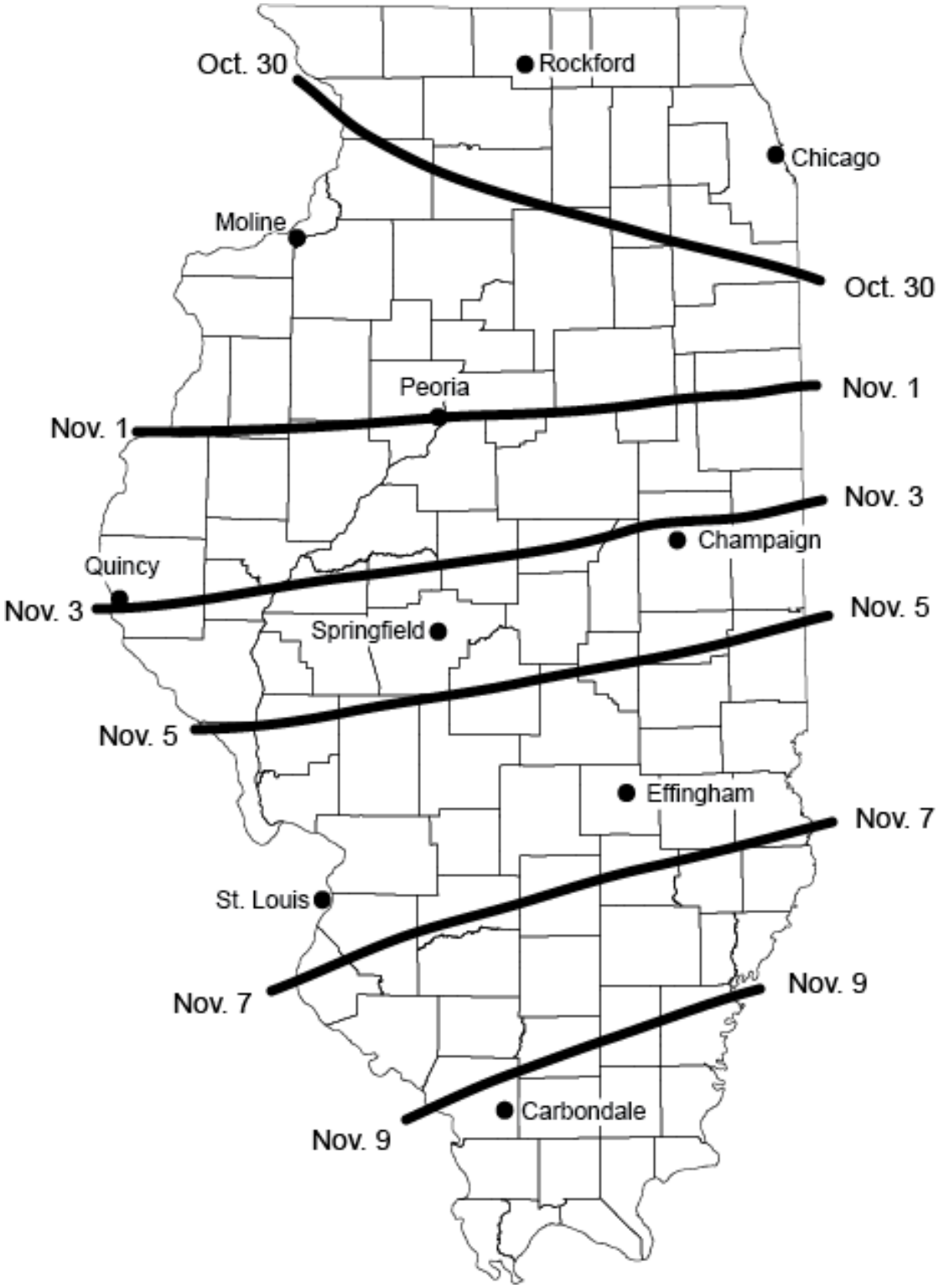

Figure F4. Average dates for 60° soil temperatures in fall across Illinois (from Illinois State Water Survey).

Figure F5. Average dates for 50° soil temperatures in fall across Illinois (from Illinois State Water Survey).


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