

Adapting NDOR's Roadside Seed Mixture for Local Site Conditions

Project RHE-07

Final Report

Submitted to the Nebraska Department of Roads on September 6, 2012

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Introduction

The Nebraska Department of Roads (NDOR) has considerable challenges with its objectives of rapidly establishing and maintaining a diverse and vigorous vegetation cover on roadsides. Establishing vegetation quickly on NDOR roadsides is important because the vegetation cover will stabilize the slopes and reduce the rate of soil erosion. In the last three decades, the seeding mixture for roadsides has switched from rapidly-establishing, exotic cool-season grasses to complex mixtures of slower-establishing, native grasses and wildflowers. The move to the newer, complex mixture(s) has been in response to interest expressed by the general public and other state and federal agencies in native plant communities and because of the desirable characteristics of native grasses (e.g., drought resilience and deep root systems). Overall, NDOR seeding mixture objectives are to select species that 1) are native, 2) are showy and attractive to the general public, 3) are adapted to roadside conditions, 4) establish relatively rapidly, 5) provide a relatively dense cover, and 6) contribute to permanent cover. The seeding mixtures should tolerate poor soil conditions and repeated mowing, while still producing a roadside that is visually appealing and diverse.

To meet these objectives, NDOR has developed separate seeding mixtures to be used on roadside shoulders (Type B) and backslopes (Type A). The shoulder mixture is dominated by short growth-form grass species and mixtures for this seeding area have been similar across the state. The backslope mixture is more diverse than the shoulder mixture and is composed of tall and mid-grasses and forbs (a.k.a., wildflowers). The

backslope mixture changes from predominately tall-grass species in the eastern sections of Nebraska to mid-grasses in the western section of Nebraska.

When selecting species for mixtures, it is generally best to select species that are adapted to local site conditions. The backslope mixtures have had some consideration in regard to local conditions when selecting species, by changing the types and amounts of tall and mid-grasses or cool-season and warm-season grasses. The same does not hold true for the shoulder mixture, which was the uniform for the sites tested across the state. With the expense of seeding projects, the use of species adapted to local site conditions become even more important. Currently, NDOR has not investigated the suitability of species in existing mixtures. If the species that demonstrate limited adaptability to local conditions could be identified and removed, then the remaining species should be more effective at rapidly establishing and stabilizing the site over the long-term.

Objectives

The primary objectives of this study are to evaluate roadside seeding segments statewide to determine what species from the seeding mixtures are currently represented and/or what non-seeded (volunteer) species occur. With this information, NDOR can develop site-specific seeding mixtures that will succeed in stabilizing the disturbed roadside, while supporting NDOR Environmental Section's long-term plan for roadside landscapes.

Study Design and Sampling Methodology

Study Design

At the initiation of the project, a list of possible research sites was developed by NDOR staff using the following criteria. Sites were selected: (1) that had both shoulders

(Type B) and backslopes (Type A) and preferably an erosion control seeding, (2) that had seeding project completion dates between 1990 and 1998, and (3) that were located on highways with an east-west orientation. From this list, UNL staff conducted site visits to evaluate appropriateness of individual sites for inclusion in the study. Sites were further evaluated on the following criteria for shoulders and backslopes: (1) located on a level landscape position, (2) were a minimum of 400 meters in length and (3) seeded species were present. In 2008, two sites were selected in each of 5 NDOR landscape regions (Table 1; Figure 1). No sites were found in landscape region E that met the criteria for study site selection. Representative seeding mixtures used on backslopes in the other landscape regions are given in Table 2. After site selection was completed, NDOR maintenance staff marked sites with signage to remove areas from annual mowing during project duration.

Data collection

Relative species composition of sites was determined using the modified-step point (MSP) method (Owensby 1957) in June and August of 2008 and 2009. Two hundred points were sampled on both the shoulders and backslopes on each of the four sampling dates. Relative species composition was determined of both seeded and non-seeded on each of the sampling dates.

Standing crop was determined by destructive harvest (clipping) of herbaceous plant material on all sites for both shoulders and backslopes in August 2009. Samples were separated by species and placed into individual sample bags. Samples were dried in a forced-air oven at 60°C for 48 hours and weighed. Weight of the individual species was

used to calculate relative species composition by weight for the individual species at each site.

Data Analysis

The species included in the Type B mixture were uniform for the entire state, which allowed all Type B data to be analyzed with ANOVA (Analysis of Variance) for landscape region effect on relative species composition. ANOVA was applied to relative species composition data from the MSP and standing crop sampling.

Seeding mixtures used on backslopes (Type A) differed among landscape regions; therefore, using ANOVA to compare site botanical composition among landscape regions was not possible. Each site within landscape region was analyzed separately. The actual botanical composition at the time of sampling each site was compared to the expected botanical composition using Kendall's tau rank correlation analysis. The rank order was based on botanical composition, the species with the highest percentage composition was ranked highest and the species with the lowest percentage composition was ranked lowest. The expected botanical composition was developed by NDOR staff based on seeding rates and likelihood of a species to persist after 10 years post seeding. The expected rank and actual rank (based on vegetation sampling at the sites) of seeded and non-seeded species for the Jansen backslope is given in Table 3 as an example of the basis for the Kendall's tau rank correlation analysis.

Results

Type B Mixtures

Results from MSP sampling indicated that there were no differences in the relative species composition of seeded species among the landscape regions ($p=0.05$) for

the Type B seeding mixture (Table 4). Seeded species composed 25 to 38% of botanical composition during 2008 and 2009, with western wheatgrass (*Elymus smithii* [Rybd.] Gould), buffalograss (*Buchloe dactyloides* [Nutt.] Engelm.) and tall fescue (*Lolium arundinaceum* [Schreb.] S.J. Darbyshire) as the dominant seeded species. Western wheatgrass composed 8.3 to 19.8% of botanical composition and was the most common of the seeded species. Relative species composition of tall fescue and buffalograss was 8.7 to 11.2% and 4.5 to 8.6%, respectively. Blue grama (*Bouteloua gracilis* [Willd. ex Kunth]) and birdsfoot trefoil (*Lotus corniculatus* L.) were uncommon. Relative species composition of blue grama and birdsfoot trefoil was 0 to 1.9% and 0 to 0.3%, respectively. Oats (*Avena sativa* L.) and perennial ryegrass (*Lolium perenne* L.) were seeded on all sites, but were not detected during sampling in 2008 and 2009.

Overall, the results of the MSP sampling indicate that shoulders were dominated by non-seeded species (Table 4). Smooth bromegrass (*Bromus inermis* Leys) and Kentucky bluegrass (*Poa pratensis* L.) were the most common non-seeded species and accounted for 23 to 35% of the total botanical composition. Intermediate wheatgrass (*Elymus hispidus* [P.Opiz] Meldris) was detected, but was limited to less than 10% of botanical composition. Relative species composition of sand dropseed (*Sporobolus cryptandrus* [Torr.] A. Gray) and warm-season tall grasses was 2.7 to 5.7% and 4.2 to 7.9%, respectively. Common weedy species in Nebraska were not frequently detected on the shoulders. Downy brome (*Bromus tectorum* L.), kochia (*Kochia scoparia* [L.] Schrad.), Russian thistle (*Salsola tragus* L.), and western ragweed (*Ambrosia psilostachya* DC.) generally composed less than 10% of total botanical composition. As

an entire group, non-seeded species composed 64.2 to 75.6% of the botanical composition of the shoulders.

There was no difference ($p>0.05$) in the ground cover of the shoulders among the landscape regions (Table 5). Ground cover was comprised of 66.6 to 76.3% litter, 22.6 to 31.4% bare ground, and 1.1 to 3.9% plant basal area.

Results from the standing crop analysis indicated that there was a difference ($p<0.05$) in relative species composition of seeded species among landscape regions (Table 6). Relative species composition of buffalograss (26.6%) in landscape region C and tall fescue (20.4%) in landscape region B was significantly greater than that in the other landscape regions. Based on weight, the seeded species composed 28.1 to 50.3% of botanical composition in all regions, except in landscape region D. The seeded species were nearly non-existent on the shoulders of the two sites in landscape region D (Nenzel and Crookston).

Non-seeded species were dominant on the shoulders of landscape regions A, D, and F and composed about 50% of the vegetation biomass in landscape regions B and D by weight (Table 6). Introduced, cool-season grasses composed 30 to 53% of the botanical composition on shoulders in landscape regions A and C. Relative species composition of smooth brome grass was greater than 27% in regions A and C, while relative species composition of Kentucky bluegrass was 21.8% in region A. In regions B and D, relative species composition of the native, warm-season tall grasses was 36% or greater. The botanical composition of shoulders in region F also was dominated by non-seeded species but not by a particular species or group of species. The diversity of non-seeded species on region F shoulders appeared to be considerably more than in other

regions. Other grasses and forbs within the non-seeded category, primarily weedy annuals, composed 5.8 to 27.3% of the botanical composition over all study sites.

Type A Mixtures

Results from the rank correlation analysis from the MSP sampling on the backslopes demonstrated that the expected and actual ranks of botanical composition were significantly correlated at a number of sites (Table 7). Actual and expected ranks at both sites in landscape region B, Aurora and Jansen, were significantly correlated at all sampling dates (Tables 8 and 9). The actual and expected ranks at the Creighton site, located in landscape region A, were significantly correlated in June 2008 and August 2009 (Table 10). In landscape region D, actual and expected ranks were correlated at the Nenzel site at all sampling dates (Table 11). Actual and expected ranks at the other sites were not significantly correlated because a seeded species (e.g., switchgrass at Jansen) became dominant over the years or non-seeded species invaded and dominated the site. The actual relative species composition of the backslopes of each site based on MSP are in Tables 12 through 21 and will be reviewed in the Discussion section.

The rank correlation analysis results for the Type A mixture based on weight indicated that there was limited correlation between expected and actual botanical composition (Table 22). There were significant correlations at Aurora and Jansen, in landscape region B, and Nenzel, in landscape region D (Tables 23 through 25). As was seen in the MSP analysis, most sites became dominated by some seeded species or invaded by non-seeded species over time (Tables 26 through 35), thus greatly reducing the occurrence of significant correlations between the expected and actual ranks.

Discussion

Botanical composition of the stands on shoulders based on MSP varied greatly within landscape regions (between sites) and among landscape regions; therefore, significant differences among landscape regions were not detected even though numeric differences were great. Averaged over all dates, seeded species composed only 30% of shoulder stands (Table 4) which is probably a concern; however, the harsh conditions of shoulders on roadsides (e.g., periodic passing of snow plows/ graders, spreading of road de-icer material, little or no top soils) create poor conditions for a solid stand of the seeded species and make for situations favorable for invasive, non-seeded species. Based on weight, seeded species composed as much as 50% and as little as 0.3% of the standing biomass (Table 6).

Landscape Region A

Seeded species were common on the shoulders in landscape region A but non-seeded grasses were a major component as well. Modified step-point sampling indicated that the relative species composition of seeded and non-seeded species were similar to that of the other landscape regions (Table 4). The standing crop sampling indicated that relative species composition of smooth brome grass and Kentucky bluegrass (two non-seeded grasses) was greater on region A sites than on sites in the other regions (Table 6). Along with western wheatgrass, these two non-seeded grasses were dominant on region A shoulders.

The results from the Plainview Type A sampling indicated that the backslope was primarily comprised of switchgrass and eastern gamagrass based on MSP and weight (Tables 12 and 26). Both of these species were seeded on the site, although eastern gamagrass is no longer seeded by NDOR. Little bluestem (*Schizachyrium scoparium*

[Michx.] Nash), indiagrass (*Sorghastrum nutans* [L.] Nash) and intermediate wheatgrass were expected to be major components of this site, but they composed only a small percentage of the botanical composition. All species of forbs were limited on the site and the group accounted for less than 10% of the total species composition. The Plainview site was dominated by two seeded, warm-season grass species, switchgrass and eastern gamagrass, suggesting that the grasses were highly adapted to the site and that a lower seeding rate could have been used. A reduction in seeding rate of these species might have allowed for an increase in the other seeded grass species.

The Type A sampling at the Creighton site demonstrated that the site is dominated by non-seeded species, primarily tall fescue (Tables 13 and 27). Tall fescue was not included in the Type A seeding mixture, but tall fescue was a component of the Type B mixture. In addition to the Type B mixture as a source, NDOR staff suggested that tall fescue was used, as a supplemental species in Type A mixtures, if seed of some species in the mixture was unavailable at the time of seeding. Seeded grass species were common, but as a whole were less than 20% of botanical composition. Tall fescue usually establishes rapidly and can be an effective competitor of the seeded species used in NDOR mixtures, thus limiting establishment of these seeded species. Seeded forbs were not common on the site and accounted for less than 10% of botanical composition by MSP or weight.

Type A seeding mixtures on backslopes in landscape region A generally did not achieve the objective of a diverse stand of seeded species. The reduction or outright exclusion of these species (e.g., switchgrass and eastern gamagrass) at the Plainview site might have resulted in greater site diversity and perhaps could have effected stand

longevity. The dominance of tall fescue on the Creighton backslopes suggests that tall fescue should not be used in Type A mixtures and/or seeding rates of tall fescue be reduced in Type B mixtures. However, the low diversity stands at Plainview and Creighton dominated by a few perennial grasses appeared to be effective in stabilizing the sites.

Landscape Region B

Seeded species were common on shoulders in landscape region B, but non-seeded grasses were a strong component as well. Modified step-point sampling indicated that the percentage composition of seeded and non-seeded species on shoulders in region B was similar to the other landscape regions (Table 4). Unlike the other landscape regions, however, seeded species based on weight composed a majority of the shoulder vegetation with western wheatgrass and tall fescue being the most common (Table 6). Warm-season tall grasses (switchgrass, big bluestem (*Andropogon gerardii* Vitman and indiagrass) were the principal non-seeded species on the shoulders. Inclusion of warm-season tall grasses in the Type B seeding mixture could be considered as a means to reduce invasion potential of smooth brome grass and Kentucky bluegrass.

The backslope at Aurora was dominated by tall fescue and orchardgrass (*Dactylis glomerata* L.) based on both MSP and weight (Tables 14 and 28). Tall fescue was not included in the Type A mixture for the site, but it was a component of the Type B mixture. In addition to the Type B mixture as a source, NDOR staff suggested that tall fescue was used, as a supplemental species in Type A mixtures, if seed of some species in the mixture were unavailable at the time of seeding. Orchardgrass was not seeded but could have been present in the hay mulch after seeding. Intermediate wheatgrass was

recorded during sampling, but was generally less than 10% of botanical composition by MSP or weight. Seeded warm-season grasses were present on the site, but generally composed less than 10% of the botanical composition by MSP. However, warm-season grasses accounted for 20% of the biomass sampled at the site. Switchgrass and indiangrass were the dominant seeded warm-season grasses, with very little sideoats grama (*Bouteloua curtipendula* [Michx.] Torr.) and little bluestem. Seeded forbs were sampled at the site, but percentage composition was low based on both MSP and weight.

Cool-season grasses were dominant on the backslope of the Jansen site (Tables 15 and 29). Intermediate wheatgrass was the most common seeded species based on either MSP (22.4 to 50.0%) or weight (26.5%). Switchgrass was the second most common grass, composing 5.8 to 16.7% of botanical composition based on MSP and 20.9% based on weight. The other seeded warm-season grasses were detected during sampling, but were generally less than 20% of botanical composition by MSP or weight. Percentage composition of seeded forbs was generally less than 15% based on MSP, but was much greater based on weight (27.1 %) with a relative species composition of 23.2% for Maximilian sunflower (*Helianthus maximiliani* Schrad.). Maximilian sunflower can grow to over one meter in height, with numerous stems radiating from one basal point. An individual plant can produce a large amount of biomass even though its relative species composition based on MSP is low.

Overall, cool-season grasses dominated region B backslopes with limited amounts of warm-season grasses and forbs. A reduction in the seeding rate of cool-season grasses might be advantageous to warm-season grasses and increase warm-season grass populations. Removing the cool-season grass canopy by mowing in late spring and early

summer could weaken cool-season grasses and help increase the competitive capabilities of warm-season grasses. Specifically, mowing at the elongation stage of the cool-season grasses would be stressful to cool-season grasses and would open the canopy in the early summer for warm-season grass growth.

Landscape Region C

As in the other landscape regions, both seeded and non-seeded species were common on shoulders in landscape region C. Modified step-point sampling indicated that the percentage composition of seeded and non-seeded species on shoulders in region C was similar to the other landscape regions (Table 4). Similar to landscape region B, seeded species accounted for around 50% of the vegetation biomass (Table 6). However, unlike the other regions, buffalograss was the principal seeded species observed in the stand. Western wheatgrass and tall fescue also were common on the shoulders. Even though region C sites had good stands of the seeded species, non-seeded species composed about 50% of stand by weight with Kentucky bluegrass being the most common.

Backslopes at Arnold and Ragan were dominated by non-seeded species (smooth brome and Kentucky bluegrass) and warm-season tall grasses (switchgrass, big bluestem and indiagrass) based on MSP and weight (Tables 16, 17, 30, and 31). Percentage composition of non-seeded species (40 to 60%) was not surprising, given results from other sites, but the percentage composition of warm-season tall grasses (30 to 60%) was greater than expected. The backslope seeding mixture in landscape region C was comprised primarily of mid-height grasses (little bluestem, sideoats grama, and western wheatgrass) but relative species composition of warm-season tall grasses was relatively

high based on MSP and weight. Increasing or adding warm-season tall grasses to the Type A mixture might improve the resistance of sites to invasion by exotic cool-season grasses. The seeded mid-height grasses were on the site, but were limited to less than 10% of botanical composition by MSP and weight. Seeded forbs were not common. American deervetch (*Lotus purshianus* F.E. & E.G. Clem. ex Otley), an annual native forb, had moved onto the site from the surrounding rangeland and the presence of this species indicated its adaptability to the site.

Landscape Region D

Seeded species were common on the shoulders at the Crookston and Nenzel sites but non-seeded grasses also were prevalent. Modified step-point sampling indicated that the percent composition of seeded and non-seeded species was similar to the other landscape regions (Table 4). By weight, tall and mid-height warm-season grasses (sand bluestem [*Andropogon hallii* Hack.] and little bluestem) composed as much as 46.2% of the shoulder vegetation (Table 6). These species likely moved onto the shoulders from the backslopes or surrounding native rangeland. The inclusion of these species could improve site resistance to invasion from annual species. Buffalograss, tall fescue, and birdsfoot trefoil are not adapted to the sandy, semi-arid conditions of the Sandhills. Blue grama and western wheatgrass also did not establish and persist well on the sites in region D. Modifying the Type B seeding mixture for landscape region D needs to be considered.

The Nenzel site was the most representative of the seeding mixture for all sites sampled (Tables 7 and 18). Warm-season grasses were 45.9 to 59.1% of the botanical composition by MSP. Little bluestem was the most common warm-season grass with a

relative species composition of 20.3 to 35.1% by MSP. By weight, relative species composition of little bluestem was 43.7% (Table 32). Relative species composition of the other seeded warm-season species was generally 10% or less by MSP and weight. The non-seeded species on the site were not the exotic cool-season grasses seen at the other sites sampled. At the Nenzel site, prairie junegrass (*Koeleria macranantha* [Ledeb.]) and native perennial forbs were the most common non-seeded species. These species likely established on the site from hay mulch or the surrounding rangeland.

Non-seeded species were dominant on backslopes of the Crookston site (Table 19). Percentage composition of non-seeded species based on MSP was 55.5 to 76.6%. Downy brome was the most common of the non-seeded species with a relative species composition of 9.6 to 26.5% of botanical composition. Seeded warm-season grasses based on MSP were common with sand bluestem composing the greatest proportion at 9.6 to 27.0%. Relative species composition of other warm-season grasses generally was less than 10%. By weight, sand bluestem and switchgrass were the most common seeded species while an assortment of native grasses, forbs, and shrubs composed most of the non-seeded species. Overall, seeded warm-season grasses composed 40.7% of biomass produced at the site (Table 33). The differences in results between the sampling methods indicate that the seeded warm-season grasses, while lower in number of individuals, actually produced more biomass, and the numerous individuals of non-seeded species filled the space between the large warm-season grass plants.

Results from the Nenzel and Crookston sites indicate that the Type A mixture used is adapted to the landscape region. Results at Crookston indicate that annual species can become an issue on these sites (Tables 19 and 33). Soils of landscape region D are

primarily sand and susceptible to disturbance. Limiting the amount of disturbance on these sites could help to reduce the open soil that allows annual species to invade and thus limit the establishment of perennial grasses.

Landscape Region E

Possible sites in landscape region E were very limited and the site that was available failed to meet the minimum site requirements.

Landscape Region F

The seeded grasses of the Type B seeding mixture established and were present at the time of sampling at the Chadron and N-71 sites but the non-seeded species were dominant. Modified step-point sampling indicated that the percentage composition of seeded and non-seeded species for landscape region F was similar to the other landscape regions (Table 4). Blue grama, buffalograss, and western wheatgrass were the only seeded species that persisted, and combined to make up 28.8% of the botanical composition by weight (Table 6). Sand dropseed was the principal non-seeded species (18.7%) by weight although western ragweed (10.4%) and a number of other grasses and forbs were present. Sand dropseed is a native, short to mid-height grass that provides good ground cover. It appears to be adapted to the shoulder in landscape region F and could be considered for inclusion in the Type B seeding mixture.

The backslope at the Chadron site was dominated by little bluestem, sideoats grama and pubescent intermediate wheatgrass and combined to compose 60 to 75% of the backslope vegetation based on MSP and weight (Tables 20 and 34). The other seeded grasses were much less common. Seeded forbs were limited on the site and generally were less than 10% of botanical composition by MSP or weight. Non-seeded species

occurred on the site, and composed 6.1-32.6% of botanical composition by MSP but were less than 5.0% based on weight.

Seeded species were not common on the backslope of the N-71 site (Tables 21 and 35). Non-seeded species composed 86.3 to 95.9% of botanical composition by MSP whereas they composed 69.3% by weight. Pubescent intermediate wheatgrass was the principal seeded species by weight (15.6%); other seeded species composed less than 10% of the total vegetation by weight. Based on MSP, non-seeded species were predominantly annuals while sand dropseed and fringed sagebrush (*Artemisia frigida* Willd) were major non-seeded components based on weight.

Results from the Chadron site indicate that the mid-height grasses in the Type A seeding mixture are adapted to conditions in landscape region F (Tables 20 and 34). The mid-height grasses were found on the N-71 site but at low amounts (Tables 21 and 35). Mid-height grasses are likely well suited to region F although establishment and persistence of these grasses cannot be certain because of the relatively high variability (i.e., unpredictability) of climatic conditions (e.g., rainfall) at the time of seeding.

Recommendations

Shoulders

As already stated, botanical composition of the sampled sites was extremely variable. The differences in botanical composition between sites within landscape region were surprisingly high and likely resulted from such things as differences in date of seeding (e.g., spring vs. fall) and year of seeding, last-minute changes in the seeding mixture, and differences in seeding contractors. Variable conditions between sites at seeding make it difficult to draw strong conclusions about the adaptability of the Type B

seeding mixture to roadside conditions. However, the following are some conclusions that can be made about seeding mixtures for shoulders.

Type B Seeding Mixture Adaptability. The Type B seeding mixture appeared to be well adapted to landscape region B and C where the seeded species composed about 50% of the vegetation. The seeding mixture was only moderately or marginally adapted to regions A and F where the seeded species composed only 25 to 30% of the standing vegetation. The Type B seeding mixture was totally unsuccessful in region D.

Recommendations:

- Continue with the Type B seeding mixture in landscape regions B and C.
- Modify Type B seeding mixture in regions A and F.
 - Remove or greatly reduce the seeding rate of blue grama because it has very low stand persistence in regions A and F as well as in the other landscape regions. Increase the seeding rate of buffalograss and western wheatgrass and/or experiment with other shortgrasses such as hairy grama.
 - Reduce the seeding rate of tall fescue because it can spread onto the backslopes and/or become dominant on the shoulders. Following seeding, tall fescue tends to emerge and establish relatively rapidly – providing for an early vegetation cover. The other seeded perennial grasses are slower in establishment but are native and do not require as frequent mowing as tall fescue. Tall fescue, as a rapidly establishing species, could be replaced largely by annual or short-lived perennial grasses such as perennial

ryegrass. These grasses would disappear from the site in a couple of years and not invade the backslopes.

- Develop a new seeding mixture for landscape region D.
 - Buffalograss is native to Nebraska but is not adapted to sandy soils and is not found in the Sandhills. Tall fescue and birdsfoot trefoil also are not adapted to the sandy, semi-arid conditions of the Sandhills. Remove these three species from the seeding mixture and experiment with other short to mid-height grasses such as hairy grama and sand dropseed.
 - The native warm-season grasses in the Type A seeding mixture appear to be adapted to the shoulder conditions. They were found on the shoulders of the sites in region D and should be considered for inclusion in the Type B mixture.
- Consider removal of birdsfoot trefoil in the Type B seeding mixture.

Management of Shoulder Vegetation. A number of management tools exist that could be used to manipulate botanical composition of roadside vegetation following establishment. However, NDOR does not commonly apply management practices once the project has been closed; therefore, management practices such as prescribed burning or herbicide application are not considered as means to control invasive, non-seeded plants and to favor seeded plants. *Recommendations:*

- Current practice is to mow vegetation on the shoulders periodically through the growing season. Because most of the invasive, non-seeded species are cool-season grasses, timing of mowing could be used to

suppress non-seeded cool-season grasses, to open the canopy, and to favor growth of warm-season grasses. Mowing should be timed so that the prevalent cool-season grasses are in elongation stage and the warm-season grasses have just started growing. In most years, this would be in late May. In years with good late summer/early fall growing conditions, mowing in early September could suppress cool-season grasses.

- Interseeding native warm-season grasses into degraded roadside stands of vegetation (where cool-season grasses are prevalent) should be considered. In 2012 and 2013, we are conducting field studies to evaluate interseeding as a management technique to increase wildflowers in roadside vegetation cover.
- Herbicides could be used as a stand maintenance tool to control the invasive, cool-season grasses on the shoulders. Proper herbicides and timing would be effective in controlling the invasive, cool-season grasses but seeded cool-season grasses and legumes would also be suppressed. Although the use of herbicides would reduce plant diversity and require periodic application, the invasive, cool-season grasses could be effectively controlled.

Backslopes

Similar to the shoulders, botanical composition of the sampled sites was extremely variable, and the variable conditions among sites at seeding make it difficult to draw strong conclusions about the adaptability of Type A seeding mixtures to roadside

conditions. Below are several recommendations coming from field observations and a review of study results.

Type A Seeding Mixture Adaptability. Most of the plant species included in the Type A seeding mixtures across the state appear to be adapted to regional growing conditions and commonly establish as part of these diverse stands (15+ species in the seeding mixtures). However, as might be expected, most species do not persist because there is little to no management during the life of the stand to create conditions favorable to the entire set of seeded species; thus diversity of the desired species declines over time. This certainly works against NDOR's goal of having a diverse stand of native species on the backslopes of roadsides. The backslopes of most sites in this study had good ground cover and were stable – there were very few indicators of soil loss; therefore, the plant communities that developed on these sites were meeting the purpose of the vegetation cover in minimizing soil erosion on the site. These simple plant communities, however, were often dominated by invasive, non-seeded species and were not the diverse, native plant communities that are expected/envisioned based on the complex seeding mixtures used. The following recommendations are based on the assumptions that the goals and management practices of NDOR will not change. *Recommendations:*

- Minimize the inclusion of perennial forbs/wildflowers in the Type A seeding mixture. Even if perennial forbs establish following seeding, most of them do not persist. They are the most expensive components of the Type A seeding mixture and are the least likely to establish and persist. Based on observations and results of this study, we recommend including the following perennial forbs in the five landscape regions studied:

Forb Species	Landscape Region A	Landscape Region B	Landscape Region C	Landscape Region D	Landscape Region F
Upright Prairie Coneflower	X	X	X	X	X
Purple Prairie Clover	X	X	X	X	X
Maximillian Sunflower	X	X			
Red Clover	X	X			
Pitcher Sage	X	X			

- Consider inclusion of more annual forbs in Type A seeding mixtures. They establish relatively well and the seeds are relatively inexpensive. Many of them are showy and conspicuous in the first year or two following seeding and show up again when growing conditions are favorable. Annual forbs to consider: American deervetch, partridge pea, plains coreopsis, and low lupine.
- Several species of native, warm-season tallgrasses were not included in Type A seeding mixtures used in the various landscape regions, especially in the eastern part of the state. Even when not seeded, several of these warm-season tallgrasses were found on backslopes when sampling. We recommend including big bluestem, indiangrass, switchgrass, little bluestem, and sideoats grama in all Type A seeding mixtures in landscape regions A, B, and C.
- A few seeded species, such as switchgrass and eastern gamagrass, became dominant in some cases, especially in eastern Nebraska. There may not be anything that can be done at the time of seeding, but keeping seeding rates of these species low may be a means of avoiding their dominance.
- Tall fescue should not be included in Type A seeding mixtures even when seeds of other perennial grasses are not available. Tall fescue establishes

relatively rapidly and appears to be aggressive and persistent once established on backslopes.

- Seeding mixture in landscape region D seems appropriate.
- Seeding mixture in landscape region F seems appropriate although sand dropseed appeared to be well adapted to sites in this region and should be included in the mixture.

Management of Backslope Vegetation. As with the shoulders, there are a number of management tools that could be used to manipulate botanical composition of backslope vegetation following establishment. However, NDOR does not commonly apply management practices once the project has been closed; therefore, management practices such as prescribed burning or herbicide application are not considered as means to control invasive, non-seeded plants and to favor seeded plants. *Recommendations:*

- Current practice is to mow vegetation on the backslopes every third year in August or September. Because most of the invasive, non-seeded species are cool-season grasses, timing of mowing could be used to suppress non-seeded cool-season grasses, to open the canopy, and to favor growth of warm-season grasses. Mowing should be timed so that the prevalent cool-season grasses are in elongation stage and the warm-season grasses have just started growing. In most years, this would be in late May. In years with good late summer/early fall growing conditions, mowing in early September could suppress cool-season grasses.
- Interseeding forbs/wildflowers (and perhaps warm-season grasses) into degraded roadside stands of vegetation (where cool-season grasses are

prevalent) should be considered. In 2012 and 2013, we are conducting field studies to evaluate interseeding as a management technique to increase wildflowers in roadside vegetation cover.

- Herbicides could be used as a stand maintenance tool to control the invasive, cool-season grasses on backslopes. Proper herbicides and timing would be effective in controlling the invasive, cool-season grasses but seeded cool-season grasses and legumes would also be suppressed. Although the use of herbicides would reduce plant diversity and require periodic application, the invasive, cool-season grasses could be effectively controlled.