

**Development of Sustainable Native Wildflower Meadows
for Highway Roadsides**

Final Report

prepared by

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I. INTRODUCTION

A four year Cooperative Agreement between the Natural Resource Conservation Service, National Plant Materials Center (NPMC), and Maryland Department of Transportation, State Highway Administration (SHA), was established in 1999 to develop technology for the establishment and maintenance of native meadows along roadsides. SHA has a need to develop roadside meadows for aesthetic qualities and to reduce roadside maintenance, namely mowing. SHA is emphasizing the use of plants native to Maryland and multi-functional plantings to increase species diversity, improve wildlife habitat, and reduce maintenance costs. NPMC has extensive experience with native wildflowers and grasses in the Mid-Atlantic region and is equipped to develop and test various seed mixes and methods of seeding.

II. PROJECT DESIGN

Objectives

1. Develop practical methods of establishing mixes of wildflowers and grasses, taking into consideration time of year, seedbed preparation, equipment needed, and the use of post-planting treatments such as mulches.
2. Develop mixes using appropriate species of wildflowers and grasses to provide a primary matrix for cover and provide a sustainable wildflower display.
3. Assess the suitability of currently underutilized but commercially available species of native wildflowers for use along highway roadsides.
4. Assess the maintenance that might be required to keep the meadow sustainable.
5. Develop standards and guidelines for use by SHA and others in seeding roadside wildflower mixes.

Materials and Methods

Two trials, an establishment and a maintenance study were designed to determine optimal factors for establishing and maintaining sustainable native grasses and wildflower meadows. These trials were established on NPMC property at the southeast corner of Soil Conservation and Beaver Dam roads on a site maintained by mowing several times a year. Soil ranged from silt loam with a pH of 6.4 to loam with a pH of 5.8. Tall fescue and sweet vernal grass were the dominant species in the weedy field. In addition, a demonstration highway planting was established along I-95 in Maryland to evaluate the best establishment techniques in an actual highway situation.

Seed Mixes and Seeding Equipment

Three grass and wildflower mixes (mixes A, B, and C) were developed for evaluation in both studies. Each mix contained a wide variety of native grasses and wildflowers designed to provide a primary matrix for cover and provide a sustainable wildflower display. Mixes A, B and C respectively were composed of tall, short, and commercially underused species. A fourth mix (D) was used in the I-95 highway planting when additional seed was required. The most locally adapted varieties that are commercially available were used. Table 1 lists all of the mixes used in the plantings. All seed mixes were divided by seed size and shape into fluffy, legume, and fine portions. This enabled accurate seeding and proper seed depth. Large, fluffy and small legume seed was drilled using a Truax Flex II-88RD no-till native seed Drill. Tilled and broadcast seeded plots were packed using a Brillion[®] seeder. Seeding rate was 15 PLS lbs/acre in all plantings and required bulking. Fluffy seed was bulked with crushed and sifted (1/4" to 1/2") cocoa shell mulch and small legume seed was bulked with short-grain rice. All fine seed was hand broadcast after bulking with sawdust-like finely-sifted crushed cocoa shell. Redtop (*Agrostis giganteus*) was included in mix A and B to determine the efficacy of using this species as a nurse crop.

Table 1. Seed Mixes

Species	Common Name	Height	% Mix
Mix A- Tall Roadside Mix		(Trial Mix)	(By Weight)
<u>Grasses</u>			
<i>Panicum virgatum</i> 'Shelter'	Switchgrass	4-5'	14.93
<i>Sorghastrum nutans</i> 'Nebraska 54'	Indiangrass	5-7'	12.61
<i>Andropogon gerardii</i> 'Niagara'	big bluestem	5-7'	8.23
<i>Agrostis giganteus</i>	Redtop	2'	4.94
<i>Elymus virginicus</i>	Virginia wildrye	3'	4.93
<u>Wildflowers/Legumes</u>			
<i>Heliopsis helianthoides</i>	ox-eye sunflower	2-5	4.92
<i>Rudbeckia triloba</i>	brown eyed susan	2-5'	4.80
<i>Aster laevis</i>	smooth aster	5'	4.71
<i>Aster novae-angliae</i>	New England aster	2-6'	3.95
<i>Liatris spicata</i>	spiked gayfeather	1-4'	3.30
<i>Desmodium canadense</i>	showy tick trefoil	3-4'	2.83
<i>Vernonia noveboracensis</i>	New York ironweed	3-7'	2.79
<i>Verbena hastata</i>	blue vervain	2-5'	2.75
<i>Helianthus giganteus</i>	sunflower	5'	2.69
<i>Penstemon digitalis</i>	beard-tongue	5'	2.57
<i>Eupatorium fistulosum</i>	joe-pye weed	4'	2.26
<i>Monarda fistulosa</i>	wild bergamont	3-5'	1.92
<i>Eupatorium perfoliatum</i>	boneset	4-5'	1.47
Mix B- Short Roadside Mix		(Trial & I-95 planting)	
<u>Grasses</u>			
<i>Dichanthelium clandestinum</i>	deertongue	3'	9.98
<i>Elymus virginicus</i>	Virginia wildrye	3'	9.87
<i>Bouteloua curtipendula</i>	sideoats grama	3-4'	9.07
<i>Schizachyrium scoparium</i> 'Aldous'	little bluestem	3-4'	8.86
<i>Andropogon virginicus</i>	broomsedge	3-4'	5.60
<i>Agrostis giganteus</i>	redtop	2'	4.90
<u>Wildflowers/Legumes</u>			
<i>Chamaecrista fasciculata</i>	partridge pea	3'	9.99
<i>Lupinus perennis</i>	wild blue lupine	1-2'	4.99
<i>Aster novi-belgii</i>	New York aster	1-2'	4.65
<i>Baptisia australis</i>	blue false indigo	3'	3.97
<i>Rudbeckia hirta</i>	black eyed susan	1-3'	3.95
<i>Liatris spicata</i>	spiked gayfeather	1-4'	3.30
<i>Achillea millefolium</i>	yarrow	3'	2.99
<i>Aquilegia canadensis</i>	eastern columbine	2'	2.99
<i>Asclepias tuberosa</i>	butterfly milkweed	1-2'	2.94
<i>Lespedeza capitata</i>	bush clover	2'	1.98
<i>Monarda fistulosa</i>	wild bergamont	3-5'	1.92
<i>Aster prenanthoides</i>	zig zag aster	1-2'	0.94
<i>Solidago nemoralis</i>	gray goldenrod	3'	0.90

Species	Common Name	Height	% Mix (By Weight)
Mix C - Underused Species		(Trial Mix)	
<u>Grasses</u>			
<i>Tripsacum dactyloides</i>	eastern gamagrass	5-8'	19.99
<i>Elymus hystrix</i>	bottlebrush grass	2-3'	13.57
<i>Tridens flavus</i>	purple top	2-5'	9.91
<i>Sporobolus cryptandrus</i>	sand dropseed	5'	6.65
<i>Hordeum jubatum</i>	foxtail barley	1-2'	2.93
<u>Wildflowers/Legumes</u>			
<i>Aster oblongifolius</i>	aromatic aster	1-2'	6.88
<i>Tradescantia ohioensis</i>	Ohio spiderwort	1-2 ½'	5.98
<i>Desmodium canadense</i>	showy tick trefoil	2-4'	5.66
<i>Thalictrum pubescens</i>	meadow rue	2-3'	3.84
<i>Eupatorium maculatum</i>	spotted joe-pye weed	5'	3.83
<i>Aster novi-belgii</i>	New York aster	1-2'	3.72
<i>Solidago speciosa</i>	showy goldenrod	4'	3.27
<i>Veronicastrum virginicum</i>	Culver's root	3-5'	1.21
Mix D – Short Mix 2		(I-95 Planting Mix)	
<u>Grasses</u>			
<i>Elymus virginicus</i>	Virginia wildrye	3'	13.33%
<i>Bouteloua curtipendula</i>	sideoats grama	3-4'	12.00%
<i>Sporobolus cryptandrus</i>	sand dropseed	5'	11.33%
<i>Dichanthelium clandestinum</i>	deertongue	3'	6.67%
<i>Schizachyrium scoparium 'Aldous'</i>	little bluestem	3-4'	6.67%
<i>Elymus hystrix</i>	bottlebrush grass	2-3'	2.00%
<i>Tridens flavus</i>	purple top	2-5'	1.33%
<u>Forbs</u>			
<i>Lupinus perennis</i>	wild blue lupine	1-2'	13.33%
<i>Chamaecrista fasciculata</i>	partridge pea	3'	10.00%
<i>Rudbeckia triloba</i>	brown eyed susan	2-5'	5.33%
<i>Achillea millefolium</i>	yarrow	3'	3.33%
<i>Asclepias tuberosa</i>	butterfly milkweed	1-2'	3.33%
<i>Aster laevis</i>	smooth aster	5'	2.67%
<i>Aster novae-angliae</i>	New England aster	2-6'	2.67%
<i>Verbena hastata</i>	blue vervain	2-5'	2.00%
<i>Rudbeckia hirta</i>	black eyed susan	1-3'	2.00%
<i>Baptisia australis</i>	blue false indigo	3'	1.33%
<i>Penstemon digitalis</i>	beard-tongue	5'	0.40%
<i>Monarda fistulosa</i>	wild bergamont	3-5'	0.27%
Mix C+D (- gamagrass) – Short Mix 3		(I-95 Planting Mix)	
Mix C	Underused Species		80.00%
Mix D	Short Mix 2		20.00%
Mix A (+gamagrass) – Tall Mix 2		(I-95 Planting Mix)	

Evaluation Protocols

Evaluations of the establishment and maintenance studies were made in fall of 2001, 2002 and 2003. Additional observations for visual impact were made in spring and summer the same years for species that mature earlier.

Evaluation Design

Each species in each plot was evaluated to provide information for both treatment and species comparisons. Qualitative estimates were chosen over quantitative measurements. Due to the large number of trials and species, determining plant densities for each species would have required an unmanageable amount of time and would have been imprecise due to the difficulty of distinguishing individuals of species which are rhizomatous or do not have a distinct crown. Also, percent cover information for a species in a plot can be more meaningful than knowing the number of plants per square meter, and can provide useful information on species dominance and compatibility. Height and visual impact were evaluated to provide information on the suitability and desired effect of each species in roadside situations. The following table details the rating scale used in the evaluation of each species in each plot.

Table 2. Evaluation Scales

Class	Range of Cover (%)	Class	Height (Inches)	Class	Visual Impact at a Distance Floral/Herbaceous
r	<<1			N	None (Inconspicuous)
1	<1	1	0-6		
2	1-5	2	6-12	L	Low (Minor)
3	5-10	3	12-24		
4	10-25	4	24-36	M	Medium (Significant)
5	25-50	5	36-48		
6	50-75	6	48-60	H	High (Stands out)
7	75-100	7	60-72		

Percent Cover

Percent cover was estimated visually and assigned a number 1-7 or the letter **r** (**rare**). The letter **r** is used when one or very few plants are found and no value when not found at all. The percentage ranges are not equal for each grouping. Numbers 1 through 4 are for a percent cover of up to 25%, but numbers 5 through 7 are for the next 75%. This provided the ability to distinguish the majority of differences that occurred among species as most species achieved less than 25% cover.

Height

A number 1-7 was assigned according to the average height of the plants in the plot.

Visual Impact at a Distance

Species were evaluated for their herbaceous and floral visual contribution at a distance. **N**one was assigned to species hidden or with an insignificant visual contribution. **L**ow was assigned to species with a very minor visual contribution. **M**edium was assigned to species with a significant, but not dramatic visual contribution. **H**igh was assigned to species with a dramatic, very obvious or dominate visual contribution.

III. STUDIES

A. Establishment Study

Purpose

The objective of the establishment trials was to develop seed mixes and practical methods of establishing sustainable meadows of wildflowers and grasses taking into consideration time of year, seedbed preparation, seeding method, mulching and species performance.

Materials and Methods

Seedbed Preparation

Various seedbed preparation methods were used to account for the varying site conditions that may exist at different roadside sites. Seedbed preparation treatments included no-till herbicide-treated existing turf, scarified herbicide-treated turf, bare soil (tilled and packed), and bare soil with cover crop. Additional preparation treatments included scarification prior to seeding and the use of a small grain (barley) cover crop. A complete description of treatments is provided in table 3. All plots were mowed 1-2 weeks prior to the first glyphosate application at a rate of 4 lbs per acre active ingredient. Bare soil treatment, consisting of tilling and packing, was done about two to three weeks after the first application. Subsequent glyphosate treatments were delayed at least 3 weeks after previous chemical or mechanical treatments to allow weed seeds to germinate. The last glyphosate application was always within four days of seeding, either just prior to or just after seeding. The following table provides an order of seedbed preparation procedures for each trial.

Table 3. Seedbed Preparation Procedures

Trial	First Glyphosate Treatment	Mechanical Treatment	Second Glyphosate Treatment	Cover Crop Seeding	Glyphosate just prior to or after seeding
1	Fall '00		Fall '00		Spring '01
2	Spring '00		Spring '00		Spring '00
3	Fall '00		Fall '00		Spring '01
4	Fall '00		Fall '00		Spring '01
5	Spring '00	Till and pack	Spring '00		Spring '00
6	Spring '00	Till and pack	Spring '00		Spring '00
7	Spring '01	Till and pack	Fall '01		Fall '01
8	Fall '00	Till and pack	Fall '00	Cover crop	
9	Fall '00	Till and pack	Fall '00		Spring '01
10	Fall '00	Till and pack	Fall '00	Cover crop	Spring '01

Time of Seeding

Both late spring and fall (dormant) seeding times were tested to determine the planting times that provide the best combination of germination, establishment and ease of maintenance. Seeding dates were June 2000, May 2001 and November 2001.

Seed Mixes

To reduce the number of trials, all three seed mixes were not used in every trial; however, mix B was used in all trials. The seed mixes used in each trial are found in table 4.

Seeding Methods

Seeding methods used in the study include the use of a Truax native no-till seed drill, a Brillion[®] seeder for packing after seeding and hand-broadcasting. All small seeds were broadcast rather than drilled to prevent them being planted too deep. Broadcast treatments had all seed hand-broadcasted and then packed with a Brillion[®] seeder. Straw mulch was applied to trial 4 after seeding to determine the effect of mulch on establishment. Table 4 indicates the seeding method used for each trial.

Trial Plots

- Number of plots: 18 per replicate, 2 replicates
- Plots size: 20' x 30'
- Species tested: 44 species included in 3 mixes
- Plot map is located at the end of this section, Figure 1.

Table 4. Establishment Trial Treatments

Trial	Mixes	Preparation Methods	Preparation Start Season	Seeding Time	Seeding Method
1	ABC	No-till	Fall '00	Spring '01	Drill
2	AB	No-till	Spring '00	Spring '00	Drill
3	B	No-till, scarify	Fall '00	Spring '01	Drill
4	B	No-till	Fall '00	Spring '01	Drill, mulch
5	ABC	Bare-soil	Spring '00	Spring '00	Drill
6	B	Bare-soil	Spring '00	Spring '00	Broadcast
7	ABC	Bare-soil	Spring '01	Fall '01	Drill
8	B	Bare-soil, cover crop	Fall '00	Spring '01	Drill
9	B	Bare-soil	Fall '00	Spring '01	Broadcast
10	AB	Bare-soil, cover crop killed	Fall '00	Spring '01	Drill

Results and Observations

A graph comparing establishment trial treatments is found in appendix A.

Seedbed Preparation

Both no-till and the bare-soil prep provided good establishment. However, the no-till treatment provided a much firmer seedbed that was easier to drill seed into at a consistent depth whether the soil was very wet or very dry. On bare soil treatment plots the Truax no-till drill was more difficult to use even after having been packed and let sit for at least a month. The drill pushed aside too much soil and pushed deeper into the soil making seeding depth unreliable. All plots except the dormant seeded plots had excellent weed control. Multiple glyphosate treatments provided excellent control of weed seeds that had germinated after being released by the first treatment. Multiple applications of glyphosate appeared most necessary after tilling. The use of a cover crop held the soil together and allowed for easier drilling into less muddy soil.

Time of Seeding

Late spring plantings were overall very successful with differences observed in species composition between years. Forbs and cool season grasses established much better in the spring '00 than spring '01 seeded plots, whereas warm-season grasses established extremely well in the spring '01 seeded plots. Dormant seeded fall '01 plots all established very poorly due to heavy weed pressure. The dormant seeded plot was mowed, but weeds were very short and dense.

Table 5. Establishment Trials Data Summary for Spring Seeded Plots

Refer to table 2 for the key to the evaluation ratings.

Mix A Species	Percent Cover Rating		Height Rating		Herbaceous Visual Impact Rating		Floral Visual Impact Rating	
	Mean	Maximum	Mean	Maximum	Median	Maximum	Median	Maximum
<i>Agrostis giganteus</i>	2.9	6	2.6	3	L	L	L	L
<i>Andropogon gerardii</i>	1.6	4	5.9	7	L	M	L	M
<i>Aster laevis</i>	1.3	3	2.1	3	L	N	L	N
<i>Aster novae-angliae</i>	2.8	5	2.8	4	L	M	L	M
<i>Desmodium canadense</i>	1.0	1	2.5	3	L	N	L	N
<i>Elymus virginicus</i>	1.0	1	4.2	5	L	N	L	N
<i>Eupatorium fistulosum</i>	1.4	2	3.1	4	L	N	L	L
<i>Eupatorium perfoliatum</i>	3.0	4	2.9	4	L	M	L	L
<i>Helianthus giganteus</i>	1.0	1	3.9	5	L	N	L	M
<i>Heliopsis helianthoides</i>	2.0	3	4.1	7	L	H	L	H
<i>Liatris spicata</i>	r	r	4.0	4	L	N	L	L
<i>Monarda fistulosa</i>	1.7	3	2.9	4	L	M	L	H
<i>Panicum virgatum</i>	2.7	5	5.4	7	M	H	M	H
<i>Penstemon digitalis</i>	1.4	2	3.1	4	L	N	L	H
<i>Rudbeckia triloba</i>	1.9	3	2.5	4	L	N	L	M
<i>Sorghastrum nutans</i>	3.9	6	6.3	7	H	H	H	H
<i>Verbena hastata</i>	1.3	3	3.1	5	L	N	L	L
<i>Vernonia noveboracensis</i>	1.0	1	3.3	5	L	N	L	L
Mix B Species								
<i>Achillea millefolium</i>	1.3	4	2.4	4	L	N	L	L
<i>Agrostis giganteus</i>	3.8	7	2.5	4	L	M	L	H
<i>Andropogon virginicus</i>	2.6	5	4.4	5	L	M	M	H
<i>Aquilegia canadensis</i>	1.3	2	2.3	3	L	N	L	N
<i>Asclepias tuberosa</i>	1.2	2	2.7	3	L	N	L	L
<i>Aster novi-belgii</i>	2.0	5	2.3	3	L	L	L	M
<i>Aster prenanthoides</i>	1.3	2	2.4	3	L	L	L	H
<i>Baptisia australis</i>	r	r	1.9	3	L	N	L	N
<i>Bouteloua curtipendula</i>	2.0	4	3.9	4	L	L	L	L
<i>Chamaecrista fasciculata</i>	2.1	3	2.6	3	L	N	L	N
<i>Dichanthelium clandestinum</i>	2.9	6	2.6	3	L	M	L	N
<i>Elymus virginicus</i>	1.4	3	4.0	5	L	L	L	L
<i>Lespedeza capitata</i>	1.1	2	3.3	4	L	N	L	L
<i>Liatris spicata</i>	r	r	4.0	4	L	N	L	N
<i>Lupinus perennis</i>	1.0	1	1.7	4	L	N	L	N
<i>Monarda fistulosa</i>	1.5	3	3.2	4	L	N	L	M
<i>Rudbeckia hirta</i>	3.9	6	3.8	4	L	M	M	H
<i>Schizachyrium scoparium</i>	3.2	5	4.4	5	L	M	M	H
<i>Solidago nemoralis</i>	1.3	2	3.1	4	L	N	L	H
Mix C Species								
<i>Aster novi-belgii</i>	2.0	4	2.1	3	L	M	M	H
<i>Aster oblongifolius</i>	2.8	5	2.3	3	M	H	M	H
<i>Desmodium canadense</i>	1.0	1	2.5	3	L	N	L	N
<i>Elymus hystrix</i>	1.0	1	3.7	5	L	H	L	L
<i>Eupatorium maculatum</i>	1.8	3	3.5	5	L	L	L	L
<i>Hordeum jubatum</i>	2.5	3	2.0	2	L	N	L	M
<i>Solidago speciosa</i>	1.4	2	3.4	5	L	L	M	H
<i>Sporobolus cryptandrus</i>	1.9	3	2.5	3	L	N	L	L
<i>Thalictrum pubescens</i>	-	-	-	-	L	N	L	N
<i>Tradescantia ohiensis</i>	1.0	1	2.3	4	L	N	L	L
<i>Tridens flavus</i>	3.4	5	6.3	7	L	M	M	H
<i>Tripsacum dactyloides</i>	2.7	4	3.8	5	M	M	L	N
<i>Veronicastrum virginicum</i>	1.5	2	2.8	4	L	N	L	L

Seed Mixes

All three seed mixes performed overall very well; however some individual species did not. *Agrostis giganteus* was overly competitive and dominated early in some of the wetter plots but did decline in the following drier years. Wetter plots also had a greater occurrence of weeds. Tall warm-season grasses dominated over time until few of the other species could be seen easily. The grasses provided good cover, but many, especially the taller grass species, competed adversely with the wildflowers. Progression from quick-establishing wildflowers to grasses and slow-establishing wildflowers is illustrated in photograph set 1 and 2 at the end of this section.

In 2003 few of the early successional species were observed in the plots such as black-eyed susan, boneset, partridge pea, blue vervain, asters, and foxtail barley. Species found in greater prevalence included many of the grasses as well as joe-pye weed, and wild bergamont. Some of the very slow to establish species were still increasing in size and did not bloom or bloomed sparsely, such as beard-tongue, Ohio spiderwort, and spiked gayfeather. The wildflower species that provided the most eye-catching color from a distance included, black-eyed susan, brown-eyed susan, wild bergamont, New England aster, and aromatic aster. Other species have the potential to put on a good floral display but were not abundant or mature enough to be easily noticed from a distance. Table 5 summarizes the data collected for each species in the spring-seeded establishment trials for all three years of data. To provide useful information pertinent to planning a spring seeding, data from the dormant seeded trial plots were not used in this table. Table 5 provides both the typical and the maximal performance of each species in the spring seeded establishment trials. Refer to table 2 for the key to the evaluation scales. Species performance tables and graphs may be found in appendix B.

Seeding Methods

Both drilling and broadcasting provided good germination results, however there were differences in ease of seeding and weed pressure. The tilling required for broadcast seeding resulted in greater weed germination and loose soils that prevented seeding in wetter conditions that were still acceptable for no-till seeding on untilled soil. Mulching did not significantly effect establishment.

Conclusions

Of the 10 establishment treatments only the dormant seeded plots resulted in poor establishment due to extreme weed pressure. Excellent weed control prior to seeding was attained in all other plots which resulted in relatively few weeds and quick establishment in the first year. However some methods were better than others. No-till prep and drilling is preferable over tilling. Tilling not only exposes additional weed seeds, but also loosens soil, which causes difficulties when drilling even after the soil is firmed with a cultipacker. Tilling however may be needed in situations where the soil is highly compacted due to construction. Multiple herbicide treatments should be used to control germinating weeds after initial treatment.

Agrostis giganteus was not needed as a nurse crop and was overly competitive in wetter soil. A cereal grain such as oats would be a better choice for areas such as steep slopes where quick cover is desired.

The diverse mixes performed well in with various planting methods and conditions, but species composition varied with the conditions. The typically reliable performing cool season grasses, *Elymus virginicus* and *Elymus hystrix* performed poorer than expected. This may be due to the less than ideal planting time for these species, which usually perform best when planted in the fall. Certain species are not cost effective to direct seed at current prices and could be more reliably planted as plugs. Table 9 in appendix B lists estimates for the cost of seeding each species. Tall warm season grasses should not be used with many expensive forbs due to the extreme competition and screening of the warm-season grasses, but may be used with quick establishing, short lived forbs and few very tall forbs. Tall

grasses are very competitive against weeds once established. Shorter grasses are less competitive, but allow for easier maintenance and spot spraying, and allow wildflowers to be better viewed.

Photograph Set 1. Progression in Species Composition

Quick-establishing species dominate in the first year. Fall 2001 and 2002 photographs of June 2000 seeded plots, trial 5, rep-2.



Mix A, Photo taken: 10/26/01



Mix A, Photo taken: 9/23/02



Mix B, Photo taken: 10/26/01



Mix B, Photo taken: 9/23/02



Mix C, Photo taken: 10/26/01



Mix C, Photo taken: 9/23/02

Photograph Set 2. Progression in Species Composition

Grasses have dominated and slow-establishing wildflowers have appeared. Spring 2002 and 2003 photograph comparison of June 2000 seeded plots , trial 5, rep-2.



Mix A, Photo taken: 6/26/02



Mix A, Photo taken: 6/10/03



Mix B, Photo taken: 6/26/02



Mix B, Photo taken: 6/10/03

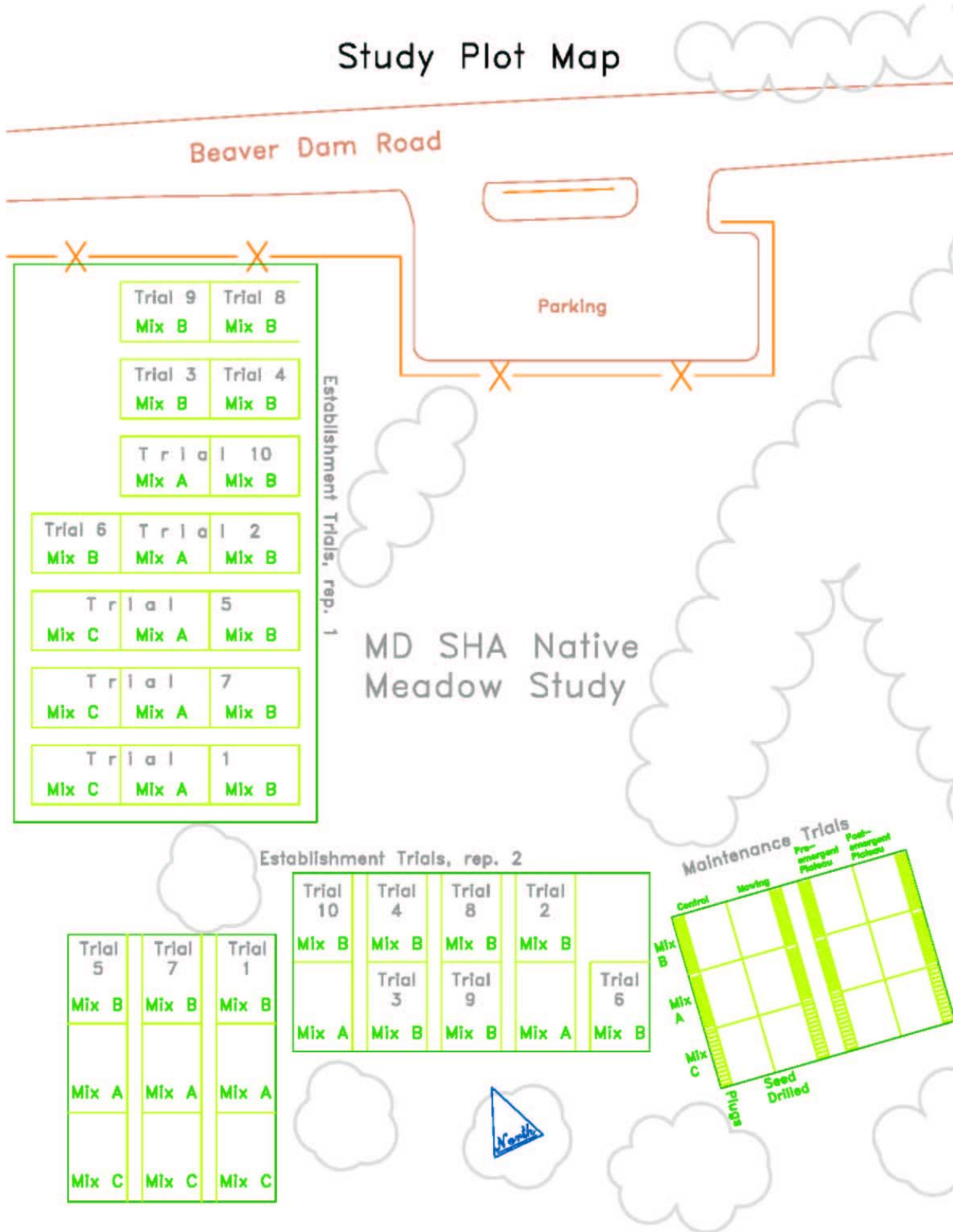


Mix C, Photo taken: 6/26/02



Mix C, Photo taken: 6/10/03

Figure 1. PLOT MAP OF ESTABLISHMENT AND MAINTENANCE STUDIES



B. Maintenance Study

Purpose

The objective of the maintenance study was to develop practical methods that best control weeds, and ensure long-term sustainability of the meadow. The inclusion of plugs in the study was designed to help determine the effects of each treatment on plugged plantings and on individual established species.

Materials and Methods

Four treatments were applied to seeded plots and plugged plots of the three mixes. The treatments included a no maintenance control, mowing at 6 to 8 inches, 4oz. per acre Plateau[®] applied preemergent and 4oz. per acre Plateau[®] applied postemergent. Table 6 summarizes the treatments for each trial. The plots were seeded on May 31, 2001 with identical procedures as trial 1 in the establishment study. Plugs were later planted July 18, 2001 with a dibble bar and watered after planting and 1 week later. Plug plots were tilled prior to planting to aid planting in the very hard soil.

Trial Plots

- Number plots: 12 seeded and 12 planted with plugs
- Seeded Plot size: 15' x 20'
- Plug Plot size: 3' x 20' - 6 plugs per species in separate rows by species
- Species tested: 44 species included in 3 mixes
- Plot map is located before this section, Figure 1.

Table 6. Maintenance Trial Treatments

Trial	Treatment	Treatment Applications	Establishment Method	Mixes
11	Control	None	Plugs	ABC
12	Control	None	Drill seeding	ABC
13	Mowing	6-8" as needed until August	Plugs	ABC
14	Mowing	6-8" as needed until August	Drill seeding	ABC
15	Preemergent Plateau [®]	Once just prior to planting	Plugs	ABC
16	Preemergent Plateau [®]	Once just prior to planting	Drill seeding	ABC
17	Postemergent Plateau [®]	1 month after seeding and following year	Plugs	ABC
18	Postemergent Plateau [®]	1 month after seeding and following year	Drill seeding	ABC

Results and Observations

Table 7. Maintenance Trials Data Summary

Refer to table 2 for the key to the evaluation ratings.

Mix A Species	Mean Percent Cover Ratings			
	Control	Mow	Preemergent Plateau	Postemergent Plateau
<i>Agrostis giganteus</i>	2.7	2.3	1.0	3.0
<i>Andropogon gerardii</i>	2.3	2.0	3.7	2.7
<i>Aster laevis</i>	-	1.0	-	-
<i>Aster novae-angliae</i>	3.0	2.7	2.3	2.7
<i>Desmodium canadense</i>	r	-	1.0	2.0
<i>Elymus virginicus</i>	-	-	-	-
<i>Eupatorium fistulosum</i>	1.0	1.0	2.7	2.3
<i>Eupatorium perfoliatum</i>	2.0	2.0	2.0	3.0
<i>Helianthus giganteus</i>	1.0	1.0	-	1.0
<i>Heliopsis helianthoides</i>	2.0	2.0	2.0	2.0
<i>Liatris spicata</i>	-	-	-	-
<i>Monarda fistulosa</i>	1.0	-	-	-
<i>Panicum virgatum</i>	4.7	4.3	3.7	4.0
<i>Penstemon digitalis</i>	r	r	-	r
<i>Rudbeckia triloba</i>	2.0	2.0	-	1.5
<i>Sorghastrum nutans</i>	4.3	4.0	5.7	5.3
<i>Verbena hastata</i>	2.0	2.0	-	2.0
<i>Vernonia noveboracensis</i>	-	-	1.0	-
Mix B Species				
<i>Achillea millefolium</i>	2.3	2.3	3.3	3.3
<i>Agrostis giganteus</i>	3.3	3.0	-	2.0
<i>Andropogon virginicus</i>	1.7	2.3	3.3	2.7
<i>Aquilegia canadensis</i>	-	-	r	-
<i>Asclepias tuberosa</i>	1.0	1.7	1.0	r
<i>Aster novi-belgii</i>	-	-	-	-
<i>Aster prenanthoides</i>	-	-	-	-
<i>Baptisia australis</i>	1.0	1.0	2.0	1.0
<i>Bouteloua curtipendula</i>	2.3	2.7	2.3	2.7
<i>Chamaecrista fasciculata</i>	4.0	3.5	3.0	2.7
<i>Dichanthelium clandestinum</i>	3.0	2.3	1.3	2.3
<i>Elymus virginicus</i>	1.0	1.5	2.0	1.0
<i>Lespedeza capitata</i>	1.3	1.3	2.0	1.7
<i>Liatris spicata</i>	-	-	-	-
<i>Lupinus perennis</i>	-	-	r	r
<i>Monarda fistulosa</i>	-	-	1.0	r
<i>Rudbeckia hirta</i>	4.0	2.7	4.0	3.5
<i>Schizachyrium scoparium</i>	3.0	3.0	2.7	2.7
<i>Solidago nemoralis</i>	-	-	r	-
Mix C Species				
<i>Aster novi-belgii</i>	1.7	1.7	1.0	1.3
<i>Aster oblongifolius</i>	2.3	1.7	1.7	1.3
<i>Desmodium canadense</i>	-	-	r	-
<i>Elymus hystrix</i>	-	-	-	-
<i>Eupatorium maculatum</i>	2.7	2.0	3.7	3.3
<i>Hordeum jubatum</i>	1.0	-	1.0	-
<i>Solidago speciosa</i>	-	-	1.0	-
<i>Sporobolus cryptandrus</i>	1.0	1.0	1.0	-
<i>Thalictrum pubescens</i>	-	-	-	-
<i>Tradescantia ohiensis</i>	-	-	-	-
<i>Tridens flavus</i>	3.7	4.3	3.7	4.3
<i>Tripsacum dactyloides</i>	3.0	2.3	1.7	1.7
<i>Veronicastrum virginicum</i>	-	-	-	-

Results and Observations

Table 7 summarizes all three years of percent cover rating data collected in the maintenance trials. Mowing reduced weed competition and seed production, but did not have a positive affect on the seeded species due to the preexistence of relatively few weeds. Preemergent Plateau[®] had a dramatic limiting effect on germination of certain weeds and seeded species and increased establishment of warm-season grasses and legume species. The establishment success of each species when treated with 4 oz per acre preemergent Plateau[®] is described in table 10 of appendix B. Four grasses and 12 wildflowers had very good establishment which was better than the control. This is presumably due to the reduced competition from weeds and seeded species that did not tolerate the Plateau[®]. Six additional grasses and 7 wildflowers showed good establishment that was similar to the control. Four species exhibited poor establishment and 4 were prevented completely by the Plateau[®]. Seven species did not occur in enough abundance in the control plots to determine a relationship. Post-emergent Plateau[®] was not as effective for controlling weeds, but most desired species tolerated Plateau[®] after seedling establishment or plugging.

Conclusions

Mowing is an effective tool for controlling weeds but may only positively affect establishment if there is significant weed pressure. Preemergent Plateau[®] (4 oz. per acre) can be a valuable tool for establishing mixtures of warm-season grasses, legumes and certain other forbs. Plateau[®] tolerant seed mixes are described in appendix C. Postemergent Plateau[®] (4 oz. per acre) could be effective at controlling weed germination in a diverse meadow, but may do little against an established perennial weed infestation at this low rate.

C. I-95 HIGHWAY PLANTING

Purpose

Two meadows were established to implement and test the results gathered from the establishment and maintenance trials. These sites are located along I-95 adjacent to the northbound and southbound Laurel rest areas and are approximately 0.9 and 0.7 acres respectively.

Materials and Methods

Site Preparation

The northbound and southbound planting sites were evaluated for potential weed control problems prior to any site preparations. Multiflora rose and Canada thistle were found in large numbers throughout the northbound site. These were spot treated with roundup in April 2002 and again just before plug planting. The sites were previously planted in annuals, but also contained a large number of narcissus bulbs. The narcissus bulbs were preserved during site preparation. Vegetation management prior to planting was limited to shallow (2-3") tilling twice followed by the application glyphosate.

Seed Mixes

Additional seed was purchased (mix D) that was comprised of the more readily established of the shorter and showier species from the trials. Utilizing remaining seed from the study, mixes A, B and C were also used with some modification. Gamagrass was removed from mix C and was added to the tall mix A to make mix C a short mix. Mix C was then combined with the remainder of mix D that was left after planting the southbound side, to make mix C+D. Table 1 lists all of the seed mixes used.

Planting Plan

Quantities of mix A, B and C were only sufficient to seed most of the northbound site. Additional seed (mix D) was purchased to seed the southbound site and part of the northbound site. The northbound site was divided into three sections with different mixes planted into each. Mixes A, B and C+D were seeded in three zones at the northbound site and mix D was seeded at the southbound site in June 2002. Mixes C and D were mixed and planted together to provide consistency and ease seeding of the planting zone nearest I-95. A map of both sites is located at the end of this Section, Figure 2.

Plug Planting

A total of 4,337 plugs of selected wildflower species were also grown for these sites to test the feasibility of planting plugs of the species that do not establish well from direct seeding. Plugs planted are listed in Table 8 at the end of this section. Plugs were trimmed by approximately 75% to reduce transpiration and promote survival. The plants were grown in deep narrow plug containers to provide deep roots. Plugs were planted with a dibble in July 2002. Within a week after planting, both sites were watered with a water truck to provide additional moisture and good soil contact with the roots.

Results and Observations

The plugs survived and established very well despite very hot and dry conditions. Success of the plugs in these dry conditions may be attributable to the ability of the deep plugs to reach the moist soil that was found 3” below the very dry surface at planting.

Seedling establishment was very selective and different from that observed in the establishment and maintenance trials. Relatively few species germinated well during the hot and dry weather following seeding. Those species that did germinate very well included the butterfly milkweed, partridge pea, wild blue lupine, sideoats gramma, and sand dropseed. The seeded butterfly milkweed grew very well and caught up in size and exceeded the plugged butterfly milkweed. Both were observed blooming in September 2002, less than three months after seeding. Many of the other species did not germinate until late summer or fall when rain and cooler weather arrived. There were many annual weeds present including many annual non-native wildflowers from previous plantings at the site. There was significant weed pressure by late summer and both sites were mowed and raked by SHA contractors to a height of approximately 6 inches. The most prevalent and harmful weed present was giant foxtail. The following year after seeding, the site was mowed once in late spring to control a thick canopy cover of annual fleabane on large areas of both sites. Despite the heavy competition many black-eyed and brown-eyed Susan’s had established and bloomed very nicely in the summer and fall of the second year.

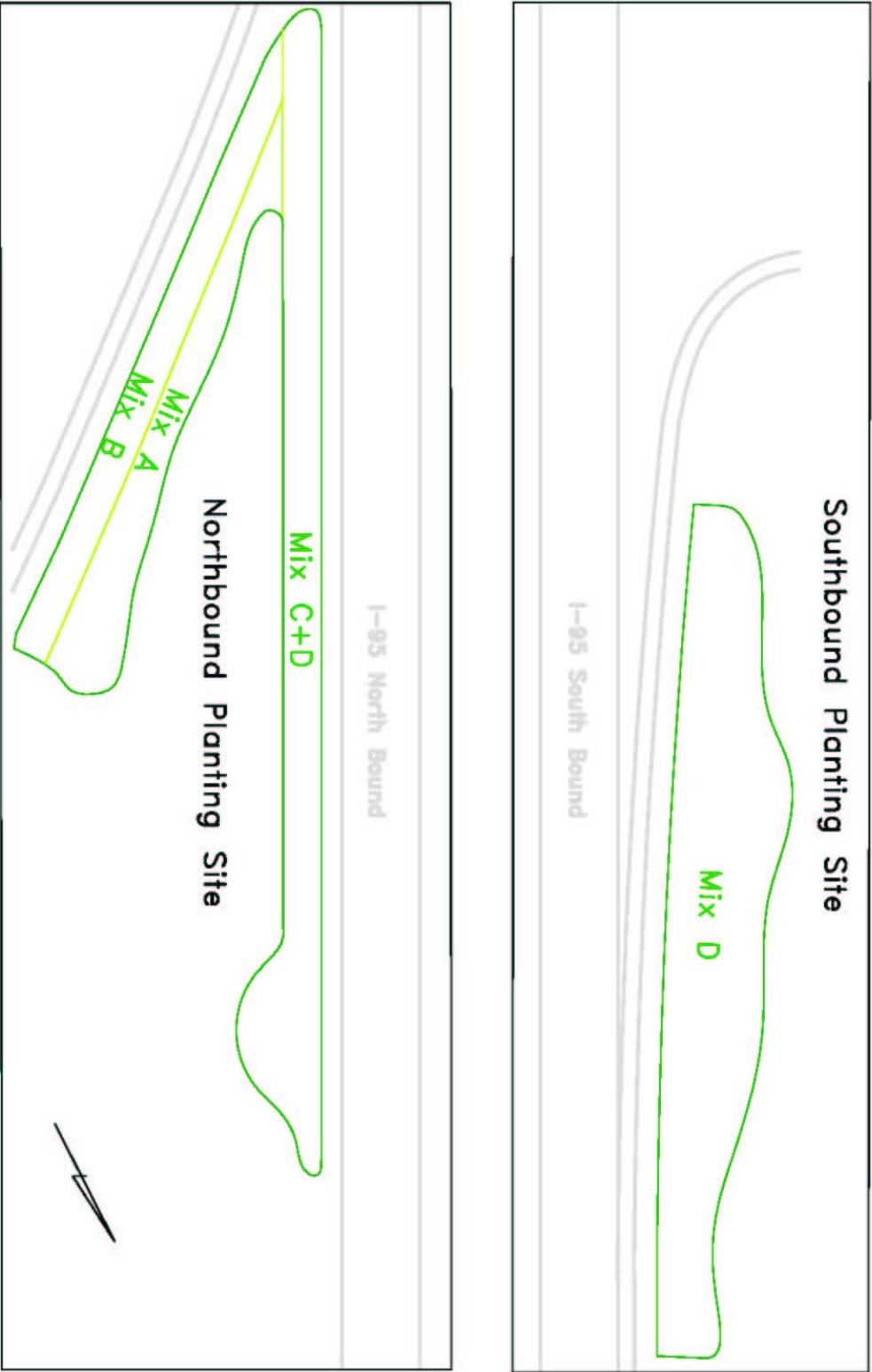
Conclusions

Only a few of the seeded species were able to establish in the hot dry weather following seeding. However, planting a diverse mix ensured that some would grow, and those that did actually grew very well. The spot treatment of multiflora rose and Canada thistle prior to light tilling and again a few weeks after seeding was necessary to eliminate these weeds at the most opportune time. To ensure the sustainability of the native meadow, continued monitoring and mowing as needed may be necessary. With mowing, the annual weeds should decline in abundance as the native perennials establish and inhibit further germination of weed species. Monitoring for woody species and spot spraying will be necessary as well due to the large number of multiflora rose and other invasive woody species nearby. Eliminating invasive weeds adjacent to the meadows would dramatically reduce weed invasion into the meadow and subsequently reduce future maintenance.

Table 8. PLUGS PLANTED AT I-95 HIGHWAY PLANTING SITES

Species	common name	Mature Height	Northbound			Southbound	Total
			Mix A	Mix B	C/D	Mix D	
<i>Asclepias tuberosa</i>	butterfly milkweed	1-2'		67	67	67	201
<i>Aster laevis</i>	smooth aster	5'			134	134	268
<i>Baptisia australis</i>	blue false indigo	3'				70	70
<i>Desmodium canadense</i>	showy tick trefoil	2-4'		168	134	402	704
<i>Eupatorium maculatum</i>	spotted joe-pye weed	5'	67				67
<i>Helianthus giganteus</i>	Sunflower	5'	201				201
<i>Liatris spicata</i>	spiked gayfeather	1-4'		67	67	268	402
<i>Lupinus perennis</i>	wild blue lupine	1-2'			10	10	20
<i>Monarda fistulosa</i>	wild bergamont	3-5'		134	67	201	402
<i>Penstemon digitalis</i>	beard-tongue	5'		33	50	67	150
<i>Solidago speciosa</i>	showy goldenrod	4'			33		33
<i>Tradescantia ohiensis</i>	Ohio spiderwort	1-2 ½'			67	134	201
<i>Vernonia noveboracensis</i>	New York ironweed	3-7'	536				536
<i>Veronicastrum virginicum</i>	Culver's root	3-5'			550		550
		Subtotal	804	469	1179	1353	3805
Plugs held-over from 2001							
<i>Aster laevis</i>	smooth aster	5'			12		12
<i>Aster novi-belgii</i>	New York aster	1-2'				78	78
<i>Aster oblongifolius</i>	aromatic aster	1-2'				38	38
<i>Aster prenanthoides</i>	zig zag aster	1-2'				40	40
<i>Achillea millefolium</i>	yarrow	3'				27	27
<i>Aquilegia canadensis</i>	eastern columbine	2'				45	45
<i>Baptisia australis</i>	blue false indigo	3'		45			45
<i>Eupatorium maculatum</i>	spotted joe-pye weed	5'	31				31
<i>Eupatorium perfoliatum</i>	Boneset	4-5'	12				12
<i>Helianthus giganteus</i>	Sunflower	5'	15				15
<i>Heliopsis helianthoides</i>	ox-eye sunflower	2-5'	30				30
<i>Solidago nemoralis</i>	gray goldenrod	3'			12		12
<i>Tradescantia ohiensis</i>	Ohio spiderwort	1-2 ½'		26			26
<i>Vernonia noveboracensis</i>	New York ironweed	3-7'	71				71
<i>Veronicastrum virginicum</i>	Culver's root	3-5'				50	50
		Subtotal	159	71	24	278	532
Total Plugs Planted in July, 2002:			Mix A	Mix B	C/D	Mix D	Total
			963	540	1203	1631	4337

Figure 2. MAP OF I-95 HIGHWAY PLANTING



IV. PROJECT CONCLUSIONS

From this study various conclusions may be made in the form of recommendations for future meadow establishment and maintenance. Sustainable meadow establishment guidelines are detailed in appendix D for use in standards and specifications developed by the SHA.

Pre Planting Weed Control

In this study the primary factor affecting establishment was the level of weed control prior to seeding. Achieving complete weed control prior to seeding should be the greatest priority in planning a seeding. No-till herbicide preparation of the site is recommended as this brings the least amount of weed seed to the surface, protects from erosion and preserves the moisture in the soil. With no-till the soil holds together better when drilling seed, allowing for better seed depth control in sandy soils and reduces caking in poorly drained soils. Multiple glyphosate herbicide applications are very important in eliminating the weeds that are often released after the initial application. Plateau[®] applied at a rate of 4 oz/ac, prior to planting a resistant seed mix, may be particularly useful for sites with a very high seed bank of weeds. This could include sites that have been previously disturbed, such as having been planted previously with annuals. Oats can be used as a temporary cover in areas being treated for extended periods of time with selective broadleaf herbicides, and prior to being sprayed with glyphosate in preparation for seeding a native meadow.

Photograph Set 3. *Agrostis giganteus* Competition on Wet and Dry Soils 2001 seeded plots



Agrostis giganteus dominated plot with wet soil. And competition has slowed establishment of the native seeded species. Establishment trial plot 10, rep1, mix B. Picture taken 9/23/02.



Agrostis giganteus is insignificant on drier soils. Native species have established well. Establishment trial plot 10, rep2, mix B. (taller mix A in background). Picture taken 9/23/02.

Species Selection

Based on study results, a detailed analysis of each species and its suitability for future use is summarized in appendix B. Included are graphs of the seeding performance of each species used in the study. Of the 43 native species tested, 29 proved reliable and cost effective for direct seeding. Using study observations and current market prices, a per-plant cost estimate of seeding each species is described in tables 9a and 9b. Table 9a lists the economically seeded grasses and wildflowers that have an estimated per-plant seeding cost of less than \$0.03 for the grasses and less than \$0.20 for the

wildflowers. Table 9b lists the species that exceed this cost and would be considered excessively expensive to seed. Also listed in these tables is the economic limit price for comparison to changing prices. Species determined to be reliably and economically seeded are recommended with suitable applications in table Appendix C. Because of the over aggressiveness of *Agrostis giganteus* (redtop) on wetter soils, it is not recommended for use as a nurse crop. Photograph set 3 illustrates this point.

Seed Mixes

Recommended species and corresponding seeding rates are provided in table 11 of appendix C. This chart is provided as a tool for assembling seed mixes. Included in this table are soil moisture preferences, tolerance to two common herbicides, and suitability for use with tall or short mixes. The short species recommended to use with the tall mix are quick establishing and short-lived, providing cover and color prior to the tall warm-season grasses becoming established. All 29 recommended species are well suited for use on average sites with mesic soils. Mesic soils are moist soils that are moderate to well-drained. Seventeen of these species are also recommended for use on dry, very well-drained soils. Ten species are recommended for use on wet, poorly-drained soils. Tolerance of 4oz/ac Plateau[®] of each species, based on study results, is listed in table 10 of appendix B. Eight seed mixes, listed in appendix C, were developed for various site conditions and height considerations.

Standard Seed Mixes

The short mesic mix is the most species diverse and should be used for most sites except on extreme dry or wet sites. A tall mesic mix is included, but for maximum wildflower display mixes with shorter grasses should be used. Photograph set 4 illustrates this. The dry mix comprised of mostly shorter species is most suitable for very dry, well-drained sites. The wet mix is suitable for wet, poorly-drained sites. This mix contains species of mixed height. If wildflower viewing is more important than erosion control on the site, the switchgrass and gamagrass may be replaced with Virginia wildrye.

Photograph Set 4. Tall Warm-season Grass Competition. 2001 seeded plots.



Tall warm-season grass dominated 'tall mix' plot. Establishment trial plot 10, rep2, mix A. Picture taken 9/23/02.



Shorter and more open grasses have greater wildflower compatibility. Establishment trial plot 1, rep1, mix C. Picture taken 9/23/02.

Plateau[®] Tolerant Seed Mixes

Short and tall Plateau[®] tolerant mixes are comprised of species that will benefit from a 4oz/acre preemergent application of Plateau[®]. Postemergent application of 4oz/acre of Plateau[®] may be made

at any time after germination with the Plateau[®] tolerant mixes. Postemergent Plateau[®] (4oz/acre) may be applied to established (5 leaf stage) meadows of the other mixes, but stunting may occur. Use the proper surfactant according to label to minimize damage.

Grass Only Seed Mixes

Two grass-only mixes have been provided to give maximum flexibility when broadleaf weed control is important. With these mixes, broadleaf herbicides may be used for areas with large infestations of broadleaf weeds that are difficult to control such as crown vetch and Canada thistle. These mixes could be used to renovate large areas with extreme broadleaf weed infestations expected to take multiple years to control.

Purchasing Seed

It is very important to purchase Pure Live Seed (PLS) and calculate seeding rates based on PLS. This ensures consistent seeding rates of seed capable of germinating. Also very important is to purchase species individually packaged. This will allow the blending of seed of similar size and seeding depth requirements at the time of seeding. Legume seed should be purchased scarified and inoculated if there is no capability to do so after purchase.

Seeding Rate

Seeding rates in the study were 15 PLS lbs per acre, with approximately 50% grass and 50% wildflower seed by weight. Future seeding rates can be lower, considering that the seeding rates in the study were more than adequate and that poorly establishing species, mostly wildflowers, will not be used. Seeding rates for mixes listed in appendix C are 12 PLS lbs per acre for all mixes except for the all grass mixes which are 10 PLS lbs per acre. Each mix includes 7 and 5 PLS lbs per acre of grasses and wildflowers, respectively. These rates can be varied between 5 to 10 pounds grasses and 4 to 8 pounds wildflowers. The higher rates should be used on steep slopes, especially when hydroseeding. Oats can also be added to mixes at a rate of 25 to 50 lbs per acre for steep slopes or sites prone to erosion where quick cover is required.

Timing of Seeding

Late spring/early summer was the optimum seeding time to balance the best weed control and germination. Appendix A shows this comparison. This allowed for the best control of the weeds in early spring and again in late spring/early summer just prior to planting. Weed control and seeding should be completed early on dry soils to take advantage of available moisture. Dormant seeding is not recommended when other seeding options are available. Dormant seedings have and can do well, but there are many more factors that make this seeding time more risky and unreliable, such as weed control, wet planting conditions, predation of seed and rotting of the seed.

Seeding Methods and Equipment

No-till preparation and drilling is preferred for providing a firm seedbed for good seed placement and seed to soil contact. Hydroseeding should be avoided with mixes containing species that require good seed to soil contact, such as warm season grasses. Seeding using a no-till seed drill designed for native seed with 3 seed boxes, including a fluffy box, allows the greatest control for seeding many different species. The seed drill should be set to seed to an average depth between 1/8 and 1/4 of an inch.

Just prior to seeding, seed is combined and mixed according to size and shape for the appropriate seed boxes in the seed drill or for broadcast sowing of fine seed. Appropriate seeding method for each species is listed in table 11. Large seeds such as eastern gamagrass are placed in the grain box. Small, smooth seeds are placed in the small/legume box. Fluffy or irregular seeds are placed in the fluffy box. Ideal seeding depth depends largely on seed size. Fine seeds such as aster seed should be planted very shallowly on or near the surface and therefore should not be drilled. Fine seed should be broadcast following drilling. Broadcast seeding and packing may be accomplished in one step by using a broadcast seeder with packer wheels, such as a Brillion[®] seeder. To ensure good seed to soil contact, the site should be packed with a cultipacker when all seeding is done.

Mixing seed with a bulking agent to increase the volume of seed may be necessary due to the low seeding rates. Using kitty litter, sawdust, sand or other inert material can be useful for broadcasting seed. Use material that is similar in size and shape of the seed to avoid separation. Short grain rice worked well for bulking up of seed in the small/legume seed box, as did crushed and sifted cocoa shell mulch in the fluffy box. Coarse sawdust should also work well for mixing with the fluffy seed.

Maintenance and Post Planting Weed Control

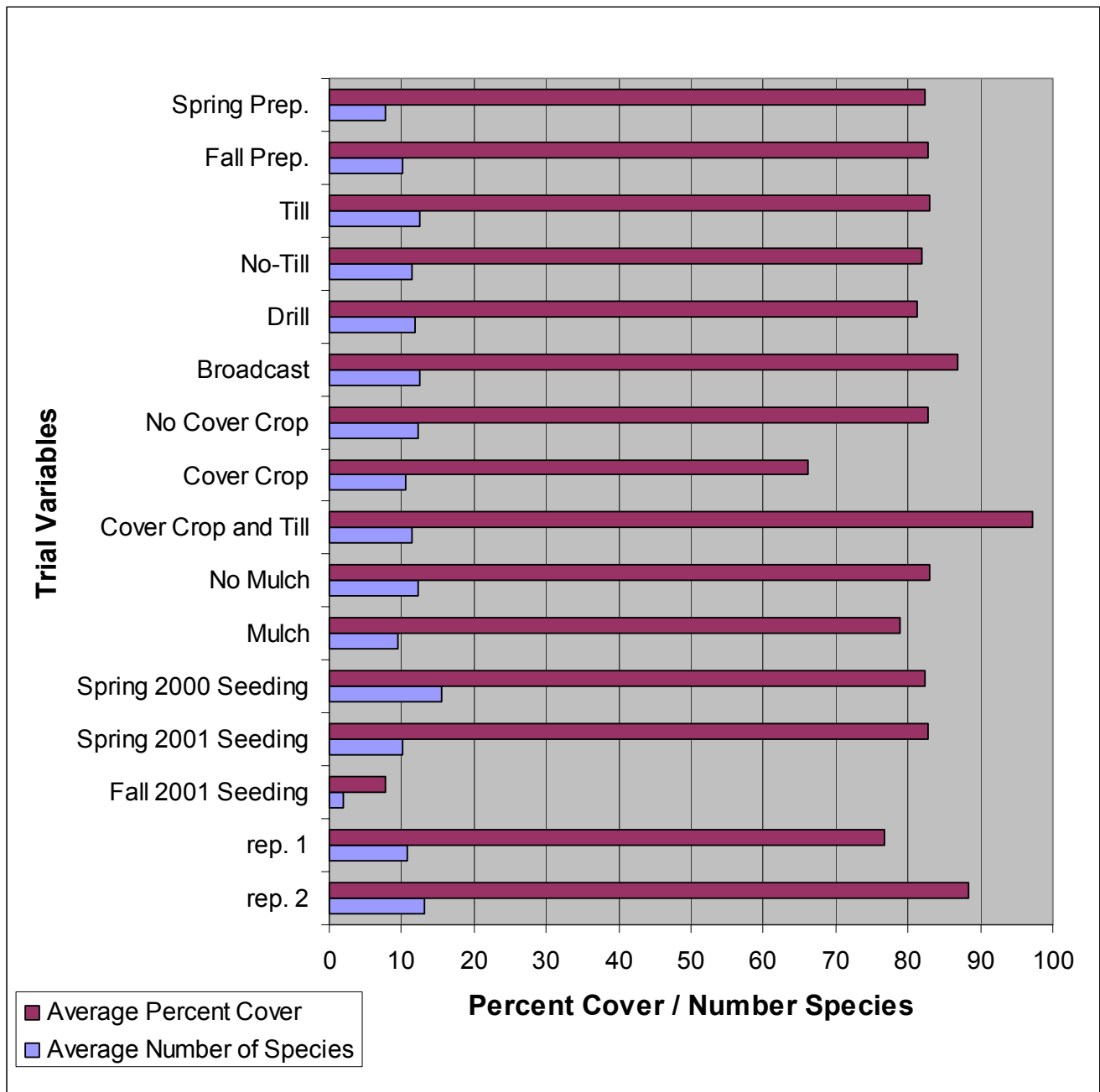
Maintenance requirements are outlined in appendix D. Annual weeds may significantly threaten establishment but are easily controlled by mowing in the first one to two years as was required for the I-95 highway planting. Mowing was not required in the establishment study. Mowing may not be required if excellent weed control is obtained prior to seeding and few weeds overtop germinating seedlings. Mowing 6"-8" in height will help prevent weeds from seeding and allow light to penetrate to the native seedlings. Weeds should not be allowed to grow above 12". After the second year, mowing should occur every 2-3 years in early spring. Prescribed burning by qualified persons may be substituted for mowing after three years or when enough combustible material has built up. Burning should occur in very early in spring to avoid damaging emerging wildflowers. Maintenance of frequently mowed cool season grass strip around each meadow will provide a firebreak and impart a maintained appearance.

Invasive perennial and woody weeds that are capable of aggressively expanding in established meadows are a very serious threat to the sustainability of a meadow. These weeds are usually capable of spreading vegetatively through rhizomes or other means, but may also seed aggressively. A list of the most common of these high threat weeds that require complete control to ensure the sustainability of the meadow is included in appendix D. In the establishment study, several single plants of crown vetch and Canada thistle barely noticeable in the first year expanded greatly after three years. Most occurrences of these perennial weeds were first observed in the year after seeding and had established along with the native seedlings. New observations of perennial weeds generally were not observed after the first year; however those already established continued to grow and spread each year. Thus, the well established meadow is likely to be resistant to new invasions of weeds. It is therefore very important to monitor for perennial rhizomatous weeds and control them very early. It is especially important to have staff trained in the identification of the immature stages of these weeds and other invasive plants. Control is most efficient and effective in the first few months after seeding when the weeds are easily found and less established. It will become more difficult to monitor for weeds as the meadow becomes more established, but will be much less necessary if excellent control of weeds is achieved in the first year. Spot spray selective herbicides or apply glyphosate with a precise method such as wick application. Many broadleaf herbicides can safely be sprayed on meadows planted solely with grasses.

ESTABLISHMENT TRIALS COMPARISON

Figure 3. Establishment Trials Performance

Chart data is derived from an average of all three years of data from mix B plots only. Data for trial variables are an average of all plots that include the specified variable. For example: the **average number of species** is the average number of species, of the 19 used in mix B, that occurred in the plots with the specified variable averaged over the three years. **Average percent cover** is the total percent cover of seeded species in each plot, as an average of all plots with the specified variable.



Appendix B

SPECIES PERFORMANCE GRAPHS AND TABLES

Figure 4. Mix A Species Performance

Chart data is derived from an average of all three years of data from all of the mix A plots across all treatments. Data represents the average percent cover for each species in mix A plots.

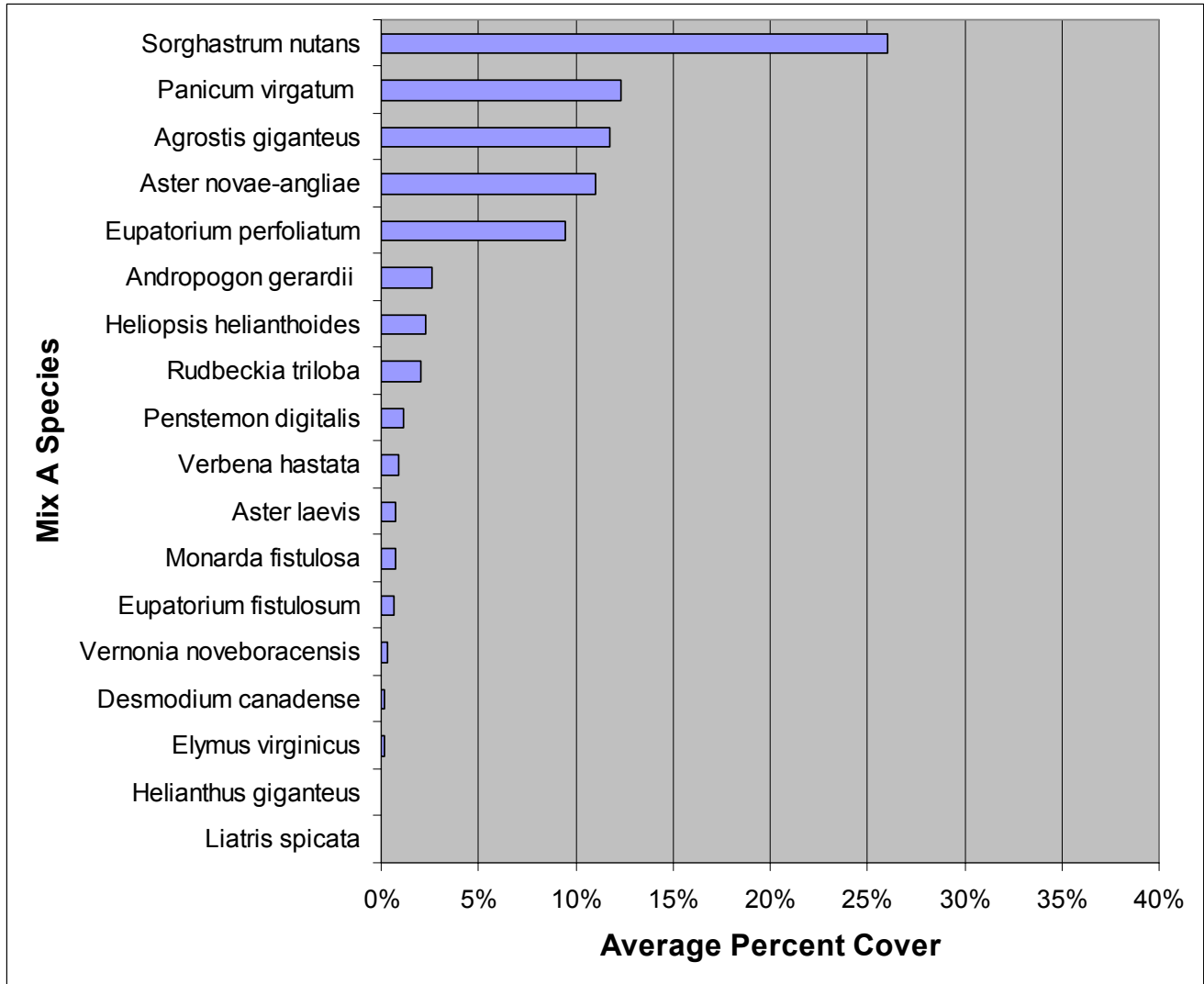


Figure 5. Mix B Species Performance

Chart data is derived from an average of all three years of data from all of the mix B plots across all treatments. Data represents the average percent cover for each species in mix B plots.

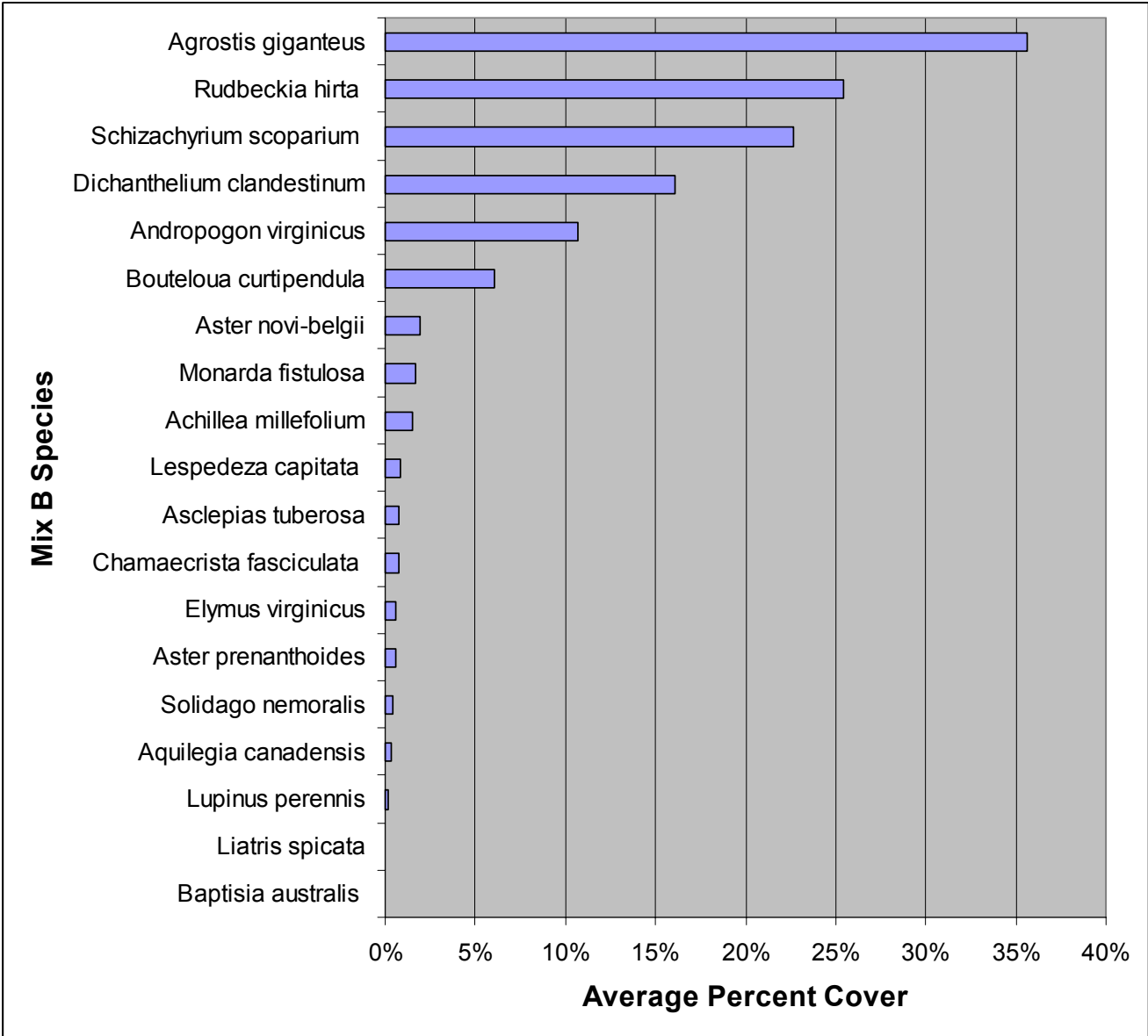


Figure 6. Mix C Species Performance

Chart data is derived from an average of all three years of data from all of the mix C plots across all treatments. Data represents the average percent cover for each species in mix C plots.

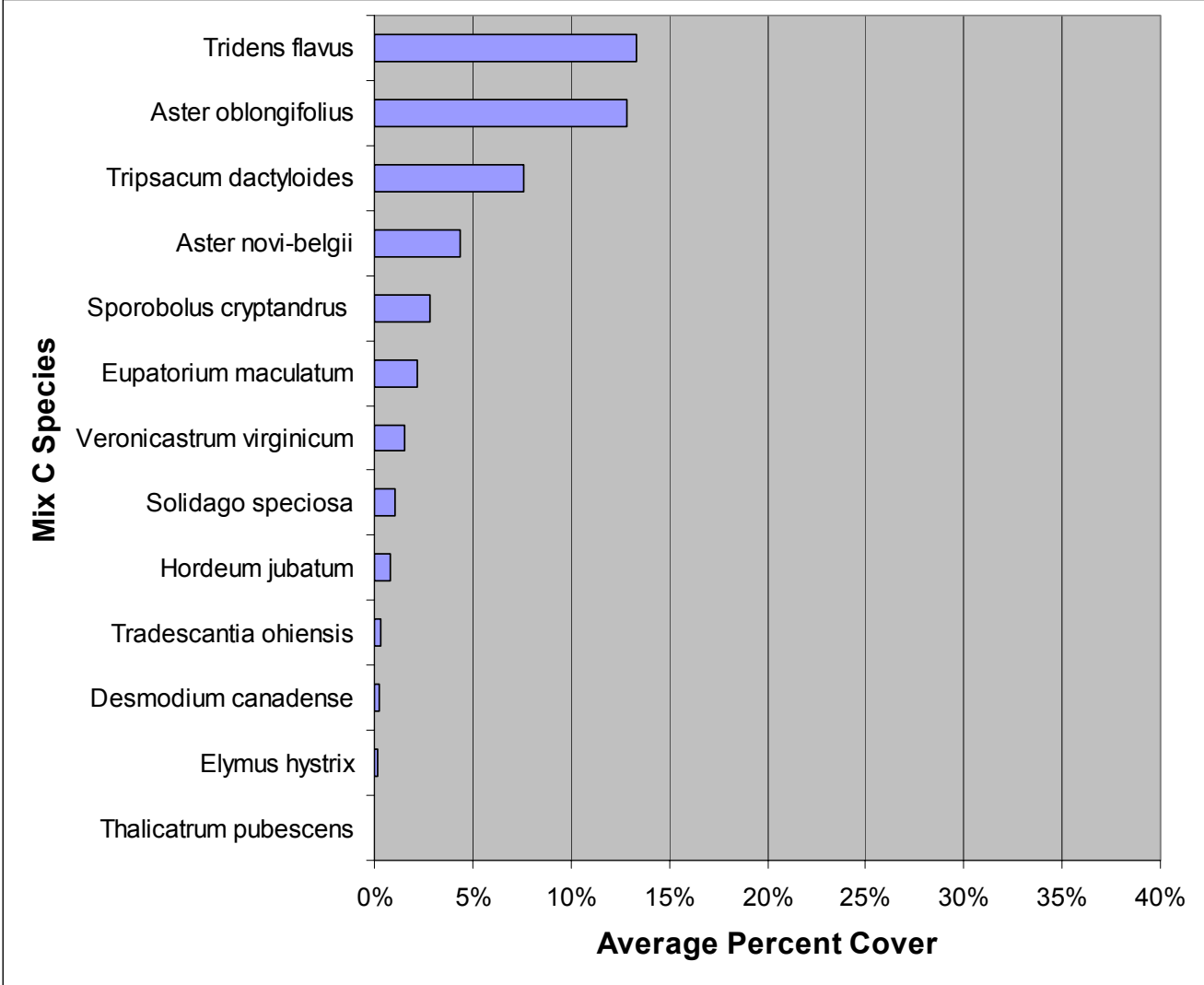


Table 9a. ESTIMATED COST OF SEEDING EACH SPECIES

Economically Seeded Species

(Species with an estimated cost of less than \$0.03 per grass and \$0.20 per wildflower)*

		Cost/lb-PLS	Estimated	Price Limit**
		as of 6/8/2004	Cost/plant	Price at \$0.03/plant
Grasses				(\$/lb-PLS)
<i>Agrostis giganteus</i>	redtop	\$2.63	\$0.0001	\$1161.60
<i>Dichanthelium clandestinum</i>	deertongue	\$13.02	\$0.0027	\$145.20
<i>Sporobolus cryptandrus</i>	sand dropseed	\$10.00	\$0.0029	\$103.71
<i>Bouteloua curtipendula</i>	sideoats grama	\$7.50	\$0.0062	\$36.30
<i>Schizachyrium scoparium 'Aldous'</i>	little bluestem	\$12.00	\$0.0071	\$50.82
<i>Panicum virgatum 'Shelter'</i>	Switchgrass	\$6.00	\$0.0074	\$24.20
<i>Sorghastrum nutans 'Nebraska 54'</i>	Indiangrass	\$10.00	\$0.0089	\$33.88
<i>Tridens flavus</i>	purple top	\$14.32	\$0.0118	\$36.30
<i>Andropogon gerardii 'Niagara'</i>	big bluestem	\$6.00	\$0.0124	\$14.52
<i>Elymus virginicus</i>	Virginia wildrye	\$5.00	\$0.0155	\$9.68
<i>Tripsacum dactyloides</i>	eastern gamagrass	\$12.50	\$0.0172	\$21.78
<i>Andropogon virginicus</i>	broomsedge	\$53.00	\$0.0263	\$60.50
Wildflowers				Price Limit**
				Price at \$0.20/plant
				(\$/lb-PLS)
<i>Achillea millefolium</i>	yarrow	\$17.16	\$0.0011	\$3,226.67
<i>Rudbeckia hirta</i>	black eyed susan	\$13.24	\$0.0011	\$2,420.00
<i>Chamaecrista fasciculata</i>	partridge pea	\$7.50	\$0.0031	\$484.00
<i>Rudbeckia triloba</i>	brown eyed susan	\$62.78	\$0.0130	\$968.00
<i>Aster prenanthoides</i>	zig zag aster	\$313.47	\$0.0216	\$2,904.00
<i>Aster novae-angliae</i>	New England aster	\$176.26	\$0.0243	\$1,452.00
<i>Heliopsis helianthoides</i>	ox-eye sunflower	\$37.04	\$0.0255	\$290.40
<i>Verbena hastata</i>	blue vervain	\$52.63	\$0.0290	\$363.00
<i>Desmodium canadense</i>	showy tick trefoil	\$40.00	\$0.0372	\$215.11
<i>Penstemon digitalis</i>	beard-tongue	\$117.15	\$0.0484	\$484.00
<i>Lupinus perennis</i>	wild blue lupine	\$28.32	\$0.0585	\$96.80
<i>Eupatorium perfoliatum</i>	boneset	\$298.09	\$0.0616	\$968.00
<i>Lespedeza capitata</i>	bush clover	\$226.81	\$0.0625	\$726.00
<i>Monarda fistulosa</i>	wild bergamont	\$178.12	\$0.0736	\$484.00
<i>Asclepias tuberosa</i>	butterfly milkweed	\$212.73	\$0.1319	\$322.67
<i>Vernonia noveboracensis</i>	New York ironweed	\$188.27	\$0.1667	\$225.87
<i>Aster laevis</i>	smooth aster	\$315.25	\$0.1916	\$329.12
<i>Tradescantia ohiensis</i>	Ohio spiderwort	\$330.19	\$0.1949	\$338.80

* Estimated cost limits were chosen to reduce costs and improve reliability of seeding. The limits of \$0.03 per grass and \$0.20 per wildflower are approximate points of rapidly diminishing returns. These costs are well below the cost of planting plugs. However, plugs are quick establishing and more reliable.

** The price limit listed is the maximum price per pound-PLS at which the estimated cost per plant exceeds \$0.03 for grasses and \$0.20 for Wildflowers.

Table 9b. COST OF SEEDING EACH SPECIES

Uneconomically Seeded Species

(Species with an estimated cost of greater than \$0.03 per grass and \$0.20 per wildflower)

		Cost/lb-PLS	Estimated	Price Limit**
		as of 6/8/2003	Cost/plant	Price at \$0.03/plant
				(\$/lb-PLS)
Grasses				
<i>Hordeum jubatum</i>	foxtail barley	\$75.00	\$0.0620	\$36.30
<i>Elymus hystrix*</i>	bottlebrush grass	\$16.00	\$0.2314	\$2.07
				Price Limit**
				Price at \$0.20/plant
				(\$/lb-PLS)
Wildflowers				
<i>Aster oblongifolius</i>	aromatic aster	\$668.90	\$0.2211	\$605.00
<i>Aster novi-belgii</i>	New York aster	\$700.00	\$0.2603	\$537.78
<i>Eupatorium fistulosum</i>	joe-pye weed	\$391.73	\$0.3035	\$258.13
<i>Eupatorium maculatum</i>	spotted joe-pye weed	\$167.34	\$0.3457	\$96.80
<i>Baptisia australis</i>	blue false indigo	\$222.35	\$0.3675	\$121.00
<i>Liatris spicata</i>	spiked gayfeather	\$114.95	\$0.4750	\$48.40
<i>Aquilegia canadensis</i>	eastern columbine	\$790.57	\$0.4900	\$322.67
<i>Helianthus giganteus</i>	sunflower	\$80.28	\$0.4976	\$32.27
<i>Solidago nemoralis</i>	gray goldenrod	\$477.53	\$0.7400	\$129.07
<i>Solidago speciosa</i>	showy goldenrod	\$306.32	\$0.7595	\$80.67
<i>Veronicastrum virginicum</i>	Culver's root	\$2,468.11	\$1.5298	\$322.67
<i>Thalictrum pubescens</i>	meadow rue	\$380.95	\$6.2967	\$12.10

*The poor germination of *Elymus hystrix* was not consistent with previous experiences and should still be considered for including in seed mixes.

** The price limit listed is the price per pound-PLS at which the estimated cost per plant exceeds \$0.03 for grasses and \$0.20 for Wildflowers. This price is lower than the current price. These species may be considered for direct seeding if the price per pound-PLS falls below this price limit or if techniques are found to improve establishment to reduce the cost per plant.

Table 10. PLATEAU® TOLERANCE

Establishment in 4 oz/acre pre-emergent Plateau® treated plots as compared to the control

Grasses	Common Name	Establishment
<i>Elymus virginicus</i>	Virginia wildrye	Very Good
<i>Andropogon gerardii</i> 'Niagara'	big bluestem	Very Good
<i>Andropogon virginicus</i>	broomsedge	Very Good
<i>Sorghastrum nutans</i> 'Nebraska 54'	Indiangrass	Very Good
<i>Hordeum jubatum</i>	foxtail barley	Good
<i>Bouteloua curtipendula</i>	sideoats grama	Good
<i>Schizachyrium scoparium</i> 'Aldous'	little bluestem	Good
<i>Sporobolus cryptandrus</i>	sand dropseed	Good
<i>Tridens flavus</i>	purple top	Good
<i>Tripsacum dactyloides</i>	eastern gamagrass	Good
<i>Agrostis giganteus</i>	redtop	Poor
<i>Dichanthelium clandestinum</i>	deertongue	Poor
<i>Panicum virgatum</i> 'Shelter'	Switchgrass	Poor
<i>Elymus hystrix</i>	bottlebrush grass	not enough data
Wildflowers		
<i>Achillea millefolium</i>	yarrow	Very Good
<i>Aquilegia canadensis</i>	eastern columbine	Very Good
<i>Baptisia australis</i>	blue false indigo	Very Good
<i>Chamaecrista fasciculata</i>	partridge pea	Very Good
<i>Desmodium canadense</i>	showy tick trefoil	Very Good
<i>Eupatorium fistulosum</i>	joe-pye weed	Very Good
<i>Eupatorium maculatum</i>	spotted joe-pye weed	Very Good
<i>Lespedeza capitata</i>	bush clover	Very Good
<i>Rudbeckia hirta</i>	black eyed susan	Very Good
<i>Solidago nemoralis</i>	gray goldenrod	Very Good
<i>Solidago speciosa</i>	showy goldenrod	Very Good
<i>Vernonia noveboracensis</i>	New York ironweed	Very Good
<i>Asclepias tuberosa</i>	butterfly milkweed	Good
<i>Aster novae-angliae</i>	New England aster	Good
<i>Aster oblongifolius</i>	aromatic aster	Good
<i>Eupatorium perfoliatum</i>	boneset	Good
<i>Heliopsis helianthoides</i>	ox-eye sunflower	Good
<i>Lupinus perennis</i>	wild blue lupine	Good
<i>Monarda fistulosa</i>	wild bergamont	Good
<i>Aster novi-belgii</i>	New York aster	Poor
<i>Helianthus giganteus</i>	sunflower	None
<i>Penstemon digitalis</i>	beard-tongue	None
<i>Rudbeckia triloba</i>	brown eyed susan	None
<i>Verbena hastata</i>	blue vervain	None
<i>Aster laevis</i>	smooth aster	not enough data
<i>Aster prenanthoides</i>	zig zag aster	not enough data
<i>Liatris spicata</i>	spiked gayfeather	not enough data
<i>Thalictrum pubescens</i>	meadow rue	not enough data
<i>Tradescantia ohiensis</i>	Ohio spiderwort	not enough data
<i>Veronicastrum virginicum</i>	Culver's root	not enough data

Appendix C

Table 11. RECOMMENDED SPECIES FOR SEEDING AND RECOMMENDED APPLICATIONS

Grasses Species	Seeding Rate (PLS-lbs/Acre)	Seeding Method	Recommended Applications Soil Type			Mix Height		Preemergent (4oz/ac) Plateau® Tolerant**	
			Dry	Mesic	Wet	Tall	Short		
<i>Andropogon gerardii</i>	1.0-2.0	Drill, fluffy		x		x			x
<i>Andropogon virginicus</i>	0.5-1.0	Drill, fluffy	x	x			x		x
<i>Bouteloua curtipendula</i>	1.0-2.0	Drill, fluffy	x	x			x		x
<i>Dichanthelium clandestinum</i>	1.0-2.0	Drill, small	x	x			x		
<i>Elymus virginicus</i>	1.0-5.0	Drill, fluffy		x	x		x		x
<i>Panicum virgatum</i>	1.0-2.0	Drill, small		x	x	x			
<i>Schizachyrium scoparium</i>	1.0-2.0	Drill, fluffy	x	x		x	x		x
<i>Sorghastrum nutans</i>	1.0-2.0	Drill, fluffy		x		x			x
<i>Sporobolus cryptandrus</i>	1.0-2.0	Broadcast	x	x			x		x
<i>Tridens flavus</i>	1.0-3.0	Drill, fluffy	x	x		x	x		x
<i>Tripsacum dactyloides</i>	3.0-6.0	Drill, grain		x	x	x			x
Wildflower Species									
<i>Achillea millefolium</i>	0.2-0.4	Broadcast	x	x			x		x
<i>Asclepias tuberosa</i>	0.3-0.6	Drill, fluffy	x	x			x		x
<i>Aster laevis</i>	0.2-0.5	Broadcast	x	x			x		
<i>Aster novae-angliae</i>	0.3-0.7	Broadcast		x	x	x*	x		x
<i>Aster prenanthoides</i>	0.2-0.5	Broadcast		x	x		x		
<i>Chamaecrista fasciculata</i>	1.0-2.0	Drill, small	x	x		x*	x		x
<i>Desmodium canadense</i>	0.5-2.0	Drill, small	x	x	x	x	x		x
<i>Eupatorium perfoliatum</i>	0.1-0.5	Broadcast		x	x		x		x
<i>Heliopsis helianthoides</i>	0.5-1.0	Drill, fluffy	x	x		x			x
<i>Lespedeza capitata</i>	0.1-0.5	Drill, small	x	x			x		x
<i>Lupinus perennis</i>	1.0-2.0	Drill, small	x	x			x		x
<i>Monarda fistulosa</i>	0.3-1.0	Drill, small	x	x			x		x
<i>Penstemon digitalis</i>	0.3-1.0	Broadcast		x			x		
<i>Rudbeckia hirta</i>	0.3-0.7	Broadcast	x	x		x*	x		x
<i>Rudbeckia triloba</i>	0.4-1.0	Broadcast		x	x		x		
<i>Tradescantia ohiensis</i>	0.2-0.8	Drill, fluffy	x	x			x		
<i>Verbena hastata</i>	0.5-2.0	Broadcast		x	x	x*	x		
<i>Vernonia noveboracensis</i>	0.2-0.5	Drill, fluffy		x	x	x			x

Seeding Rate: Recommended seeding rate when used in a diverse mix.

Seeding Method: Preferred method of seeding. Broadcast = surface sown or no greater than 1/16 inch deep. Drill = drill to a depth of 1/8 to 1/4 of an inch. Small, fluffy or grain denotes the appropriate seed box of the seed-drill in which the seed should be placed for seeding.

Soil Type: x = Species is suitable for planting on this type of soil.

Mix Height: x = Species is suitable for including in a seed mix of this intended height.

x* = Wildflower species that are not very tall, but establish quickly and should provide a showy bloom prior to the tall warm-season grasses growing to their full height and density.

Preemergent Plateau®: x = Species is tolerant to 4 oz/acre of Plateau® applied preemergently.

** Post

Appendix C

RECOMMENDED MIXES

6

Mesic, Short

For sites with well to moderately drained soils

Grasses		Pounds PLS / Acre	Percent
<i>Elymus virginicus</i>	Virginia wildrye	1.5	12.50%
<i>Bouteloua curtipendula</i>	sideoats grama	1.0	8.33%
<i>Dichanthelium clandestinum</i>	deertongue	1.0	8.33%
<i>Schizachyrium scoparium</i>	little bluestem	1.0	8.33%
<i>Sporobolus cryptandrus</i>	sand dropseed	1.0	8.33%
<i>Tridens flavus</i>	purple top	1.0	8.33%
<i>Andropogon virginicus</i>	broomsedge	0.5	4.17%
	Total Grasses:	7.0	58.33%
Wildflowers			
<i>Aster novae-angliae</i>	New England aster	0.5	4.17%
<i>Chamaecrista fasciculata</i>	partridge pea	0.5	4.17%
<i>Desmodium canadense</i>	showy tick trefoil	0.5	4.17%
<i>Lupinus perennis</i>	wild blue lupine	0.5	4.17%
<i>Verbena hastata</i>	blue vervain	0.5	4.17%
<i>Asclepias tuberosa</i>	butterfly milkweed	0.4	3.33%
<i>Rudbeckia triloba</i>	brown eyed susan	0.4	3.33%
<i>Monarda fistulosa</i>	wild bergamont	0.3	2.50%
<i>Penstemon digitalis</i>	beard-tongue	0.3	2.50%
<i>Rudbeckia hirta</i>	black eyed susan	0.3	2.50%
<i>Achillea millefolium</i>	yarrow	0.2	1.67%
<i>Tradescantia ohioensis</i>	Ohio spiderwort	0.2	1.67%
<i>Aster laevis</i>	smooth aster	0.1	0.83%
<i>Aster prenanthoides</i>	zig zag aster	0.1	0.83%
<i>Eupatorium perfoliatum</i>	boneset	0.1	0.83%
<i>Lespedeza capitata</i>	bush clover	0.1	0.83%
	Total Wildflowers:	5.0	41.67%
	Total:	12.0	100.00%

Mesic, Tall

For sites with well to moderately drained soils

Grasses		Pounds PLS / Acre	Percent
<i>Tripsacum dactyloides</i>	eastern gamagrass	3.0	25.00%
<i>Andropogon gerardii</i>	big bluestem	1.0	8.33%
<i>Panicum virgatum</i>	switchgrass	1.0	8.33%
<i>Sorghastrum nutans</i>	Indiangrass	1.0	8.33%
<i>Tridens flavus</i>	purple top	1.0	8.33%
	Total Grasses:	7.0	58.33%
Wildflowers			
<i>Chamaecrista fasciculata</i>	partridge pea	1.5	12.50%
<i>Heliopsis helianthoides</i>	ox-eye sunflower	1.0	8.33%
<i>Desmodium canadense</i>	showy tick trefoil	0.8	6.67%
<i>Aster novae-angliae</i>	New England aster	0.6	5.00%
<i>Rudbeckia hirta</i>	black eyed susan	0.6	5.00%
<i>Vernonia noveboracensis</i>	New York ironweed	0.5	4.17%
	Total Wildflowers:	5.0	41.67%
	Total:	12.0	100.00%

Extreme Soil Moisture Mixes

Dry, Short

For sites with well drained soils

Grasses		Pounds PLS / Acre	Percent
<i>Bouteloua curtipendula</i>	sideoats grama	2.0	16.67%
<i>Schizachyrium scoparium</i>	little bluestem	2.0	16.67%
<i>Dichanthelium clandestinum</i>	deertongue	1.0	8.33%
<i>Sporobolus cryptandrus</i>	sand dropseed	1.0	8.33%
<i>Andropogon virginicus</i>	broomsedge	0.5	4.17%
<i>Tridens flavus</i>	purple top	0.5	4.17%
Total Grasses:		7.0	58.33%
Wildflowers			
<i>Chamaecrista fasciculata</i>	partridge pea	1.0	8.33%
<i>Lupinus perennis</i>	wild blue lupine	1.0	8.33%
<i>Asclepias tuberosa</i>	butterfly milkweed	0.6	5.00%
<i>Rudbeckia hirta</i>	black eyed susan	0.6	5.00%
<i>Achillea millefolium</i>	yarrow	0.4	3.33%
<i>Desmodium canadense</i>	showy tick trefoil	0.4	3.33%
<i>Aster laevis</i>	smooth aster	0.3	2.50%
<i>Monarda fistulosa</i>	wild bergamont	0.3	2.50%
<i>Lespedeza capitata</i>	bush clover	0.2	1.67%
<i>Tradescantia ohiensis</i>	Ohio spiderwort	0.2	1.67%
Total Wildflowers:		5.0	41.67%
Total:		12.0	100.00%

Wet, Mixed Height

For sites with poorly drained soils

Grasses		Pounds PLS / Acre	Percent
<i>Elymus virginicus</i>	Virginia wildrye	2.5	20.83%
<i>Panicum virgatum</i>	switchgrass	1.5	12.50%
<i>Tripsacum dactyloides</i>	eastern gamagrass	3.0	25.00%
Total Grasses:		7.0	58.33%
Wildflowers			
<i>Verbena hastata</i>	blue vervain	2.0	16.67%
<i>Desmodium canadense</i>	showy tick trefoil	0.8	6.67%
<i>Rudbeckia triloba</i>	brown eyed susan	0.7	5.83%
<i>Aster novae-angliae</i>	New England aster	0.5	4.17%
<i>Eupatorium perfoliatum</i>	boneset	0.4	3.33%
<i>Vernonia noveboracensis</i>	New York ironweed	0.4	3.33%
<i>Aster prenanthoides</i>	zig zag aster	0.2	1.67%
Total Wildflowers:		5.0	41.67%
Total:		12.0	100.00%

Plateau[®] Tolerant Mixes

Plateau[®], Short

For sites prepared with preemergent Plateau[®] (4oz/acre)

Grasses		Pounds PLS / Acre	Percent
<i>Bouteloua curtipendula</i>	sideoats grama	2.0	16.67%
<i>Schizachyrium scoparium</i>	little bluestem	1.5	12.50%
<i>Elymus virginicus</i>	Virginia wildrye	1.0	8.33%
<i>Sporobolus cryptandrus</i>	sand dropseed	1.0	8.33%
<i>Tridens flavus</i>	purple top	1.0	8.33%
<i>Andropogon virginicus</i>	broomsedge	0.5	4.17%
Total Grasses:		7.0	58.33%
Wildflowers			
<i>Chamaecrista fasciculata</i>	partridge pea	1.0	8.33%
<i>Lupinus perennis</i>	wild blue lupine	1.0	8.33%
<i>Desmodium canadense</i>	showy tick trefoil	0.8	6.67%
<i>Aster novae-angliae</i>	New England aster	0.5	4.17%
<i>Asclepias tuberosa</i>	butterfly milkweed	0.4	3.33%
<i>Rudbeckia hirta</i>	black eyed susan	0.4	3.33%
<i>Monarda fistulosa</i>	wild bergamont	0.3	2.50%
<i>Achillea millefolium</i>	yarrow	0.2	1.67%
<i>Eupatorium perfoliatum</i>	boneset	0.2	1.67%
<i>Lespedeza capitata</i>	bush clover	0.2	1.67%
Total Wildflowers:		5.0	41.67%
Total:		12.0	100.00%

Plateau[®], Tall

For sites prepared with preemergent Plateau[®] (4oz/acre)

Grasses		Pounds PLS / Acre	Percent
<i>Tripsacum dactyloides</i>	eastern gamagrass	3.0	25.00%
<i>Andropogon gerardii</i>	big bluestem	2.0	16.67%
<i>Sorghastrum nutans</i>	Indiangrass	1.0	8.33%
<i>Tridens flavus</i>	purple top	1.0	8.33%
Total Grasses:		7.0	58.33%
Wildflowers			
<i>Chamaecrista fasciculata</i>	partridge pea	1.2	10.00%
<i>Desmodium canadense</i>	showy tick trefoil	1.2	10.00%
<i>Heliopsis helianthoides</i>	ox-eye sunflower	1.0	8.33%
<i>Aster novae-angliae</i>	New England aster	0.6	4.17%
<i>Rudbeckia hirta</i>	black eyed susan	0.5	5.00%
<i>Vernonia noveboracensis</i>	New York ironweed	0.5	4.17%
Total Wildflowers:		5.0	41.67%
Total:		12.0	100.00%

Grass Only Mixes

Grass Only, Short

For sites requiring future broad leaf weed control		Pounds PLS / Acre	Percent
<i>Elymus virginicus</i>	Virginia wildrye	2.5	25.00%
<i>Bouteloua curtipendula</i>	sideoats grama	1.5	15.00%
<i>Dichanthelium clandestinum</i>	deertongue	1.5	15.00%
<i>Schizachyrium scoparium</i>	little bluestem	1.5	15.00%
<i>Andropogon virginicus</i>	broomsedge	1.0	10.00%
<i>Sporobolus cryptandrus</i>	sand dropseed	1.0	10.00%
<i>Tridens flavus</i>	purple top	1.0	10.00%
Total:		10.0	100.00%

Grass Only, Tall

For sites requiring future broad leaf weed control		Pounds PLS / Acre	Percent
<i>Tripsacum dactyloides</i>	eastern gamagrass	3.0	30.00%
<i>Andropogon gerardii</i>	big bluestem	2.0	20.00%
<i>Panicum virgatum</i>	Switchgrass	2.0	20.00%
<i>Sorghastrum nutans</i>	Indiangrass	2.0	20.00%
<i>Tridens flavus</i>	purple top	1.0	10.00%
Total:		10.0	100.00%

Appendix D

SUSTAINABLE MEADOW ESTABLISHMENT GUIDLINES

1. Site Evaluation

- a. Inspect and identify current vegetation especially aggressive perennial weeds at least one year prior to seeding. These include Canada thistle, crown vetch, Johnson grass, quack grass, Tree of Heaven, multiflora rose, brambles, and Japanese honeysuckle. Begin control of aggressive perennial weeds no later than the fall prior to spring seeding to attain complete control prior to seeding.

High Threat, Aggressive Perennial Weeds:

Canada Thistle (*Cirsium arvense*)
Crown Vetch (*Coronilla varia*)
Johnsongrass (*Sorghum halepense*)
Quackgrass (*Agropyron repens*)
Tree of Heaven (*Ailanthus altissima*)
Multiflora Rose (*Rosa multiflora*)
Brambles (*Rubus spp.*)
Japanese Honeysuckle (*Lonicera japonica*)

- b. Test soil and determine soil moisture regimes. Do not lime unless less than pH 5.0. A pH of 5.0-6.0 will limit fertility and invasion of weeds. Do not fertilize unless very deficient as additional nutrients will encourage weeds. If necessary use a low nitrogen fertilizer. Soil amendments should be applied just prior to seeding.

2. Seed Purchase

- a. Choose appropriate mix for soil conditions and future weed control considerations as described in appendix C.
- b. Base purchases on Pure Live Seed (PLS) and purchase each species individually packaged or refer to table 11 for which species may be mixed.
- c. PLS lbs seeding rate should be 5 to 10 pounds grasses, 4 to 8 pounds forbs. For steep slopes where erosion is a concern add oats at 20 lbs per acre.
- d. Legume seeds should be scarified and inoculated. Inoculum should be available from the seed dealer.

3. Timing of Seeding

Seed between April 10 and June 15.

4. Site Preparation

- a. Begin preparations in March or when target weeds have begun to grow. If aggressive perennial weeds are present begin control with spot or broadcast herbicide treatments in the prior fall.
- b. Mow to a height of 2 to 4 inches.
- c. Spray glyphosate herbicide 1-2 weeks after mowing.
- d. Spray a second application of glyphosate 2 to 4 weeks after first application when additional weeds have emerged.
- e. If weeds were abundant at second spraying, schedule a third application 2-4 weeks later to control additional germinating weeds.
- f. Scheduled seeding within 4 days prior to or after applying glyphosate the final time.

- g. Plateau[®] (4oz/acre) added to the last treatment of glyphosate, can be used in areas of heavy annual weed pressure. Use the Plateau[®] tolerant seed mix in this case.
- h. A frequently mowed cool season grass border of at least 6' should be maintained surrounding the site to serve as firebreak and provide a maintained look. A firebreak is recommended even if a prescribed burn is not planned for the site. Accidental ignition of dormant warm-season grasses should be anticipated and planned for. Large, dense stands of tall warm-season grasses should be avoided where a potential fire would be a hazard.

5. Seeding Equipment and Methods

- a. Seed according to size and shape of seed as listed in table 11 appendix C.
 - i. Large seeds such as eastern gamagrass are placed in grain box or fluffy box.
 - ii. Small, smooth seeds are placed in small/legume box.
 - iii. Fluffy seeds such as little bluestem and indiagrass are placed in the fluffy box.
 - iv. Very fine seed such as aster is broadcasted on the surface after drilling.
- b. Bulk up the volume of seed using kitty litter, sawdust, sand or other inert material as needed for easier and more accurate drilling or broadcasting of the seed.
- c. Use a No-till native seed drill with fluffy and small/legume seed boxes such as a Truax Flex II seed drill.
- d. Drill perpendicular to the slope to reduce erosion and loss of seed.
- e. Drill to a depth between ¼ and ½ inch after which fine seed is broadcast by hand or with broadcast seeder.
- f. For slopes too steep for drilling, hydroseed and track up and down slope with a bulldozer or other tracked equipment. Use 50 to 100% more seed and apply mulch after hydroseeding.

6. Weed Control Methods After Planting

- a. Use selective herbicides to reduce damage to native seedlings by spot applying to small infestations of aggressive perennial weeds, or broadcast spray over herbicide tolerant mixes with heavy infestations.
- b. Use non-selective herbicides with very targeted application methods only, such as cut stump treatment or with a wick applicator.

7. First Year Maintenance

- a. Inspect site and control all aggressive perennial weeds 2-4 weeks after seeding and monthly thereafter. The first inspection and herbicide treatment 2-4 weeks after seeding should be very thorough. Control aggressive perennial weeds completely by the end of the first year.
- b. Mow monthly to a height of 6-8" to control annual weeds and allow light to penetrate to seedlings. Do not allow weeds to grow above 12". Clippings are to be evenly distributed or removed. Mowing may be skipped if there are no weeds growing or above the native seedlings.

8. Second Year Maintenance

- a. Inspect site and control any aggressive perennial weeds twice per year in May and October.
- b. Mow in spring between March 15 to April 10 at a height of 8-10" and again as necessary to prevent weeds from smothering native seedlings.

9. Maintenance After Second Year

- a. Inspect site and control any aggressive perennial weeds twice per year in May and October.
- b. Mow once every 2-3 years in spring between March 15 and April 10. To accommodate wildlife, mow no more than 1/2 of each site per year.