GDOT Research Project 12-14

Developing Extension Recommendations for Establishing Native Species on Georgia Roadsides

Final Report

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16. Abstract: The objective of this research was to develop new recommendations for establishing 29 native grass and forb species for roadside vegetation in Georgia. Blackeyed Susan (*Rudbeckia hirta* L.), swamp milkweed (*Asclepias incarnata* L.) and indiangrass (*Sorghastrum nutans* (L.) Nash) were the quickest to establish of all species, while blackeyed Susan, lanceleaf coreopsis (*Coreopsis lanceolata* L.) and wild bergamot (*Monarda fistulosa* L.) provided the greatest ground cover over the 12 month experiment. At four of the five sites, an additional 1 to 4 more of the species evaluated established ≥20% ground cover in the spring seeding compared to fall. Species seeded in the spring also established faster during the first four months after seeding. Overall, blackeyed Susan, indiangrass, lanceleaf coreopsis, swamp milkweed, and wild bergamot have the best potential, of the species tested, to establish under roadside conditions in Georgia.		
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EXECUTIVE SUMMARY

The Georgia Department of Transportation (GDOT) is responsible for establishing and maintaining roadside vegetation for vehicle safety, aesthetics, and soil stabilization. Roadside projects conducted throughout the state by GDOT require establishment of new vegetation to mitigate soil erosion. Several species native to Georgia are currently used in riparian mixes that stabilize soil near plantings in disturbed streams and may also have potential for establishment beyond stream buffers as roadside vegetation.

Native species to Georgia have potential for establishment, growth, and improving aesthetics of roadside vegetation. These species, including grasses and non-grassy species, are adapted to soils and climates of Georgia that may allow for long-term growth and competition with weeds. Additionally, these species may require less maintenance compared to bermudagrass, tall fescue, and other grasses currently utilized for roadsides in Georgia. The introduction of native species for roadsides would require timely establishment in order to stabilize soil, reduce erosion, and compete with undesirable vegetation.

The objective of this proposed research was to develop new recommendations for establishing 29 native grass and forb species for roadside vegetation in Georgia. Experiments were conducted to evaluate fall or spring establishment of these species in five locations. The species that emerged first were not necessarily the same species noted to persist throughout the study. Blackeyed Susan, lanceleaf coreopsis and wild bergamot had the best performance and most consistent results for final establishment after one year. Indiangrass and swamp milkweed also had good establishment and persistence from spring plantings. Forb species tended to have more consistent establishment than grass species.

The speed of establishment as well as the number of species present was generally higher when seeding was done in spring. More research may be needed to make specific recommendations concerning seeding rate, due to the high variation in seed size and emergence among the species tested.

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INTRODUCTION

The Georgia Department of Transportation (GDOT) is responsible for establishing and maintaining roadside vegetation for vehicle safety, aesthetics, and soil stabilization. Roadside projects conducted throughout the state by the GDOT require establishment of new vegetation to mitigate soil erosion. Several species native to Georgia are currently used in riparian mixes that stabilize soil near plantings in disturbed streams and may also have potential for establishment beyond stream buffers as roadside vegetation.

Native species to Georgia have potential for establishment, growth, and improving aesthetics of roadside vegetation. These species, including grasses and non-grassy species, are adapted to soils and climates of Georgia that may allow for long-term growth and competition with weeds. Additionally, these species may require less maintenance compared to bermudagrass, tall fescue, and other grasses currently utilized for roadsides in Georgia. The introduction of native species for roadsides would require timely establishment in order to stabilize soil, reduce erosion, and compete with undesirable vegetation.

Currently, there are 29 native grass and forb species used in riparian mitigation projects as a 60/40 seed mix with potential for Georgia roadsides (GDOT SP 700 specifications). However, research is needed to determine the potential performance of these plants for best management practices in roadside areas. Additionally, the diversity of soils, climates, and environments throughout the four hardiness zones of Georgia may influence establishment and growth of these species. Thus, comprehensive research is warranted by the Georgia DOT to determine the potential suitability of these 29 species for use on roadsides.

OBJECTIVE

The objective of the proposed research is to develop new recommendations for establishing 26 native grass and forb species for roadside vegetation in Georgia. Research will be conducted to evaluate suitability of 26 plant species listed in the GDOT SP 700 specifications at road construction sites for soil stabilization and ground restoration in areas beyond the clear zone.

PROCEDURES

Field experiments were conducted in Macon, Tifton, Commerce, Newnan and Griffin, GA (Figure 1). Site description, soil type, soil pH, GPS coordinates, plot size and seeding dates are presented in Table 1. A total of 29 species were seeded at two timings (spring and fall). In September 2012, all sites were treated with glyphosate (Roundup Pro® 4L, Monsanto Company, Creve Coeur, Missouri) at 4 kg ae ha^{-1} in order to kill existing vegetation. A sequential treatment was made after three weeks. Glyphosate treatments were applied by a CO_2-pressured backpack sprayer calibrated to deliver 374 L ha^{-1} with a single 9504E flat-fan nozzle (Tee Jet, Spraying Systems Co., Roswell, GA). On the day of seeding, sites were sliced at 1 cm depth with a mechanical slicer (Graden GS04 Verticutter, Graden USA Inc., Richmond, VA). Debris was blown off and plots were seeded by hand. All seed was mixed with milorganite as a carrier at ~18 g per square meter.

Commerce and Newnan sites were seeded with all 29 species (Table 2) in Fall 2012 and then again in Spring 2013. Both seedings were conducted in a split-plot design with

four replications. Seeding time served as the main plot treatment, and species served as a subplot treatments. All seeding was done at the rate of 11 kg ha^{-1}. The Newnan site was mowed in September 2013 and thus data for 12 months after seeding (MAS) is not available for the fall seeding.

Table 1. Site information for the five locations used in field experiments.

Site	GPS Coordinates	Soil Type	pH	Plot Size (m^2)	Seeding Date	Description
Commerce	34.26°N, 83.46°W	Sandy Loam	5.3	2.16	Fall Timing - October 5, 2012 Spring Timing - April 2, 2013	Plots off I-85
Griffin	33.25°N, 84.30°W	Sandy Clay Loam	5.3	3.24	Fall Timing - October 9, 2012 Spring Timing - April 12, 2013	Plots at Dempsey Research Farm at UGA Griffin
Macon	32.91°N, 83.70°W	Sandy Clay Loam	5.1	3.15	Fall Study - October 1, 2012 Spring Study - March 29, 2013	Plots off I-75
Newnan	33.33°N, 84.77°W	Sandy Loam	7.3	3.15	Fall Timing - October 5, 2012 Spring Timing - April 9, 2013	Plots on side of I-85
Tifton	31.48°N, 83.52°W	Sandy Clay Loam	6.8	2.7	Fall Study - October 11, 2012 Spring Study - March 28, 2013	Plots off I-75

Table 2. Species and viability of seed used in field experiments, 2012-2014, at five locations in Georgia.

Common Name	Botanical Name	Percent Seed Viability
Black-eyed Susan	*Rudbeckia hirta*	94
Boneset	*Eupatorium perfoliatum*	100
Bottlebrush Grass	*Hystrix patula*	98
Butterfly Weed	*Asclepias tuberosa*	86
Canada Wild Rye	*Elymus canadensis*	91
Deertongue	*Panicum clandestinum*	96
Eastern Gamagrass	*Tripsacum dactyloides*	100
Fringed Loosestrife	*Lysimachia ciliata*	100
Frost Aster	*Aster pilosus*	92
Goldenrod	*Solidago nemoralis*	100
Indiangrass	*Sorghastrum nutans*	79
Ironweed	*Vernonia noveboracensis*	90
Joe Pye Weed	*Eupatorium fistulosum*	90
Lanceleaf Coreopsis	*Coreopsis lanceolata*	80
Little Bluestem	*Schizachyrium scoparium*	78
Mountain Mint	*Pycnanthemum tenuifolium*	100
Partridge Pea	*Chamaecrista fasciculata*	84
Purple Top	*Tridens flavus*	98
Rice Cut Grass	*Leersia oryzoides*	100
River Oats	*Chasmanthium latifolium*	100
Sneezeweed	*Helenium autumnale*	77
Swamp Milkweed	*Asclepias incarnata*	90
Swamp Sunflower	*Helianthus angustifolius*	100
Switchgrass	*Panicum virgatum*	97
Tall Coreopsis	*Coreopsis tripteris*	94
Virginia Wild Rye	*Elymus virginicus*	94
White Snakeroot	*Ageratina altissima*	100
Wild Bergamot	*Monarda fistulosa*	87
Woolgrass	*Scirpus cyperinus*	100

The Griffin site was seeded with all 29 species in both Fall 2012 and Spring 2013, with two seeding rates used per species. The experimental design was a randomized complete split-block design. The whole plot treatment was time of year and the subplot treatments were species and seeding rate. Seeding rates for each species were randomized within each appropriate seeding time and block. Seeding rates were 11 kg ha^{-1} and 100 seeds m^{-2}.

At Macon and Tifton, the 17 cool-season species were seeded in Fall 2012 and the 12 warm-season species were seeded in Spring 2013 (see Table 2). Experimental design for the Macon and Tifton sites was thus a randomized complete block with four replications. All seeding was done at the rate of 11 kg ha^{-1}.

Visual percent cover and plant counts were recorded for each plot at 4, 8, and 12 MAS. Data were subjected to analysis of variance at the 0.05 probability level in SAS (SAS® Institute v. 9.4, Cary, NC) using the proc glimmix procedure (a mixed model). Means were separated using pairwise t-tests.

FINDINGS

Commerce Site. In the fall seeding, plant emergence and establishment were slower than the spring planting (Table 3). By 4 MAS, the only species that began to establish in fall was wild bergamot. By 12 MAS, wild bergamot reached 23% ground cover and 18 plants m^{-2}. Mountain mint had slow establishment in the fall but obtained 14% ground cover and 13 plants m^{-2} at 12 MAS. Lanceleaf coreopsis and blackeyed Susan ground cover measured 12% and 14% at 8 MAS and increased to an average of 47% at 12 MAS. Blackeyed Susan and lanceleaf coreopsis plant counts at 12 MAS were 42 and 32 plants m^{-2}, respectively.

Deertongue, indiangrass and purpletop had 5 to 20% cover at 12 MAS but had <10 plants m^{-2}. Although indiangrass, purpletop and deertongue were the only grasses present at 12 MAS, these species were not observed at 4 or 8 MAS. Other species tested had inconsistent or no establishment from the fall planting.

Black-eyed Susan, mountain mint, and wild bergamot had the quickest establishment of the species planted in spring and reached 71%, 51%, and 64% cover at 4 MAS, respectively (Table 3). Ground cover measured ~50% after 12 MAS for these species and plant counts ranged 56 to 78 plants m^{-2}. Lanceleaf coreopsis had 18% cover at 4 MAS and increased to 29% ground cover and 32 plants m^{-2} by 12 MAS. The only other forb present at 12 MAS was tall coreopsis. This species had 8% cover and 4 plants m^{-2} at the final evaluation. Partridge pea and swamp milkweed emerged with 16% and 23% cover at 4 MAS, respectively, but neither species was found at 12 MAS. At 4 MAS, indiangrass, little bluestem, and switchgrass had >10% cover and were the only three grasses present throughout the experiment. Indiangrass had the best establishment of the grasses at 4 MAS with 30% cover but decreased to 14% at 12 MAS. All other species not mentioned were unable to establish >2% cover at 4 or 12 MAS.

Newnan Site. In the fall seeding, the only forbs to establish by 4 MAS were blackeyed Susan and wild bergamot (Table 3). Both species had comparable establishment at this time averaging 14% cover. By 8 MAS, lanceleaf coreopsis and mountain mint averaged 11% cover and 19 plants m^{-2}. Mountain mint was slow to establish in the fall compared to the spring. The only grass that established in the fall seeding was Virginia wild rye at 4

MAS but cover only reached 2% and the species did not persist. All other species planted in fall did not reach greater than 2% cover.

In the spring, mountain mint had the best establishment of any forb species at 4 MAS with 60% cover and 131 plants m^{-2} (Table 3). By 12 MAS, mountain mint had 53% cover and 88 plants m^{-2}. Blackeyed Susan followed a similar trend in reduction of cover by the end of the study, with cover declining from 50% cover to 38% at 12 MAS. Wild bergamot cover measured 24% at 4 MAS but declined to 19% cover and 17 plants m^{-2} by 12 MAS. Lanceleaf coreopsis establishment increased from 18% to 29% cover from 4 to 12 MAS. Tall coreopsis performed poorly throughout the study, with 10% cover and 5 plants m^{-2} at 4 MAS and 11% cover and 4 plants m^{-2} at 12 MAS. Partridge pea, swamp milkweed, deertongue, switchgrass, and sneezeweed established from 4 to 8 MAS but these species were not detected in plots after 12 months.

Table 3. Plant cover and count from 29 species established in two experiments, 2012-2014, in Commerce and Newnan, GA.

		Commerce (MAS)[a]						**Newnan (MAS)**					
		Cover			**Plants/m^2**			**Cover**			**Plants/m^2**		
Establishment	Species	4	8	12	4	8	12	4	8	12	4	8	12
Fall	Blackeyed Susan	0	14	63	0	18	42	16	36	.	17	78	.
	Bottlebrush Grass	0	1	0	0	<1	0	0	0	.	0	0	.
	Butterfly Weed	0	0	1	0	0	<1	0	0	.	0	0	.
	Deertongue	0	0	5	0	0	5	0	0	.	0	0	.
	Eastern Gamagrass	1	0	0	<1	0	0	0	0	.	0	0	.
	Indiangrass	0	0	20	0	0	4	0	0	.	0	0	.
	Lanceleaf Coreopsis	0	12	31	0	5	32	0	14	.	0	20	.
	Little Bluestem	0	0	0	0	0	0	0	0	.	0	0	.
	Mountain Mint	0	0	14	0	0	13	0	8	.	0	17	.
	Partridge Pea	0	0	10	0	0	1	0	2	.	0	1	.
	Purple Top	0	0	20	0	0	7	0	0	.	0	0	.
	Rice Cut Grass	4	0	0	1	0	0	0	0	.	0	0	.
	River Oats	0	0	0	0	0	0	0	0	.	0	0	.
	Sneezeweed	0	0	0	0	0	0	0	0	.	0	0	.

	Swamp Milkweed	0	0	8	0	0	2	0	0	.	0	0	.
	Switchgrass	0	0	0	0	0	0	0	0	.	0	0	.
	Tall Coreopsis	0	0	9	0	0	7	0	0	.	0	0	.
	Virginia Wild Rye	0	0	0	0	0	0	2	0	.	1	0	.
	Wild Bergamot	7	0	23	18	0	18	12	34	.	14	70	.
Spring	Blackeyed Susan	71	.	50	87	.	56	50	.	38	60	.	32
	Bottlebrush Grass	0	.	0	0	.	0	0	.	0	0	.	0
	Butterfly Weed	0	.	0	0	.	0	0	.	0	0	.	0
	Deertongue	0	.	0	0	.	0	14	.	0	6	.	0
	Eastern Gamagrass	0	.	0	0	.	0	0	.	0	0	.	0
	Indiangrass	30	.	14	19	.	12	0	.	0	0	.	0
	Lanceleaf Coreopsis	18	.	29	11	.	32	18	.	29	10	.	20
	Little Bluestem	11	.	0	1	.	0	0	.	0	0	.	0
	Mountain Mint	51	.	53	75	.	78	60	.	53	131	.	88
	Partridge Pea	16	.	0	2	.	0	14	.	0	1	.	0
	Purple Top	0	.	0	0	.	0	0	.	0	0	.	0

	Rice Cut Grass	0	.	0	0	.	0	0	.	0	0	.	0
	River Oats	0	.	0	0	.	0	0	.	0	0	.	0
	Sneezeweed	2	.	0	1	.	0	28	.	0	29	.	0
	Swamp Milkweed	23	.	0	5	.	0	29	.	0	17	.	0
	Switchgrass	11	.	0	5	.	0	9	.	0	5	.	0
	Tall Coreopsis	0	.	8	0	.	4	10	.	11	5	.	4
	Virginia Wild Rye	0	.	0	0	.	0	0	.	0	0	.	0
	Wild Bergamot	64	.	49	87	.	67	24	.	19	52	.	17
	Season	*	n/a	NS	*	n/a	*	*	n/a	n/a	*	n/a	n/a
	Species	*	*	*	*	*	*	*	*	*	*	*	*
	Season*Species	*	n/a	*	*	n/a	*	*	n/a	n/a	*	n/a	n/a

[a]MAS = months after seeding.

[b]Species that did not establish on any date included boneset, Canada wild rye, fringed loosestrife, frost aster, goldenrod, ironweed, Joe Pye weed, swamp sunflower, white snakeroot, and woolgrass.

= significant; NS = not significant; n/a = analysis not applicable.

Griffin Site. The species that established and maintained cover in the fall seeding were mountain mint, lanceleaf coreopsis, black-eyed Susan, and wild bergamot (Table 4). No species were identified until 12 months after seeding (MAS) at either rate. All species that established by 12 MAS had higher percent cover and plant counts at the 11 kg ha^{-1} rate than at the 100 seeds m^{-2} rate. Lanceleaf coreopsis showed better final establishment at the 11 kg ha^{-1} rate, having 84% cover and 47 plants m^{-2}, while only 39% cover and 20 plants m^{-2} was reached at the 100 seeds m^{-2} rate. Blackeyed Susan reached 35% cover and 17 plants m^{-2} at the 11 kg ha^{-1} rate, but only 18% cover and 6 plants m^{-2} was observed at the 100 seeds m^{-2} rate. Wild bergamot had 59% cover and 43 plants m^{-2} at the 11 kg ha^{-1} rate, and 28% cover and 23 plants m^{-2} at the 100 seeds m^{-2} rate. Mountain mint was the only species to not establish by 12 MAS at the 100 seeds m^{-2} rate, and at the 11 kg ha^{-1} rate had the poorest establishment of all species observed at 11% cover and 8 plants m^{-2}. The spring seeding had very poor establishment due to intensive weed pressure. Wild bergamot was the only species to emerge and reached 29% cover and 23 plants m^{-2} at 12 MAS at the 11 kg ha^{-1} rate. No species, including wild bergamot, established at the 100 seeds m^{-2} rate.

Table 4. Plant cover and count from 29 species established in two experiments, 2012-2014, in Griffin, GA.

			Griffin (MAS)[a]					
			Cover			Plants/m2		
Rate	Seeding Time	Species	4	8	12	4	8	12
11 kg ha^{-1}	Fall	Blackeyed Susan	0	0	35	0	0	17
		Lanceleaf Coreopsis	0	0	84	0	0	47
		Mountain Mint	0	0	11	0	0	8
		Wild Bergamot	0	0	59	0	0	43
	Spring	Blackeyed Susan	0	.	0	0	.	0
		Lanceleaf Coreopsis	0	.	0	0	.	0
		Mountain Mint	0	.	0	0	.	0
		Wild Bergamot	0	.	29	0	.	23
100 seed m^{-2}	Fall	Blackeyed Susan	0	0	18	0	0	6
		Lanceleaf Coreopsis	0	0	39	0	0	20
		Mountain Mint	0	0	0	0	0	0
		Wild Bergamot	0	0	28	0	0	17
	Spring	Blackeyed Susan	0	.	0	0	.	0
		Lanceleaf Coreopsis	0	.	0	0	.	0
		Mountain Mint	0	.	0	0	.	0
		Wild Bergamot	0	.	0	0	.	0
		Rate	n/a	n/a	*	n/a	n/a	*
		Season	n/a	n/a	*	n/a	n/a	*
		Species	n/a	n/a	*	n/a	n/a	*
		Season*Species	n/a	n/a	*	n/a	n/a	*
		Season*Rate	n/a	n/a	*	n/a	n/a	NS
		Species*Rate	n/a	n/a	*	n/a	n/a	*
		Season*Species*Rate	n/a	n/a	*	n/a	n/a	NS

[a]MAS = months after seeding.

(Table 4 continued)

[b]Species that did not establish on any date included boneset, bottlebrush grass, butterfly weed, Canada wild rye, deertongue, Eastern gamagrass, fringed loosestrife, frost aster, goldenrod, indiangrass, ironweed, Joe Pye weed, little bluestem, partridge pea, purple top, rice cut grass, river oats, sneezeweed, swamp milkweed, swamp sunflower, switchgrass, tall coreopsis, Virginia wild rye, white snakeroot, and woolgrass.

* = significant; NS = not significant; n/a = analysis not applicable.

Macon Site. Lanceleaf coreopsis had the greatest establishment of any species planted in the fall. It reached 65% cover and 32 plants m^{-2} at 12 MAS (Table 5). Blackeyed Susan established more quickly than lanceleaf coreopsis and increased from 6 to 42% cover from 4 to 8 MAS (Figure 2). Mountain mint was very slow to emerge but had 49% cover and 33 plants m^{-2} at 12 MAS. Wild bergamot also had slow establishment in the fall but reached 54% cover and 24 plants m^{-2} at 12 MAS. Tall coreopsis was the only other forb with >10% cover at any date, with 12% cover and 3 plants m^{-2} at 12 MAS. Other plants that established but had low ground cover (<10%) included sneezeweed, river oats, white snakeroot, and Virginia wild rye.

In the spring experiment, no forbs were observed at 12 MAS (Table 5). At 4 MAS, butterflyweed and swamp milkweed averaged 32% ground cover. Partridge pea was the only other forb observed to establish in spring but only reached 6% cover at 4 MAS. Indiangrass had the fastest establishment with 54% cover at 4 MAS. However, indiangrass cover declined to 34% cover and 8 plants m^{-2} by 12 MAS. Switchgrass had the best establishment of any grass with 39% cover and 27 plants m^{-2} at 12 MAS. Deertongue and little bluestem averaged 18% cover and 5 plants m^{-2} at 12 MAS.

Tifton Site. In the fall study, lanceleaf coreopsis had the best final establishment at 12 MAS with 94% cover and 63 plants m^{-2} (Table 5). Establishment with lanceleaf coreopsis was slow, with only 5% cover at 4 MAS and 35% at 8 MAS. Blackeyed Susan had the quickest establishment with 31% cover at 4 MAS and reached 56% cover after 12 MAS and 22 plants m^{-2}. Wild bergamot showed poor establishment and only reached 29% cover at 12 MAS. Similarly, mountain mint had slow establishment but reached 10% cover at 12 MAS. No grasses were observed to have established in the fall study. All other species did not establish >1% cover.

Although establishment was observed from spring plantings, no species were present at 12 MAS due to heavy weed pressure (Figure 3). Butterfly weed had the best establishment of any forb at 4 MAS with 29% cover and 12 plants m^{-2}. Partridge pea had a comparable ground cover of 20%, with only 2 plants m^{-2}. The only other forb observed throughout the experiment was swamp milkweed that established 6% cover. Indiangrass had the quickest establishment of the grasses, with 60% cover and 44 plants m^{-2}. Switchgrass established 41% cover with 10 plants m^{-2}. Purple top was the only other grass species with >10% cover at 4 MAS, establishing 16% cover and 8 plants m^{-2}. Little bluestem had very poor establishment with only 5% cover and 1 plant m^{-2}. All other species did not establish >1% cover.

Table 5. Plant cover and count from 29 species established in two experiments, 2012-2014, in Macon and Tifton, GA.

		Macon (MAS)[a]						Tifton (MAS)					
		Cover			Plants/m^2			Cover			Plants/m2		
Experiment	Species	4	8	12	4	8	12	4	8	12	4	8	12
		------ % -----			------ # -----			------ % -----			------ # -----		
Fall	Blackeyed Susan	6	42	51	2	8	25	31	45	56	47	34	22
	Lanceleaf Coreopsis	4	21	65	1	11	32	5	35	94	6	21	63
	Mountain Mint	0	0	49	0	0	33	0	0	10	0	0	5
	River Oats	0	0	7	0	0	4	0	0	0	0	0	0
	Sneezeweed	0	0	7	0	0	1	0	0	1	0	0	0
	Tall Coreopsis	0	0	12	0	0	3	0	0	0	0	0	0
	Virginia Wild Rye	0	5	0	0	2	0	0	0	0	0	0	0
	White Snakeroot	0	0	6	0	0	1	0	0	0	0	0	0
	Wild Bergamot	0	6	54	0	12	24	0	4	29	0	7	18
		*	*	*	*	*	*	*	*	*	*	*	*
Spring	Butterfly Weed	36		0	18		0	29		0	12		0
	Deertongue	20		16	13		6	1		0	0		0
	Indiangrass	54		34	39		8	60		0	44		0
	Little Bluestem	11		19	6		3	5		0	1		0
	Partridge Pea	6		0	1		0	20		0	2		0
	Purple Top	0		0	0		0	16		0	8		0
	Swamp Milkweed	28		0	5		0	6		0	1		0
	Switchgrass	0		39	0		27	41		0	10		0
		*		*	*		*	*		n/a	*		n/a

(Table 5 continued)

[a]MAS = months after seeding.

[b]Species that did not establish on any date in the fall experiments included boneset, bottlebrush grass, Canada wild rye, fringed loosestrife, frost aster, goldenrod, Joe Pye weed, and woolgrass. Species that did not establish on any date in the spring experiments included Eastern gamagrass, ironweed, rice cut grass and swamp sunflower.

* = significant; NS = not significant; n/a = analysis not applicable.

CONCLUSIONS AND RECOMMENDATIONS

Blackeyed Susan, swamp milkweed and indiangrass had the quickest establishment across the majority of sites. Blackeyed Susan had the best establishment of these species in the first 4 MAS. Swamp milkweed was the only other forb species with >20% cover in a majority of the sites (Commerce, Newnan and Macon). This may be indicative of higher soil moisture content at these sites, as the species is known to inhabit wet roadsides. Indiangrass was the quickest grass to establish at Commerce, Macon and Tifton. Blackeyed Susan, lanceleaf coreopsis and wild bergamot are the most promising species observed to persist at least 12 MAS based on the performance observed across all sites. No grass species had >0% cover at a majority of the sites at 12 MAS. Several of the grasses established more successfully at the sites with more acidic soils; both little bluestem and indiangrass had a higher average percent cover at Commerce than at Newnan, and deertongue, indiangrass, and little bluestem all had a higher average percent cover at Macon than at Tifton.

Differences in establishment were observed due to timing of seeding. More of the 29 species tested established by 4 MAS in the spring seedings of Commerce and Newnan than in the fall seedings. At both Commerce and Newnan, more grass species were observed in the spring seeding at 4 MAS than in the fall seeding. Contrary to initial establishment at 4 MAS, more grass species persisted to 12 MAS in Commerce when seeded in the fall compared to the spring. Heavy spring/summer weed pressure could have caused poor grass persistence in spring seedings. Heavy spring weed pressure was noted at Griffin and Tifton sites. Large crabgrass (*Digitaria sanguinalis* (L.) Scop.) and southern crabgrass (*Digitaria ciliaris* (Retz.) Koel.) were grasses that were observed to be

particularly problematic in the plots seeded in the spring across all sites. The most problematic broadleaf weeds were dog fennel (*Eupatorium capillifolium* (Lam.) Small) and mare's tail (*Conyza canadensis* (L.) Cronq.). Overall, spring seeding was more effective for initial establishment. Further research is needed to evaluate the possible benefits from herbicide use. Appropriate postemergence herbicide use could improve native plant establishment by enhancing interspecific competition with weeds, particularly when seeded in the spring.

The vast difference in size of seed of native species warrants further investigation in order to make recommendations for proper seeding rates. Appropriate seeding rates should be species-specific. For instance, seeding lanceleaf coreopsis at 100 seeds m^{-2} is the equivalent of a 2.8 kg ha^{-1} seeding rate, while a rate of 100 seeds m^{-2} for seeding blackeyed Susan is equivalent to only 0.29 kg ha^{-1}. Within each species that established, the differences in cover between both seeding rates suggest there may be a point in which increasing the seeding rate causes too much intraspecific competition. Determining an optimal seeding rate for native grass and forb species may be critical for roadside establishment in Georgia and warrants further investigation. The poor establishment of native species at the Griffin site may be related to irrigation. Griffin was the only site to receive irrigation, and past research has noted significantly increased weed cover and dominance over natives when irrigation is applied to areas being renovated.

Recommendations. The species with most potential to quickly establish on Georgia roadsides are blackeyed Susan, indiangrass, and swamp milkweed. Blackeyed Susan, lanceleaf coreopsis and wild bergamot had the best performance and most consistent results

across the five sites. Determining which species is most appropriate may depend on the speed of ground cover establishment needed. Forb species tended to have more consistent establishment than grasses. The speed of establishment as well as the number of species observed was generally higher when seeded in the spring. Further research is warranted on successful practices in establishing native grass and forb communities on roadsides. In particular, the effect of irrigation practices, seeding rate, mowing, and pre-seeding herbicide treatments for weed control should be investigated to determine the magnitude of their effect of restoring areas with native plants. Consideration of site-specific factors such as soil organic matter and pH may also provide important insight in the success of native species establishment on Georgia roadsides.

Figure 1. Plots in field experiments on the day of seeding in fall at the five locations.

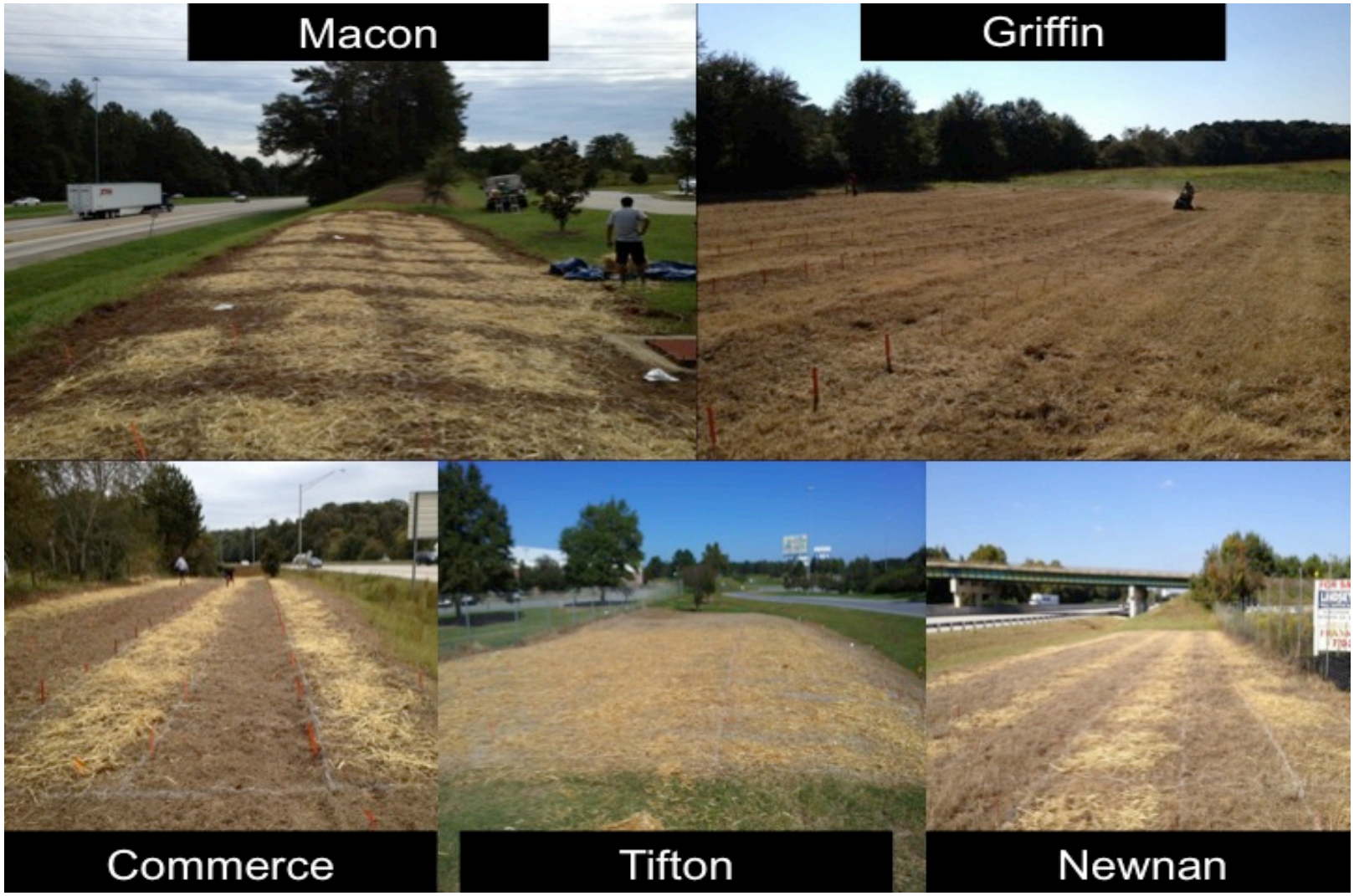

Figure 2. Blackeyed susan establishment in Macon, GA at eight months after the fall seeding.

Figure 3. Wild bergamot establishment at eight months after the spring seeding in Tifton, GA.