EFFECTS OF FERTILIZATION AND DISTURBANCE ON NATIVE SPECIES ESTABLISHMENT ON HIGHWAY CORRIDORS IN WEST VIRGINIA[1]

Christina Venable and Jeff Skousen[2]

Abstract. Introduced and invasive species have been recognized as potential threats to natural plant communities. Many such plant species are introduced along roadways, which then can spread to adjacent fields and forests. The West Virginia Division of Highways is required to develop seeding mixtures comprised of native plants for revegetating highway corridors and thereby reducing the potential for introduction of non-native species along roads. Therefore, the objectives of this project were to identify native plants that are suitable for seeding on highway sites and to document the establishment of these species after seeding on highway cut and fill areas. Phase 1 of the project began in April 2002, when three sites (Baker, Hazelton, and Parkersburg) were seeded with five seed mixes (Control, Native, DOH, DOH-Native, and DOH½-Native) into fertilized and unfertilized plots. Plots were 2m by 2m and each treatment (seed mix and fertilizer) was replicated four times (40 plots per site). Phase 2 of the project began in March 2003 when a native seed mix was sown on three sites (Weston, Buckhannon, and Elkins) into five different surface treatments and two fertilizer rates. After 2 years, Phase 1 results show that fertilizer and seeding mixture have a significant affect on plant growth and ground cover. The fertilized DOH and DOH-Native plots had the highest ground covers while the unfertilized Control and Native plots had the lowest. Unseeded, unfertilized plots generally had more weedy species than other plots. Native species establishment was poor and plots seeded to native species were mostly colonized by non-native and non-seeded species from adjacent areas. Native species were seen minimally by the second year. Phase 2 first year results also show that fertilizer and surface treatment had a significant affect on plant growth and ground cover. Tilled and herbicided plots tended to promote the establishment of native species best. In subsequent years, it is anticipated that the native species will emerge and become a more prominent contributor to the ground cover.

Additional Key Words: fertilization, highway construction, invasive species, revegetation, seed mixtures.

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[2] Christina Venable, Graduate Research Assistant, and Jeff Skousen, Professor of Soils and Reclamation Specialist, Division of Plant and Soil Sciences, West Virginia University, Morgantown, WV 26506.

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Introduction

Due to the mountainous nature of West Virginia, the process of highway construction often involves the blasting and removal of large amounts of geologic material from one area to be used as fill for other areas. These "cut and fill" areas are highly disturbed and easily eroded. Therefore, a fast and effective ground cover is required to control erosion. The current method is to provide a vegetative cover that is fast-growing and easy-to-establish. However, owing to their known ability to control erosion, ease of establishment and cost-effectiveness, nearly all species used for this control are non-native and/or invasive (Skousen and Fortney, 2003). Once established, the non-natives can persist indefinitely and can use vehicular traffic as a vector to expand their range. Thus, the use of these species is of special concern to West Virginia and the environment.

Native species can be defined as, with respect to a particular ecosystem, those plants that historically occurred or currently occur in an ecosystem without having been originally introduced. Invasive species are those non-natives that cause or are likely to cause harm to the economy, environment or human health (Executive Order 13112, 1999). However, this definition for invasives leaves out what is often a key aspect of their behavior: proliferation and spread. To be sure, not all non-natives are invasive, nor are all invasives non-native.

Invasive plants cause an estimated $137 billion a year in environmental damage. Over 40% of the species listed as threatened or endangered under the Endangered Species Act are there primarily because of competition from non-native species (Nature Conservancy, 2003). Former president Bill Clinton signed the Executive Orders on Invasive Species (EO 13112) and Greening the Government through Leadership in Environmental Management (EO 13148) in 1999 and 2000, respectively. These orders were designed to prevent the introduction of invasive species, control their spread, and implement cost-effective, environmentally sound landscaping practices. This is to be done by both using existing programs to limit the introduction and spread of invasives, as well as creating new programs to promote the use of native plant species.

However, the use of native plants on roadsides has two major problems. First, these are highly disturbed and rigorous sites, which tend to inhibit the successful establishment of the competitively disadvantaged natives. Second, the seeds of native plants are often unavailable in large quantities and/or are too expensive to be cost effective for seeding large areas.

Much research has been done on using native plants on roadsides (Ahern et al. 1992, Barton et al. 2002, Corley 1995, Fiedler et al. 1990, Harper 1988, Morrison 1981). Swan et al. (1993) conducted a study in Tennessee and found native species vegetation on roadsides to be viable and economical. The purpose of this research is to identify native plants suitable for seeding along highways, to document the growth and establishment of these species on highway cut and fill sites, and to develop methods to enhance their establishment in roadside environments.

Materials and Methods

Phase 1

West Virginia can be divided into three distinct physiographic provinces: Eastern Ridge and Valley, Allegheny Mountain and Upland, and Western Hill. A research site was chosen in each province. The first site was located along a newly completed section of Appalachian Corridor H near Baker, Hardy County. This is in the Eastern Ridge and Valley province, which is a lowland, above which rises longitudinal ranges. The area has a trellis-type drainage pattern and is dominated by farmland and oak-hickory-pine forests (Strausbaugh and Core, 1977).

The second site is located on I-79 at the West Virginia Welcome Center, near Hazelton, Preston County, in the Allegheny Mountain and Upland province of the state. This area is composed of northeast-southwest oriented mountain ranges, with deep intervening valleys. Drainage is dendritic in nature (Skousen and Fortney, 2003) and the vegetation can be described as belonging to the Northern Evergreen and Hardwood forest types (Strausbaugh and Core, 1977).

The third site is located near the intersection of I-77 and U.S. Route 50 in Parkersburg, Wood County, in the Western Hill province of the state. It is characterized as a mature plateau of strong to moderate relief. The drainage pattern is dendritic and the vegetation is classified as the Central Hardwood forest type (Strausbaugh and Core, 1977).

The study consists of testing five seed mixtures with two fertilizer treatments in a completely randomized design with four replications per treatment combination (40 plots per site). Plots measure 2m by 2m, with a 1-m buffer area between plots. Seeded species and seeding rates within each seed mixture are shown in Table 1 (Skousen and Fortney, 2003).

Table 1. Seeded species and seeding rates (kg/ha) of the four seed mixtures used in Phase 1 of the Native Plant Highway Study in West Virginia (DOH, Native, DOH-Native, and DOH½-Native seed mixtures).

	Seed Mixtures			
Seeded Species	DOH	Native	DOH-Native	DOH½-Native
	----------kg/ha----------			
Tall Fescue (*Festuca arundinacea*)	5		5	2.5
Red Fescue (*F. rubra*)	5		5	2.5
Annual Ryegrass (*Lolium multiflorum*)	1.75		1.75	0.875
Birdsfoot Trefoil (*Lotus corniculatus*)	2.5		2.5	2.5
Indiangrass (*Sorghastrum nutans*)		1.25	1.25	1.25
Big Bluestem (*Andropogon gerardii*)		1.25	1.25	1.25
Early Goldenrod (*Solidago juncea*)		0.5	0.5	0.5
Butterfly weed (*Asclepius tuberosa*)		0.25	0.25	0.25
Brown-eyed Susan (*Rudbeckia triloba*)		0.25	0.25	0.25
Gray Beardtongue (*Penstemon canescens*)		0.25	0.25	0.25
Wild Senna *(Cassia hebecarpa*)		1.25	1.25	1.25

Plots were established in April 2002. The soil was lightly tilled prior to seeding and plot boundaries were established with wooden stakes and twine. Fertilizer and seed was spread by hand on designated plots. The fertilizer used was a 10-20-20 N-P-K fertilizer at a rate of 150 kg/ha. After fertilizing and seeding, straw mulch was spread over the plots at an approximate rate of 1500 kg/ha to obtain about 80% coverage, then covered with a light plastic erosion control blanket to hold the straw in place. Plots were surveyed in June and October 2002 and again in late June and October 2003 for total ground cover and dominant species.

Fall plantings were also established on the Baker and Hazelton sites in October 2002 using the same methods as above to evaluate differences between times of seeding. These sites were also surveyed in late June and October 2003 for total ground cover and dominant species.

Phase 2

Three sites were chosen along U.S. Route 33 in West Virginia. The first site is located near Weston, Lewis County, on the bench of a cut slope, which was constructed about 20 years ago. The second site is located in Barbour County, approximately 10 miles east of Buckhannon, on

the bench of a fill area, constructed about 10 years old. The third site is located east of Elkins, Randolph County, in a fill area and was constructed three years ago.

The study consists of testing five surface treatments and two fertilizer rates in a completely randomized block design with four replications per treatment combination. Plots are 2m by 2m with a 1m buffer zone between plots. Surface treatments were as follows: 1) mow and seed, 2) till and seed, 3) herbicide and seed, 4) control (no treatment) and seed, and 5) control (no treatment) with no seed. Plots were established in April 2003. Once plot boundaries were established with wooden stakes and twine, the designated surface treatments were applied. The herbicide used was Glyphosate in the form of Roundup and was applied two weeks before seeding. This is the recommended length of time for the herbicide to become inactive in the soil and thus not harm or prevent the germination and establishment of the seeded plants. Plots designated to receive fertilizer were hand fertilized at a rate of 300 kg/ha of 10-20-20 N-P-K fertilizer. Plots were hand seeded and seeded species and rates can be found in Table 2.

Plots were surveyed in late June and again in October 2003 for total ground cover, as well as individual species cover. This was done by visually estimating projected cover contributed by the vegetation in four, randomly selected, 0.25m by 0.25m sub-plots. Cover was recorded as a class (Table 3) and the midpoint of the class range was used for averaging across sub-plots (Daubenmire, 1968).

Table 2. Seeded species and seeding rates (kg/ha) used for Phase 2 in the Native Plant Highway Study in West Virginia.

Seeded Species	Rate
	kg/ha
Switchgrass (*Panicum virgatum*)	5
Little Bluestem (*Andropogon scoparius*)	5
Partridge Pea (*Chamaecrista fasciculata*)	5
American Vetch (*Vicea americana*)	2
Ox-Eye Sunflower (*Heliopsis helianthoides*)	2
Brown-eyed Susan (*Rudbeckia triloba*)	2

Table 3. Values used for the estimation of vegetative cover.

Cover Class	Range, %	Midpoint of Cover Class, %
0	0	0.0
1	1-5	2.0
2	5-25	15.0
3	25-50	37.5
4	50-75	62.5
5	75-95	85.0
6	95-100	97.5

Results and Discussion

For first years results of Phase 1, see Skousen and Fortney (2003).

Phase 1 – Second Year Results

Total percent ground cover varied with treatment and sampling time (Table 4, Table 5). It was found that site had a significant effect ($p=0.05$) on total percent ground cover, with Parkersburg having the highest coverages and Baker the lowest. The Parkersburg site also had very similar coverages across all treatments, especially in the October sampling. This is due to Department of Highway crews inadvertently hydro-seeding over the plots in the summer of 2002. The hydro-seeded mixture included fertilizer, lime, and a mixture of annual ryegrass (*Lolium multiflorum* Lam.), tall fescue, and red clover (*Trifolium pratense* L.). With several years of monitoring, more information may be obtained about the ability of the seeded native species to germinate and thrive under the dense cover of the hydro-seeded vegetation at the Parkersburg site. The Baker site, on the other hand, is the newest of the sites and had very little vegetation established prior to seeding, thus resulting in low coverages on Native and Control plots.

Time of planting (i.e. spring or fall) also had an effect on total percent ground cover. Spring plantings had significantly higher coverages than fall plantings (72% and 54%, respectively). However, a portion of this effect may be a result of the fall plantings having one less growing season than their spring counterparts. This effect should disappear within the next year.

Table 4. Total percent ground cover of spring plantings with and without fertilizer and seeded with various seeding mixtures in June and October 2003.

Treatment	Hazelton		Parkersburg		Baker	
	Jun-03	Oct-03	Jun-03	Oct-03	Jun-03	Oct-03
Fertilized †	----------%----------					
DOH	72	80	79	98	83	88
DOH-1/2Native	46	68	73	95	87	87
DOH-Native	77	88	75	95	81	86
Native	57	78	86	97	17	43
Control	50	78	70	97	24	40
Unfertilized						
DOH	69	83	68	93	76	85
DOH-1/2Native	54	75	79	96	58	74
DOH-Native	77	84	79	98	80	91
Native	43	64	82	98	19	43
Control	47	71	73	98	21	44

† Plots fertilized with 150 kg/ha 10-20-20 fertilizer.

Table 5. Total percent ground cover of fall plantings with and without fertilizer and seeded with various seeding mixtures in June and October 2003.

Treatment	Hazelton		Baker	
	Jun-03	Oct-03	Jun-03	Oct-03
Fertilized †	----------%----------			
DOH	68	91	14	75
DOH-1/2Native	57	83	16	62
DOH-Native	52	90	28	67
Native	49	90	19	61
Control	59	91	26	65
Unfertilized				
DOH	32	83	11	62
DOH-1/2Native	60	88	10	47
DOH-Native	47	78	29	64
Native	55	82	27	60
Control	52	84	6	38

† Plots fertilized with 150 kg/ha 10-20-20 fertilizer.

Across all sites, fertilized plots had significantly higher total ground cover percentages than unfertilized plots, although within sites, they did not. There were also significant effects among treatments. The DOH and DOH-Native plots had the highest ground coverages, while the Control and Native plots had the lowest. There was no significant difference between the unseeded Control plots and the Native plots.

As expected, all plots had significantly higher total percent ground cover for the October sampling compared to the June sampling.

The percent ground cover contributed by the seeded natives was minimal at all sites (Table 6, Table 7). The Native and unfertilized plots showed the highest seeded native coverages. While not statistically significant and all under one percent, the Parkersburg site had the highest seeded native coverages and Hazelton had the lowest. The Hazelton site had been hydro-seeded prior to plot establishment, resulting in a large seed bank remaining in the soil. The tilling used in plot establishment may have brought much of that seed to the surface for germination and as a result inhibited the successful establishment of the seeded natives. While the Parkersburg site was hydro-seeded over, a portion was inadequately hydro-seeded, as evidenced by the plots in that portion having lower ground cover estimates overall, as well as containing fewer of the hydro-seeded species. It was in this portion that the seeded natives were observed. While not many individual plants were seen, those present were larger than those observed at the Baker site. The Baker site is a newer and harsher site that had not been previously seeded and therefore has a smaller seed bank from which to regenerate. It is highly compacted and contains 40% rock fragments (compared to 10% for Parkersburg and 25% for Hazelton). More individual seeded natives were observed at this site when compared to the other sites. However, probably as a result of compaction, their size was small so they did not contribute much ground cover.

Phase 2

Ground cover was generally highest on Control, Seed and Mow treatments across all sites (Table 8). Total percent ground cover was significantly increased in the October evaluation when compared to the June evaluation. While Site had no significant influence on ground cover, the Elkins site had the lowest total percent cover and Weston, the highest. Across sites and within sites, fertilizer significantly increased the total ground cover, with the most noticeable difference being at the Elkins site which had an overall average of 62 % for the fertilized plots

Table 6. Percent ground cover contributed by the native seeded species in spring plantings with and without fertilizer and seeded with various seeding mixtures in June and October 2003.

Treatment	Hazelton		Parkersburg		Baker	
	Jun-03	Oct-03	Jun-03	Oct-03	Jun-03	Oct-03
Fertilized †	----------%----------					
DOH	0	0	0	<1	0	0
DOH-1/2Native	0	0	0	0	0	0
DOH-Native	<1	0	0	0	0	0
Native	0	0	<1	0	<1	<1
Control	0	0	0	0	0	0
Unfertilized						
DOH	0	0	0	0	0	0
DOH-1/2Native	0	0	0	0	0	0
DOH-Native	0	0	<1	<1	0	0
Native	<1	0	<1	<1	<1	<1
Control	0	0	<1	0	<1	0

† Plots fertilized with 150 kg/ha 10-20-20 fertilizer.

Table 7. Total percent ground cover of fall plantings with and without fertilizer and seeded with various seeding mixtures in June and October 2003.

Treatment	Hazelton		Baker	
	Jun-03	Oct-03	Jun-03	Oct-03
Fertilized †	----------%----------			
DOH	0	0	<1	0
DOH-1/2Native	0	0	<1	0
DOH-Native	0	0	0	0
Native	0	0	<1	0
Control	0	0	<1	0
Unfertilized				
DOH	0	0	0	0
DOH-1/2Native	0	0	0	0
DOH-Native	0	0	<1	0
Native	0	0	0	0
Control	0	0	0	0

† Plots fertilized with 150 kg/ha 10-20-20 fertilizer.

Table 8. Percent ground cover of plots with and without fertilizer with various surface treatments as observed in June 2003 and October 2003.

Treatment	Elkins		Weston		Buckhannon	
	Jun-03	Oct-03	Jun-03	Oct-03	Jun-03	Oct-03
Fertilized †	----------%----------					
Control	65	81	90	88	88	87
Seed	74	83	84	88	77	88
Herbicide	29	38	23	58	25	40
Mow	79	82	94	94	79	90
Till	37	56	43	70	28	43
Unfertilized						
Control	47	66	96	98	78	91
Seed	47	60	89	88	79	88
Herbicide	17	38	27	47	20	42
Mow	44	62	88	91	49	74
Till	26	45	56	83	22	36

† Plots fertilized with 300 kg/ha 10-20-20 fertilizer.

and 45% for the unfertilized. This is most likely due to the newness of the site. Even though the site had been seeded previously, very little ground cover had established before this project began. Perhaps, this reflects a nutrient poor soil, unable to adequately support plant life without the addition of fertilizer. Testing is planned to determine the fertility of all sites to verify this hypothesis.

Treatment also had a significant effect on total percent ground cover. The Control, Mow, and Seed plots had the highest coverages, while the Herbicide and Till plots had the lowest. This is to be expected, as the herbicide used, Glyphosate, is a non-selective, foliar applied, symplastically translocated herbicide. Therefore, all vegetation within the herbicided plots was destroyed. Tilling also destroyed most of the plants located within the plots. Plants subsequently found in these plots were either from seeds in the soil seed bank, wind deposited seeds, or those seeded for this study.

Percent ground cover contributed by the native seeded species was once again minimal at all sites (Table 9). Fertilizer had no significant effect on the seeded natives, however, treatment did have a significant effect. While having the lowest total percent ground cover averages, the Till and Herbicide plots had the highest ground cover averages as contributed by the seeded natives.

These plots had the competing vegetation removed, allowing the seeded natives to germinate and become established before other species invaded.

Table 9. Percent ground cover contributed by native seeded species plots with and without fertilizer with various surface treatments as observed in June 2003 and October 2003.

Treatment	Elkins		Weston		Buckhannon	
	Jun-03	Oct-03	Jun-03	Oct-03	Jun-03	Oct-03
Fertilized †	----------%----------					
Control	<1	0	0	0	0	<1
Seed	<1	<1	0	0	<1	1
Herbicide	1	2	1	2	<1	<1
Mow	<1	<1	0	0	<1	<1
Till	2	3	1	1	<1	1
Unfertilized						
Control	<1	<1	0	0	0	<1
Seed	1	<1	<1	<1	<1	<1
Herbicide	1	3	<1	1	<1	1
Mow	2	1	0	0	<1	1
Till	2	3	1	1	<1	2

† Plots fertilized with 300 kg/ha 10-20-20 fertilizer.

While Site did not have a significant effect on cover contributed by the seeded natives, it can be noted that the Elkins site had the most seeded native cover. This site had much less ground cover prior to plot establishment compared to Buckhannon and Weston, and the seeded natives were better able to become established with a lack of competing vegetation.

Conclusion

While still early, the data seems to show that natives cannot be seeded into established stands and be expected to become an important contributor of ground cover during the first two years after seeding. Instead, some action must be taken to remove the competing vegetation to allow the slow growing natives to become established or simply allow time for these native species to establish and contribute cover. This slow growing nature may indicate the need for a temporary ground cover, such as an annual grass, for site stabilization until the natives have a chance to

become established and expand their coverage. While increasing ground cover overall, fertilizer has not had an effect on the ground cover contributed by the seeded natives. In fact, the opposite may be true; therefore, to encourage the native species, no fertilizer should be applied. It is expected that over the next couple of years the seeded natives will emerge and become a more prominent contributor to the ground cover.

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Literature Cited

Ahern, J., C. Niedner, and A. Barker. 1992. Roadside wildflower meadows: summary of benefits and guidelines to successful establishment and management. Transportation Research Record 1334: 46-53.

Barton, S., G. Schwetz, and R. Darke. 2002. Enhancing Delaware highways: a roadside vegetation management study. Land and Water May/June 2002: 26-30.

Executive Order 13112: Invasive Species. 1999. Federal Register. Vol. 64, No. 25, Presidential Documents. Signed by W. J. Clinton. Washington, DC.

Executive Order 13148: Greening the Government Through Leadership in Environmental Management. Federal Register. Vol. 65, No. 81, Presidential Documents. Signed by W. J. Clinton. Washington, DC.

Corley, W.L. 1995. Enhancement of native wildflowers for roadside beautification. Georgia Department of Transportation Report No. FHWA-GA-95-9206. University of Georgia, Athens, GA.

Daubenmire, R. 1968. Plant Communities: A Textbook of Plant Synecology. Harper and Row, New York, NY.

Fiedler, R. R., Schaefer, M. J., and Jaskaniec, M.E. 1990. Roadside Vegetation Management Policy. Division of Highways and Transportation Services, Madison, WI.

Harper, B.L. 1988. Return of the natives to Minnesota roadsides. In: 67th Annual Meeting of the Transporation Research Board, Paper No. 870410, January 11-14, 1988, Washington, DC.

Morrison, D.G. 1981. Use of prairie vegetation on disturbed sites. Transportation Research Record 822:10-17.

Nature Conservancy. 2003. Invasive Species Initiative. 19 Dec 2003.<http://nature.org/initiatives/invasivespecies/index.html>.

Skousen, J., and Fortney, R. 2003. Native Species Establishment on Highway Corridors in West Virginia. *In*: 2003 National Meeting of the American Society of Mining and Reclaimation, Billings, MT, June 3-6, 2003. ASMR., Lexington, KY.

Strausbaugh, P.D., and E.L. Core. 1977. Flora of West Virginia. Seneca Books, Inc., Grantsville, WV.

Swan, C., Cripps, R., Coorts, and B. Byler. 1993. Landscaping with native plants and wildflowers on Tennessee Interstates. Tennessee Department of Transportation Report TN-RES1004, June 1993, Nashville, TN.