INITIAL RESULTS OF NATIVE SPECIES ESTABLISHMENT ON HIGHWAY CORRIDORS IN WEST VIRGINIA[1]

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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 to reduce the potential for introducing non-native species along roads. Therefore, the objective of this project was to identify native plants that are suitable for seeding on highway sites, and to document survival and growth of these species after seeding on highway cut and fill areas. Three sites (Baker, Hazelton, and Parkersburg) in West Virginia were chosen as demonstration sites and seeded in April 2002. At each site, five seed mixes (Control, Native, DOH, DOH-Native, and DOH½-Native) were seeded 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). First year results show that fertilized plots showed a trend for promoting higher ground cover compared to unfertilized plots. 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 species from adjacent areas. Regardless of seed mixture, most plots contained birdsfoot trefoil (*Lotus corniculatus* L.) and annual ryegrass (*Lolium multiflorum* Lam.) as dominant plants. Due to their slow-establishing nature, native species were not seen during the first year. In subsequent years, it is anticipated that the native species will emerge and become a more prominent contributor to the ground cover. It is also anticipated that plots with a combination of less-aggressive introduced species with low fertilizer rates will allow opportunities for the later-establishing native plants to develop and grow.

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

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Introduction

Four-lane highway construction began in the 1960's in West Virginia, and continues to the present day. Due to the mountainous nature of the state, construction of these highways requires large cut and fill areas in order to maintain moderate road grades, which in turn disturbs large volumes of rock material. In our state, much of the rock strata disturbed for highway construction contains potentially acid-producing materials associated with coal seams, while other sections contain strata that are neutral or alkaline-producing (Jones et al., 2003, this volume). During early construction periods (before 1995), little geologic information was collected on potential disturbed sites and hence there was little effort to determine the effect of the disturbance of these geologic materials on soil and water quality. Therefore, some of the stretches of roads that intersect acid-producing rock layers produce acid drainage, which then flows into nearby streams.

These acid-producing strata, when exposed and left on the surface, also produce acid soils, which often remain barren of vegetation for years. Such sites are eyesores and open to erosion (Orndorff et al., 2002). The few plants inhabiting these more acid highway sites are often native species common to abandoned farmlands and nearby abandoned surface mines. Other disturbed highway sites, being comprised of primarily rocks with suitable properties for vegetation establishment and growth, are completely vegetated and covered with a mixture of seeded non-native species, and some native plants.

Surface mining disturbances for sand and gravel, metal, and coal are generally thought to be the major land disturbance activities in the United States. Land disturbances associated with highway construction and other urban surface disturbances may be equal to or surpass those associated with surface mining in some areas. In West Virginia with its large coal deposits and extensive mining over the past 150 years, coal mining is still the most significant disturbance to the land surface. For instance, the West Virginia Division of Highways estimates (using mileage figures and assuming average widths from specific types of roads) that about 95,000 ha (230,000 ac) of land have been disturbed by roads and highways in the state (1.5% of total land area in West Virginia), whereas about 500,000 ha (1.2 million ac) have been disturbed by surface mining (7.1% of total land area).

Geologic materials disturbed for highways are quite similar to those disturbed for coal mining, except that highway disturbances tend to follow topographic features (to reduce rapid elevation changes in road grade) rather than geologic features in surface mining (i.e., coal seam outcrops). Furthermore, disturbances for highways tend to be linear and narrow, while disturbances for coal mining are broader and cover circular or square land areas. Nevertheless, the blasted geologic materials used for filling low areas for a highway are very similar to the blasted geologic materials used for backfilling on surface mines. The process of blasting, moving, placing, compacting, and revegetating unweathered geologic materials disturbed by either highway construction or surface mining are nearly the same.

An important component of highway construction is effective sediment and erosion control. Erosion control is facilitated through seeding of quick-growing, temporary vegetation or through seeding of permanent (perennial) vegetation. Nearly all plants currently used for both temporary and permanent stabilization in West Virginia and most other states in the eastern U.S. are non-native species (USDA, 1993), because they are effective in stabilizing disturbed sites, are readily accessible and easy to purchase in large quantities, and are known to have excellent germination and establishment characteristics. The typical species used for highway seeding and revegetation in West Virginia (West Virginia Division of Highways, 2000) are tall fescue (*Festuca arundinaceum* (Schreb.)), red fescue (*Festuca rubra* L.), annual ryegrass (*Lolium multiflorum* Lam.) weeping lovegrass (*Eragrostis curvula* (Schrad.) Nees), birdsfoot trefoil (*Lotus corniculatus* L.), and crownvetch (*Coronilla varia* L.). These species, when fertilized, establish quickly and form an almost complete ground cover that makes the invasion of native species nearly impossible.

In many situations, native species could be used, especially where the goal is permanent stabilization with little maintenance and where the substrate material (seedbed and soil) is of good quality. However, native seeds are generally less available in large quantities and are expensive to purchase compared to the non-native species. They also tend not to be suited for primary sites composed of fresh geologic materials. Further, native species are often unsuitable for conventional seeding techniques, such as hydroseeding, because the seeds are fluffy and do not distribute well in a hydroseeding tank.

Several states have evaluated the use of native plants in landscaping roadsides. Byler et al. (1993) concluded that it was both economically and environmentally feasible to use native plants and wildflowers in landscaping roadsides in Tennessee. Corley and Smith (1991) and Corley (1995) tested 32 wildflower species in direct seeding mixes and concluded that 27 performed satisfactorily. However, they noted that few of the tested species were available through wholesale seed sources and therefore would be difficult to secure enough seed to plant large areas. Most other states have tested native species for roadside plantings and evaluated their potential for large-scale seeding of highways including Delaware (Barton et al., 2002), Idaho (Rinard, 1986), Massachusetts (Ahern et al., 1992), Minnesota (Harper, 1988), Texas (Schutt and Teal, 1994), and Wisconsin (Morrison, 1981).

One problem with highway roadsides is that they are disturbed and open to invasion by aggressive non-native plants (invasive plants). These invasive plants are sometimes noxious weeds and once established can persist for decades. Pimentel et al. (2000) estimate invasive plants cause environmental damage adding up to more than $138 billion per year, and they report that 400 of 958 species listed as threatened or endangered are at risk primarily because of competition from non-native species. Therefore, the seeding of native, slow-growing species on new sites provides an opportunity for the colonization of the site by faster-growing invasive plants. The highway network also can serve as an effective carrier or vector for seeds of these unwanted plants thereby expanding their range. Many sites in West Virginia are inhabited by these invasive species, and are the most prevalent plant species in some areas. With the signing of the Executive Orders on Invasive Species (EO 13112) and Greening the Government through Leadership in Environmental Management (EO 13148) by former President Clinton in 1999 and 2000, respectively, there is a mandate to address problems associated with roadside vegetation and reclaimed mine lands (Boyce, 2002). The mandate requires limiting the spread of invasive species and promoting the establishment of native species.

The objective of this research was to compare the establishment and growth of seed mixtures with native species to seed mixtures (commonly used by WVDOH) containing non-native species at three distinct locations in West Virginia. We also used mixtures that combined native and non-native species in one seed mix. This paper presents first year establishment data for species seeded along highways.

Materials and Methods

Three sites with distinct geology in West Virginia were selected for this native plant highway seeding study. The first site was located near Baker, Hardy County, in the Eastern Panhandle of West Virginia, which is dominated by the Ridge and Valley topographic province. As the name suggests, the area is a series of lowlands above which rise longitudinal ranges, drained by a series of parallel streams (trellis type). Surface geology is primarily shales and limestones of the Mississippian and Devonian Eras. The area is dominated by farmland along broad valley bottoms with fertile and deep soils, and by the oak-hickory-pine (*Quercus-Carya-Pinus*) vegetation type on the mountain slopes adjacent to the valleys (Strausbaugh and Core, 1977).

The second site is located near Hazelton, Preston County, in the Allegheny Mountain and Upland province of West Virginia. This area is composed of mountain ranges oriented in a northeast-southwest direction, with deep valleys intervening, and drainage in a dendritic pattern. Surface geology is from the Pennsylvanian System with layers of sandstone, shale, and coal. Soils are relatively thin along mountain ridges and edges, and thicker in valleys. The vegetation is primarily composed of the Northern Hardwood forest type (Strausbaugh and Core, 1977), with dominant species including maple (*Acer* spp.), beech (*Fagus* spp.), birch (*Betula* spp.), ash (*Fraxinus* spp.), cherry (*Prunus* spp.), and oak (*Quercus* spp.).

The third site is located in Parkersburg, Wood County, in the Western Hill province of West Virginia. This province is characterized as a mature plateau of strong to moderate relief in a random orientation, with a dendritic drainage pattern, with streams and rivers all flowing to the Ohio River. Surface geology is Permian and upper Pennsylvanian aged rocks, with calcareous shales, sandstones, and siltstones. Vegetation is composed of the Central Hardwood forest type (Strausbaugh and Core, 1977) and is composed of a diversity of mixed mesophytic tree species including oaks, pines, hickories, originally chestnut (*Castanea* spp), basswood (*Tilia* spp), maples, ashes, gums (*Nyssa* spp.), and walnuts (*Juglans* spp.). Soils are moderately deep and moderately fertile. Farms dot the landscape amidst the forest, and are found in the narrow valleys in the mountains and along the floodplains of major streams and rivers.

At each site, a major highway intersects the area and our study sites were situated near constructed four-lane highways. The Baker site is located along a recently completed section of Appalachian Corridor H. The Hazelton site is located on I-79 at the West Virginia Welcome

Center near the state line between West Virginia and Maryland. The Parkersburg (Park) site is located at the intersection of I-77 and U.S. Route 50 where a new by-pass highway (Appalachian Corridor D) is being constructed through Parkersburg. All sites have been recently constructed or disturbed during the past year (2001).

The study consisted 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 measured 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.

All plots were seeded in early April 2002. The surface soil at each site was prepared by light tillage with a disk to slightly roughen the surface the morning before seeding. Plot boundaries (2m by 2m) were established with wooden stakes and baler twine, and fertilizer was spread by hand on those plots designated to receive fertilizer. The fertilizer rate was the equivalent of 600 kg/ha of 10-20-20 (60 kg/ha N, 120 kg/ha P_20_5, and 120 kg/ha K_20) or roughly 68 grams per plot as required by WVDOH standards. Seeds of each mixture at the appropriate rate were also spread by hand on each plot. After fertilizing and seeding, straw mulch was spread on the surface at a rate of about 1500 kg/ha to represent about 80% coverage. A plastic mesh fabric was then placed over the straw to hold the material in place and stapled down.

About three months after planting (June), all plots were measured for % ground cover, and the prominent species were identified. Later in October, the same sampling procedure was used to determine % ground cover, and the major plant species within each plot were again determined.

Soil samples were extracted from the surface 10 cm at each site from three points at the edge of the plots. Analyses were conducted to determine rock fragment content, texture, soil pH, lime requirement, and nutrient contents (P, K, Ca, Mg, and Na). Further analyses are being conducted.

Results and Discussion

June Evaluation

Percent ground cover was similar for all treatments within a specific site, and distinct differences were found among sites. The average percent ground cover was 28% at Baker, 48% at Hazelton, and 85% at Parkersburg (Table 2), which reflect the soil conditions at each site. The

Parkersburg site showed very high ground cover percentages in all plots because the soil material at the surface was a good topsoil material that had been saved and replaced after construction. No significant differences were found between fertilizer treatments or among seed mixes at Parkersburg for the June sampling time. When comparing treatment interactions, there were slight differences with both the unfertilized control and native plots showing the lowest ground cover.

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

	MIXTURES AND RATES			
Seeded Species	**DOH**	**Native**	**DOH-Native**	**DOH½-Native**
	------------------------------------ kg/ha --			
Tall Fescue	20		20	10
Red Fescue	20		20	10
Annual Ryegrass	7		7	3.5
Birdsfoot Trefoil	10		10	10
Indiangrass		5	5	5
Big Bluestem		5	5	5
Early Goldenrod		2	2	2
Butterfly Weed		1	1	1
Blackeyed Susan		1	1	1
Penstamen		1	1	1
Partridge Pea		5	5	5
Total	57	20	77	53.5

Similar treatment results were found at the Hazelton site in June, although the ground cover percentages were generally lower than those at Parkersburg (Table 2). Average ground cover across all sites at Hazelton in June was 48% instead of 85% at Parkersburg, and there were no significant effects of fertilizer treatment or seed mixes. Some of the interactions were significantly different ($p<0.05$). For example, the unfertilized DOH and Native plots were significantly lower than their fertilized counterparts.

Table 2. Percent ground cover of plots with and without fertilizer, and seeded with five different seed mixtures, and treatment combinations. Ground cover was determined in June 2002 (two months after seeding).

Treatments	Baker	Hazelton	Parkersburg
	-------------------------- % ground cover ------------------------- ---		
Fertilizer			
Fertilized	36	53	89
Not Fertilized	20	43	80
Seed Mix			
DOH	41a[1]	41	88
DOH-Native	39a	53	85
DOH1/2-Native	35a	58	90
Native	14b	38	75
Control	10b	45	80
Interactions			
DOH F	55a	48b	93a
DOH NF	28ab	34c	83b
DOH-Native F	46a	66a	90a
DOH-Native NF	31ab	39bc	90a
DOH1/2-Native F	44a	59a	95a
DOH1/2-Native NF	26ab	58a	80b
Native F	17bc	42b	85b
Native NF	11bc	34c	65c
Control F	15bc	39bc	77b
Control NF	6c	52b	82b

[1]Values within main effects (fertilizer, seed mix or interactions) and within columns (sites) with the same letter are not significantly different.

The Baker site was by far the harshest site of the three as evidenced by ground cover percentages. Average percent ground cover in June was only 28% across all plots. Fertilizer treatment did not show a significant effect, although fertilized plots averaged 36% cover, while unfertilized plots averaged 20% cover. There was, however, a significant seed mixture effect ($p<0.05$). The Native and Control plots were significantly lower ($p<0.05$) in ground cover than plots containing the DOH seed mix. The larger seeds of the DOH seeded species were capable of germinating on this site compared to the smaller seeds of the native seed mix. Evidently, the material at the surface of these plots also contained no seed bank, and only the seed that we applied (and some that perhaps had blown onto the site) were available to germinate. The same treatment combination trends we found at Hazelton are also found at Baker with the unfertilized native and control plots showing the lowest ground cover.

<u>October Evaluation</u>

No data were collected during October at Parkersburg because highway construction crews inadvertently hydroseeded over the plots during the latter part of June after the initial ground cover evaluation had been done. The hydroseeding process included spraying fertilizer, lime, and a mixture of annual ryegrass, tall fescue, and red clover (*Trifolium repens* L.) seeds on the area. Subsequently when we revisited the plots in October, the entire area including the plots was completely covered over with the hydroseeded species (Table 3). Even the control plots exhibited the same ground cover and species composition as our seeded plots. Ensuing years of monitoring will allow an evaluation of whether the native species originally seeded before the hydroseeding event will germinate, establish and grow underneath the thick hydroseeded vegetation.

The slight differences in ground cover between fertilized and unfertilized plots at the June evaluation at Hazelton disappeared by the October sampling. Average ground cover for all plots increased to 70% (from 48% in June), and there were no significant differences in ground cover among treatments (fertilizer or seed mix), nor among treatment interactions (the range being from 59 to 76%)(Table 3).

The differences found in June at Baker were maintained in the October monitoring data. Average ground cover remained nearly the same from 28% in June to 30% in October (Table 3). Fertilizer treatment did not significantly affect ground cover, and the seed mix treatments were still significantly different ($p<0.05$) with the native and control mixes being significantly lower than others. Ground cover of treatment combinations showed similar results as in June, with unfertilized Native and Control plots being significantly lower than DOH plots.

<u>Species Composition</u>

While in most cases it was difficult to identify plant species in the seedling stage on our plots, there were some general observations that can be made. At Parkersburg where good soil material was present, most of the plots were dominated by annual ryegrass and birdsfoot trefoil.

In the control plots, other species were dominant, such as purslain (*Portulaca oleracea* L.), clovers (*Trifolium* spp.), plantain (*Plantago* spp.), sorrel (*Oxalis* spp.), and dandelion (*Taraxacum* spp.). As mentioned, the fall evaluation showed that all plots were completely covered by winter wheat (*Triticum aestivum* L.), tall fescue, clovers, and birdsfoot trefoil.

Table 3. Percent ground cover of plots with and without fertilizer, and seeded with five different seed mixtures, and treatment combinations. Ground cover was determined in October 2002 (seven months after seeding).

Treatments	**Baker**	**Hazelton**	**Parkersburg**
	-------------------------- % ground cover ---------------------- ----		
Fertilizer			
Fertilized	34	70	100[2]
Not Fertilized	26	69	"
Seed Mix			
DOH	43a[1]	71	"
DOH-Native	37a	75	"
DOH1/2-Native	33a	75	"
Native	21b	62	"
Control	17b	65	"
Interactions			
DOH F	46a	70	"
DOH NF	40a	71	"
DOH-Native F	40a	76	"
DOH-Native NF	34a	71	"
DOH1/2-Native F	39a	76	"
DOH1/2-Native NF	26ab	75	"
Native F	25ab	65	"
Native NF	17b	59	"
Control F	17b	61	"
Control NF	16b	69	"

[1]Values within main effects (fertilizer, seed mix or interactions) and within columns (sites) with the same letter are not significantly different.

[2]Parkersburg plots were completely covered (100% ground cover) because the contractor hydroseeded the area with a WVDOH mix containing non-native species (Table 1), fertilizer, and mulch.

Hazelton had been seeded before and tillage broke up the ground cover that had already established. So the plants we observed in June were largely the regrowth of plants that had been disturbed during tillage, such as ryegrass, clover, birdsfoot trefoil, timothy (*Phleum pratense* L.), and fescue. During the fall evaluation, these same species were dominant, with the addition of some weeds like ragweed (*Ambrosia* spp.), groundsel (*Senecio* spp.), aster (*Aster* spp.), goldenrod (*Solidago* spp.), which was probably not seeded, dock (*Rumex* spp.), and other species in the Asteraceae family.

At Baker, many more weeds were found on the plots than on other sites. However, ryegrass was still a dominant species on many of the plots since surrounding areas had been seeded with it. Birdsfoot trefoil was also prominent, but there was a very large difference in plant size, with fertilized plots having much larger trefoil plants. Peppergrass (*Lepidium* spp.), groundsel, clovers, purslain, plantain, and several unidentified grasses were found. At the fall evaluation, ryegrass and birdsfoot trefoil were by far the dominant plant species on the site. While similar weeds were found in native and control plants as before, knotweed (*Polygonum* spp.), dock (*Rumex* spp.), lambsquarters (*Chenopodium* spp.), and wild lettuce (*Lactuca* spp.) became more apparent. We also observed some of the seeded pea (*Senna* spp.) coming up in native plots.

<u>Soils</u>

Table 4 contains general characteristics of soil at each of the three sites. Baker had far more rock fragments than the other sites. This site was extremely hard to till (compacted) and rocks were found all over the surface. The pH was also very high at Baker and the soil contained very high amounts of potassium, calcium, and magnesium. But the high rock fragment content made this a very droughty soil and one that plants did not invade quickly. The Hazelton site also had high rock fragment contents, but there was much more soil among the rocks than at Baker, and it was evident that more weathering had occurred in the surface soil. The pH was quite low with corresponding low values for calcium and magnesium. Base saturation was only 29% at Hazelton. We did not apply lime at Hazelton, but lime should have been supplied for better growth of plants. The Parkersburg site, even with the good soil material at the surface, showed low pH, low base saturation, and a high lime requirement. Phosphorus was moderately high, while calcium and magnesium were moderate. It is clear that soil properties greatly affected the vegetation establishment and ground cover amounts at these three sites. More soil analyses are forthcoming for each site.

Future Research

Fall plantings (October 2002) were just completed at the Baker and Hazelton sites. The same seed mixes and fertilizer treatments were applied to plots of the same size with the same number of replications. Site preparation was performed with a garden tiller and mulch was applied after fertilization and seeding as before. By developing spring and fall plantings, we hope to evaluate the establishment, growth, and survival of these plants species during the next several years across these various treatments during different seasons. It also will be interesting to see if native plants are able to establish through the heavy ground cover at Parkersburg in subsequent years. Future seeding trials will include different seeded species and perhaps increases in seeding rates to determine the best practices to establish native plants along roadsides.

Table 4. General characteristics of the surface soils at the three sites.

Parameter	**Baker**	**Hazelton**	**Parkersburg**
% Rock Fragments	40	25	10
Texture	Silt Loam	Sandy Loam	Clay Loam
pH	7.5	4.8	4.9
Phosphorus (mg/kg)	145	125	174
Potassium (mg/kg)	190	550	404
Calcium (mg/kg)	7800	3750	4600
Magnesium (mg/kg)	1680	890	1760
% Base Saturation	48	29	34
Lime Req (Mg/ha)	0	18	17

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