# Reclamation Grading and Seeding Influences on Trees on a Virginia Mine Site after Six Years

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## Introduction:

Soil grading and seeding practices are known to influence forest re-establishment success on Appalachian surface coal mines but much remains to be learned about these influences – especially seeding. The Forestry Reclamation Approach (FRA) specifies soil grading and seeding practices that are intended to aid survival and growth of planted trees and native plant invasion (Burger et al. 2005). Excessive grading is known to compact soil, hindering water infiltration, water movement within the soil, soil-air exchange, and tree root growth. Seeding with fast-growing herbaceous species can hinder planted trees, as fast-growing herbaceous plants compete with young trees for sunlight, soil water, and soil nutrients (Franklin et al. 2012).

## Research Goals:

The research goal is to compare the effects of two land reclamation practices - soil grading and herbaceous seeding - on plant community restoration.

Specific objectives are to determine the effects of soil grading and seeding practices on:

- Indicators of land reclamation success that are evaluated by mine regulatory agencies: woody species density and total groundcover.
- Indicators of plant community restoration success, including both native and non-native plant species recruitment; development of woody cover and biomass comprised of native species; plant community diversity; and planted trees' growth.

## Research Methods:

As a means of learning more about how grading and seeding practices affect plant community development on coal surface mines, an experiment was established on a Virginia surface mine in late 2007 and early 2008. Two grading (conventional smooth grading, vs. loose grading as recommended by the FRA) and three seeding treatments (conventional fast-growing species vs. a tree-compatible seeding mix as recommended by the FRA vs. a "native invasion" seeding of annual ryegrass only; Table 1) were established in all combinations on two experimental sites occupying approximately 12 acres in total. Following application of the grading and seeding treatments, the areas were planted with native trees of 13 species in early 2008 (Table 2).

Two of the treatments being studied were applied operationally during reclamation operations by the mining firm. In late 2005, an area was reclaimed using "smooth grading" and conventional groundcover seeding; this area was planted with native hardwood trees in early 2006. An adjacent area with soils constructed from similar mine spoils was reclaimed the following year using loose grading for soil preparation, followed by seeding with tree-compatible groundcover; and was planted with native hardwood trees in early 2007 (Table 3).

Table 1. Prescribed species and application rates for seeding treatments.

| Seeding Treatment † | Species | Rate (kg $ha^{-1}$) |
|---|---|---|
| Annual Ryegrass | Annual ryegrass (*Lolium multiflorum* Lam.) | 22 |
| Tree Compatible | Annual ryegrass (*Lolium multiflorum* Lam.) | 22 |
| | Perennial ryegrass (*Lolium perenne* L.) | 11 |
| | Timothy (*Phleum pretense* L.) | 6 |
| | Birdsfoot trefoil (*Lotus corniculatus* L.) | 6 |
| | Ladino clover (*Trifolium repens* L.) | 3 |
| | Weeping Lovegrass (*Eragrostis curvula* Schrad.) Nees) | 2 |
| Conventional | Rye grain (*Secale cereale* L.) | 34 |
| | Orchardgrass (*Dactylis glomerata* L.) | 22 |
| | Perennial ryegrass (*Lolium perenne* L.) | 11 |
| | Korean lespedeza (*Kummerowia stipulacea* (Maxim.) Makino ) | 6 |
| | Birdsfoot trefoil (*Lotus corniculatus* L.) | 6 |
| | Ladino clover (*Trifolium repens* L.) | 6 |
| | Redtop (*Agrostis gigantean* Roth) | 3 |
| | Weeping lovegrass (*Eragrostis curvula* Schrad.) Nees) | 2 |

† Soil amendments (22 kg/ha fertilizer N, 68 kg/ha fertilizer P, 18 kg/ha fertilizer K, and 1680 kg/ha wood cellulose fiber mulch) were applied by hydroseeder with the seed for all seeding treatments.

Table 2. Prescribed tree planting rates.

| **Crop Tree Species** | **Prescribed Rate (trees $ha^{-1}$)** |
|---|---|
| White Ash (*Fraxinus americana* L.) | 205 |
| White Oak (*Quercus alba* L.) | 205 |
| Sugar Maple (*Acer saccharum* Marsh.) | 205 |
| Black Cherry (*Prunus serotina* Ehrh.) | 205 |
| Red Oak (*Quercus rubra* L.) | 205 |
| Chestnut Oak (*Quercus prinus* L.) | 205 |
| Black Oak (*Quercus velutina* Lam.) | 205 |
| Yellow-poplar (*Liriodendron tulipifera* L.) | 124 |
| **Other Tree Species, for Wildlife** | |
| Gray Dogwood (*Cornus racemosa* Lam.) | 54 |
| Red Mulberry (*Morus rubra* L.) | 25 |
| Redbud (*Cercis Canadensis* L.) | 54 |
| White Pine (*Pinus strobus* L.) | 91 |
| Shagbark Hickory (*Carya ovata* (Mill.) K. Koch) | 62 |
| **All** | **1,845** |

In 2014, plant community status on the two experimental areas (planted with trees in early 2008) and the two operational areas (planted with trees in early 2006 and 2007) was assessed. In spring 2014, all trees growing within sampling plots established on the experimental areas and the operational areas were tallied by species and measured for height and diameter. In summer, 2014, soil samples were taken from the sampling plots at two depths: at the surface, and about 6 inches below the surface. In late summer, 2014, vegetation sampling plots were established within the tree-sampling plots, and all vegetation growing within each of those plots was identified by species and by groundcover class; and all observed species were classified as either planted or non-planted volunteer; and as either native or non-native (alien).

Table 3. Areas studied and their characteristics.

| Plot Feature | | Block 1 | Block 2 | Block 4 |
|---|---|---|---|---|
| Rock Type | | Mix of weathered and unweathered sandstone | Mix of sandstones and siltstones, mostly unweathered | Hard unweathered sandstone, whitish in color |
| Soil pH (in 2008) | | 5.7 ± 0.3 | 7.4 ± 0.2 | Not measured |
| Plot Origin | | Experimental | Experimental | Operational |
| Treatments Represented: | | | | |
| <u>Grading</u> | <u>Seeding:</u> | | | |
| Loose | Conventional | 2008 | 2008 | |
| Loose | Tree Compatible | 2008 | 2008 | 2007 |
| Loose | Annual Ryegrass | 2008 | 2008 | |
| Smooth | Conventional | 2008 | 2008 | 2006 |
| Smooth | Tree Compatible | 2008 | 2008 | |
| Smooth | Annual Ryegrass | 2008 | 2008 | |

<u>Preliminary Results:</u>

A preliminary analysis of the tree-measurement data was performed in late July, 2014. Tree stocking is the number of living trees present per unit area. The preliminary analysis of the experimental areas indicated that grading treatments had little effect on tree stocking or growth. This result was contrary to expectations. We speculate that this result occurred because the soil had not been compacted by the smooth grading operations that were conducted in the very steep slopes that are present over most of the experimental areas. Although the areas were graded smoothly, they were not tracked in.

Preliminary analysis of the experimental areas revealed that seeding practices had little apparent effect on tree stocking, but tree growth differences were observed among seeding-treatment areas – especially for the high-value timber trees that were planted on the experimental sites (including oaks, tulip poplar, and black cherry). Generally, trees were larger on the annual rye and the tree-compatible seeding areas than on the conventionally seeded areas; but no consistent differences of tree heights were observed between tree-compatible and annual rye seeding.

Overall tree stocking exhibited minimal difference between the two operationally reclaimed areas, although greater crop-tree stocking was observed on the loose-graded area that had been revegetated with tree-compatible groundcover. Most tree species also exhibited greater height in the areas reclaimed using the loose grading and tree-compatible-seeding, despite the fact that trees growing in the smooth-graded conventionally seeded reclamation areas were one year older.

The largest differences observed occurred among the planting areas. Tree performance, as indicated by both stocking and growth, was best on Block 1 where soils had been constructed using a mix of weathered and unweathered sandstone. Tree performance, as indicated by both stocking and growth, was poorest on Block 2, with soils constructed from mostly unweathered siltstones and sandstones. Tree performance on Block 4, with soils constructed from hard unweathered sandstone, was intermediate between performance on Blocks 1 and 2. The superior performance of trees planted on the mixture of weathered and unweathered spoil materials is consistent with results of prior studies (Zipper et al. 2013).

## Future Plans

Results of a similar assessment conducted on the experimental areas, conducted in late 2009 after 2 growing seasons, have been reported previously (Fields-Johnson et al. 2014). Additional analysis of tree data, and initial analysis of soil and plant community data, will be completed over the next year. After those analyses, a more complete description of research results will be prepared.


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