INFLUENCE OF GRADING INTENSITY ON GROUND COVER ESTABLISHMENT, EROSION, AND TREE ESTABLISHMENT [1]

by

J.L. Torbert and J. A.Burger [2]

Abstract. In 1991, a five year study was established in eastern Kentucky to evaluate the effect of surface grading intensity on ground cover development, erosion, and tree establishment. The study included three grading treatments: The "moderately" graded treatment consisted of backfilling a 40% slope and back-blading with a Caterpillar D-9 bulldozer to create a smooth slope. The "intensively" graded treatment involved additional back-blading passes, followed by "tracking-in" with D-9 bulldozers. The "roughly" graded treatment was created by ripping plots with a 36 inch ripping bar pulled directly downslope with a D-9 bulldozer. Each plot (150 X 150 ft) was installed on the slope, with a level area at the base of each plot. Five species of trees were planted in each plot (white pine, loblolly pine, sycamore, sweetgum, and yellow-poplar), and the entire area was hydroseeded with a "tree-compatible" groundcover. Erosion was measured monthly using erosion rods. Groundcover was measured along a transect after the first growing season. Total ground cover averaged 44% after the first year and was not affected by grading treatment, although there was a significantly higher amount of legume cover on the roughly graded plots. Erosion was highest on intensively graded plots; the amount of deposition recorded at the base of the slope was significantly greater than that on the other treatment areas. Overall, tree survival was 91% for the hardwood species, and 46% for the pine species, but there was little grading effect on tree survival and growth after the first year.

Additional Key Words: reclamation, compaction, productivity.

Proceedings America Society of Mining and Reclamation, 1992 pp 579-586
DOI: 10.21000/JASMR92010579

https://doi.org/10.21000/JASMR92010579

Introduction

Our reclamation research in the central Appalachian region of Virginia, West Virginia, and Kentucky has caused us to conclude that the single-most important factor limiting forestry land use opportunities on mined land is mine soil compaction, specifically, compaction caused by grading the final surface and "tracking-in" with bulldozer treads to create a seedbed. These conclusions are partially based on a compaction study that was maintained for two years before the study site was lost to remining (Torbert et. al, 1990). We find this compaction to be particularly disturbing when forest land is the specified post mining land use. Smooth surfaces (free of boulders, depressions, and gullies) are desirable for hayland or pasture, but are not typical of natural Appalachian forest land, and are not beneficial to forest productivity or forest management activities. We believe coal companies could save money and increase land-use productivity by reducing their grading activities on reclaimed forest land. We also believe that creating a productive forest ecosystem is the best way to provide long term environmental benefits.

The reasons that intense grading practices persist on land reclaimed with trees are understandable. Coal companies usually do not own the land being mined, and consequently, they have no financial interest in the long-term implications of grading impacts on forest productivity. Coal company reclamationists have a corporate mandate to reclaim the land and achieve bond release as quickly and efficiently as possible. As long as reclamation inspectors expect coal companies to construct smooth surfaces and establish a vigorous ground cover dominated by Kentucky-31 tall fescue, there will be no incentive for coal companies to modify their grading practices, despite pleas from landowners to maximize the productivity of reclaimed forest land. It is also understandable that regulators will have little reason to discourage intensive grading until its adverse effects on tree growth are clearly demonstrated by research. Regulators also need to be convinced that less grading to improve forest productivity will not compromise environmental protection.

To address the issues of grading effects on forest productivity and environmental protection, a five-year study was established in 1990 to evaluate the effect of reclamation grading practices on ground cover development, erosion, and tree growth. The purpose of this paper is to provide some preliminary results of the study.

---

[1] Paper presented at the 1992 National Meeting of the American Society for Surface Mining and Reclamation. Duluth, Minnesota, June 14-18, 1992.

[2] John L. Torbert is Research Associate, and James A. Burger is Associate Professor of Forest Soils; Department of Forestry; Virginia Polytechnic Institute and State University, Blacksburg, VA, 24061-0324.

Methods

Site Selection and Treatments

The study is located on land mined by Martiki Coal Corporation near Lovely, Kentucky. A slope, approximately 150 ft (upslope) by 1500 ft (along the contour), had been backfilled and moderately graded to its final contour (40% slope). The site was awaiting final surface grading and hydroseeding when it was selected for study in January 1991. The slope was divided into nine plots (150 X 150 ft) which were used to accommodate three replications of three grading treatments. The three grading treatments, installed on March 26, 1991 were:

1) "Moderate" Grading; For this treatment, no further grading was applied. Grading already completed when the study site was selected resulted in a fairly smooth surface, although some small boulders and small gullies were present. Since six months elapsed between the time these sites were graded and seeded, a hard crusted surface had developed.

2) "Intensive" Grading; This treatment is typical of operational reclamation practices in the region. The purpose of intensive grading is to eliminate small boulders and gullies such as those that existed in the moderately graded treatment, and to break the surface crust and create a better seedbed for ground cover germination. Bulldozers (D-9 Caterpillars) smoothed the slopes by dragging their blades as they backed downhill, after which they "tracked-in" the surface by running up and down the slope until the entire surface was covered with grouser tracks from the bulldozer treads.

3) "Rough" Grading (or Ripped"); The initial study design called for a rough graded treatment where the slope had been returned to its approximate original contour by backfilling with a minimal amount of grading. Such a site would have an uneven surface with boulders and depressions, and a loose surface soil. Unfortunately, when selected the study site was already beyond a roughly graded level to the moderately graded treatment. To create a rough surface with loose soil, the minesoil was ripped with a 36 inch subsoiler pulled down the slope with a D-9 bulldozer. Rips were created at 10 ft intervals. On the level area at the base of the slope, rips were installed perpendicular to the slope. Ripping created a very rough surface by pulling large boulders to the surface and creating gullies and ridges of loose soil aligned up and down the slope.

Tree Planting

Trees were planted on April 1 and 2, less than one week after installation of the grading treatments. Five species of trees were planted: white pine (Pinus strobus), loblolly pine (Pinus taeda), yellow-poplar (Liriodendron tulipifera), sweetgum (Liquidambar styraciflua), and sycamore (Platanus occidentalis). Approximately 40 of each of the pines and 20 of each of the hardwood species were planted in each plot. All species were one-year-old seedlings except white pines which were two-year-old seedlings. Trees in the roughly graded treatment were planted in the gullies created by ripping.

After the first growing season, tree heights were measured and survival rates were determined.

Ground Cover Establishment

On April 16, two weeks after tree planting, a "tree-compatible" ground cover was established by hydroseeding (Table 1). After the first growing season (January 1992), three 100-ft transects were established in each plot to measure ground cover. These transects were installed along the contour of each plot, approximately 1/4, 1/2, and 3/4 of the distance from the bottom to top of the slope. At 2-ft intervals along the transect, a 1 inch diameter sighting tube was used to assess ground cover. If more than half the area observed through the tube consisted of bare spoil, the point was tallied as such. If more than half the area was covered with vegetation, the existing species were tallied. This was done at 150 points per plot. On the ripped plots, the location of each transect point was recorded as occurring within a "trough" (bottom of gully), "peak" (top of ridge adjacent to rip) or on a "side" (between rips).

Table 1. Ground cover species and seeding rates

Species	Application Rate
winter rye*	10 lbs/ac
perennial ryegrass	5 "
orchard grass	5 "
redtop	3 "
weeping lovegrass	3 "
ladino clover	3 "
kobe lespedeza	5 "
Appalow lespedeza	5 "
birdsfoot trefoil	5 "
crown vetch	1 "

* foxtail millet (5 lbs/ac) would have been used instead of winter rye, but was unavailable at time of seeding.

Erosion measurements

Soil movement from the slope and deposition at the base of the slope were monitored by measuring the changes in the distance between the soil surface and the top of metal rods installed in each plot. Three rows of ten metal rods (spaced ten feet apart) were installed along the contour of each plot, approximately 1/4, 1/2, and 3/4 of the distance from the bottom to top of the slope. Another row was placed at the base of each slope, and another row was placed approximately 20 ft from the base. On ripped plots, there was a rip located between these two rows of rods on level ground. Rods were measured every 30-35 days from the time of installation (April 30) to October 30, 1991.

Results

Site Description

The study was installed on a steep slope where the likelihood for erosion effects would be greater than on a level or slight slope. The spoil on the site was derived mostly from gray siltstone with a minor component of gray and brown sandstone. The site was not topsoiled. Spoil samples collected from each plot prior to hydroseeding had pH values ranging from 7.7 to 8.8. All plots had a south to southeast aspect, which combined with dark spoil resulted in high surface temperatures during the summer. The climate at this site was very dry during 1991. This site received virtually no rainfall from July through September. Rainfall that did occur in the early summer came as short, intense storms.

Ground Cover Establishment

The species hydroseeded in this study were mostly acid-tolerant, short statured species (Vogel, 1980) which have provided good cover without overtopping trees in other studies (Torbert et. al, 1991). Grading treatment had no effect on ground cover during the first year (Table 2). The average cover was 44%, and ranged from 21% in a moderately graded plot to 83% in another moderately graded plot. Most of the cover in the study resulted from weeping lovegrass, which was virtually the only species surviving on some of the moderately and intensively graded plots. The average amount of legume cover in the study was 12%; it ranged from 0% in a moderately graded plot to 27% in one of the ripped plots.

For the most part, ground cover on the moderately and intensively graded treatments was uniformly distributed across the plot. On ripped plots, however, values in Table 2 are a weighted average of the relatively vigorous cover that existed within the "troughs" of the ripped gullies and the relatively sparse cover that existed between rips. Despite a dry summer, ground cover within the troughs was 76% (with 43% legumes), whereas the cover on the "peaks" was only 9% (with 2% legumes).

The ground cover species, seeding rates, and nitrogen fertilizer rate (40 lbs/ac) used in this study were selected to create a "tree-compatible" cover which provides some first year erosion control without overtopping and killing tree seedlings. In other studies, similar ground cover prescriptions applied to acidic spoils (pH 3.5 to 5.5) produced a 70 to 90% cover during the first year (dominated by foxtail millet and short grasses; Torbert et.al, 1991). In subsequent years, the leguminous component became more vigorous as trees grew above the cover; birdsfoot trefoil and Appalow lespedeza eventually produced a dense cover beneath the trees. In this study, first year cover was much lower than anticipated, partially due to dry weather. Areas adjacent to the study that were operationally seeded with a conventional mixture of Kentucky-31 tall fescue and other species were even sparser than the study plots. The ground cover may also have been somewhat affected by the high pH of this study site, although weeping lovegrass did very well even though it is typically considered to be a very acid tolerant species.

The most important ground cover attribute to follow as this study proceeds is the legume component. Legumes are critical to the development of an adequate nitrogen supply for long term forest productivity. Some of the moderately and intensively graded treatment plots had such a sparse legume cover after the first year that it seems unlikely that an adequate and timely nitrogen supply will develop to support good ground cover or tree growth.

Mine Soil Erosion

Compaction on intensively graded plots reduced water infiltration and increased surface runoff. During a heavy storm in the early summer, surface runoff was observed flowing from the intensively graded plots. On ripped plots, water flowed between the rips, but within the area disturbed by the rips, high infiltration rates prevented any overland flow. At the bottom of the slope, no water flowed from the gullies created by ripping.

Table 2. Ground cover after first growing season as affected by grading treatment.

Grading Treatment	% Total Cover average	% Total Cover range	% Legume Cover average	% Legume Cover range
Ripped	42a*	(36-48)	17a	(11-27)
Moderate	52a	(21-83)	10a	(0-23)
Intensive	38a	(25-53)	9a	(1-24)

* Values within a column followed by the same letter are statistically similar according to Duncan's Multiple Range Test (p<.10)

Erosion was expressed as the average depth of spoil lost at the 30 erosion rods located on each plot, and as the amount of deposition at the base of the slope and twenty feet from the base (Table 3). Although the average soil loss from the intensively graded plots was 18 times greater than the roughly graded plots, the difference was not statistically significant due to the variation among individual replicates. Deposition recorded at the base of the slope, however, was significantly higher on the intensively graded plots. For the most part, sediment that reached the base of ripped plots was captured by the first rip on the level ground and did not reach the second row of erosion rods.

Table 3. Average soil loss from study plots and deposition at bottom of plots during the first growing season as affected by grading treatment.

Grading Treatment	Soil Loss from slope ave.	Soil Loss from slope range	Soil Deposition at toe of slope ave.	Soil Deposition at toe of slope range	Soil Deposition 20 feet from toe ave.	Soil Deposition 20 feet from toe range
	cm					
Ripped	.04a	(-1.07-0.55)	1.51ab	(1.09-2.06)	0.28b	(-0.06-0.50)
Moderate	.44a	(0.11-1.01)	0.50b	(0.26-0.65)	0.27b	(-0.11-0.47)
Intensive	.72a	(0.06-1.19)	3.48a	(1.66-6.48)	1.82a	(1.31-2.58)

* Values within a column followed by the same letter are statistically similar according to Duncan's multiple range test (p<.10)

Tree Survival and Growth

The original study design involved only loblolly pine and white pine. These are two commercial species commonly planted on mined land in the region, and they are species which the landowner (Pocahontas Land Corp) intends to manage for sawtimber production. Unfortunately, the average pH of this site was greater than 8, which is much higher than the acidic conditions to which pines are best adapted. Consequently the hardwood species were added to the study.

As a group, the hardwoods survived better than the pines (Table 4). To some extent, the pines performed poorly as a result of dry weather and possibly the high pH, but these problems were compounded by inadequate care of the pine seedlings before planting. It was noted at time of planting, that many of the pines had broken dormancy and the loblolly pines began shoot elongation before they were taken out of their bundles.The pines were further stressed as a result of hydroseeding after the trees were planted. Many pines were encased in hydromulch that did not wash off during the summer.

A comparison of growth among species based on height is not meaningful at this early age, considering differences in size of seedlings. For example, most sycamores were 2-3 ft tall at time of planting, whereas many of the sweetgums were only 2-3 inches tall. It was obvious, however, that the hardwoods were more vigorous than the pines. At the end of the season, the hardwoods had developed healthy foliage (particularly in the ripped plots), but the pines had stunted and chlorotic foliage. Loblolly pine needles were very yellow with red coloration at the tips, suggesting that a high pH and/or soluble salt

Table 4. First year survival and height as affected by species and surface grading treatment.

	Surface Grading Treatment					
	"Rough" Graded		"Moderate" Graded		"Intensive" Graded	
Tree Species	Survival (%)	Height (in)	Survival (%)	Height (in)	Survival (%)	Height (in)
Sycamore	89	42	98	35	86	29
Sweetgum	100	24	98	22	96	21
Yellow-poplar	94	28	64	34	92	25
Loblolly pine	78	26	46	30	50	29
White pine	26	17 *	39	24	37	21

* Average white pine height on the roughly graded treatment plots was significantly lower than that on moderately graded plots according to Duncan's multiple range test ($p<0.10$). No other grading effects were significant.

problem existed. It is anticipated that the hardwoods will begin rapid growth in the second season, and dramatic growth differences will reflect differences in available rooting volume and moisture holding capacity by the third year. The pines will probably perform poorly for several years until weathering causes the pH to decrease and legumes can increase soil nitrogen levels.

White pine was the only species for which grading had a significant growth effect. Average white pine height was lowest in the ripped treatment, undoubtedly as a result of the vigorous herbaceous cover which developed in the gullies where the trees were planted.

Summary

Reclaimed surface mines in the central Appalachians are routinely graded and tracked-in to create smooth surfaces. Some have argued that intensive grading operations are needed to establish uniform ground covers and reduce erosion. Others have argued that such an approach is short-sighted, and that the greatest erosion control in the long-term will result from efforts that promote the establishment of a healthy forest. This study was established to provide some information about the short- and longer term impacts of grading on environmental protection and forest productivity. Preliminary results show that intensive grading did not result in better ground cover establishment or erosion control. In fact, erosion was highest on the intensively graded plots, and the poor performance of legumes on the moderately and intensively graded plots suggest that long term ground cover performance may be poorer than on the ripped plots. The conditions created by ripping the sites were completely opposite of conditions generally strived for during reclamation. To the surprise of many people involved with this project, the gullies created by ripping did not cause immediate slope stability or erosion problems. These rips enhanced water infiltration and ground cover establishment, and, although trees have not shown any growth response yet, we expect them to respond positively to this treatment by the third year.

Literature Cited

Torbert, J.L., and J.A. Burger. 1990. Tree survival and growth on graded and ungraded minesoil. Tree Planters Notes. 41(2)3-5.

Torbert, J.L., J.A. Burger, and T. Probert. 1991. A reforestation case study on a reclaimed Appalachian mine soil in West Virginia. pp 663-668. In W.Oaks and J.Bowden (eds) Proceedings of the 1991 National Meeting of American Society of Surface Mining and Reclamation. May 14-17, Durango, CO.
http://dx.doi.org/10.21000/JASMR91020663

Vogel, W.G. 1981. A guide for revegetating coal minesoils in the eastern United States. Northeast For. Exp. Stn Gen. Tech. Rep. NE-68.