CHAPTER 4: LOW COMPACTION GRADING TO ENHANCE REFORESTATION SUCCESS ON COAL SURFACE MINES

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INTRODUCTION

This Forest Reclamation Advisory describes final-grading techniques for reclaiming coal surface mines to forest postmining land uses. Final grading that leaves a loose soil and a rough surface increases survival of planted seedlings and forest productivity. Such practices are often less costly than traditional "smooth grading" while meeting the requirements of the federal Surface Mining Control and Reclamation Act of 1977 (SMCRA).

LOW COMPACTION GRADING IS SMART RECLAMATION

Avoiding compaction during reclamation to forest makes good economic sense. It costs money to operate a dozer. Smooth surfaces do not contribute to postmining land use success and are not required under SMCRA. Therefore, grading with multiple passes to create smooth surfaces on reforestation sites is an unnecessary expense. The practice of covering the land surface with dozer track and cleat marks—often called walking-in or tracking-in—is also unnecessary and hinders reforestation success.

Leaving surface soils loose and uncompacted helps planted trees survive and grow:

- By helping planters get trees planted correctly: The planting hole must be large enough to hold the entire root system without requiring planters to bend or fold the roots. Generally, planting holes should be at least 8 to 10 inches deep. Planters will usually insert the planting tool to open the hole just one time. A seedling whose roots have been chopped short or folded to fit a shallow hole will be less likely to survive than a seedling that has been planted correctly with a full root system in an adequate hole. Leaving the soil loose makes it easier for the planters to get the tree's roots into the ground correctly.
- By allowing rainwater to infiltrate the soil: Soil surfaces that are loosely graded with rough configurations, or are left ungraded, allow

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Publication History

This chapter is based on Forest Reclamation Advisory No. 3, which originally appeared in July 2007 on the Appalachian Regional Reforestation Initiative's Web site (http://arri.osmre.gov) hosted by the U.S. Department of the Interior's Office of Surface Mining Reclamation and Enforcement. (Note that authors' affiliations were current when the Advisory was originally written.)

more water to infiltrate than the smooth, tight surfaces produced by conventional grading. Increased infiltration means more water is available in the soil for the planted trees.

- By allowing the soil to hold more water and air: Spaces between soil particles hold and store water and air. Soil compaction compresses soil particles, making those spaces smaller. Thus, compacted soils will provide less water to growing trees between rainfalls, and will be less able to provide the air exchange that tree roots and soil organisms need.
- By allowing roots to grow more freely: The tree's roots are essential to its survival and growth. A loose, uncompacted soil allows roots to grow freely; in contrast, compacted soils limit root growth. A tree with a larger root mass will be able to reach a larger soil volume for water and nutrients, will have a greater chance of survival in the short run, and will grow bigger and faster in the long run.

Many scientific studies have found that soil compaction hinders survival and growth of planted trees. In eastern Kentucky, Torbert and Burger (1992) found that reducing soil compaction increased survival and growth of hardwood species and reduced soil erosion. Jones and others (2005) found that soil density on Virginia and West Virginia mine sites had a greater effect on eastern white pine growth than any other measured soil property. (Please refer to the Appendix starting on p. A-1 for scientific names of species mentioned in this chapter.) Seedlings planted in loosely graded experimental plots on eastern Kentucky's Starfire mine demonstrated excellent survival and growth, relative to trees planted in conventionally graded plots (Angel and others 2006). Emerson and Skousen (2006) reported greater than 80-percent survival of hardwood trees planted into end-dumped spoils that were graded with only one or two passes in southern West Virginia. Rodrigue and Burger (2004) found that pre-SMCRA mine soils with favorable chemical properties made excellent forest sites for both hardwood and softwood species—but only if the soils were left loose and uncompacted. Many other studies have had similar findings.

LOW COMPACTION GRADING PRACTICES

The Forestry Reclamation Approach (FRA) is a way of reclaiming active surface mines to maximize reforestation success (Chapter 2, this volume); Step 2 of the FRA is to loosely grade the topsoil or topsoil substitutes to create a noncompacted growth medium. This practice can be used on any type of surface mine. Techniques for low compaction grading are described next for various landforms.

Flat and Gently Rolling Surfaces on Mountaintop, Area, and Contour Mines

On surface mines where the final configuration will be flat or gently rolling, place the subsurface backfill using standard practices—whatever is required by the permit, including any compaction necessary for stability. When the postmining land use is forest, however, the surface material should be at least 4 feet deep and only lightly graded, if at all. To accomplish this where trucks are used to deliver the surface material, a process called end-dumping, tail-dumping, or loose-dumping is used (Fig. 4-1). The trucks dump the surface material into tightly spaced piles that abut one another across the reclamation area. Then, a light dozer can grade the spoil piles and level the area with one or, at most, two passes (Fig. 4-2). When this practice is used, it is essential that the piles be dumped close together so that the final surface thickness is 4 feet or more.

Level the loose-dumped materials with the lightest equipment available and using the fewest passes possible. If possible, grading should be done with just one pass of a low ground pressure (LGP) dozer. Equipment with rubber tires should not be used for final grading because rubber-tired equipment concentrates its weight on a smaller "footprint" and creates more surface compaction than tracked equipment.

Figure 4-1.—Loose-dumping a topsoil substitute over a compacted subsurface on a West Virginia surface mine. The topsoil-substitute material is being dumped in closely spaced piles and will be graded using only a single dozer pass. The final surface will be revegetated with a tree-compatible ground cover and trees will be planted in the loose topsoil-substitute materials. Photo by J. Skousen, West Virginia University, used with permission.

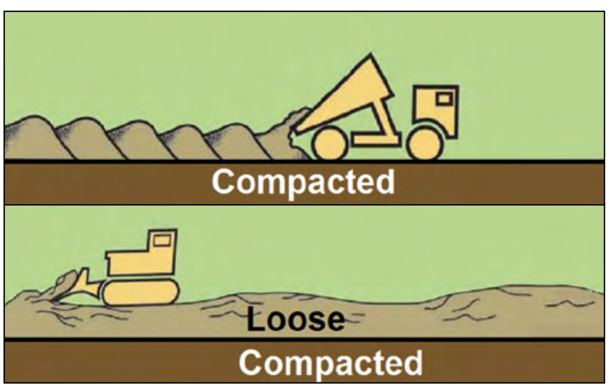

Figure 4-2.—Diagram of end-dumping and final grading on a truck-and-haul surface mine. Subsurface materials have been placed as described in the permit and have been compacted by equipment operations. Surface materials are dumped over the compacted subsurface to a depth of 4 to 6 feet (upper) and are graded only lightly so that they remain loose and uncompacted (lower).

Note the example of loose-dumped surface materials in Figure 4-3. Grading of these materials with a single pass of a track dozer during dry conditions would create soil conditions suitable for trees. Depending on State program policies and on material properties, it may be possible to plant trees in loose-dumped spoils such as those in Figure 4-3 with no further grading or leveling. This method is especially applicable if the material will drain water easily and weather to create a more level surface over time. If such piles are left on a sloped area, placing them in an alternating pattern that does not create linear downward channels can help prevent erosion.

Where a dragline is used, the spoil material can be cast and shaped in a manner that reduces the amount of final grading needed by tracked equipment. As with end-dumping, place the final surface in piles or ridges that tightly abut one another across the entire area. Then grade the spoil material with a single pass, or, at most, two passes (Fig. 4-4).

Another method of moving spoils to create a final surface suitable for trees is called dozer push-up (Fig. 4-5). This method can be used where spoils are moved only a short distance, so that the dozer is a more cost-effective way of moving the material than hauling in trucks. The materials are

Figure 4-3.—Loose-dumped soils on the surface at an Ohio mine site. Photo by M. Hiscar, OSMRE.

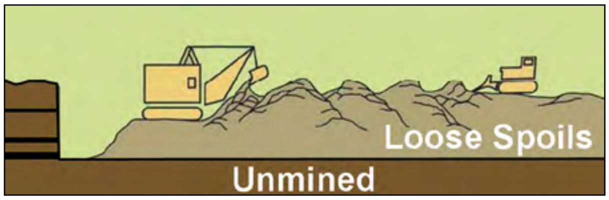

Figure 4-4.—Diagram of final grading on spoils placed by a dragline on a mountaintop or area mine.

Figure 4-5.—Diagram illustrating the “dozer push-up” method. This method can be used to prepare uncompacted surfaces that are suitable for reforestation where materials for surface placement are moved over a short distance. Depending on the situation and State program policies, it may be possible to use the “dozer push-up” surface for reforestation without a final strike-off grading. Otherwise, the push-up piles should be struck off with one or, at most, two passes with a light dozer.

pushed into long parallel ridges and are kept loose during each push. The dozer starts on one edge of an area with the material and pushes the first pile of the first ridge into place and then backs up and moves over one blade-width to push the next pile of the first ridge into place. Then the dozer returns to the starting edge and repeats the process for the next ridge. When viewed from above, the final grade surface looks like an old-fashioned washboard. In some situations and depending on State program policies, mine operators may have the option of leaving the dozer push-up ridges as the final surface for tree planting. Otherwise, strike off the surface by using a light dozer under dry conditions with only one or two passes, leaving a material depth of at least 4 feet.

Reconstructing Slopes

Practices for achieving an uncompacted growth medium on sloped backfills will vary from operation to operation. Backfill construction, however, should not vary much from what would be done normally—except that grading of the final surface is minimized. If the backfill materials are suitable and approved for use as a topsoil substitute, place those materials to construct the backfill using the usual practices. When all materials are in place, the dozers shape the fill to its final form—but they do not smooth and track-in the surface (Fig. 4-6). Do all grading moving downslope; confine upslope tramming to roads or tramways, which avoids tracking over and compacting materials that have already been shaped.

If the backfill requires compaction for stability, place all materials except the surface and compact as needed to construct a stable backfill using normal practices (Fig. 4-7). Dump topsoil or topsoil-substitute materials as needed to cover the outer surface of the compacted fill with 4 to 6 feet of loose, uncompacted material. Place the material from the outer edge of each lift, or construct an access road to enable the entire fill’s surface to be dumped over from the top. If necessary, strike off the dumped spoil to shape the final landform. Again, do all dozing moving downslope and only as needed to shape the fill; confine upslope tramming to roadways or the like, which avoids tracking back over and compacting the shaped materials. It is essential to leave the outer surface of the underlying compacted materials in a rough configuration so as to assure a good interface with the uncompacted surface. Leaving a smooth surface on the compacted base of a steeply sloped fill can create a slide plane, making the surface material vulnerable to instability.

The mine operator is responsible for assuring that approximate original contour and backfill stability are achieved, as in any other SMCRA-regulated operation. Place and stabilize areas that will support final drainage ditches and waterways as in normal practice.

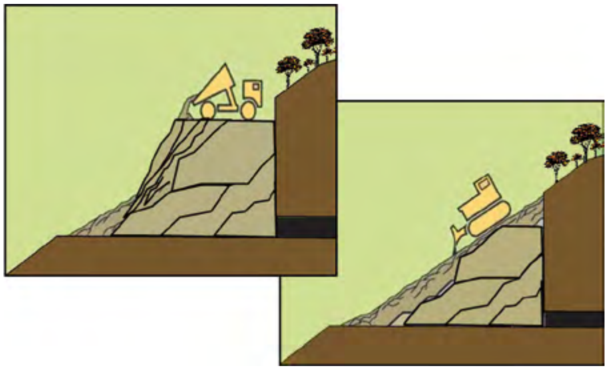

Figure 4-6.—Diagram of soil placement and final grading on a steep-slope contour mine where the backfill is constructed of approved topsoil substitute material and does not require compaction to maintain stability. The material is dumped in place (left) as per normal practice and then struck off to shape the backfill (right) but not graded smoothly. The dozer grades moving downward and trams back up on roads or defined tramways so as to minimize tracking back over materials that have already been shaped.

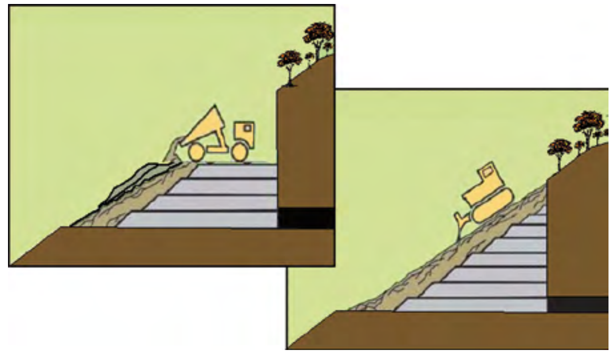

Figure 4-7.—Diagram depicting spoil placement and final grading to achieve stability on a steep-slope contour mine where backfill compaction is specified by the permit. The backfill materials are placed and compacted by using standard procedures as required for stability. Then loose materials suitable for surface placement are dumped over the compacted spoil material (left) and graded only lightly (right) and only if necessary to shape the final surface. The surface materials can be placed over the compacted backfill as each lift is completed, or they can all be dumped from the top lift.

Leaving a Rough Soil Surface

On any surface mine, low compaction grading techniques that create excellent forest soils will leave rough surfaces. Mine sites being prepared for reforestation can be left with rough surfaces similar to natural forests. Grading practices that leave small depressions and rocks on the surface will be an aid to successful reforestation (Fig. 4-8). Such surfaces absorb rainwater more easily than the smoothly graded surfaces that are used in reclamation for hayland, pasture, and other agricultural postmining land uses. The surface depressions and void spaces that occur on such sites can capture and germinate seeds that are carried to the site by wind or animals, and the rough surface increases water infiltration. Any water that infiltrates cannot cause erosion by running off the surface. If the surface materials contain old stumps or other organic debris from the pre-mining forest, these materials can also be left on the surface to aid reforestation.

Figure 4-8.—A topsoil-substitute material that has been prepared for revegetation by using the low-compaction grading technique on a coal surface mine. The materials have been left in a loose condition. The rocky, rough surface will aid water infiltration and will not hinder the forest postmining land use that is being established on this site. Photo by J. Skousen, West Virginia University, used with permission.

Final Grading

Do final grading only when surface materials are dry. This will help to reduce compaction and will be more cost-effective than grading moist materials. When spoil materials are damp or moist, the pressures exerted by the dozer can pack the soil particles together more tightly than would occur under dry conditions. If the surface materials are wet, damp, or moist, delay final grading until they dry.

Keeping Traffic off the Final Surface

Once the final surface has been graded, exclude all equipment traffic from the area. If it becomes necessary for heavy equipment to travel over some portion of the graded area, use deep ripping to restore that area's suitability for trees (Chapter 5, this volume).

FREQUENTLY ASKED QUESTIONS ABOUT LOW COMPACTION GRADING

What about site stability?

Regulations under SMCRA require that reclaimed mine sites be stable. Therefore, handle and place all below-surface spoils as needed to ensure stability as described in the permit; only the top 4 to 6 feet must remain loose and uncompacted for successful reforestation.

What about backfill settlement?

Successful postmining forests require that compaction be avoided only on the top 4 to 6 feet; therefore, place most of the backfill material using procedures that would normally be used to prevent settlement and highwall exposure. Any settling that occurs because the top 4 to 6 feet has been left loose will be minimal. Operators can overfill the top of the highwall using the same amount of loose spoil that they would otherwise compact—but without the added expense of compacting this final lift of material.

If the site is not graded smoothly, will that be "ugly reclamation"?

Each loose-graded site will look different, with some rougher and some smoother. Some sites will have many rocks on the surface while others will not. But whether or not these sites should be considered "ugly reclamation" is in the eye of the beholder. To a person who can envision a productive natural forest with diverse vegetation and wildlife emerging from the mine site, such reclamation can be beautiful. Many natural, unmined forests in the Appalachian region have rough and rocky soil surfaces.

If the surface is not compacted to "hold it in place," will soils erode more rapidly?

Scientific research (Torbert and Burger 1992) and onsite observations demonstrate that compacting soil surfaces accelerates soil erosion. Soils erode when rainfall fails to infiltrate the soil and runs off the surface. Surface compaction prevents rainfall infiltration, encouraging erosion. Mine soils reclaimed with low compaction grading allow water to infiltrate the surface, which prevents erosion. Mine operators who switch from conventional to low compaction grading often observe that sediment-pond cleanouts are needed less frequently.

If gullies develop in the uncompacted materials, should they be regraded?

Because low compaction grading encourages infiltration of rainfall, gullies are less likely to form when low compaction grading is used.
If small gullies form in the final surface, they should not be regraded. When regrading occurs, it compacts the soil surface. If regrading occurs after the site has been planted with trees, those trees within the regraded area are destroyed.
The maximum allowable gully size that does not require regrading varies with State program policies. Generally, the States allow stabilized gullies to remain in place on forested mine sites if they are not large enough to hinder the operation of forestry equipment.

Will the mine inspector like it?

Most inspectors will approve low compaction grading without problem or difficulty because the FRA is allowed under SMCRA. The U.S. Department of the Interior's Office of Surface Mining Reclamation and Enforcement (OSMRE) and the States that participate in the Appalachian Regional Reforestation Initiative (ARRI) have issued directives to that effect (Chapter 1, this volume). Both federal and State inspection personnel in those States have been informed of this "new" way of reclaiming mine sites for forests, which includes low compaction grading. OSMRE and the mining agency for each State in the Appalachian region have assigned one or more people to encourage use of FRA practices in permits and in the field, and to ensure that FRA practices are accepted as means of achieving bond release.

If a mining firm is concerned that its inspector will not favor low compaction grading, it should state in the mining permit that low compaction grading practices will be used. If the company is not certain that its inspector will approve low compaction grading, a mine supervisor can ask the inspector for an onsite meeting. Carrying a copy of this volume or other ARRI publications (available at http://arri.osmre.gov/Publications/Publications.shtm#FRAs) to the meeting can help communication with the inspector. If such a meeting were to be unsuccessful, a call to that State's ARRI liaison, or to any member of the Core or Science Teams, could be the next step. FRA practices—including low compaction grading—are allowed under SMCRA when the postmining land use is forest, and are encouraged by both OSMRE and State agencies.

SUMMARY

Since SMCRA's early years, equipment operators and inspectors have taken pride in the clean and smooth "golf course" look produced by fine grading. Scientific research has made it clear, however, that such practices compact soils and hinder development of planted trees.

To reestablish a healthy and productive forest after mining, surface compaction should be minimized by placing surface spoils using techniques that leave them loose, leveling with the lightest equipment available with the fewest passes possible during dry conditions, and permanently removing all equipment from the area after leveling.

The low compaction grading techniques described in this Advisory are less costly than conventional smooth-grading and tracking-in practices that have been common since SMCRA went into effect. Low compaction grading for forestry postmining land uses is consistent with SMCRA and with federal and State regulations. Low compaction grading will aid seedling survival, reduce the need for replanting, increase the likelihood of prompt bond release, and allow the planted trees to grow into a productive forest.

ACKNOWLEDGMENTS

The authors express their appreciation to Karrie Bernhard with OSMRE for the graphics in Figures 4-2 and 4-4 through 4-7.

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