LOW MINE SOIL COMPACTION RESEARCH

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Abstract

A multidisciplinary group of researchers at the University of Kentucky initiated a diverse study to evaluate the effects of soil compaction on the survivability and growth of high value tree species. This study was established on the Starfire Mine owned by Cyprus-Amax in Perry County, Kentucky. The team of researchers encompassed the various expertise areas in the departments of agricultural engineering, forestry, mining engineering, and ecology.

Since its initiation, a weather station has been established, over 57,000 trees have been planted, a passive dewatering system initiated, and a fertigation study constructed. The trees consisting of seven species have been planted on areas that were compacted, partially compacted and uncompacted.

Bulk densities and penetrometry data have been gathered on all the planted sites to determine the relative compaction of each planting area. Compaction is already a contributing factor to either or both tree survival and growth.

Additional studies being conducted include the effects of alternative ripping methods on reclaimed areas that were compacted in the normal manner prior to the concept of a new grading standard. These plots were mulched and planted this month. Additional studies will be planned depending upon the availability of funds.

Introduction

The University of Kentucky Department of Biosystems and Agricultural Engineering, Department of Forestry, and Department of Mining Engineering began an extensive reclamation research project in 1995. This project is intended to extend the efforts of past and ongoing research programs at the University of Kentucky, Southern Illinois University, and VPI's Powell River project. It also was designed to be an integrated effort that would utilize as many areas of expertise as possible.

The basis for justifying this research was the established facts presented by the Kentucky Reclamation Association that they had reclaimed 187,000 acres since 1948. Prior to 1980, 101,000 acres were planted primarily to trees. Since 1980, 86,000 acres were reclaimed with 1,500 acres being a return to forest land. Most of the area returned to forest land does not meet minimum stocking standards. Three thousand acres were planted to shrub species. The result has been the establishment of 81,500 acres of lespedeza and tall fescue.

Early research at Southern Illinois University found that by simply striking off old prelaw strip mine spoils created areas that resulted in the highest site index areas in the state for yellow poplar, white oak, and walnut. VPI (The Powell River Project) reported that applications of uncompacted spoil at a depth of 12 inches resulted in a white pine site index of 60 while 4 feet resulted in a site index of over 100. The result would be that an acre at site index 60 would be worth $100 in 30 years while an acre at site index 100 would be worth over $2400 at the same age.

Since the project was initiated the total area impacted has grown to approximately 83 acres. These include nine 3-acre cells that contain twenty one 1/10-acre plots that are comprised of seven species replicated three times. The cells consist of three that are compacted in the normal manner that has been accepted since the initiation of PL95-87. Three were back-dumped and left ungraded and three were back-dumped and "lightly graded." Lightly graded depended on how closely the dozer operator was supervised in the process.

One cell in each grading treatment was mulched with 45 ton per acre of hardwood bark, one mulched with 45 ton

per acre barn litter, and one was left unmulched. Berms were constructed around each cell to contain all rainfall and eliminate any runoff that might be construed as detrimental to any surrounding area.

A fully automated recording weather station was placed on the research site. A passive dewatering sediment pond was constructed adjacent to the three compacted cells. All precipitation from the cells was diverted through the dewatering structure and recorded.

Additionally, a 1.5-acre area has been created to study sedimentation and a two-acre area to evaluate trickle irrigation and infiltration. These also have been mulched and planted with trees. To study methods of modifying existing reclaimed mine spoil to facilitate productive tree growth, six 2.5-acre cells have been mechanically ripped. Three were cross-ripped on approximately 6 foot centers to a depth of 30 inches or more. Three were ripped with conventional multitined rippers at a depth less than one foot. These areas were mulched as the other cells and planted with the same seven species replicated three times.

Additionally, a 20-acre area of moderately graded to ungraded dragline spoil was planted to simulate the planting systems common prior to PL95-87. These installations provide data that range from the completely ungraded to that completely compacted with additional information concerning the redisturbance of compacted sites.

To date approximately 57,000 trees have been planted with more planned, depending on availability of resources, for further expansion of treatment modifications. Equipment has been designed to make more radical modification of previously reclaimed areas, but we have not had the resources to initiate trials using the system.

Rick Sweigard will discuss the bulk density and penetrometer data that is being gathered on these areas. Tree survival and growth information is being correlated to the density measurements that are found with each treatment.

We have had to install 2.5 miles of high tensil electric fences to prevent cattle, deer, and elk damage to the trees. An additional 1.5 miles will be necessary this year.

Results

This project is expected to continue for 20 years or more. It is now in its infancy but beginning to yield some interesting results. In the uncompacted dragline spoil after three years, white ash has an average survivability of 91 percent and has averaged 24 cm of height growth. Yellow poplar is the least successful survivor with an average of 44 percent and walnut has only averaged 1 cm of height growth.

In the compacted dragline spoil, white ash still has a survivability rate of 87 percent. White ash and northern red oak have averaged 7 cm of height growth. Yellow poplar averaged only 13 percent survivability and walnut averaged a negative 7 cm of height growth during the three years. Negative height growth is a result of dieback and browse damage.

Survival in the loose-dumped cells after three years are very good. White ash averages 88 percent but is closely followed by northern red oak, yellow poplar, and white pine. Paulownia averaged only 37 percent survivability. This survivability can primarily be attributed to the planting stock. Those paulownia that survived averaged 47 cm of height growth. White ash had averaged 11 cm of height growth after two years. Black walnut averaged a negative 1 cm after two years. The overall survival averaged 76 percent with 11 cm height growth.

Black walnut was the leading average survivor in the rough-graded cells at an average of 92 percent followed closely on white ash. The lowest survivability was paulownia with an average of 48 percent. Paulownia height growth averaged 52 cm for the two years, and white ash averaged 13 cm. Black walnut averaged a negative 10 cm of height growth while the northern red oak averaged a negative 1 cm. The overall survival of these cells was 74 percent and had an average growth of 9 cm. White ash was the leading survivor in the compacted cells averaging

87 percent. The lowest survival was again paulownia which averaged only 11 percent. The surviving paulownia height growth averaged 33 cm for the two years, while black walnut averaged a negative 28 cm over the same period. The average survival in these cells was 45 percent and averaged a negative 1 cm for two years with ash

being the only species with a positive growth other than paulownia.

When we look at the average survival from 1996 to 1998 in the loose dragline spoil, we see that northern red oak, yellow poplar, and black walnut are slowly declining. White oak, white ash, and white pine are showing increases from resprouting dieback or browse. On the compacted dragline spoil only black walnut is increasing after initial dieback or browse damage. White ash resprouted and then declined the next year. Northern red oak is decreasing each year, while white oak, yellow poplar, and white pine are holding their own after the initial mortality.

Survivability is decreasing slowly in the loose-dumped cells for every species except paulownia and black walnut. In the rough-graded cells, all species are declining except white oak and black walnut. The survivability of all species are decreasing in the compacted cells.

The average height growth was greater for all species in the uncompacted dragline spoil, except white oak. The compacted cells resulted in a decreased height growth for all species. Greatest height growth averages were attained in rough-graded areas by white ash, paulownia, and white oak. White pine, walnut, yellow poplar, and northern red oak appear to prefer the loose-dumped cells.

Conclusion

There are some very positive trends beginning to appear in the data from this research area. There is not much doubt that compaction has a very negative effect on both survival and growth for the species selected in this study. We are seeing at this time that light compaction is not detrimental to some species at this stage of development. We also see that no compaction is beneficial to those species not affected by light grading. Time will be the determinate of which system works best but evidence from past research indicates that growth, yield, and soil formation are increased by either having little or no compaction by heavy equipment and are, in fact, better than undisturbed areas since more root development depth is attained than in normal natural stands.

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[1]Dr. Graves holds a B.S. in Forestry from Purdue, an M.S. in Forestry from the University of Florida, and a Ph.D. in Agricultural Forest Economics from the University of Kentucky. He has been at the University of Kentucky since 1964. Currently, he is the Chairman of the Forestry Department. He has served with distinction on many task forces and committees and played a significant role in Kentucky's Reforestation Initiative. He has authored and contributed to numerous publications related to reforestation of mined lands.