

Effect of Grading Technique on Forest Productivity of High-Value Tree Species in Reforested Surface Mine Lands

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Figure 1: An aerial view of the Starfire FRA plots in eastern Kentucky in 2016. (Photo by Matt Barton)

Project Description and Objectives: This project sought to evaluate tree growth, woody plant colonization and carbon accumulation in a 19-year-old experimental forestry reclamation approach (FRA) planting located on the Starfire surface mine in eastern Kentucky. Three grading treatments (loose dump, strike-off and control) and three surface amendment treatments (hardwood bark mulch, straw mulch and control) were evaluated.

Applicability to Mining and Reclamation: The FRA was developed in order to successfully return native tree species to Appalachian surface mines. The Starfire experimental stand was among the first study sites established in order to develop this approach (See Figure 1). The data gathered in this study therefore has the potential to offer novel insights into the long-term trajectory of FRA stands in the region.

Methodology: The study site was located at the Starfire Mine in Knott County and Perry County, KY (37° 24" N, 83° 08' W) and consisted of 9, 1.0 hectare experimental reforestation cells planted with 6 native tree species. In August 2015, diameter of all live planted trees was measured and recorded for all plots occurring in each 1.0 hectare cell. Survival for each plot was calculated by dividing the number of living trees by the number of planted trees (121) and multiplying by 100%. Heights of a subsample of live overstory trees were measured during the winter of 2016. In order to develop biomass accumulation estimates for white oak, yellow-poplar and eastern white pine, trees of these species were destructively sampled during the summer of 2016. Subsamples of the dried material from destructively sampled trees were analyzed for total carbon and nitrogen. Per area aboveground carbon sequestration was subsequently calculated for each species.

Highlights: This study showed that native hardwoods planted on a surface mine using FRA grading methods (loose dump and strike-off) achieved heights and accumulated biomass at rates similar to those seen in non-mined regional reference forests. Aboveground and soil carbon sequestration rates were found to exceed those noted in other reclamation studies as well as those seen during the conversion of agricultural land to forest. Additionally, woody vegetation colonization increased as compaction decreased across grading treatments. Proportions of native colonizing species versus exotic exhibited a similar pattern.

Results/Findings:

Table 1: Mean survival percentage for all species and standard errors by surface amendment within grading treatment levels. For each row, means with same letter are not significantly different. For each column, means with same symbol are not significantly different ($p < 0.05$). A significant interaction was present between grading and surface amendment treatments.

Amendment	Grading		
	Control	Strike-Off	Loose-Dump
Control	33.2a* ± 0.7	51.5a* ± 0.1	81.3b* ± 0.2
Bark	19.9a*† ± 0.6	67.3b* ± 0.1	81.1b* ± 0.1
Straw	9.4a† ± 0.5	60.9b* ± 0.2	85.6c* ± 0.1

Table 2: Mean overstory height (m) and standard errors for all species by surface amendment within grading treatment levels. For each row, means with same letter are not significantly different. For each column, means with same symbol are not significantly different. ($p < 0.05$)

Amendment	Grading		
	Control	Strike-Off	Loose-Dump
Control	7.5a* ± 0.5	9.0ab* ± 0.4	9.8b* ± 0.5
Bark	6.9a* ± 0.4	10.4b*† ± 0.3	10.6b* ± 0.5
Straw	7.7a* ± 0.8	11.8b† ± 0.4	11.5b* ± 0.4

Table 3: Mean biomass (Mg) per hectare by grading treatment levels for eastern white pine, white oak and yellow-poplar. Values have been pooled for surface amendment treatment levels.

Species	Grading		
	Control	Strike-Off	Loose-Dump
Eastern White Pine	8.6	144.9	192.8
White Oak	7.6	49.8	53.0
Yellow-Poplar	10.1	50.1	60.6

Table 4: Mean aboveground biomass carbon and carbon sequestration rates for eastern white pine, white oak and yellow-poplar in loose dump and strike-off plots. Values have been pooled for surface amendment treatment levels.

	Species		
	White Oak	Eastern White Pine	Yellow-Poplar
Aboveground C (Mg ha ⁻¹)	25.8	66.1	42.8
Sequestration Rate (Mg C ha ⁻¹ yr ⁻²)	1.4	3.5	2.3

Table 5: Mean volunteer stems per hectare and standard errors by surface amendment within grading treatment levels. For each row, means with same letter are not significantly different. For each column, means with same symbol are not significantly different ($p < 0.05$). A significant interaction was present between grading and surface amendment treatments for this species.

Amendment	Grading		
	Control	Strike-Off	Loose-Dump
Control	228.6a* ± 47.6	744.1b* ± 58.0	1545.2c* ± 120.7
Bark	189.3a* ± 28.1	614.3b* ± 81.9	1695.2c* ± 212.3
Straw	179.8a* ± 37.9	444.1a* ± 39.3	453.6a† ± 98.4



Figure 2: Technicians remove needles from a destructively sampled eastern white pine. (Photo by Wes Dement)



Figure 3: A destructively sampled yellow-poplar bole is weighed in the field. (Photo by Wes Dement)

Website Information: The final project report can be found at <https://www.osmre.gov/programs/tdt/appliedscience/project.s.htm>

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