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Influence of Mine Soil Properties on White Oak Seedling Growth: A Proposed Mine Soil Classification Model

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ABSTRACT

Appalachian landowners are becoming increasingly interested in restoring native hardwood forest on reclaimed mined land. Trees are usually planted in topsoil substitutes consisting of blasted rock strata, and reforestation attempts using native hardwoods are often unsuccessful due to adverse soil properties. The purpose of this study was to determine which mine soil properties most influence white oak (*Quercus alba* L.) seedling growth, and to test whether these properties are reflected adequately in a proposed mine soil classification model developed for application in field assessments of mine soil suitability for reforestation. Seventy-two 3-year-old white oaks were randomly selected across a reclaimed site in southwestern Virginia that varied greatly in spoil/site properties. Tree height was measured and soil samples adjacent to each tree were analyzed for physical, chemical, and biological properties. Our proposed mined land classification model used rock type, compaction, and slope aspect as mapping criteria. Tree height, ranging from 15.2 to 125.0 cm, was regressed against mine soil and site properties. Mapping units were not well correlated with differences in tree height. Microbial biomass, pH, exchangeable potassium, extractable inorganic nitrogen, texture, aspect, and extractable phosphorous accounted for 52% of the variability in tree growth. The regression model shows that white oaks were most successful on northeast-facing aspects, in slightly acidic, sandy loam, fertile mine soils that are conducive to microbial activity. Nutrient availability, although found to be highly influential on tree growth, was not adequately represented in the classification model. We recommend that pH be included as a classification criterion, because it was correlated with all nutrient variables in the regression model.

Keywords: site index, native hardwoods, mine soil classification

The eastern deciduous hardwood forest of Appalachia is one of the most valuable, productive, and diverse temperate forests in the world (American Forest and Paper Association 2001). This forest is important, both environmentally and economically, throughout the Appalachian region. However, several hundred hectares of this forest are being removed each year because of surface mining, and few reclaimed mines are restored to native forest.

Over 600,000 ha of land have been surface mined in the eastern United States since the implementation of the Surface Mining Control and Reclamation Act (SMCRA) in 1978 (Office of Surface Mining 1999). Federal and state regulations based on the SMCRA have helped improve water and environmental quality as well as the safety of active and reclaimed mines, but common reclamation procedures emphasizing revegetation with agronomic grasses are not conducive to reforestation (Angel et al. 2005). Mine soils restored using procedures that have been commonly applied in Appalachia since the SMCRA often are compacted, salty, and infertile and do not support native forest plant communities. Large areas of land have been reclaimed mostly to grassland or wildlife habitat (grassland with wildlife shrubs). Many reclaimed grassland sites have low productivity and are often abandoned from active management. Restoration of native forests on such sites would create a valuable economic alternative and add ecosystem services including watershed control, water quality, carbon sequestration, and wildlife habitat.

Black locust (*Robinia pseudoacacia* L.) and a variety of other early successional trees are able to survive and grow on these mined sites (Vogel and Berg 1973, Filcheva et al. 2000). However, these species have little commercial value and do not provide the same level of ecosystem services as the native, mixed, mesophytic hardwoods that usually are present before mining. In this area, where fire and other disturbances are common on ecological timescales, oaks (*Quercus* spp.) represent a mature successional stage in forest development (Johnson et al. 2002). They are an essential component of the native hardwood forest, and their replacement on these sites would be a positive step toward the return of commercially valuable hardwood forests.

Mine spoils can have highly variable physical and chemical properties, ranging from very acid pyritic materials to alkaline shales (Sencindiver and Ammons 2000). Compared with native soils, mine spoils can be high in rock fragments and have low moisture content, low porosity, poor structure, and high bulk density (Bussler et al. 1984). Chemical properties such as high pH, high soluble salt level, and low nutrient levels also can adversely affect tree growth

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