From Forest Nursery Notes, Winter 2012

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Forest Restoration Potentials of Coal-Mined Lands in the Eastern United States

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The Appalachian region in the eastern United Sates is home to the Earth's most extensive temperate deciduous forests, but coal mining has caused forest loss and fragmentation. More than 6000 km^2 in Appalachia have been mined for coal since 1980 under the Surface Mining Control and Reclamation Act (SMCRA). We assessed Appalachian areas mined under SMCRA for forest restoration potentials. Our objectives were to characterize soils and vegetation, to compare soil properties with those of pre-SMCRA mined lands that were reforested successfully, and to determine the effects of site age on measured properties. Soils were sampled and dominant vegetation characterized at up to 10 points on each of 25 post-SMCRA mines. Herbaceous species were dominant on 56%, native trees on 24%, and invasive exotics on 16% of assessed areas. Mean values for soil pH (5.8), electrical conductivity (0.07 dS m^{-1}), base saturation (89%), and coarse fragment content (50% by mass) were not significantly different from measured levels on the pre-SMCRA forested sites, but silt+clay soil fraction (61%) was higher, bicarbonate-extractable P (4 mg kg^{-1}) was lower, and bulk density (1.20 g cm^{-1}) was more variable and often unfavorable. Pedogenic N and bicarbonate-extractable P in surface soils increased with site age and with the presence of weathered rocks among coarse fragments. Our results indicate a potential for many of these soils to support productive forest vegetation if replanted and if cultural practices, including temporary control of existing vegetation, soil density mitigation, and fertilization, are applied to mitigate limitations and aid forest tree reestablishment and growth.

The Appalachian region in the eastern United States contains abundant coal resources and supports the world's most extensive temperate deciduous forests (Riitters et al., 2000). Appalachian forests provide ecosystem services, including C storage, watershed and water quality protection, and habitat for diverse flora and fauna, and produce high-quality timber. Surface mining of coal in Appalachia has transformed forest lands to other land-cover types (Sayler, 2008; Drummond and Loveland, 2010).

More than 6000 km^2 in Appalachia have been mined for coal since 1980 under the US national coal mine reclamation law, the Surface Mining Control and Reclamation Act (SMCRA), and an additional >100 km^2 are being mined each year (USOSM, 2010). The SMCRA requires that miners "restore the land affected to a condition capable of supporting the uses which it was capable of supporting before any mining, or higher or better use" [Sec. 515(b)(2)]. Although the SMCRA contains a requirement for topsoil salvage and replacement during reclamation, it allows coal miners to obtain a variance from that requirement if an alternative material ("topsoil substitute") is more suitable. Appalachian mountain soils are often thin, rocky, and difficult to salvage on steep premining slopes, and fragmented geologic materials, known as "mine spoils," are often used as topsoil substitutes when constructing surface media (Daniels and Amos, 1985). It is a cost-effective and common practice to use the same spoil materials for landscape construction and as topsoil substitute, especially in mountainous areas. After placement, the mine soil materials are often graded to a smooth condition to stabilize the surface and prevent erosion, a procedure that compacts the surface (Angel et al., 2005). Mine sites are generally revegetated by hydroseeding with a mixture of herbaceous seeds (typically agricultural grasses and legumes) with fertilizer nutrients, a practice that creates dense herbaceous vegetation that is hostile to native trees and planted seedlings (Chaney et al., 1995; Skousen et al., 2006). If shrubs or trees have been prescribed for the postmining land use, these are generally hand planted as bare-root seedlings into the mine soil materials. Research has demonstrated that rock spoils reclaimed in this manner often form soil-like properties, including soil

J. Environ. Qual. 40:1567–1577 (2011)
doi:10.2134/jeq2011.0040
Posted online 25 July 2011.
Received 8 Feb. 2011.
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Assigned to Associate Editor Douglas Smith.

Abbreviations: BD, bulk density; BS, base saturation; CF, coarse fragments; EC, electrical conductivity; S+C, silt plus clay, as % of soil by mass; SiS+Sh, siltstones and shales; SMCRA, Surface Mining Control and Reclamation Act.