Soil quality and productivity responses to watershed restoration in the Ouachita mountains of Arkansas, USA

John A. Stanturf[1], Daniel A. Marion', Martin Spetich[3], Kenneth Luckow[4], James M. Guldin[3], Hal 0. Liechty[5], Calvin E. Meier[6]

1. US Forest Service, Center for Bottomland Hardwoods Research, MS 38776 USA
2. US Forest Service, Forest Hydrology Laboratory, Oxford, MS 38655, USA
3. US Forest Service, Southern Research Station, Hot Springs, AR 71902, USA
4. US Forest Service, Ouachita National Forest, Hot Springs, AR 71902,
5. School of Forest Resources, University of Arkansas at Monticello, AR 71656. USA
6. US Forest Service, Center for Bottomland Hardwoods Research, Pineville, LA 71360, USA

The Ouachita Mountains Ecosystem Management Research Project (OEMP) is a 'large interdisciplinary research project designed to provide the scientific foundation for landscape management at the scale of watersheds. The OEMP has progressed through three phases: developing natural regeneration alternatives to clearcutting and planting; testing of these alternatives at the stand scale; and the present Phase III which compares the effects of landscape scale ecosystem management in the Upper Lake Winona Watershed and measures cumulative impacts. This 6,586 ha watershed was divided into six sub-watersheds, each with a different management objective and treatments. One of these sub-watersheds and the focus of our study is the 1,364 ha North Alum Creek sub-watershed which is being managed to recreate a Shortleaf Pine-Bluestem Ecosystem.

The objectives of the study are (1) to determine the soil quality response to restoration methods of overstory density reduction, mid-story removal, and frequent burning; (2) to compare the long-term productivity of the shortleaf pine-bluestem woodland with the present shortleaf pine-mixed hardwood forest; (3) to characterize soil disturbance from logging and burning; and (4) to characterize the effects of these restoration treatments on streamflow quantity, water quality, and aquatic diversity. In this paper, we limit the focus to soil quality and productivity responses. We summarize from other studies the effects of the separate restoration' treatments on similar sites and hypothesize the combined effects on the watershed of the restoration treatments.

The restoration goal is to restore a vegetation complex characteristic of that found prior to European settlement of the region. This condition was dominated by pines, primarily shortleaf (*Pinus echinata*) with a minor hardwood component in the overstory, mostly *Quercus* spp. A native herbaceous understory dominated by bluestem grasses was maintained by' fire. Restoration is designed to mimic these conditions. Treatments applied to the North Alum Creek sub-watershed include commercial thinning of the overstory, with residual pines and scattered hardwoods in the main canopy at lower basal areas than in the controls. Total basal area of the restoration treatment will be approximately half the controls (15 m^2 ha" versus 27 m^2 ha-'). The predominantly hardwood midstory and understory will be removed by hand labor (chainsaws or handtools). Burning will be conducted at 2 to 5 year intervals for 10 years, during the dormant or growing season, with moderate intensity fires. Over time, sustainability will be achieved by an area-based approach using even-aged reproduction methods, primarily two-aged shelterwoods. The resulting stands will be open and park-like. Approximately 63,000 ha of shortleaf pine-bluestem ecosystems are planned to be restored on the Ouachita National Forest in Arkansas and Oklahoma.

Soils research on the Ouachita Plateau over the last 20 years has focused on changes in soil characteristics that result from specific forest management practices rather than soil and ecosystem processes (Liechty et al. in review). Little information exists on nutrient cycling' in shortleaf pine ecosystems, especially the potential for nutrient depletion after multiple rotations on the low to medium quality sites that typify the Ouachita Mountains. Soils are generally moderately deep to deep (50 cm to 150 cm) and frequently classified as Typic Hapludults (Luckow unpublished data). Shortleaf pine site index on the deeper soils ranges between 18 m and 21 m at age 50. On soils with depths of less than 50 cm, site index is typically between 12 m and 15 m.

On steep upper slopes, site index can be as low as 9 m (Guldin 1986; Graney 1986). Most of these soils have moderate to severe erosion potential, which can be predicted from rock content; the greatest potential is in soils of less than 15% rock (Luckow 1998).

Total organic matter in fine. and non-woody forest floor components is relatively insensitive to harvest intensity but there are drastic differences in coarse woody debris (Liechty and Shelton 1998). Prolific herbaceous growth above- and belowground follows harvesting and offsets the toss of leaf litter from the reduced canopy. The differences in coarse woody debris are related to the amount of logging slash. Fire on the other hand reduces the amount of forest floor with greater reductions found on sites burned repeatedly over a number of years (Masters et al. 1993). Organic matter content of surface mineral soils, however, has been found to increase as much as 14% in the upper 15 cm under a frequent burning regime (Luckow unpublished data).

Studies have shown that short-term reductions in soil nutrient pools following harvesting are minimal (Stoin et al. 1985). Changes in nutrient levels following harvest are profoundly influenced by the level of hardwood removal. For example, concentrations of Mg and Mn were reduced in one study where hardwoods were removed as the hardwood foliage typically contains 40% to 50% higher concentrations than pine foliage (Liechty and Shelton 1998).

Nevertheless, these studies do not indicate the long-term impacts of harvesting and tree removal. In particular, they do not indicate the long-term impacts of permanently changing to a system where the herbaceous component dominates nutrient cycles. In fact, fire has been found to increase soil nutrient pools and could enhance site productivity (Waldrop et al. 1987). Short-term studies of these restoration techniques indicate increased levels of soil pH, percentage organic matter, cation exchange capacity, percent base saturation, and available N, K, Ca, and Mn. Although not significant, soil P tended to be lower.

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