IMPACTS OF PINE BLUESTEM RESTORATION ON NUTRIENT REGIMES OF SHORTLEAF PINE-HARDWOOD STANDS IN THE OUACHITA MOUNTAINS OF ARKANSAS

Hal O. Liechty, Kenneth R. Luckow, and James M. Guldin[†]

The current forest and vegetative communities of the Ouachita Mountains reflects fire suppression that followed removal of the virgin forests during the late 19th and early 20th century (Bukenhofer and Hedrick 1997). Shortleaf pine (*Pinus echinata* Mill) still dominates the overstory of these second growth forests but current forests contain a much higher density of hardwoods than did the frequently burned, virgin shortleaf pine forests (Foti and Glenn 1991). Woody understory vegetation, rather than the forbs and grasses that occurred in the more open grown virgin forest, dominate the understories of these second growth forests. In an effort to provide habitat for red-cockaded woodpeckers (*Picoides borealis*) and other biota, the Ouachita National Forest is currently restoring shortleaf pine-bluestem grass (SPBG) ecosystems to a portion of this region (Bukenhofer and Hedrick 1997). Restoration includes harvesting and competition control to reduce pine and hardwood basal areas to approximately 13-14 and 2-3 m^2/ha respectively. In addition prescribe fires are performed on a 3-5 year interval during the dormant season to reduce understory woody vegetation (Masters et al. 1996). To better quantify the effects of long-term shortleaf pine bluestem restoration activities on nutrient availability, we compared mineral surface soil chemistry and foliar nutrient concentrations in stands that had experienced SPBG restoration activities for 17-21 years to those in unrestored stands. We feel that results from this study may be applicable to land managers who are converting dense mixed hardwood stands to more open oak woodlands, since both practices significantly reduces stand density, initially adds large amounts of hardwood woody debris to the forest floor, and utilizes repeated prescribed fires to control unwanted vegetation and alter understory composition.

Six shortleaf pine-hardwood stands were used for the study. Three stands had not received any restoration or silvicultural activities for a period of 40 years prior to the study and were typical closed canopy shortleaf pine-hardwood stands (control). The other three stands were restored SPBG stands. Initial overstory and midstory harvesting and competition control activities occurred from 1978-1980 in the SPBG stands. Midstory and overstory hardwoods that were felled were typically left on the ground due to the lack of suitable hardwood markets. Prescribed fires were generally applied on a 2-4 year interval starting between 1978-1980. The last prescribed fire at all three SPBG stands occurred during March of 1997 prior the initiation of the study. All stands occurred on Carnasaw or Sherless soils series (NRCS 1998) and have loamy surface textures. These soils have similar surface soil (35-50 percent) and subsurface soil (35-40 percent) rock contents. Stands chosen for the study were located on 10-20 percent slopes, on southern to southwestern aspects at elevations between 237 and 317 m above MSL, and within 2-3 km or 34° 47′ N Latitude and 94° 10′ W Longitude.

Mineral soil to a depth of 15 cm from five locations and current year foliage from five dominate shortleaf trees was collected from each of four 25-35 m diameter plots in each stand. Soils and foliage were collected in the fall for three consecutive years following the March 1997 fires. Soils were air dried and sieved through a 2 mm screen. Soil pH (1:2 soil:water ratio), total nitrogen and carbon (Leco CN analyzer), mineralizable N (anaerobic incubation), and P, K, Ca, and Mg (Mehlich III extraction) were determined. Foliage was collected from the top 1/3 of the crowns. Foliage was ground to pass a 1 mm sieve and then N, P, K, Ca, Mg, and S concentrations were determined following either a micro-Kjeldhal or a perchloric digestion.

[†]Associate Professor (HOL), Soil Scientist (KRL), Project Leader (JMG), respectively School of Forest Resources, University of Arkansas-Monticello, Monticello AR (870) 460-1452, liechty@uamont.edu; U.S. Department of Agriculture, Forest Service, Ouachita National Forest, Box 1270, Hot Springs AR; Southern Research Station, U.S. Department of Agriculture, Forest Service, Box 3516, Monticello AR.

Table 1.—Mean surface soil (0-15 cm) charteristics collected during the fall of 1997-1999 within three shortleaf pine bluegrass stands (SPBG) and three control stands in the Ouachita Mountains of Arkansas.

	SPGB	Control	P-Value
pH	5.3	4.9	0.010
C (g/kg)[1]	25.6	19.8	0.003
C:N[1]	20.9	17.9	0.016
N (g/kg)[1]	1.2	1.1	0.041
Min. N (mg/kg)	59.8	50.4	0.011
P (mg/kg)	6.2	7.0	0.379
K (mg/kg)	76.0	66.1	0.142
Ca (mg/kg)	533.1	332.2	0.031
Mg (mg/kg)	117.2	134.7	0.525

[1]Measurements only from the fall 1999 sample collection

In 1998 shortleaf pine and hardwood basal areas averaged respectively 24.3 and 8.4 m^2/ha at the control stands and 15.8 and 3.7 m^2/ha at the SPBG stands. Surface mineral soil pH, mineralizable N, C:N ratios, as well as Ca, N, and C concentrations were consistently higher in the SPGB stands than the controls (table 1). Increases of pH and Ca frequently occur following fire (Fisher and Binkley 2000). However, increases of soil Ca concentrations have also been reported following harvesting in mixed oak stands (Johnson and Todd 1998) and attributed to decomposition of Ca rich slash and woody debris. Initial harvesting and competition control in shortleaf pine-hardwood stands within the Ouachita Mountains frequently adds large amounts of hardwood woody debris to the forest floor because there are poor markets for hardwood pulp and sawtimber. Increases of C, N, and mineralizable N have also been reported following harvesting and application of fire. However, we believe that the large increases in C, N, mineralizable N as well as Ca observed in this study were due to the combination of these two silvicultural treatments. Masters et al. (1993) reported that increases in nutrient concentrations in soils of shortleaf pine-hardwood stands were much greater when these two treatments were combined than they were applied individually. Our results support this conclusion since increases in pH and Ca were generally greater than those reported for McKee Jr. (1991) following application of dormant season fires in southern pine stands on similar intervals and time spans as those utilized in this study.

Alterations of foliar nutrient concentrations of the dominate and codominate shortleaf pine were also evident (table 2). During the fall immediately following the March 1997 prescribed fire, foliar concentrations of N, P, and K were higher in the SPBG stands than the control stands. Only foliar concentrations of K remained elevated in the SPBG stands during the entire study period. It seems likely that the short-term increases in foliar N and P were directly related to an increase in available N and P following the fire. The elevated concentrations of foliar K for a longer period of time reflect a more long-term impact of fire and/or the reductions in stand densities within the restored stands.

These results indicate that harvesting and prescribed fire associated with pine bluestem grass ecosystem restoration has altered nutrient regimes in these stands. However, rather than having a negative impact and a reduction in nutrient availability, these activities have appeared to increase nutrient availability. Availability of N and Ca has increased in the soils of the restored stands. In addition concentrations of nutrients such as K have increased in the foliage of the shortleaf pine. We hypothesize that the use of similar harvesting and prescribed fire scenarios in at least poor quality dense mixed oak stands may have similar impacts. First, conversion of dense mixed oak stands to open woodland condition entails large reductions in overstory and midstory densities. Second, conversion of dense mixed oak stands like initial shortleaf pine restoration activities dramatically increases the amount of hardwood slash and downed woody debris in the stand. Finally, conversion of these mixed hardwood stands will most likely require recurring use of prescribed fire to maintain an oak dominated overstory.

Table 2.—Mean nutrient concentrations collected during 1997-1999 from shortleaf pine dominate and codominate trees in three shortleaf pine bluestem grass (SPBG) and three control stands in the Ouachita Mountains of Arkansas.

Nutrient	1997		1998		1999	
(g/kg)	SPBG	Control	SPBG	Control	SPBG	Control
N	12.5a[1]	11.4b	13.4b	14.2a	13.3a	13.8a
P	0.9a	0.8b	1.1a	1.1a	1.0a	1.0a
K	4.0a	3.6b	4.5a	4.2b	4.4a	4.0b
Ca	2.5a	2.2a	2.0a	2.1a	2.3a	2.4a
Mg	1.2a	1.2a	1.1a	1.3a	1.3a	1.4a

[1]Treatments for a given year and concentration with the same letter are not different at the p=0.05

Literature Cited

Bukenhofer, G.A. and Hedrick, L.D. 1997. **Shortleaf pine/bluestem grass ecosystem renewal in the Ouachita Mountains.** *In* Transaction of the Sixty-second North American Wildlife and Natural Resources Conference. March 14-18, 1997. Wash. D.C. *Edited by* K.G. Wadsworth. pp. 509-515

Fisher, R.F. and Binkley, D. 2000. **Ecology and management of forest soils**. 3rd Ed. John Wiley and Sons Inc., New York. 487 pp.

Foti, T.L. and Glenn, S.M. 1991. **The Ouachita Mountain landscape at the time of settlement.** *In* Proceedings of the conference on Restoration of Old Growth Forests in the Interior Highlands of Arkansas and Oklahoma. Ouachita Nat. For. Winrock Intern. Inst., 19-20 Sept. 1990. Morrilton, Ar. *Edited by* D. Henderson and L.D. Hedrick. pp. 49-65.

Masters, R.E., Engle, D.M. and Robinson, R. 1993. **Effects of timber harvest and periodic fire on soil chemical properties in the Ouachita Mountains.** Southern Journal of Applied Forestry 17: 139-145.

Masters, R.E., Wilson, C.W., Bukenhofer, G.A., and Payton, M.E. 1996. **Effects of pine-grassland restoration for red-cockaded woodpeckers on white-tailed deer forage production.** Wildlife Society Bulletin. 24: 77-84.

McKee, W.H. Jr. 1991. **Long-term impacts of fire on coastal plain pine soils.** Proceedings of an international symposium on Fire and the Environment: Ecological and Cultural Perspectives. 20-24, March 1990. USDA For. Serv. Gen. Tech Rep. SE-GTR-69. *Edited by* S.C. Nodvin and T.A. Waldrop. pp. 405-413.

Johnson, D.W. and Todd Jr., D.E. 1998. **Harvesting effects on long-term changes in nutrient pools of mixed oak forest.** Soil Science Society of American Journal. 62:1725-1735.