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S. A. Wilson
Stephen F Austin State University

K. W. Farrish
Stephen F Austin State University, kfarrish@sfasu.edu

B. P. Oswald
Stephen F Austin State University, boswald@sfasu.edu

H. M. Williams
Stephen F Austin State University, hwilliams@sfasu.edu

J. L. Yeiser
Stephen F. Austin State University

EFFECTS OF MIDROTATION INTENSIVE SILVICULTURE ON FOREST SOILS IN EAST TEXAS: FIRST-YEAR RESULTS

S.A. Wilson, K.W. Farrish, B.P. Oswald, H.M. Williams, and J. L. Yeiser[1]

Abstract—Intensive forest management is becoming increasingly common in east Texas. Included in intensive management are such practices as mid-rotation fertilization, prescribed fire, and herbicide application. There is insufficient information about the effects of these treatments on soil physical, chemical, and biological properties when applied at mid-rotation. The objectives of this research are to evaluate the effects of these treatments on soil physical properties including organic matter content and bulk density; chemical properties including soil nitrogen and phosphorus; and on populations of resident earthworms. Five replications were installed in each of two loblolly pine (*Pinus taeda* L.) plantations aged 15 and 17. Both were thinned in 1998. Accord SP and Chopper emulsion were ground applied in the fall of 1999. The prescribed burn treatment occurred the following spring. Fertilizer was applied one to two weeks after completion of the burn to supply 224 kilograms per hectare of N and 28 kilograms per hectare of P. First-year results are presented.

INTRODUCTION

Intensive forest management, which is considered essential for meeting future timber production goals (Vann and Brooks, 1983), is becoming increasingly common in east Texas. Included in intensive management are such practices as mid-rotation fertilization, prescribed fire, and herbicide application. For example, as of 1996, fertilizer was applied to more than 150,000 hectares of loblolly pine (*Pinus taeda* L.) plantations in the United States each year (Zhang and Allen, 1996).

Each of these silvicultural practices has a number of potential effects on forest soils and tree nutrition. Fire, especially, has been shown to alter soil nutrient status, pH, and organic matter content. Fertilization and herbicide may have both indirect and direct effects on soil properties. These treatments may also impact earthworm populations, which can have long-term effects on soil fertility and structure (Francis and Fraser 1998, Thornes 1980). However, there is little information on the effects of these treatments when applied at mid-rotation in southern pine silviculture.

This study examines the individual and combined effects of fertilization, herbicide application, and prescribed burning on soils under two recently thinned mid-rotation loblolly pine plantations in Cherokee County, Texas. Baseline soil physical and chemical parameters were measured and monitored after treatment. The effects of intensive silviculture on earthworm populations are largely unknown; and this study evaluated effects of treatment on resident populations of earthworms.

MATERIALS AND METHODS

Study Sites

This study is located on two plantations in Cherokee County, Texas. The first site, referred to as the Cherokee Ridge site (CR), is on 78 hectares owned by the International Paper Corporation. The trees were planted in 1985, and were thinned to a basal area (BA) of 13.1 square meters in 1998. Soils on this site have sandy surface horizons, and include the Darco (Grossarenic Paleudult), Teneha (Arenic Hapludult), and Osier (Typic Psammaquent) series. The second site, referred to as the Sweet Union site (SU), is located on 45 hectares of land that is also owned by the International Paper Corporation. The trees were planted in 1982, and were row-thinned to a BA of approximately 22.0 square meters in 1998. The soils on this site have sandy loam surface horizons, and include the Ruston (Typic Paleudalf) and Attoyac (Typic Paleudult) series.

Experimental Design and Treatment Application

The experimental design is a split-plot, with fertilization as the whole plot treatment and competition control (herbicide, prescribed burning, both, or neither) as the sub-plot treatment. Five replications consisting of two 32 meter by 158 meter whole plots were installed at each site. Nested within each whole plot are four subplots measuring 32 meters by 32 meters (0.10 hectare), which are separated by 10 meter buffer strips. Within each sub-plot is an 11 meter radius (0.04 hectare) measurement plot.

Treatment application began in October of 1999. A mixture of 4.5 liters Chopper (imazapyr), 2.2 liters Accord SP (glyphosate), 11.2 liters Sun-It 2 oil, and 76.7 liters of water per hectare was applied at the Cherokee Ridge site using

[1]Research Assistant, Associate Professor, Associate Professor, Associate Professor, and T. L. L. Temple Chair, Arthur Temple College of Forestry, Stephen F. Austin State University, P.O. Box 6109 SFA Station, Nacogdoches, TX 75962-6109, respectively.

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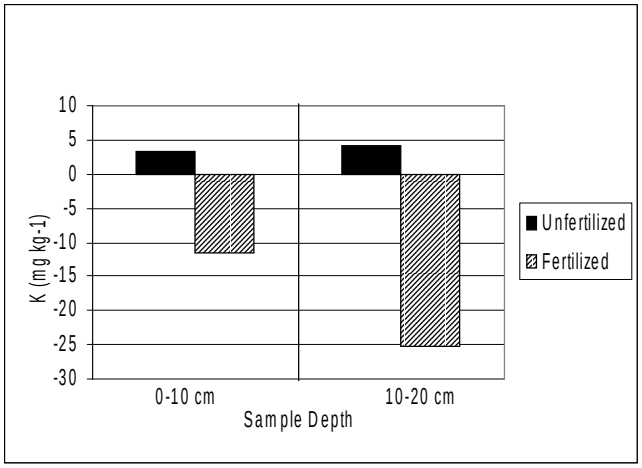

Figure 1-Change in K levels at the Cherokee Ridge site. In the fertilized plots, the level of K was greatly reduced by fertilization with urea and diammonium phosphate (DAP).

a backpack aerial sprayer with a 3.7 meter boom. At the Sweet Union site, a mixture of 4.5 liters Chopper, 2.5 liters Accord SP, 11.2 liters Sun-It 2 oil, and 76.7 liters of water per hectare was applied using the same backpack sprayer. Trees greater than 3.7 meters in height were injected with 100 milliliters of Arsenal AC (imazapyr) via the “hack and squirt” method; this is included in the total amount of imazapyr applied per plot. The prescribed burn treatment was applied in March of 2000, with fires applied as backfires to reduce damage from scorch. Tiles painted with heat-sensitive paints were installed in the center of each measurement plot to estimate temperatures at four levels: below the surface, ground level, 0.33 meter, and 0.66 meter. Fertilizers were applied in April of 2000, using diammonium phosphate and urea to supply 224 kilograms per hectare of nitrogen (N) and 28 kilograms per hectare of phosphorus (P).

Sampling Procedures

Soil samples were taken in July of 1999 and July of 2000 using an impact sampler and a bucket auger. Soil was sampled in three depth increments (0-10 centimeters, 10-20 centimeters, and the top 10 centimeters of the first B horizon), which were analyzed separately. The Soil, Plant, and Water Analysis Laboratory of Stephen F. Austin State University measured all micro- and macronutrients with the exception of N and P via the Ammonium Acetate EDTA method. P was measured using the Bray I method, and total N was determined via a LECO C/N Analyzer by the same lab. Earthworms were hand-sorted from a 0.25 meter sub-plot randomly located within each measurement plot. They were counted in the field, then were taken to the lab, re-counted, then oven-dried for biomass determination

RESULTS AND DISCUSSION

Cherokee Ridge

Competition control had no significant impact upon measured soil properties during the first year following treatment at this site. Soil pH was not affected by any of the treatments, nor was soil bulk density (Db). Organic matter content, measured as percent carbon, was also unaffected. Earthworm populations decreased at this site, from 376,000 per hectare in 1999 to 145,000 per hectare in 2000, a decrease of 61.4 percent. However, the population decrease was not correlated to forest management practices.

Total N was not affected by fertilization, but displayed a trend towards increasing in fertilized plots. Bray I-P remained constant regardless of fertilization. However, K dropped significantly (alpha = 0.05) as a result of fertilization in the top two samples (figure 1). The decrease

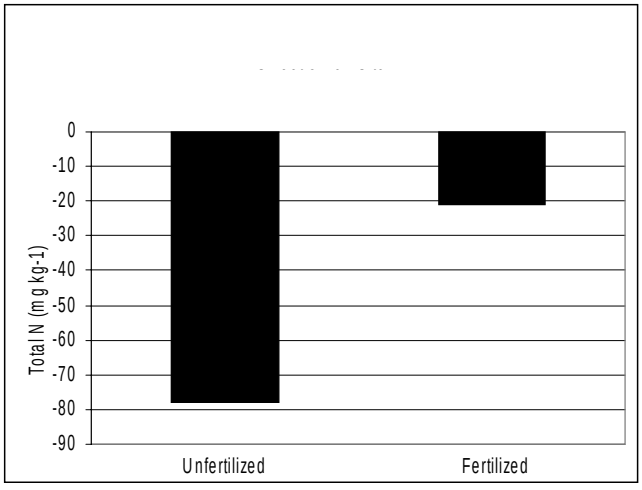

Figure 2-Change in total N at the Sweet Union site. Total N decreased in both fertilized and unfertilized plots, but decreased significantly less in the fertilized plots.

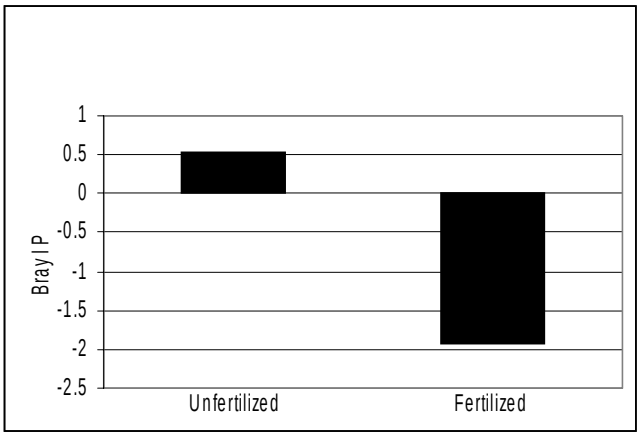

Figure 3-Change in Bray-I P at the Sweet Union site. Bray-I P increased in the unfertilized plots, and decreased in the fertilized plots, most likely due to uptake.

in K was most likely caused by leaching and was exacerbated by the sandy texture of the soils on this site.

Sweet Union

Soil bulk density and organic matter were unaffected by treatment at this site. Competition control had no significant effects on soil nutrient levels at this site. Earthworm populations decreased at this site as well, from 980,000 per hectare in 1999 to 734,000 in 2000, a decrease of 25.1 percent. This decrease was not correlated to management practices.

At this site, total N was unaffected by fertilization in the top 20 centimeters, but displayed a trend towards a decrease in fertilized plots. At the top of the B horizon, however, total N decreased significantly in both fertilized and unfertilized plots, but decreased less in plots receiving fertilization (figure 2).

Bray I-P was unaffected in the top 10 centimeters. In the 10-20 centimeter depth, P increased slightly in the unfertilized plots and decreased in the fertilized plots (figure 3). This is probably an uptake response.

At this site, magnesium was the only micronutrient that was significantly affected by fertilization; levels of Mg dropped in the 0-10 centimeter and B horizon depths. Leaching resulting from the influx of ammonium cations from fertilization probably caused this decrease. Soil pH also decreased in the 10-20 centimeter depth as a result of fertilization.

Both Sites

Of all of the treatments applied, fertilization was the only one to have significant impacts on the soils at these sites. Although fire can often have a number of effects on soils, the fires at these sites were relatively cool, which has minimized the fire impacts at these sites. The herbicides used in this study did not appear to have any effects on the soil properties that were measured.

The drought that the east Texas region has experienced for the last several years has almost certainly affected the outcomes of this project, especially the earthworm study. Although none of the treatments had statistically significant effects on earthworms, several trends became apparent during the course of sampling. Earthworm populations tended to be somewhat higher in plots that received herbicide and prescribed fire, either alone or combined, than in the control plots. Fire, especially, appeared to be beneficial; James (1988) found similar results in tallgrass prairie ecosystems. Furthermore, earthworm populations tended to be lower in plots that received fertilization than in the control plots. The number of sample plots for earthworms will be increased for the second sampling period of this study in the summer of 2001.

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