SYNOPSIS

Project Number: 05
Start: June 1, 1991
End: May 31, 1994

Title: Altering Vegetation During Forest Regeneration to Influence Water Quantity and Quality

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Focus Categories: \[ \mathcal{E} \mathcal{L} - \mathcal{M} \mathcal{D} - \mathcal{G} \omega \]

Congressional District: Third

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Problem and Research Objectives:

Forest managers can choose among several methods to regenerate upland forests after harvest. Some methods reduce abundance of herbs, hardwood trees, or both to favor establishment and early growth of pine. Other methods encourage establishment of all three plant life forms. Because pines, herbs and hardwood trees differ in their growth rates, depth of rooting, use of soil nitrogen, and timing of root growth, the abundance of the three life forms may have important impacts on water flow through the forest ecosystem, and the nitrogen concentration in that water. Thus, forest managers have the potential to influence ground water quantity and quality by the choice of regeneration method.

The objectives of this project were to: 1) measure soil water and nitrogen use by vegetation in a newly regenerated forest system, and determine implications for changing ground water quantity and quality; 2) determine the degree to which differences in species composition influence water use, nitrogen uptake, and ground water inputs; and 3) ascertain which growth, physiological, and morphological characteristics of the tested plant species are most strongly associated with patterns of water use.

Methods:

During fall 1991, a mature slash pine forest on Alabama Agricultural Experiment Station property near Auburn, AL was harvested. Shortly after harvest, 21 plots, each 7 X 7 m in size, were delineated and surrounded by 1.2 m deep trenches to cut roots going into or out of plots. During winter and spring of 1992, each plot was instrumented with 8 minirhizotron tubes, 5 soil lysimeters, 6 temperature probes, 6 sets of time domain reflectometry rods and wave guides to measure soil moisture, and
a water table well. In late spring, the following seven vegetation treatments were installed on three plots each: pure herbaceous, pure hardwood, pure loblolly pine, and all possible mixtures of the three. Vegetation was manipulated by selective use of herbicides, planting, and hand weeding. By May, 1992, the first measurement of root growth, soil water nitrate and ammonium concentration, soil temperature, and water table depth were completed. Between June 1992 and June 1993, three sets of stereo-photos and ground surveys of each plot were taken to estimate above-ground vegetation biomass. By June, 1994, more than 15 measures of soil temperature and soil moisture were made along with 7 soil water and 10 root density collections.

Principal Findings:

Root Dynamics. From May 1992 through July 1994, ten minirhizotron samples were collected. For all samples, significant differences in root densities were found among treatments. In general, treatments containing herbaceous vegetation had higher root densities, particularly within 30 cm of the soil surface. From May 1992 to May 1993 the pine only treatment had the lowest root density at all depths. Rapid growth of herbaceous roots was expected because herbs must complete their life cycles before dominance of the site by woody plants (i.e., within 6-12 years). The faster growth in hardwoods compared to pines reflects the smaller initial size of the planted pine. By the end of the study the root density of pines caught up with those of the other treatments.

Treatments also had differences in the vertical depth profile of density. By 1994, pines had a peak of root density in the surface soil layers and also at the 70 to 90 cm depth. Herbaceous and hardwood plots had their greatest densities near the surface. The addition of pines and herbaceous plants resulted in density peaks at both soil depths while the addition of pines and hardwoods did not. The lack of additive effect in pine plus hardwood may be due to the poor performance of pines when grown with hardwoods. Pines had twice the crown volume index in pine plus herbaceous plots than in pine plus hardwood plots. This is probably a direct result of competition for light between pines and the hardwood overstory.

Water Quantity. Overall soil moisture levels were significantly lower at all depths in the 1993 growing season than in the 1992 growing season. The difference between years reflects greater transpiration demands and interception losses as vegetation develops over time.

During the 1992 and 1993 growing seasons, the pure hardwood treatment tended to have lower soil moisture levels than the herbaceous and pine treatments, especially at the lowest depths. Apparently, hardwoods intercepted or transpired more water than did the other treatments. Overall, pine had the greatest mean soil water content. Pine plots also had the greatest soil
temperature in 1992 and 1993. With more water and greater temperatures, pine plots had the greatest potential for organic matter decomposition and subsequent nitrogen mineralization.

**Water Quality.** A nitrate pulse was observed for pine only plots in the 1992 growing season but not for any of the other vegetation treatments nor for pine only plots in 1993. Ammonium levels were generally low for all treatments in both years.

The high concentrations of nitrate were unexpected. Some of the individual levels measured at the 20 and 60 cm depths: 1) exceeded EPA recommended drinking water standards; and 2) approximated levels seen in forest nurseries and row crops where nitrogen fertilization is usually applied. This was not a simple concentration effect because soil moisture levels were also highest in pine plots. These data show, therefore, that choice of regeneration method may have an impact on water quantity and quality in the Coastal Plain of the Southeastern U.S. However, in most operational reforestation efforts, vegetation removal is not as severe as in the pine only plots of this experiment. Nonetheless, surveys of nitrate in soil water and groundwater at operational sites may be needed to determine if a large-scale problem does exist.

**Publications and Student Participation:**

**Publications.**


**Manuscripts Submitted for Publication.**


Graduate Students with Significant Involvement in Study.

Douglas G. Pitt, Ph.D., Graduated August, 1994
Walter H. Burch, M.S. Graduation Anticipated December, 1994