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SOIL RESPONSE TO CLEARCUTTING AND SITE PREPARATION IN EAST TEXAS[1/]

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Abstract.-- On an east Texas forest site, clearcutting and site preparation did not change the soil pH. Chopping and KG blading significantly reduced organic matter in the surface soil, while burning slightly increased it. Organic matter showed a positive and significant relationship to potassium, calcium and magnesium. All site treatments increased phosphorus and potassium, with the greatest increase on the burned plots. Calcium and magnesium contents also increased with burning but decreased with KG blading. Burning appeared better than the other treatments for maintaining or improving the soil nutrient regime. However, planted loblolly pine seedlings survived and grew best with mechanical treatments that controlled competing vegetation.

INTRODUCTION

For fifty years clearcutting has been a serious issue among forest managers. In the late twenties and early thirties, many European foresters expressed concern about the effects of clearcutting on the soil. Wittich (1930) found no biological changes in the soil after clearcutting in Germany and attributed temporary changes in the nutrient regime to the transition from one plant successional stage to another. Fehér (1931) in Hungary supported Wittich's findings that the effects of clearcutting are short-lived and are reversed by the beneficial shading of upcoming vegetation.

The clearcutting issue became more complicated with the addition of questions about its unsightliness and loss of wildlife habitat. But the current controversy centers largely on loss of soil productivity. As a result, court decisions have banned clearcutting in many parts of the United States. Facts are needed to clarify some of the misunderstandings between proponents and opponents of clearcutting and site preparation. Recent studies in New Hampshire and in the central and southern Appalachians indicated relatively little adverse effects from clearcutting on soil nutrients (Reinhart 1973).

OBJECTIVE

The objective of this study was to determine soil response to timber clearcutting and the preparation of planting sites in the loblolly-shortleaf pine-hardwood forest type that covers nearly 70 million ac in the South and reaches its westernmost extension in east Texas.

STUDY SITE

The study site was located on a nearly level to gently sloping terrace on the Angelina River in Jasper County, Texas. The tract, owned by Temple-Eastex, Incorporated, had never been cleared for agricultural crops, although it was probably grazed by livestock in the past (Stransky 1976).

The area is part of the Gulf Coastal Plain's Quaternary deposits, which are underlain by sands, sandstones, and clays of the Tertiary's Oligocene period (Dumble 1918).

Soils belong to the Bernaldo-Elysian complex and to the Sacul series. Bernaldo-Elysian soils are moundy and occur in such a complex pattern that separation is very difficult. Bernaldo soils (Glossic Paleudalfs, fine-loamy siliceous) occupy the lower part of the mounds and most of the

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adjoining low areas, and compose about 50 percent of the mapped areas. Elysian soils (Haplic Glossudalfs, coarse-loamy, siliceous) occupy most of the large mounds and compose about 40 percent of the area. The major difference between these soils is that the sandy surface layer is more than 20 inches thick on the Elysian soil, but is thinner on the Bernaldo. Slopes of both soils range from 0 to 3 percent. These are well drained, moderately permeable soils that have slow runoff.

Sacul soils (Aquic Hapludalfs, clayey, mixed) occur at the head of drains and normally have a concave topography. They occupy slopes from 1 to 6 percent, are moderately well drained, and have slow permeability.

Summers are hot and humid, and the winters mild. The growing season is about 240 days long. Annual rainfall averages about 51 inches, but in 1972, 1973, and 1974 it was 54, 87, and 70 inches; often interfering with planned study activities.

On the experimental site, loblolly pine (Pinus taeda L.) and some shortleaf pine (Pinus echinata Mill.) occurred in admixture with southern red oak (Quercus falcata Michx.), post oak (Quercus stellata Wang.), water oak (Quercus nigra L.), sweetgum (Liquidambar styraciflua L.), and blackgum (Nyssa sylvatica Marsh.).

Prominent shrubs were American beautyberry (Callicarpa americana L.), yaupon (Ilex vomitoria Ait.), blackberry (Rubus spp.), and southern waxmyrtle (Myrica cerifera L.). Carolina jessamine (Gelsemium sempervirens (L.) Ait. f.), muscadine grape (Vitis rotundifolia Michx.), and greenbriers (Smilax spp.) were the most prominent vines.

Longleaf uniola (Uniola sessiliflora Poir.), devils's grandmother (Elephantopus tomentosus L.), and two-eyed-berry (Mitchella repens L.) were the most abundant herbaceous plants.

STUDY METHODS

Design and Treatments

In September 1972 all the merchantable trees were cut and removed from the study area. During February and March 1974 the following site preparation treatments were applied to 1 1/2 ac plots in a randomized block design with unequal replications:

Control--No site preparation, all woody stems greater than 1 inch in diameter at breast height (d.b.h.) were cut.
Burn--all stems greater than 1 inch d.b.h. were cut and burned with the logging slash. Fanned by a steady wind of about 12 miles per hour, the head fire consumed the tops of all herbaceous plants, most shrubs and small trees, nearly all the leaf litter, and all but the large branches of the logging slash.
Chop--logging slash and all stems were cut with a chopper and burned. The chopper resembles a huge lawn roller equipped with cutting blades parallel to the long axis of the cylinder. Pulled by a large crawler tractor, the chopper cut non-merchantable trees and shrubs into small chunks and crushed the debris into the surface soil. The chopped plots have been prepared in October 1972, but heavy rains prevented completion of the other treatments. These plots were rechopped when the other site treatments were applied.
KG--all stems were cut with a KG blade, and the logging slash was raked off the plots and burned. The KG blade resembles a straight razor and is mounted at an angle on the front of a tractor. It sheared off all stems in its path. The cutting process greatly churned up the soil surface and pushed some litter and topsoil off the planting site.

The area was handplanted with 1-0 loblolly pine seedlings at 8 x 10 foot spacing in mid-March 1974.

Soil Response Measurements

In August 1972 (before clearcutting) and in December 1974 (one growing season after site treatments were applied) five 1 inch diameter soil cores were taken at the depth of 0 to 2 and 2 to 5 inches near each of 20 sample points that were established in the interior 1 ac center of each plot. The five individual samples from each depth were composited and analyzed for organic matter by loss on ignition, pH by glass electrode, phosphorus by the sulfomolybdic blue color method, and potassium, calcium, and magnesium by the atomic absorption method.

The 1972 and 1974 data were compared by analysis of variance. All testing was at the 0.05 percent level of significance. The Bernaldo-Elysian and the Sacul soils were combined and considered as one soil because initially (1972) neither forage yield nor most surface soil characteristics were significantly different between the two soil types.

RESULTS AND DISCUSSION

Clearcutting itself probably did not remove sizeable amounts of nutrients as only the logs were taken from the area. The upper stems and crowns with their branches, twigs, and foliage were left on the ground to be incorporated into the soil by decay, fire, or chopping. Nutrient losses from this type of logging are small because the logs contain few nutrients, and most are in the leaves and twigs (Stone 1973). Some leaching of soil nutrients could occur after clearcutting, but rapid revegetation usually protects the soil surface and continues to add nutrients (Burns and Hebb 1972, Stransky et al. 1974).

pH

Soil pH values were similar for all treatments and at both soil depths before and after site preparation (Table 1). This result is somewhat in contrast to another study that shows small increases in pH by burning (Wells 1971).

Organic Matter

In both 1972 and 1974, organic matter was about two times higher in the surface soil than in the 2 to 5 inch depth (Table 1). Differences between plots were not significant in 1972, but in 1974 the soil on the chopped and KG plots had significantly less organic matter content in the surface soil than the control and burned plots.

Several studies have described the positive relationship between fertility and organic matter content of southern forest soils. Stransky (1961, 1964) showed that the growth of planted pine seedlings was retarded by organic matter removal. Thus, the decreased organic matter on the chopped and KG plots can possibly influence the future productivity of the site. The effects of litter and slash removal are likely to be most pronounced where hardwoods predominate because the hardwood litter contains more nutrients and decomposes faster than pine litter (Alway et al. 1933, Coile 1937).

The explanation for the lowered organic matter content on the KG plots is fairly obvious. The organic matter was simply removed from the plots. Haines et al. (1975) warned that such practices would be detrimental to the soil nutrient regime, and Hicock et al. (1931) noted that the removal of litter alone would seriously deplete organic matter reserves.

The losses with chopping are difficult to explain as no organic matter was removed from the plots. The slash was broken up by repeated chopping and pressed into the soil surface, possibly resulting in more rapid decay. Because of heavy rains in 1973 and 1974, some of it could have been washed from the ridges into the valleys cut by the chopper blades. As only the ridges were sampled, some of the organic matter may have been excluded. It is unlikely that the organic matter moved to lower soil depths as the 2 to 5 inch depth showed no increase.

Phosphorus

Before clearcutting, the soils had a higher phosphorus content in the surface layer than in the 2 to 5 inch depth. After the timber was cut and the sites prepared, however, the differences between depths became non-significant (Table 1). In this study it appeared that phosphorus increased in the lower depth as a result of leaching from the surface.

Table 1.-- Soil characteristics before clearcutting (1972) and after site preparation (1974).

Soil Characteristics	Soil Depth (in)	Site treatments: Control 1972	Control 1974	Burn 1972	Burn 1974	Chop 1972	Chop 1974	KG 1972	KG 1974
pH	0-2	5.3	5.3	5.4	5.5	5.6	5.6	5.2	5.4
	2-5	5.3	5.3	5.5	5.5	5.7	5.6	5.3	5.4
Organic Matter (percent)	0-2	5.8	5.2	5.3	5.6	5.7	4.4	6.0	3.6
	2-5	2.8	2.5	2.4	2.6	2.7	2.6	3.0	2.0
Phosphorus (ppm)	0-2	6.5	5.2	5.4	6.4	4.0	4.4	4.7	5.5
	2-5	3.7	4.6	3.5	4.6	1.9	4.0	2.0	5.8
Potassium (ppm)	0-2	39.3	39.9	30.7	38.9	30.8	34.2	31.2	34.2
	2-5	16.3	19.7	16.9	18.4	18.9	19.4	17.5	18.7
Calcium (ppm)	0-2	243.6	286.4	180.6	232.4	232.7	227.0	157.2	145.3
	2-5	85.4	84.3	65.1	67.0	99.7	87.7	46.9	46.0
Magnesium (ppm)	0-2	65.2	50.8	51.6	54.8	42.6	43.8	49.9	38.0
	2-5	41.0	27.9	22.0	19.9	17.1	19.7	22.0	22.0

In 1972, the plots to be chopped and KG bladed were significantly lower in phosphorus than the control and burn plots, but the reason why was not obvious. In 1974, phosphorus had increased on all treatments except the control, and treatment differences were still significant. The greatest increase in phosphorus occurred on the burned plots, probably because of the phosphorus released in burning. The interactions of depth x treatments were not significant in either 1972 or 1974.

Potassium

Potassium content of the soil was consistently higher in the surface than in the 2 to 5 inch depth (Table 1). For an as yet unknown reason it was higher, too, in the surface soil of the control plots than on the other plots in 1972. After site preparation the treatment differences were no longer significant. This difference in potassium between years was significant in the surface soil, but not in the 2 to 5 inch depth, indicating greater increases in the surface between years. The depth x treatment interaction was non-significant in both years.

Calcium

Calcium content was significantly greater in the surface soil than in the 2 to 5 inch depth in both 1972 and 1974 (Table 1). Calcium contents at both soil depths were not significantly different between plots before cutting and site treatments. However, differences in calcium levels between treatments were significant for the surface soil layer in 1974 as a result of increases on the control and burned plots and slight decreases on the chopped and KG bladed plots.

Magnesium

Magnesium content was approximately two times higher in the surface soil than in the 2 to 5 inch depth (Table 1). In 1972, magnesium content was significantly higher on the control plots than on any others. In 1974, the KG bladed plots had the lowest content of magnesium in the surface soil, probably because raking the logging slash off the plots removed organic matter.

Nutrient Relationships

Simple linear regressions indicated that organic matter was significantly related to calcium, magnesium, and potassium content of the soil. Other studies have also shown the close relationship between organic matter and mineral content of coarse-textured soils (Wilde 1946). The increase of phosphorus, potassium, calcium, and magnesium in the 0 to 2 inch layer of soil corroborates studies which indicate that fire benefits the soil nutrient regime in southern upland forests (Moehring et al. 1966, Stone 1971, Wells 1971).

However, despite of their generally lower nutrient regime and higher soil bulk density (Stransky 1981), the planted pines survived and grew best on the mechanically prepared sites where competing vegetation was effectively reduced (Stransky and Halls 1981).

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