SOUTHERN FOREST EXPERIMENT STATION

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PROPERTIES OF FORESTED LOESS SOILS AFTER REPEATED PRESCRIBED BURNS

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Nine annual burns have had little effect on the nutrient content and structure of the surface 4 inches of loess soils on flat terrain.

Because prescribed burns must often be repeated to obtain desired results, many foresters are apprehensive about the possible deleterious effects on soils. In 1954 the Timber Management Laboratory at Crossett, Arkansas, in cooperation with the Crossett Division of Georgia-Pacific Corporation, undertook a study of repeated burns in shortleaf-loblolly pine stands. The primary objective was to compare the efficacy of annual and biennial burns in eradicating small understory hardwoods. This note reports effects of the fires on the nutrient content and physical structure of the surface 4 inches of soil as measured after 10 years.

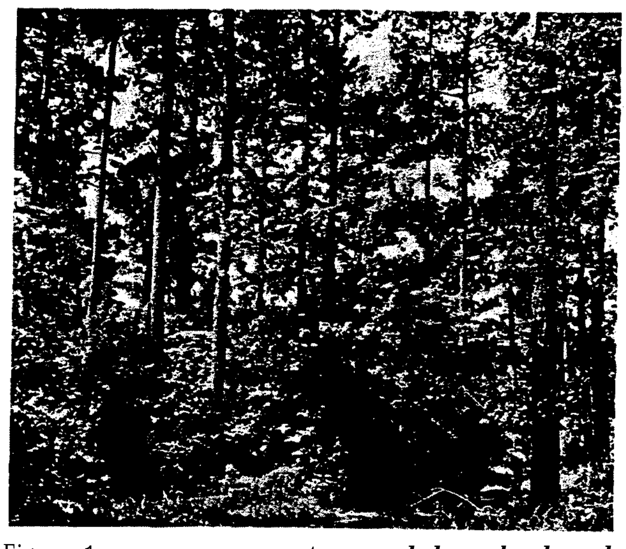

Figure 1 overstory ***and dense hardwood*** ground cover ***originally*** occupied ***the study area.***

METHODS

The test was made in an even-aged shortleaf-loblolly pine stand on Grenada and Calloway silt loams. These are imperfectly drained loess soils underlain by a fragipan at a depth of 18 to 24 inches. A 2 percent north-to-south slope provides good surface drainage. At the beginning of the study (fig. 1) the overstory consisted of pine averaging 64 square feet of basal area per acre and 15 inches d.b.h., and 17 square feet of oaks and gum averaging 8 inches d.b.h. The site was also occupied by a very dense understory consisting of 10,000 small hardwood stems per acre. The understory trees averaged 1.6 inches in diameter measured 6 inches above ground. They were predominantly southern red oak, sweetgum, and blackgum.

The effectiveness of annual and biennial fires in eradicating the small hardwoods was tested on eight O.l-acre plots-four for each treatment. Although not required in the original study, unburned check plots were needed to evaluate the effects of the fires on the soil. Therefore, in the autumn of 1964 four O.l-acre check plots were established in the unburned strip surrounding the burned area. Differences in soil properties between the burned and check plots were tested in a completely randomized design: the hypothesis was that the soil properties measured did not differ significantly among plots. This evaluation assumed that soil properties on all plots were similar in 1954 (as the vegetative cover was known to be), and that soil differences in 1964, if any, were attributable to burning.

Treatments.-One set of four plots was first burned in the winter of 1954-55 and then reburned in the summer of 1956 and each summer thereafter except during 1958. A second set of four plots was first burned in the winter of 1954-55 and reburned in the summer of 1957 and at 2-year intervals thereafter.

To determine the amount of fuel, litter was sampled prior to each burn at four fixed points adjacent to each plot. Fire severity was classified visually into three broad categories:

(1) Light: fire sluggish and discontinuous, leaving unburned patches. Surf ace litter consumed but lower layers largely intact. Leaves of hardwood understory scorched and base of stems lightly charred.

(2) Medium: momentum of fire well sustained, resulting in a clean, even burn of litter over the entire area. Some green hardwood leaves consumed and the remainder completely scorched. Decided charring of hardwood stems.

(3) ***Intense:*** clean, hot burn over the entire area. Litter, including lower layer, completely consumed. The leaves and the stem and branch ends of most small hardwoods ignited. Small hardwood stems deeply charred or destroyed.

Soil ***sampling and*** analysis.-Soil samples were collected in the autumn of 1964 before leaves fell. Near the four corners of each plot, one 70-cc. and two 250-cc. undisturbed cores were removed from each of two depths (0- to 2-inch and 2- to 4-inch) to determine soil porosity *(3)* and bulk density, respectively. Total pore space (P), in percent, was calculated as

$$P = 100 - \frac{(100)\ (\text{Bulk density})}{2.65}$$

Chemical properties were determined on duplicate composite samples taken along transects across each plot. Prior to analysis, each sample was air dried, thoroughly mixed, and ground to pass through a 2-mm. sieve. Samples were analyzed for pH (calomel-glass electrode, soil-water ratio of 1: 1), organic matter content (wet combustion), total nitrogen (Kjeldahl) , phosphorus (Bray and Kurtz No. 2), and exchangeable cations (neutral, 1.0 *N* ammonium acetate extract) . Detailed analytical procedures are outlined in Jackson (2).

RESULTS AND DISCUSSION

Effects on physical properties.-Bulk density and pore space are indexes to compaction, penetrability, aeration, infiltration, and percolation-properties important to soil stability and the growth of plants. In medium-textured soils such as loess, bulk density ranges from less than 1.0 for porous soils to about 1.6 for compact ones. An increase in bulk density tends to curtail root penetration, reduce aeration, and decrease rates of infiltration and percolation.

Pores may be divided into two types-large and small. Large pores detain water for 1 or 2 days and then permit ready movement of air. In contrast, small pores retain water for long periods and impede airflow. For purposes of this report, large-pore space is equivalent to the volume of water extractable from a soil in the range between saturation and 0.06 atmosphere (atm.) tension.

On both burned and check plots the bulk density of the 0- to P-inch depth was less, and the total pore space was greater, than in the 2- to 4-inch depth (table 1). The difference may be attributable to the higher organic matter content in the surface layer (table 2), which increases soil aggregation and thus reduces bulk density.

Bulk density and small-pore space did not vary by treatment, but in the 0- to 2-inch layer large-pore space was significantly less (0.01

level) on the annually burned than on the check plots. On the burned plots some soil aggregates probably crumbled and plugged large pores. In these flatwoods such plugging has small effect on the soil water regime; on steep terrain, infiltration and runoff might be adversely affected.

Table 1.—*Bulk density and pore space related to fire treatments*

Burning treatment	Bulk density	Pore space	
		Large pores	Small pores
	G. per cc.	*Percent*	*Percent*
0- to 2-inch depth			
Annual	1.18	5.9	49.6
Biennial	1.19	7.3	47.8
None (check)	1.12	8.5	49.2
2- to 4-inch depth			
Annual	1.34	5.8	43.6
Biennial	1.35	4.6	44.5
None (check)	1.34	4.5	44.9

Table 2.-Amount of *organic matter present in autumn* of 1964

Burning treatment	0- to 2-inch depth		2- to 4-inch depth	
	Percent dry weight	*Pounds per acre*	*Percent dry weight*	*Pounds per acre*
Annual	4.5	24,100	2.0	12,100
Biennial	4.7	25,300	1.9	11,600
None (check)	5.2	26,400	2.1	12,700

These results generally agree with those of metz et al. *(4),* who studied the effects of burning in pine flatwoods in South Carolina on very fine sandy loam soils with poor surface drainage and very slow permeability. They found that various burning treatments neither benefited nor adversely affected bulk density, pore space, or percolation rate.

Effects on soil nutrients and organic matter content.-Prior to the 1954 burn, the accumulated pine and hardwood litter averaged 11,300 pounds per acre. After 1959 the litter originated almost entirely from the overstory, and tended to stabilize at approximately 5,000 pounds per acre (fig. 2). This being the case, fire severity during the last 6 years was related to weather conditions rather than to fluctuations in the fuel supply. Although the fires killed the aboveground portions of practically all small hardwoods (fig. 3), the even distribution and quick-burning quality of the fuel virtually prevented incineration of the humus (A_{00}) layer and incrustation of the mineral soil surface.

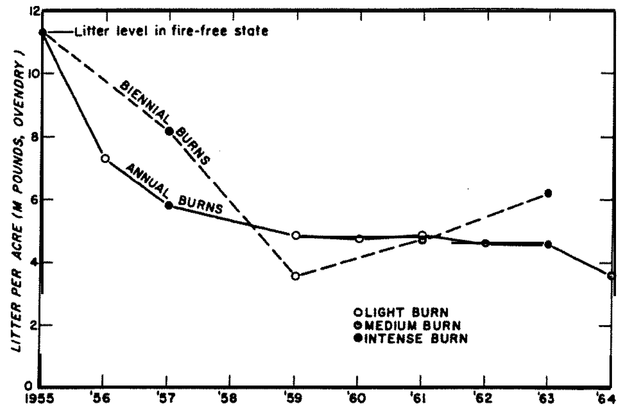

Figure 2.-*Litter supply trends and fire* severity.

Figure ***3.-Open aspect of area subjected to nine annual burns.***

When sampled in 1964, soil organic matter and nutrients varied by depth but not by treatment (tables 2 and 3). Other researchers have found that burning did not affect soil organic matter content, some have found that burning reduced it, and still others have reported an increase following burning *(1).* Contradictory results are not surprising, for the extent to which soil organic matter is affected by fire varies with soils, preburn vegetation, climate, humus type, and fire intensity.

Table 3.—*pH and* amounts of nutrients *related to* fire treatments

Treatment	pH	Exchangeable cations						Base sat.	N	C:N ratio	P
		Ca	Mg	Na	K	H	Total				
		- *Meq./100 g. dry soil* -						Percent	Percent *weight*		P.p.m.
					0- to t-inch depth						
Annual	5.9	4.3	1.2	0.2	0.2	3.4	9.3	63	0.13	20.3	10
Biennial	6.0	4.2	1.3	.2	.2	3.3	9.2	64	.15	18.3	7
None (check)	5.9	4.5	1.5	.2	.3	3.3	9.8	66	.16	19.0	6
					2- to I-inch depth						
Annual	5.3	2.0	.7	.2	.1	3.0	6.0	49	.08	14.8	3
Biennial	5.5	1.8	.8	.2	.1	2.8	5.7	52	.08	14.1	3
None (check)	5.5	2.1	1.0	.2	.2	2.8	6.3	56	.08	14.4	3

These results show that nine annual burns have had little effect on the surface 4 inches of soil. If in practice no more than this number of **burns** are made, it is reasonable to conclude that no harm will be done to loess soils on relatively flat terrain.

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