CHARACTERISTICS OF SOILS IN AN OAK-DOMINATED FOREST SUBJECT TO LONG-TERM PRESCRIBED FIRES IN FRANKLIN COUNTY, TENNESSEE

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ABSTRACT

Plots of land in an oak-dominated forest at the Highland Rim Forestry Experiment Station, Franklin County, Tennessee, have undergone 35 years of prescribed surface fires at 1- and 5-year intervals. The objective of this study was to determine whether the controlled burns have affected the chemical characteristics of the surface horizons. The soil at the study site was mapped as the Dickson series, which is classified as a fine-silty, siliceous, thermic, Glossic Fragiudult. A fragipan was present approximately 35–75 centimeters below the surface. Shallow rooting resulting from the fragipan was responsible for wind throw of trees on the site. The chemical characteristics of the upper portion of the soil (surface to argillic horizon above the fragipan) were determined by the following analyses: pH, percent total C, N and S, Mehlich I extractable soil nutrients (Ca, K, Mg, P), and KCl-extractable Al. There was no significant difference for chemical analysis among the different treatments from the surface horizon and underlying horizons down to the fragipan. On all of the treatment plots, similar chemical compositions of the E horizons and argillic subsurface (Bt horizons) above the fragipan suggested that the surface horizon chemistry was not greatly influenced by the fragipan. It appeared that the uneven distribution of ash, and perhaps previous land use practices and vegetational changes, was responsible for the variability.

keywords: barrens, chemical analysis, fragipan, Highland Rim, long-term prescribed fires, nutrient cycling, oak-dominated forest.

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INTRODUCTION

This study investigated long-term (35-year) controlled burns on plots of land in an oak-dominated forest in Franklin County, Tennessee. Despite much research interest in controlled burn treatments, only a few studies have been made of hardwood forests, especially under long-term prescribed burns. Prescribed fires increase net mineralization (Knoepp et al. 1993), nutrient mobility (Covington and Sackett 1984), and nutrient cycling (Christensen 1977) in forest stands. After fires, concentrations of the metallic cations (Ca, K, and Mg) may also increase due to ashfall, and P may increase due to increased decomposition (Christensen 1977).

On land protected from fire over lengthy periods of time, herbaceous vegetation decreases and there is an invasion of and increase in longer-lived woody species (Lewis and Harshbarger 1976). Fires are generally more intense after this fuel change, and lead to greater nutrient fluxes (Myers 1985). Variance in soil nutrients within a single area may be greatly increased by burning. The uneven distribution of ash is thought to be responsible (Christensen 1995).

The objective of this study was to determine whether long-term (35-year) controlled burnings have affected the chemical characteristics of the surface horizons of the soil under an oak-dominated forest at the Highland Rim Forestry Experiment Station in Franklin County, Tennessee. In addition, the data from this soil study will help determine whether there has been any long-term change in the chemistry of the soils since Thor and Nichols (1974) studied this site.

Site Characteristics

The study area at the Highland Rim Forestry Station in Franklin County is 6 kilometers southeast of Tullahoma, Tennessee. The burn plots, which comprise approximately 6.5 hectares, are located at 36°30′N; 86°08′W on the edge of the Interior Low Plateau Province (eastern Highland Rim) in middle Tennessee. This portion of the Highland Rim consists of broad ridge crests with an undulating upland landscape. The term "Barrens" was used as early as the 1700's (Haywood

Table 1. Previous fires and land use practices at the study site in Franklin County, TN.

Date	Land use
Present	Oak-dominated forest under long-term 35-year controlled burn study.
Early 1960's	Excess land containing the site was deeded to the University of Tennessee Agricultural Experiment Station.
1940's	Part of U.S. Army Camp Forest (World War II)—a POW camp and a place where Army maneuvers were carried out. After WW II, the area where the site is located became known as the Arnold Engineering and Development Center.
Mid-19th century	Most of the land was in farms or grazed woodland.
1780's	Early European settlers established farms. Area was known as the "Barrens."
400–11,000+ years BP (Historic, Woodland, Archaic, and Paleolithic Periods) (Martinez et al., 1969:361.)	Native Americans burned the land to attract game. (Paleo points[a] found in nearby Coffee Co., Tennessee.)

[a] Paleo points: projectile points from the Paleolithic period (>11,000 years BP).

1823:504) for the area in which the study site is found (DeSelm et al. 1974). This weakly dissected plateau landscape association extends from Smithville in Dekalb County, Tennessee, southwestward to the Tennessee River in north central Alabama. A considerable portion (54,675 hectares) of the barrens is located in Tennessee (Smalley 1983).

The climate is warm and humid with hot summers and cool winters. Temperatures range from −2.7–5.6°C in January and from 19.1–31.0°C in July. Precipitation ranges from 11.2 centimeters in January to 12.8 centimeters in July. The average annual precipitation is 146.3 centimeters (Owenby and Ezell 1992).

In 1963, 3 fire return interval treatments were established in 9 plots. These treatment plots of 0.73 hectares consisted of 3 controls, 3 periodic (5-year), and 3 annual (1-year) burn intervals. Controlled burns usually took place in March between 1000–1200 hours, at times of low relative humidity and light northwesterly winds. In addition to these burns, there is much evidence that fires occurred before the establishment of this burning experiment (Table 1). Soils were sampled in July 1996, 6 months and 3.5 years after the last annual and periodic burns, respectively.

Grass fires are sometimes started by train sparks from a railroad line that was established in the late 1800's about 300 meters from the study area (DeSelm et al. 1974). None of these fires, however, has affected the burn plots since the study began 35 years ago (M. Seay, Highland Rim Forestry Field Station, Franklin Co., TN, personal communication).

Vegetation

Striking vegetational differences are observed between the different treatment plots. Figure 1 shows the oak-dominated forest on a control plot where overstory trees and understory vegetation are dense. Figure 2 illustrates the increase in herbaceous vine and shrub cover and decrease in overstory on the 5-year-interval (5-YI) burn plots. Figure 3 shows the grass and forb cover and the decrease in overstory vegetation on the 1-year-interval (1-YI) burn plots. Table 2 lists the vegetation on the site as reported by DeSelm et al. (1991).

Fig. 1. Dense overstory and understory vegetation on a control plot in Franklin County, TN.

The Highland Rim Barrens flora has vegetation typical of 2 regions. One regional influence is western, which includes *Aster sericeus, Helianthus sipphioides, Prenanthes aspera,* and others. The other is a Coastal Plain influence, which includes *Hypericum denticulatum, Lespedeza angustifolia,* and *Rhexia mariana* (DeSelm and Clebsch 1991). The 1-YI plots have sparse grass growth and bare ground exposed to the effects of weather. Similar observations were reported for a pine forest subject to annual burns, but grass covered the once exposed areas after 2 years of protection from fires (Heyward 1937, 1939).

Soil

The soil at the site is mapped as the Dickson series, which is classified as a fine-silty, siliceous, thermic, Glossic Fragiudult. The Dickson series primarily occurs on the Highland Rim in middle Tennessee. This moderately well drained soil has a fragipan, and is

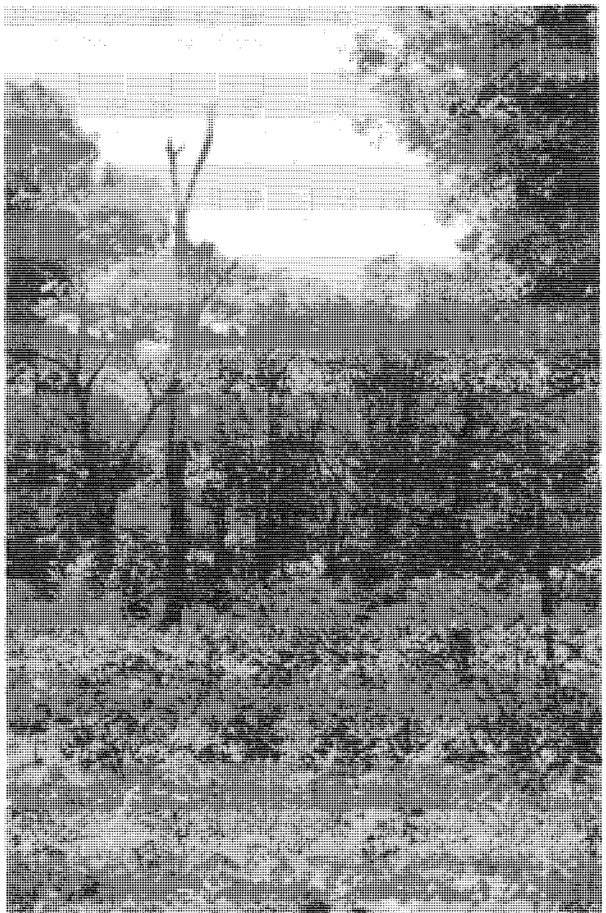

Fig. 2. Dense shrub and vine vegetation on a plot burned every 5 years in Franklin County, TN. The last 5-YI burn that took place before the sampling was in March 1993, 3.5 years before sampling.

present on broad ridges or plateau-like upland flats with slopes of 1.5–4%. At this study site, the Dickson series is associated with the Mountview and Guthrie soil series.

The upper 35–50 centimeters of this soil is a yellowish-brown layer derived from wind-blown loess that is thought to have been deposited during the Pleistocene Era (10,000–250,000 years BP). This silt loam material overlies a red, clayey residuum that developed from cherty Mississippian limestone. A fragipan is present directly above and in the upper portion of a zone where the loess and underlying old clayey residuum are mixed. On the study site, fragipan development appears to be variable, and water movement is restricted downward in the winter and spring and upward in the summer. Therefore, the annual moisture levels in the root zone are highly variable. Permeability is moderate above the fragipan and moderately slow to slow in the fragipan. The available water holding capacity is moderate, and water perches at 61.0–91.4 centimeters in depth (Campbell et al. 1995:117). Wind throw is a common problem on the site because the fragipan impedes the downward penetration of tree roots.

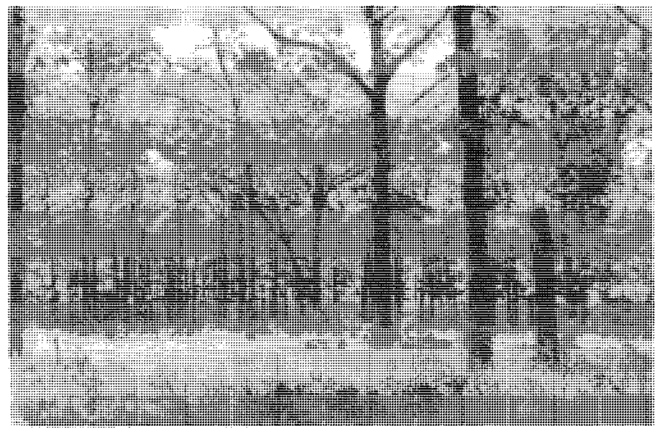

Fig. 3. Open grass area on a plot burned annually in Franklin County, TN. Tree density has decreased.

METHODS

Field and Laboratory Procedures

Soils were bulk-sampled from 4 areas on each of the 9 treatment plots. These samples were collected from a deep soil profile and auger-sampled from 3 points approximately 5 meters from this profile on each plot. Soil samples were taken from the surface down to the upper argillic layer (Bt1 horizon) in these carefully selected areas, which were undisturbed by wind throw. Intact samples of surface horizons were also collected for soil thin sections, which were made according to FitzPatrick (1993). To decrease chances of variability due to thickness of A horizons (controls: ~6 centimeters thick; 5-YI: ~5 centimeters thick; 1-YI: ~3 centimeters thick) that varied by treatment, A horizons were sampled at 4–5 centimeters. Separate samples for total N analysis were collected from the bulk samples, and placed in ice chests to retain field moisture and prevent consequent loss of N. These samples were kept in cool storage and analyzed within a week after sampling for total N, C, and S analysis. Bulk soil samples were air dried, sieved to separate fine (<2 millimeters) and coarse (>2 millimeters) fractions, and mixed separately. Chemical analyses were carried out on the <2 millimeter fraction.

Soil pH was measured with a 1:1 weight to volume (w/v) soil-to-H_2O and soil to 0.01M $CaCl_2$ solution. Percent total N, S, and C were determined on field moist samples with a Leco® carbon/nitrogen/sulfur analyzer. Soil nutrients (Ca, K, Mg, Na) were extracted using the Mehlich I (0.05M HCl in 0.0125M H_2SO_4) extraction and measured by emission (Mehlich 1953). Phosphorus was measured photometrically (Nelson et al. 1953). Exchangeable Al was extracted with 1.0M KCl and estimated by titration (Thomas 1982). Calcium, K, Mg, Na, and Al were measured on a Thermo Jarrell Ash® model ICAP61 ICAP-AES.

Statistical Analysis

In 1963, the treatment plots on the study area were set up in a completely randomized design with replications of 3 treatments. Data from the A horizons were

Table 2. Vegetation of the study site in Franklin County, TN, in 1989 as reported by DeSelm et al. (1991).

Dominant stand overstory vegetation	
post oak (*Quercus stellata*)	black oak (*Q. velutina*)[a]
scarlet oak (*Q. coccinea*)	willow oak (*Q. phellos*)[a]
southern red oak (*Q. falcata*)	white oak (*Q. alba*)[a]
blackjack oak (*Q. marilandica*)[a]	red maple (*Acer rubrum*)[a]
Understory vegetation	
Control Plots	
southern red oak (*Q. falcata*)	eastern redcedar (*Juniperus virginiana*)
sweetgum (*Liquidambar styraciflua*)	mockernut hickory (*Carya tomentosa*)[a]
scarlet oak (*Q. coccinea*)	post oak (*Q. stellata*)[a]
willow oak	white oak[a]
blackgum (*Nyssa sylratica*)	flowering dogwood (*Cornus florida*)[a]
red maple	
Plots Burned Every 5 Years	
winged sumac (*Rhus copallina*)	sassafras (*Sassafras albidum*)
red maple	white oak (*Q. alba*)
post oak	mockernut hickory
southern red oak	flowering dogwood
scarlet oak	blackjack oak (*Q. marilandica*)
blackgum	sweetgum
Plots Burned Annually	
winged sumac (*R. copallina*)	mockernut hickory[a]
post oak[a]	blackjack oak[a]
southern red oak[a]	scarlet oak[a]
black oak[a]	

[a] To a lesser extent.

analyzed using the analysis of variance (ANOVA) procedure of SPSS (1995) for comparison of treatments. Statistical significance was tested at the 0.05 and 0.1 levels of probability on the A horizon data for the different treatments. Means and percent coefficient of variations (CV) were also calculated. Subsamples from the different horizons were analyzed separately for variations within plots.

RESULTS

The pH of these acidic soils generally increased with depth on all of the treatment plots (Table 3). The H_2O pH values of the A horizons were slightly higher from the burn plots as compared to control plots. In the A horizons, pH values ranged from 4.90 for the 5-YI plots, and 4.84 for the 1-YI plots, to 4.70 for the control plots. The 5-YI plots had the highest mean pH values, ranging from 5.09 for the Bt1 horizon to 4.90 for the A horizon. $CaCl_2$ pH values were fairly constant from the surface down to the fragipan.

Percent total C and N values were also higher for the A and E1 horizons of the burn plots as compared to the controls. These values decreased with depth. Total C values for the A horizons ranged from 4.74% for the 5-YI and 1-YI plots to 4.34% for the control plots. In the E2 and Bt1 horizons on all of the treatments, N values were ~0.1%. Total S values were very low, ranging from 0.005% to 0.052%.

Concentrations of the Mehlich I extractable soil nutrients were highest in the A horizons and generally decreased with depth to the Bt1 horizon. Higher K, Ca, and Mg values were observed for the soil surface on the burn plots as compared to the control plots. Of the burn plots, highest nutrient concentrations were observed for the 5-YI plots, where K was 109.14 milligrams per kilogram, Ca was 542.69 milligrams per kilogram, and Mg was 67.68 milligrams per kilogram. Concentrations of K, Ca, and Mg decreased dramatically from the A horizon to the E1 horizon on all treatment plots. As compared to the other nutrients in the A horizons, Ca had the highest concentrations, ranging from 542.69 milligrams per kilogram for the 5-YI plots to 335.11 milligrams per kilogram for the control plots.

In contrast to K, Ca, and Mg values, concentrations of Na and P were highest in the control plots. The 5-YI plots had higher Na and P values than did the 1-YI plots. Although Na generally decreased with depth, there was only a slight change in concentration throughout the profiles.

KCl-exchangeable Al varied slightly throughout the soil profiles on the control and 1-YI plots, and increased with depth on the 5-YI plots. In the A horizons, KCl Al ranged from 13.79 milligrams per kilogram for the 1-YI plots to 9.95 milligrams per kilogram for the 5-YI plots. On all of the treatment plots, KCl Al values were highest in the Bt1 horizons.

Analysis of variance showed no significant differences in chemical concentrations in the A and lower horizons across treatments. The coefficient of variation revealed that the chemical measurements from the different treatment plots were site specific.

DISCUSSION

Long-Term Chemical Changes

To compensate for the difference in sampling depths between Thor and Nichols (1974), who sam-

Table 3. Means and percent coefficient of variation of soil reaction, total C, N, S, Mehlich I extractable nutrients, and KCl-extractable Al for soils.

Horizons	Depth (cm.)	pH 1:1 H_2O	pH 1:5 $CaCl_2$	Total C	Total N	Total S	Mehlich K	Mehlich Ca	Mehlich Mg	Mehlich Na	Mehlich P	KCl Al
				percent			milligrams per kilogram					
						CONTROL PLOTS						
A[a]	0–6	4.70	4.02	4.34	0.21	0.023	87.34	335.11	48.99	30.82	7.33	13.52
		(6.42)[b]	(7.51)	(53.54)	(50.01)	(50.01)	(41.61)	(74.94)	(40.04)	(20.11)	(93.16)	(43.70)
E1	6–15	4.90	3.92	1.13	0.23	0.021	42.74	46.94	12.40	26.13	1.13	10.98
		(4.13)	(2.64)	(54.61)	(150.00)	(50.02)	(35.12)	(62.71)	(51.63)	(18.82)	(36.42)	(27.30)
E2	15–29	5.00	4.04	0.64	0.12	0.014	38.62	33.60	9.92	26.54	0.35	15.10
		(2.02)	(2.52)	(33.31)	(0.00)	(200.01)	(33.70)	(39.33)	(43.54)	(24.91)	(133.00)	(33.10)
Bt1	29–75	5.02	4.03	0.40	0.10	0.008	34.53	40.23	19.33	23.92	0.00	30.30
		(2.03)	(2.53)	(25.04)	(0.00)	(0.000)	(31.93)	(46.01)	(81.35)	(30.52)	(0.00)	(54.13)
						5-YI BURN PLOTS						
A	0–5	4.90	4.11	4.74	0.23	0.008	109.14	542.69	67.68	30.22	5.31	9.95
		(8.22)	(9.82)	(31.88)	(50.00)	(100.00)	(41.69)	(86.54)	(58.42)	(22.50)	(49.13)	(82.00)
E1	5–12	5.00	4.01	1.23	0.11	0.007	37.96	55.63	12.41	24.72	1.23	11.54
		(4.03)	(2.50)	(4.20)	(0.00)	(100.00)	(43.23)	(78.11)	(59.73)	(32.84)	(83.34)	(31.33)
E2	12–29	5.03	4.03	0.48	0.12	0.005	26.53	32.49	9.87	25.83	0.40	15.72
		(4.01)	(2.47)	(20.04)	(0.00)	(0.00)	(31.29)	(30.81)	(41.40)	(30.61)	(174.95)	(31.11)
Bt1	29–75	5.10	4.04	0.40	0.14	0.005	26.98	37.53	21.34	24.86	0.40	28.42
		(5.90)	(2.52)	(24.90)	(0.00)	(0.00)	(25.63)	(33.62)	(53.93)	(36.64)	(100.00)	(34.92)
						1-YI BURN PLOTS						
A	0–3	4.84	4.00	4.74	0.23	0.052	102.12	439.06	60.02	28.16	5.00	13.77
		(6.30)	(9.99)	(33.96)	(50.03)	(20.01)	(38.10)	(109.34)	(61.12)	(21.95)	(67.96)	(60.17)
E1	3–10	4.91	4.03	1.42	0.085	0.023	30.01	48.88	10.76	25.09	0.74	12.92
		(4.13)	(2.53)	(28.58)	(0.00)	(15.01)	(39.67)	(74.43)	(49.96)	(27.03)	(71.43)	(24.54)
E2	10–29	5.07	4.02	0.53	0.084	0.022	22.43	25.62	9.83	23.81	0.32	12.99
		(2.02)	(2.50)	(20.00)	(0.00)	(100.00)	(23.70)	(35.24)	(60.24)	(32.01)	(166.71)	(24.81)
Bt1	29–75	5.12	4.01	0.44	0.081	0.009	24.14	48.30	24.74	26.58	0.18	22.73
		(3.93)	(2.49)	(50.00)	(0.00)	(100.00)	(19.11)	(59.64)	(82.62)	(36.13)	(150.33)	(21.96)

[a] A horizon varies somewhat with depth; was sampled to 4–5 centimeters.
[b] Percent coefficient of variation.

pled the upper 15 centimeters of the soil in 1970, and this study, in which we sampled by horizon in 1996, both the A and E1 horizon values in this investigation were averaged together. We took this step to determine whether there has been a long-term change in values for H_2O pH and K. There was no significant difference in H_2O pH values from 1970–1996. The acidic H_2O pH values for the average of the A and E1 horizons (sampled in 1996) on the treatment plots ranged from 4.8 for the control plots to 4.9 for the 5-YI plots (Table 4). Thor and Nichols (1974) reported no significant difference in mean pH values from 1967–1970. The pH values ranged from 5.1 for the control plots to 4.9 for the burn plots in 1970. Higher H_2O pH values for surface horizons on the burn plots as compared to control plots is also perhaps due to the presence of higher amounts of available nutrients (cations). Lower pH values at the surface as compared to the other sections of the soil profile were due to leaching and the presence of more organic matter. The $CaCl_2$ pH values were lower than H_2O pH values because of a high displacement of Al^{3+} and H^+ ions. In the A horizons, these values ranged from 4.11 for the 5-YI plots to 4.02 for the control plots.

Table 4. Comparison of pH and K measured in 1970 (Thor and Nichols 1974) and 1996 from the upper 15 centimeters of soil.

Year	pH C	pH 5-YI	pH 1-YI	K C	K 5-YI	K 1-YI
				(milligrams per kilogram)		
1970	5.1	4.9	4.9	69.1	59.1	68.1
1996	4.8	4.9	4.9	65.0	73.6	66.0

Heyward and Barnette (1934) reported that changes in pH were confined to the upper few centimeters of the soil surface after burning. However, Thor and Nichols (1974) stated that samples from the upper 2.5 centimeters of soil on the annual plots before and after the 1971 burn showed no change in pH.

No significant difference occurred between the mean K values recorded in 1970 and 1996. Unexpectedly, Thor and Nichols (1974) found that the levels of K were considerably lower following the burn. They reported that available K changed significantly ($P < 0.1$) between the treatments from 1967 and 1970. The greatest change over time occurred on the control plots. Potassium ranged from 69.1 milligrams per kilogram for control plots to 59.1 milligrams per kilogram for 5-YI plots and 68.1 milligrams per kilogram for 1-YI plots in 1970 (Thor and Nichols 1974) (Table 4). In 1996, the mean K values from the averaged A and E1 horizons did not significantly differ among treatments and ranged from 65.0 milligrams per kilogram for control plots to 73.6 milligrams per kilogram for 5-YI plots and 66.0 milligrams per kilogram for 1-YI plots. However, K increased notably from 1970–1996 on the 5-YI plots, perhaps because the more intense burns of the periodic fires increased the rate of nutrient cycling (Christensen 1977).

The KCl Al did not greatly vary between the treatment plots. Due to elevated clay content, KCl Al was highest in the Bt1 horizons (argillic-horizon of clay accumulation).

Percent Total Carbon, Nitrogen, and Sulfur

In the surface horizons, total C and N values were slightly higher for the burn plots as compared to control plots. Total S was present in very small concentrations throughout the soil on all treatment plots, and was higher in the A horizons of the 1-YI plots. The presence of a higher amount of shallow rooted vegetation such as shrubs on 5-YI plots and grasses and forbs on 1-YI plots may contribute to higher percent C, N, and S values on the burn plots. Additionally, incomplete burning breaks down the litter, and this partially burned organic matter is mixed into the underlying A horizons by soil organisms and the fires. Knoepp and Swank (1993) reported that *in situ* measurements showed increased net mineralization with increased burn severity in a mixed southern Appalachian hardwood forest.

Nutrient Cycling

The Mehlich I extraction procedure was used to investigate nutrient cycling because it extracts the soil nutrients potentially available for uptake by plants in the southeastern United States. Thus, the Ca, K, Mg, P, and Na reported in the study are nutrients active and available for nutrient cycling. Higher amounts of extractable K, Ca, and Mg in the A horizons on the burn plots as compared to control plots suggested that the availability of these nutrients has been increased by the controlled burns. Furthermore, these nutrients were higher on 5-YI plots than on 1-YI plots. Perhaps the burning of greater amounts of fuel, which produced higher temperatures and greater ashfall on 5-YI plots as compared to 1-YI plots, resulted in the higher availability and increase in Ca, Mg, and K. According to Covington and Sackett (1984), fires increase nutrient mobility.

Additionally, the presence of a higher amount of shallow-rooted vegetation such as shrubs on 5-YI plots and grasses and forbs on 1-YI plots was also responsible for nutrient cycling, contributing to higher concentrations of K, Mg, and especially Ca. Calcium oxalate is formed in some roots (FitzPatrick 1993). Figure 4a-b shows Ca oxalate crystals within root material. Calcium oxalate in roots was observed in soil thin-sections from the control plots and particularly from the 5-YI plots. Calcium oxalate was present in live roots as opposed to burned roots. Perhaps the fires released these highly concentrated accumulations of Ca from the roots into the soil, thereby contributing to the variability.

The controlled burns appeared to have a direct effect on concentrations of the metallic cations, Ca, Mg, and K, as compared to P. Christensen (1977) reported that Ca, Mg, and K concentrations increased immediately after burning, whereas P concentrations increased in burned areas after several months. The A horizons from the control plots had higher concentrations of Na and P than did the burn plots. Additionally, both Na and P were higher on the 5-YI plots as compared to the 1-YI plots. Sodium values, though higher in surface horizons, did not vary greatly throughout the profile with depth.

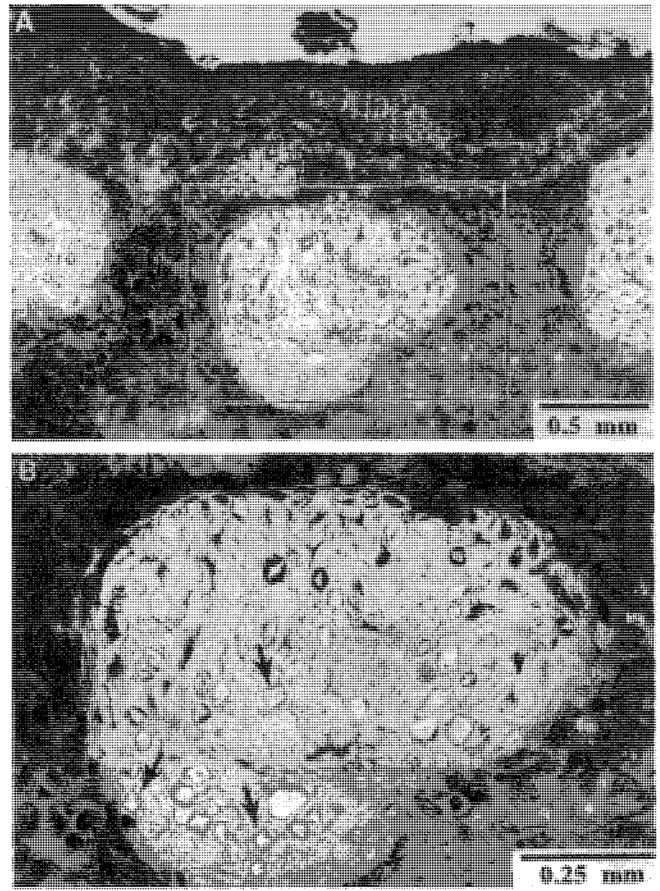

Fig. 4. (a) Photomicrograph of a longitudinal section of root material in an A horizon of a plot burned every 5 years in Franklin County, TN. (b) Very small crystals of calcium oxalate (arrow) were observed throughout this material, especially in the white section (xylem?).

Insignificant differences were also observed between nutrient availability for the different treatment plots in this study. This is not an uncommon occurrence. Richter and Ralston (1982) reported that 5-year prescribed fires had limited effects on soils, nutrient cycling, and hydrologic systems of a coastal plain pine forest.

Variability

Forest floor material and mineral soils have a great variability that has long hindered forest soil research (Lloyd and McKee 1983, McColl 1984). In this study, variability decreased with depth to the Bt1 horizon, indicating that the incipient fragipan did not greatly influence the surface horizon chemistry. The higher variability of surface horizons observed on the different treatment plots may have resulted from uneven distribution of ash from prescribed fires (Christensen 1995), as well as past land use and vegetational changes. Care was taken to select sampling points undisturbed by wind throw, which would have also increased variability.

CONCLUSIONS

No significant difference was found between pH and K values from samples measured in 1970 and 1996; however, K values increased from 1970–1996 for 5-YI treatments. Higher amounts of C, N, and S were found on burn plots as compared to control plots due to shallow roots and perhaps mineralization. Concentrations of Ca, Mg, and K were greater on burn plots than on control plots. These values were highest on 5-YI plots. Calcium oxalate crystals were present in live roots on control and, to an even greater extent, 5-YI plots. Phosphorus and Na were higher on control plots than on burn plots. Sodium varied slightly throughout the profiles. No significant difference existed between treatments for Ca, Mg, and K due to high variability. This variability resulted from uneven distribution of ash, and possibly previous land use.

From a land management perspective, long-term controlled burning of this site has increased the availability of Ca, K, and Mg. Despite the observed chemical trends of the soil at the study site, however, no great change in the other measured soil chemical parameters is observed, even though striking vegetational changes occur between the different treatment plots.

ACKNOWLEDGMENTS

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