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Notes and Discussion

Legacy of Charcoaling in a Western Highland Rim Forest in Tennessee

Abstract.—Forests of the Western Highland Rim were heavily influenced by the iron industry during the 19th and 20th centuries. The production of iron required large amounts of charcoal. Timber was cut, burned in hearths to produce charcoal and then the charcoal was transported to local furnaces and forges. The goal of our study was to document the lasting effects of charcoal production on soil characteristics, species composition and stand structure for a forest on the Western Highland Rim in Tennessee. Fires used in hearths to produce charcoal were intense, spatially concentrated events that modified soil characteristics differently than typical surface fires. We hypothesized there would still be a footprint of the charcoal making process evidenced by systematic differences in forest composition and structural attributes that could be related to soil properties. Results show there were significant differences in some soil traits between charcoal hearths and surrounding sites. However, differing soil conditions have not significantly influenced forest development. Although tree density differed between hearths and adjacent areas, there were no systematic differences in tree species richness, diversity (H'), evenness (J) or basal area between charcoal hearth and non-hearth sites. Results of this study indicate the historic land use has minimal influence on modern forest communities in our Tennessee study site.

Introduction

Land-use practices such as clearcutting, burning, grazing and row cropping have been important factors in shaping the floristic composition and structure of post-European settlement landscapes throughout the Eastern Deciduous Forest Region (Raup, 1966; Cronon, 1983; Foster, 1988, 1992, 2002; Orwig and Abrams, 1994a; Ruffner and Abrams, 1998; Foster *et al.*, 2003). Investigations of land-use history and vegetation change provide a background for understanding the development of contemporary plant communities (Christensen, 1989; Foster, 2002). Despite increased recognition of the importance of disturbance in determining forest composition and structure, few studies have assessed the relative influence of historical factors on modern vegetation assemblages, in part because detailed knowledge of prior disturbance events is often lacking, especially information concerning the intensity of individual disturbances (Motzkin *et al.*, 1999; van de Gevel, 2002). Variability of disturbance intensity may create patches across the landscape that favor certain species and increase heterogeneity in forested environments at the landscape level.

Anthropogenic (*e.g.*, iron industry, grazing, select forest cutting) and natural (*e.g.*, fire, windthrow, tornadoes) disturbances during the 19th and 20th centuries altered the landscape and influenced forest communities on the Western Highland Rim in Tennessee. Charcoal production, an intense, anthropogenic forest disturbance in the southeastern U.S. has received relatively little attention in the scientific literature (but *see* Ash, 1985; Clatterbuck, 1990; Gildrie, 1991; Mikan and Abrams, 1995; Young *et al.*, 1996). In this study, we used soil, forest inventory and tree ring analyses to investigate development of a Western Highland Rim forest in Tennessee. Our specific objectives were to: (1) quantify differences in soil properties for remnant charcoal hearths and surrounding sites, (2) compare forest composition and structural attributes of charcoal hearth and non-hearth sites and (3) document recruitment pulses using size and age structure of trees in our study plots in order to document the lasting effects of charcoaling on soil characteristics and forest development in a Western Highland Rim forest in Tennessee.

HISTORY OF CHARCOALING IN THE REGION

Prior to the Civil War, iron production was an important manufacturing commerce in the southeastern U.S. (Burchard, 1934). By 1850 the production of iron was well established in middle Tennessee and concentrated along the Western Highland Rim, which was geographically ideal for the establishment of the industry (Burchard, 1934; Honerkamp, 1987; Clatterbuck, 1990; Gildrie, 2002; O'Neill and Doyle, 2002). The region contained extensive deposits of limestone and brown hematite (an iron-rich ore), which produced high quality pig and bar iron (Burchard, 1934; Franklin *et al.*, 2002). The Cumberland and Tennessee Rivers provided transportation routes of iron products to larger market areas to the north and south and the extensive hardwood forests located in the region provided the timber necessary for the iron industry.

Hardwood charcoal was the fuel used for smelting iron ore and forging wrought iron. Throughout the eastern U.S. large tracts of forests were intensively managed for charcoal to be used in the iron industry (Mikan *et al.*, 1994; Gildrie, 2002). Approximately 971 km^2 of forested land on the Western Highland Rim was managed to support the large number of iron furnaces and forges in the region (Luther, 1977). The charring of wood usually occurred in easily accessible *Quercus–Carya* stands near furnaces and forges. The products were transported to iron furnaces and forges that were usually located near water sources via horse drawn carts or small donkey tracks.

The cut timber was charred in a hearth, a dry, level circular clearing ranging from 9–15 m in diameter (Maher, 1964). Wood was cut into approximately 1.2 m segments and stacked in a conical shape. Soil was piled on the stacked wood to limit the oxygen consumption of the fire so colliers (*i.e.*, charcoalers) could control fire temperatures.

Typical charcoal hearths were 3.5 m high and contained as many as 180–220 m^3 of densely packed timber (Overman, 1854). An average furnace would consume approximately 28 m^3 of charcoal every 24 h, which required about 180 m^3 of wood averaging 20–30 y of age (Muntz, 1960; Mikan and Abrams, 1995). A typical furnace consumed 0.4 ha of forested land per day while in blast (Burchard, 1934).

METHODS

STUDY AREA

The study was conducted in Stewart State Forest (SSF) in Stewart County, Tennessee, in the north-central portion of the state (Fig. 1). The study area is located within the Western Highland Rim section of the Interior Low Plateau physiographic province (Fenneman, 1938). The area is characterized by broad ridges dissected by numerous streams (Miller, 1974) with a rolling terrain (Griffith *et al.*, 1997). The soils of the area are moderate to well drained, thin silt loams that are underlain by cherty limestone of the Warsaw Formation (Soil Conservation Service, 1953). Regionally, soils are acidic and low to moderate in fertility (Chester, 2002).

The climate is classified as humid mesothermal (Thornthwaite, 1948), with long-hot summers and short-mild winters. The average frost-free period is 191 d (mid-Apr. to mid-late Oct.) and mean annual temperature is 15 C. The Jul. average is 26 C and the Jan. average is 3 C (Smalley, 1980). The area receives steady precipitation throughout the year with no distinct dry season. The study area is a component of the Western Highland Rim (71f) level IV ecoregion (Omernik, 1987). Braun (1950) classified the area as part of the Western Mesophytic Forest Region, which transitions from the drier *Quercus–Carya* dominated forests to the west and the true mesophytic forests to the east. Generally, the forests of the Western Highland Rim are more similar to the *Quercus–Carya* region than to the Mixed Mesophytic Region (Chester *et al.*, 1995; Chester, 2002).

SAMPLING AND ANALYSIS

Research plots in SSF were separated into two land-use classifications according to the presence of charcoal hearths (hearth sites) or lack thereof (non-hearth sites). We sampled 30 0.04 ha fixed-radius circular plots for present forest composition, vertical, size and age structure within SSF. Fifteen plots were chosen on sites previously used as charcoal hearths, which are still evident on the landscape today. We identified the charcoal hearths by locating 9–11 m flattened circular surfaces containing charred soil and surrounded by small earthen mounds. Hearth sites were chosen to represent a variety of aspects, elevations and topographic positions. Fifteen additional plots were located in areas indirectly influenced by charcoal production. Trees in the non-hearth plots were cut for charcoal production, but were not growing in remnant charcoal hearths that would have experienced the intense heating required for the charcoal making process. All 15 hearth plots were paired with a non-hearth plot located ca. 25 m away along the same slope contour. Thus, for each hearth plot sampled, we sampled a non-hearth plot with similar site conditions (*e.g.*, slope position, aspect, elevation, gradient).

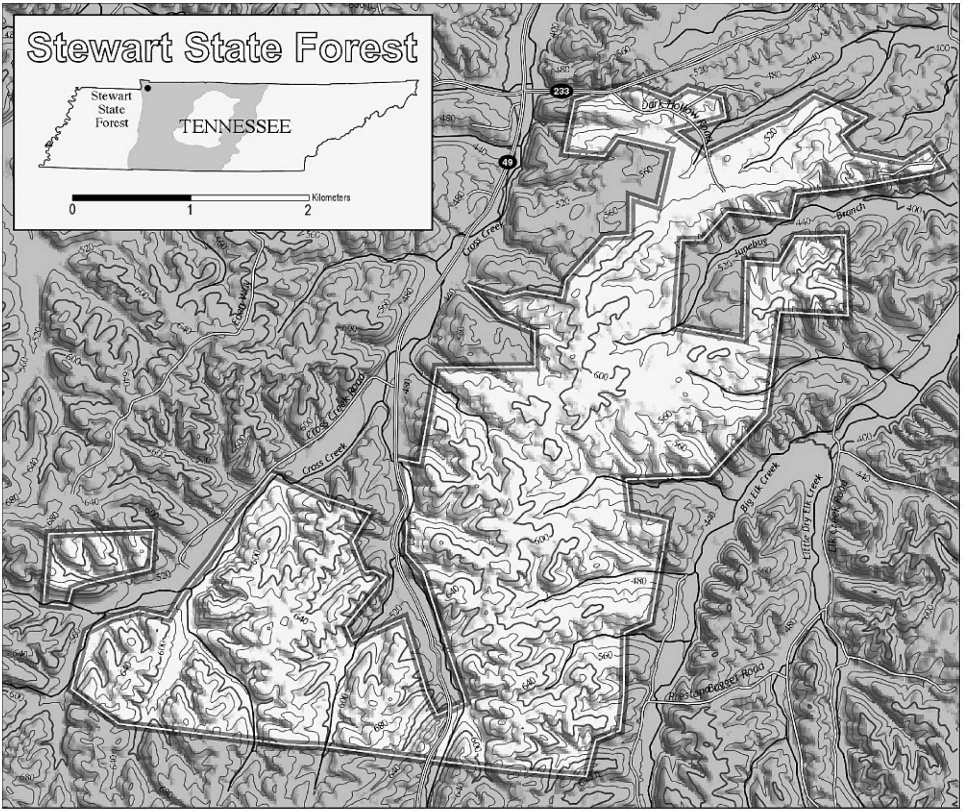

FIG. 1.—Map of Stewart State Forest in Stewart County, Tennessee. Shaded area on Tennessee inset map is the Highland Rim physiographic section

In each plot we recorded species, crown class and diameter at breast height (dbh) for all stems ≥10 cm dbh. Crown class categories (overtopped, intermediate, codominant and dominant) were based on the amount and direction of intercepted light (Oliver and Larson, 1996). Within each plot 2–4 trees were cored at breast height with increment borers to evaluate stand age and recruitment pulses. Cored trees were selected to represent a variety of diameter classes. Our study focused on overstory vegetation because we hypothesized growth and development of trees ≥10 cm dbh would have been more strongly influenced by the historic disturbances than saplings, seedlings or herbaceous plants.

In 20 plots (10 hearth and 10 non-hearth) we collected soil samples from three depths (0–5, 5–15 and 15–30 cm) using a tubular soil corer. While dividing the soil by depth we were careful to follow natural horizon breaks rather than adhering strictly to set numerical breaks. Within each plot we collected soil from 8–10 locations and then mixed the soil thoroughly in a bag to get composite samples for each depth at each site.

Soil samples were analyzed for pH, NO_3, P, K, Ca, Mg, percent organic matter and cation exchange capacity (CEC) by A and L Analytical Laboratories in Memphis, Tennessee. Vegetation was analyzed by standard descriptors of density, basal area (dominance) and importance (Cottam and Curtis, 1956). We used overstory tree richness (number of species), the Shannon diversity index (H') and evenness (J) to compare forest community diversity among treatments (*see* Ludwig and Reynolds, 1988 for equations).

Soil data were analyzed using a two-tailed independent t-test and vegetation data were analyzed using a pairwise t-test in SAS 9.1. Dependent variables included pH, NO_3, P, K, Ca, Mg, organic matter percent and CEC for soil characteristics and overstory tree richness, diversity (H'), evenness (J), basal area, density of all trees ≥10 cm dbh and density of *Quercus alba* L., *Q. coccinea* Muenchh., *Q. stellata* Wangenh., *Carya ovata* (Mill.) K. Koch, *C. tomentosa* (Poir.) Nutt. and *Liriodendron tulipifera* L. per 0.04 ha for forest community analysis. The six selected tree species were chosen because they all had the potential to be canopy dominants and were all relatively important species. We also analyzed canopy class percentages, diameter distributions and diameter-age relationships for hearth and non-hearth plots.

RESULTS

SOIL

A total of 58 soil samples were collected from 20 plots (10 plots of each treatment). In two plots we could not get to the 15–30 cm sample because of a pan layer at a shallow depth. Of the 58 samples collected only 53 could be accurately analyzed in the laboratory because of the small amount of material collected. At the 0–5 cm and 5–15 cm depths, hearth sites had significantly higher values of Ca, Mg and CEC compared to non-hearth sites (Table 1). In addition, percent organic matter was also significantly higher in hearth vs. non-hearth soils at depths of 5 to 30 cm. At the 15–30 cm depth, levels of Ca, percent organic matter and CEC remained significantly higher in hearth soils (Table 1). As with other depths, Mg was higher on hearth sites, but low sample size may have precluded statistical significance. There were no systematic differences in pH at any depth between hearth and non-hearth soils.

COMPOSITION

Both hearth and non-hearth sites were dominated by *Quercus alba*, *Q. stellata*, *Liriodendron tulipifera* and *Q. coccinea* (Table 2). Although *Q. alba* was the most dominant species on both sites, it was more abundant (39.6% more stems/ha) on non-hearth sites and had an overall greater importance value in that treatment. *Quercus alba*, *Q. stellata*, *L. tulipifera* and *Nyssa sylvatica* Marsh. had the highest densities on hearth sites while *Q. alba*, *L. tulipifera* and *Carya tomentosa* had the highest densities on non-hearth sites. Total treatment richness was higher on hearth sites. Four species occurred in remnant hearths that did not occur in non-hearth plots (*Q. rubra* L., *Cercis canadensis* L., *Carpinus caroliniana* Walt. and *Sassafras albidum* (Nutt.) Nees), while two species occurred only on non-hearth sites (*Acer saccharum* Marsh. and *Fagus grandifolia* Ehrh.). There were no systematic differences in richness, diversity, or evenness between the two historic land uses (Table 3). Tree density was significantly higher on non-hearth sites (Table 3). However, there were no differences in individual species densities between site types (Table 3).

Examination of the vertical structure revealed that *Quercus* species were most abundant in dominant canopy positions on hearth sites, but in codominant positions on non-hearth sites (Fig. 2). Percentage of *Liriodendron tulipifera* was greatest in dominant canopy positions on non-hearth sites and species other than *Quercus* and *Carya*, most notably *Nyssa sylvatica*, were more abundant in overtopped and intermediate positions on hearth sites relative to non-hearth sites.

DIAMETER STRUCTURE

Hearth plots had a reverse J-shaped diameter distribution typical for regenerating stands (Fig. 3). On hearth sites, the fewest number of trees occurred in the >60 cm size class. Two individuals occurred in this class a *Quercus alba* (68.25 cm dbh) and a *Q. coccinea* (69 cm dbh). On hearth sites the most abundant species in the smallest size class was *Nyssa sylvatica*.

Non-hearth sites did not have a diameter distribution typical of regenerating stands, but a distribution indicative of forests recovering from past disturbance. Although the smallest size class did have the highest number of individuals and the largest size class had the fewest, there was a noticeable peak in the 27.5 cm class (Fig. 3). We only documented one individual on non-hearth sites in the two largest size classes. However, the largest tree documented in our study did occur in a non-hearth plot (a *Quercus falcata* (72 cm dbh). On non-hearth sites, *Carya tomentosa* was the most abundant species in the smallest size class.

There were no systematic differences in basal area supported on hearth and non-hearth sites (Table 3). Total basal area on hearth sites was 17.83 m^2/ha (Table 2) and mean basal area per hearth

TABLE 1.—Mean values with standard errors for eight soil traits on charcoal hearth and non-charcoal hearth sites in Stewart State Forest, Tennessee

	0–5 cm		5–15 cm		15–30 cm	
Soil trait	Hearth	Non-hearth	Hearth	Non-hearth	Hearth	Non-hearth
pH	4.87 ± 0.18 a	5.09 ± 0.19 a	5.02 ± 0.09 a	4.88 ± 0.17 a	4.9 ± 0.07 a	4.76 ± 0.13 a
NO3 (ppm)	28.6 ± 2.97 a	25.39 ± 4.33 a	13.5 ± 2.09 a	18.44 ± 2.62 a	6.38 ± 1.11 a	7.21 ± 1.49 a
P (ppm)	15.4 ± 1.51 a	13.11 ± 1.11 a	9.1 ± 1.35 a	7.78 ± 1.18 a	10.88 ± 1.91 a	18.71 ± 7.43 a
K (ppm)	93.8 ± 9.28 a	91.33 ± 8.74 a	62.2 ± 8.31 a	65.56 ± 6.65 a	61.25 ± 5.75 a	82.71 ± 10.93 a
Ca (ppm)	2014.1 ± 354 a	793.3 ± 135 b	1504.1 ± 227 a	381.2 ± 71 b	952.9 ± 156 a	371.1 ± 48 b
Mg (ppm)	215.8 ± 21.4 a	127.33 ± 21.3 b	164.8 ± 26.0 a	74.56 ± 10.9 b	116.88 ± 26.9 a	74.57 ± 10.2 a
Organic (%)	6.16 ± 0.51 a	5.14 ± 0.37 a	4.37 ± 0.38 a	2.5 ± 0.23 b	2.59 ± 0.36 a	1.59 ± 0.22 b*
CEC (meq/100 g)	17.66 ± 1.67 a	8.12 ± 0.78 b	14.86 ± 1.63 a	6.17 ± 0.52 b	9.46 ± 1.18 a	5.76 ± 0.37 b

Means with rows followed by same letter are not significantly different ($P < 0.01$). * indicates significant at $P < 0.05$

TABLE 2.—Density, basal area and relative importance of trees (≥10 cm dbh) on charcoal hearth (H) and non-hearth (NH) sites in Stewart State Forest, Tennessee. Values shown are per hectare. Basal area is expressed as m^2/ha

Species	Density		Basal area		Importance	
	H	NH	H	NH	H	NH
Acer rubrum	3.34	3.34	0.05	0.17	0.85	0.96
Acer saccharum	—	1.67	—	0.03	—	0.36
Betula nigra	3.34	1.67	0.04	0.02	0.83	0.34
Carpinus caroliniana	1.67	—	0.02	—	0.41	—
Carya cordiformis	1.67	3.34	0.05	0.08	0.50	0.76
Carya glabra	1.67	3.34	0.02	0.32	0.42	1.32
Carya ovata	8.35	11.69	0.19	0.48	2.30	3.11
Carya tomentosa	18.37	35.07	0.75	1.34	5.99	9.09
Cercis canadensis	3.34	—	0.05	—	0.85	—
Cornus florida	8.35	5.01	0.09	0.05	2.03	0.97
Diospyros virginiana	8.35	11.69	0.21	0.22	2.37	2.48
Fagus grandifolia	—	1.67	—	0.02	—	0.34
Liriodendron tulipifera	25.05	46.76	1.99	3.65	10.90	16.54
Nyssa sylvatica	23.38	5.01	0.33	0.05	5.89	0.96
Ostrya virginiana	5.01	1.67	0.07	0.01	1.25	0.31
Prunus serotina	3.34	1.67	0.07	0.05	0.90	0.41
Quercus alba	53.44	88.51	6.04	6.61	28.27	30.61
Quercus coccinea	20.04	18.37	2.96	2.18	12.56	8.28
Quercus falcata	5.01	15.03	0.60	2.30	2.74	7.99
Quercus rubra	3.34	—	0.21	—	1.31	—
Quercus stellata	25.05	21.71	2.51	1.10	12.34	6.27
Quercus velutina	8.35	18.37	1.52	2.10	6.05	8.08
Sassafras albidum	1.67	—	0.02	—	0.40	—
Ulmus rubra	3.34	1.67	0.05	0.23	0.85	0.83
Totals	**235.47**	**297.26**	**17.83**	**21.03**	**100**	**100**

TABLE 3.—Means with standard errors of diversity, structural, and compositional measures of charcoal hearth and non-hearth sites in Stewart State Forest, Tennessee. Measures for the six listed species are number of individuals per 0.04 ha

Parameter	Hearth	Non-hearth
Richness	4.20 ± 0.47 a	4.47 ± 0.50 a
Diversity (H')	1.18 ± 0.13 a	1.19 ± 0.10 a
Evenness (J)	0.81 ± 0.06 a	0.85 ± 0.03 a
Density	9.40 ± 0.51 a	11.93 ± 1.30 b
Basal area	0.71 ± 0.09 a	0.84 ± 0.06 a
Quercus alba	2.13 ± 0.64 a	3.40 ± 0.70 a
Quercus coccinea	0.80 ± 0.44 a	0.73 ± 0.30 a
Quercus stellata	0.93 ± 0.52 a	0.73 ± 0.66 a
Carya ovata	0.33 ± 0.27 a	0.40 ± 0.19 a
Carya tomentosa	0.73 ± 0.30 a	1.33 ± 0.52 a
Liriodendron tulipifera	1.00 ± 0.41 a	1.87 ± 0.64 a

Means with rows followed by same letter are not significantly different ($P < 0.05$)

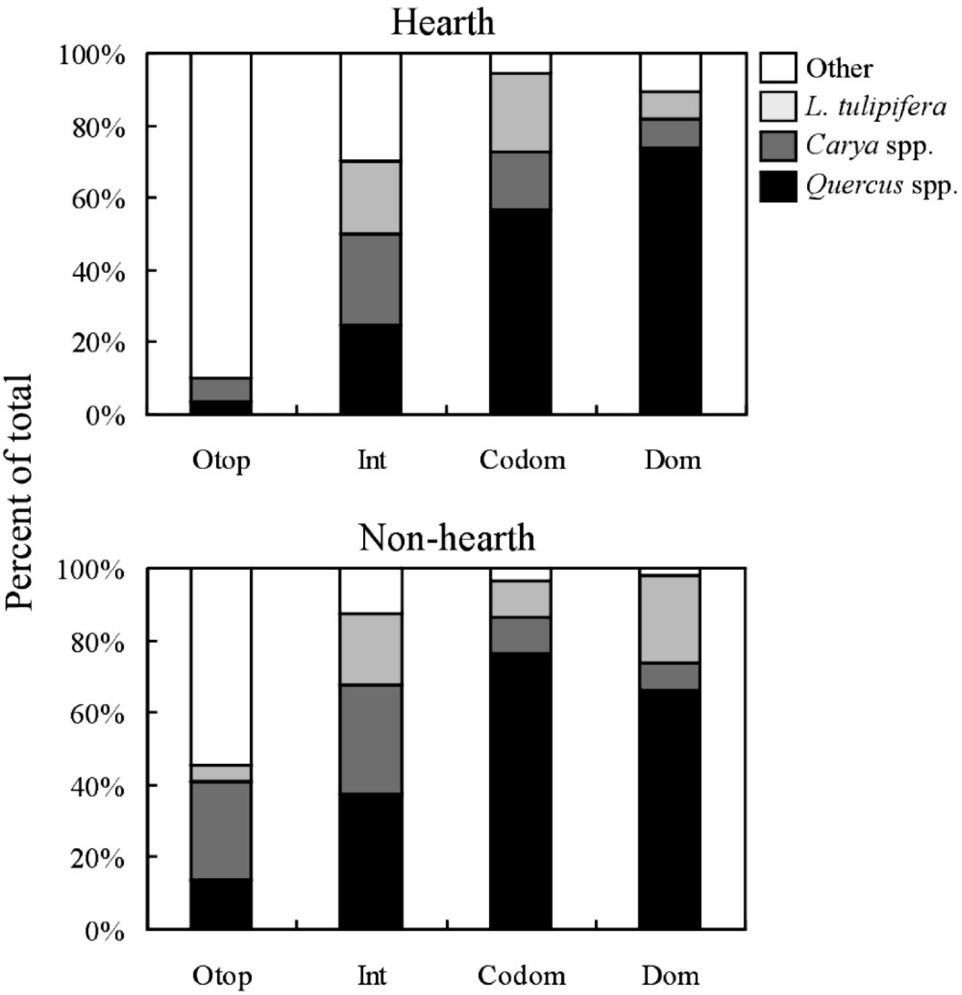

FIG. 2.—Canopy class distributions for charcoal hearth and non-hearth plots in Stewart State Forest, Tennessee. For a list of species included as ''other'' *see* Table 2. Categories are based on the amount and direction of intercepted light following Oliver and Larson (1996). Otop: overtopped, Int: intermediate, Codom: codominant, Dom: dominant

plot was 0.71 m^2/0.04 ha (Table 3). Total basal area on non-hearth sites was 21.03 m^2/ha (Table 2) and mean basal area per plot was 0.84 m^2/0.04 ha. Although there were no significant differences in dominance, non-hearth sites supported 15% more basal area than hearth sites and 21% more individuals per hectare.

AGE STRUCTURE

A total of 87 trees were successfully dated across the two treatments (44 in hearth plots and 43 in non-hearth plots) to investigate maximum stand age and recruitment pulses. The oldest tree on the hearth sites was a *Quercus alba* that reached breast height in 1895 (Fig. 4). The second oldest tree was a *Q. stellata* that reached breast height 10 y later in 1905. A recruitment pulse of *Quercus* and *Carya* species

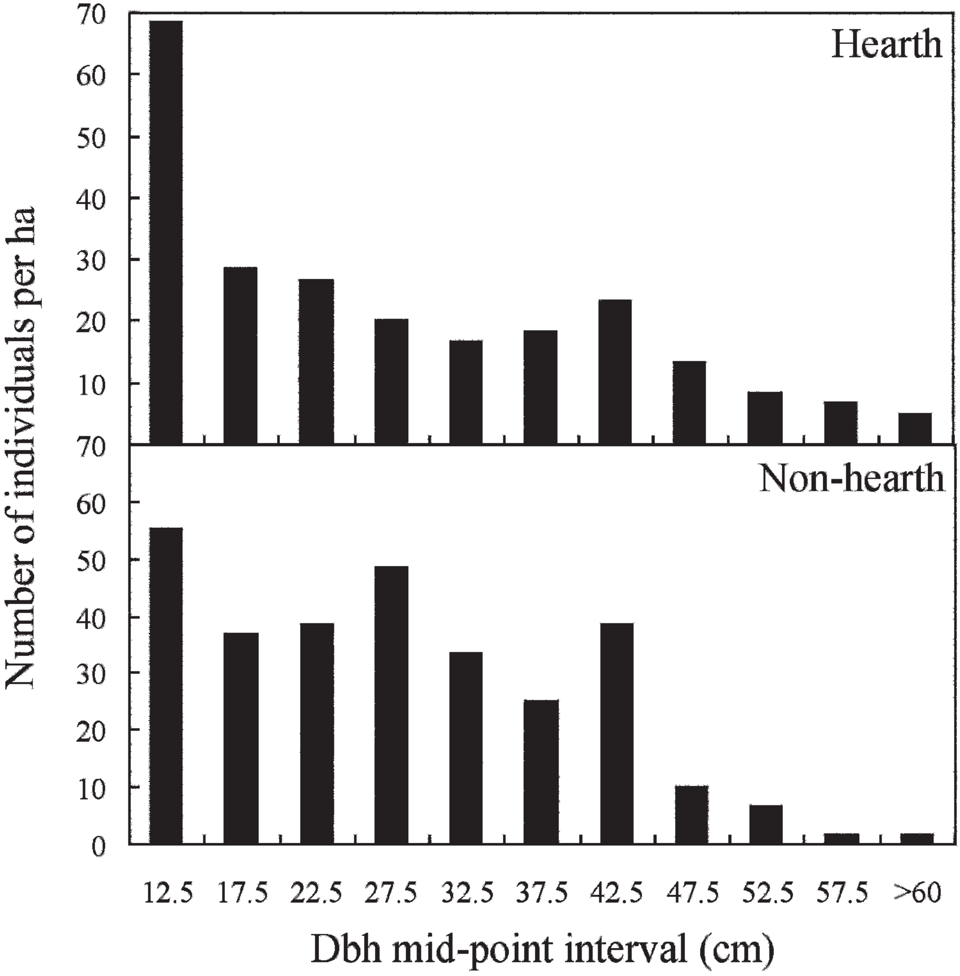

FIG. 3.—Number of trees (≥10 cm dbh) per ha vs. dbh mid-point interval for all species on charcoal hearth and non-hearth sites in Stewart State Forest, Tennessee. Each dbh interval includes all stems ±2.5 cm of the stated value with the exception of the >60 cm category

began in 1907 and was continuous until the mid-1950s. Several hardwood species reached breast height within the last 30 y.

In non-hearth plots the oldest tree was a *Quercus alba* that established in 1893 (Fig. 4). There was a window of 15 y before we documented the breast height date of another tree in our non-hearth plots (a *Q. coccinea* in 1909). There was continual recruitment of *Quercus* and *Carya* species from 1919–1956 with no recruitment after 1960. The cluster of tree recruitment years on the non-hearth sites was more narrowly concentrated than the charcoal hearth sites.

DISCUSSION

The fires used in the charcoal making process were high intensity, spatially concentrated events and the heat would have permeated soil profiles at greater depths than would occur during typical surface fires. Organic matter would have been rapidly volatilized at the high temperatures and should have

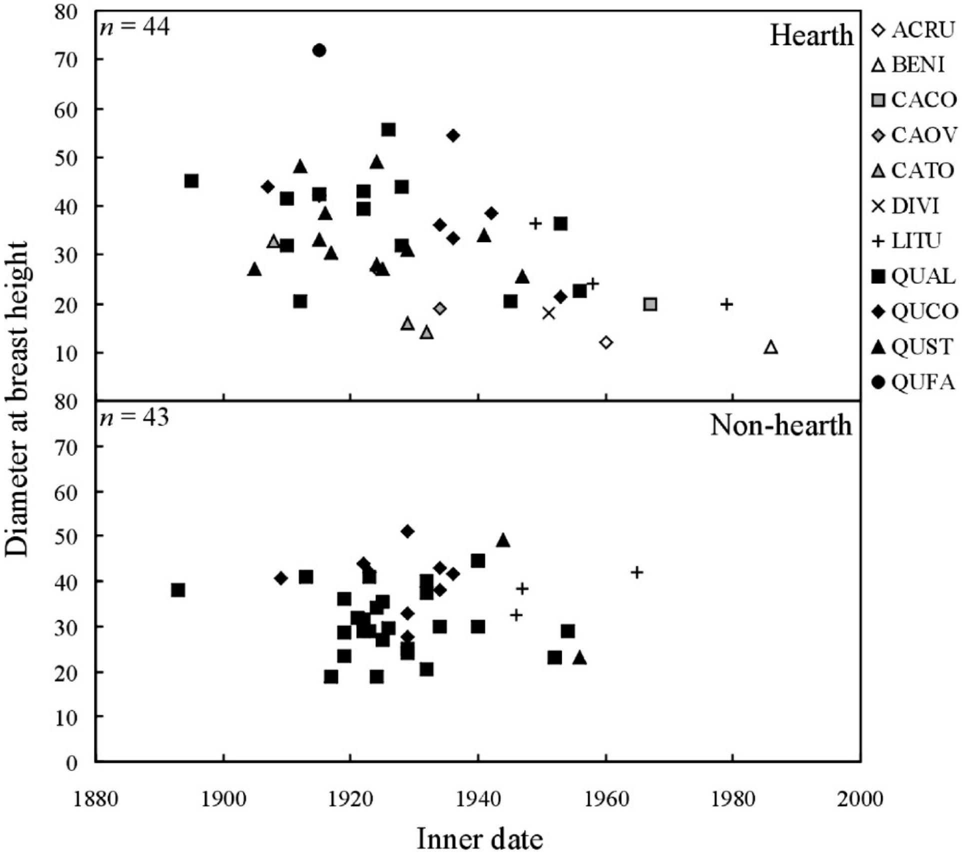

FIG. 4.—Diameter-age relationships for all cored trees that could be accurately dated for both hearth and non-hearth land uses in Stewart State Forest, Tennessee. Species acronyms are based on the first two letters of the genus and the first two letters of the specific epithet (*see* Table 2 for complete binomials)

resulted in nutrient poor, hydrophobic soils in remnant charcoal hearth sites (DeBano *et al.*, 1970; Brady and Weil, 2002; Mataix-Solera and Doerr, 2004). Furthermore, soils in hearths likely experienced high summer temperatures because of the removal of overstory vegetation and their dark color (Mikan and Abrams, 1995). Currently, soil chemistry, at least pH, NO_3, P and K, in remnant charcoal hearths is no different from characteristics of surrounding soils. The differences that do exist (Ca, Mg, organic matter, CEC) do not appear to have a major impact on forest community development, with the exception of tree density. Our soil sampling was somewhat limited and a larger sample size may have revealed additional systematic differences among treatments. Nonetheless, some of our soil findings (*e.g.*, higher Ca in hearths) were consistent with those reported from similar studies in the Appalachian Highlands (Mikan and Abrams, 1995; Young *et al.*, 1996). However, we did not find significant differences in soil pH, P, and K that have been reported elsewhere.

Tree density was higher on non-hearth sites, but there were no significant differences in tree species richness, diversity or evenness between hearth and non-hearth land uses. These results were similar to what was reported by Young *et al.* (1996) from sites in Pennsylvania and Virginia. There were also no significant differences in the abundance of the six selected tree species between the two treatments although we did document more *Quercus alba, Carya ovata, C. tomentosa* and *Liriodendron* *tulipifera* individuals on non-hearth sites and more *Q. coccinea* and *Q. stellata* on hearth sites. Interestingly, the two *Quercus* species encountered more in hearth plots generally dominate on drier and often times poorer quality sites (Johnson, 1990; Stransky, 1990). Hearth sites did support four mesophytic species that we did not encounter on non-hearth sites and had higher total overstory tree richness (n = 22 vs. n = 20). Also of interest, *Acer saccharum* and *Fagus grandifolia* occurred only on non-hearth sites.

Quercus species were most abundant in dominant canopy positions on hearth sites, but in codominant positions on non-hearth sites. On non-hearth sites there was a greater percentage of *Liriodendron tulipifera* in dominant canopy positions. Later establishment dates of shade intolerant *L. tulipifera* indicate they established in canopy gaps (Buckner and McCracken, 1978; Orwig and Abrams, 1994b). Hearth sites had a diameter structure more indicative of regenerating stands (Smith *et al.*, 1996), while non-hearth sites did not. The more open canopies, lower tree densities and the harsher soil conditions of the hearth sites probably contributed to the longer period of stem recruitment. The diameter distribution of non-hearth sites exhibited peaks in the middle size classes. These peaks may have been related to disturbances that removed overstory vegetation and allowed for the establishment and recruitment of individuals (Lorimer, 1980). Although we did not quantify saplings or seedlings in this study, we did document that *Nyssa sylvatica* was more abundant on hearth sites than non-hearth sites (78.6% more stems/ha). The high density of *N. sylvatica* in the understory may account for the diameter structure of the hearth plots. The high density of *N. sylvatica* on hearth sites may also help explain the relatively higher percentage of species listed as ''other'' in overtopped positions on hearth sites (Fig. 2). We did not quantify forest canopy cover, but it is possible hearth sites had a more open canopy relative to non-hearth sites that would promote regeneration. Canopy cover has been shown differ between remnant hearths and adjacent areas (Mikan and Abrams, 1995; Young *et al.*, 1996).

The primary goal of this study was to document the lasting effects of the charcoal making process on forest development and soil characteristics for a Western Highland Rim forest. We hypothesized that the intense fires in charcoal hearths would have altered edaphic conditions and created microsites that would support different species and stand structures. Mikan and Abrams (1995) found charcoaling had a significant influence on forest composition and age structure more than a century after its abandonment in Pennsylvania. However, Young *et al.* (1996), in Pennsylvania and Virginia, did not find differences in compositional measures, but only in tree density and overstory cover. Our results show that vegetative composition did not systematically differ between remnant charcoal hearths and the surrounding environment. Although remnant charcoal hearths are still visible on the modern landscape, the results of this study indicate the historic land use has minimal influence on modern forest community dynamics in SSF.

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