Pre-Columbian Native American Use of Fire on Southern Appalachian Landscapes

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Introduction

Fire suppression in the southern Appalachians is widely considered responsible for decreased regeneration in oak (*Quercus*) and fire-adapted species such as table mountain pine (*Pinus rigida*) and pitch pine (*Pinus pungens*) (Barden & Woods 1976; Harmon 1982; Abrams 1992). How fire-adapted species survived in the southern Appalachian highlands in pre-Columbian times is an enigma; lightning-set fires are very infrequent (Harmon 1982; Bratton & Meier 1995) in this region of high annual precipitation. Barden and Woods (1976), Harmon (1982), and Abrams (1992) have speculated that in pre-Columbian times, Native American use of fire may have been important in the eastern deciduous forest region, but no published studies have documented that the use of fire by prehistoric Native Americans affected the composition of southern Appalachian vegetation.

We evaluated the importance of pre-Columbian human impacts on vegetation of the southern Appalachian highlands by comparing the fossil pollen and charcoal-particle record preserved in peat deposited during the past 3900 calendar years in Horse Cove Bog, Highlands, North Carolina, with the archaeological record. We examined the implications of our findings for conserving biodiversity and maintaining landscape heterogeneity using prescribed burning.

Study Area

Horse Cove is located in Macon County, North Carolina (35°2′30″N, 83°9′30″; 887 m elevation), in the northern Chattooga River watershed along the southeastern Blue Ridge escarpment (Fig. 1). Horse Cove Bog is a 12-ha alluvial wetland developed on relatively level terrain within the 2 × 0.7 km valley. Surrounding hillslopes are steep, with gradients up to 80% and >750 m relief. Annual rainfall is the highest in eastern North America and ranges between 202 and 254 cm at nearby Highlands and Whiteside Mountain (McIntosh 1990). Horse Cove is situated within the Appalachian oak (formerly oak-chestnut [*Quercus-Castanea dentata*]) forest region (Stephenson et al. 1993). Within a 9-km radius of Horse Cove, 28 archaeologically significant sites dating from 8000 BC to the present have been identified (R. Snedeker, written communication). Horse Cove was settled by Euro-Americans in AD 1837 (McIntosh 1990). In AD 1811, before widespread logging, the regional composition of forests consisted of 42% oak, with 25.5% pine, 19.5% chestnut (*Castanea*), and 2% hickory (*Carya*) (Meier & Bratton 1995).

In the Highlands Ranger District, from AD 1955 to 1994, only 5 years had records of lightning-set fire, with an average of about 7 years between fires (Bratton & Meier 1995). Lightning strikes occurred on ridgetops and along xeric, upper hillslopes with west-, southwest-, or south-facing aspects, with 72% of lightning ignitions on the most xeric slopes. Ridge-crest fires did not spread into lower, sheltered coves or stream valleys. Lightning strikes within mesic, deciduous forest rarely ignited into wildfires.

Methods

From a 40-cm vertical column of peat, we sampled and chemically processed the sediment for pollen and charcoal using standard methods (Delcourt et al. 1986). Chronology of the site was based on four radiocarbon dates and three pollen levels that characterized historic forest

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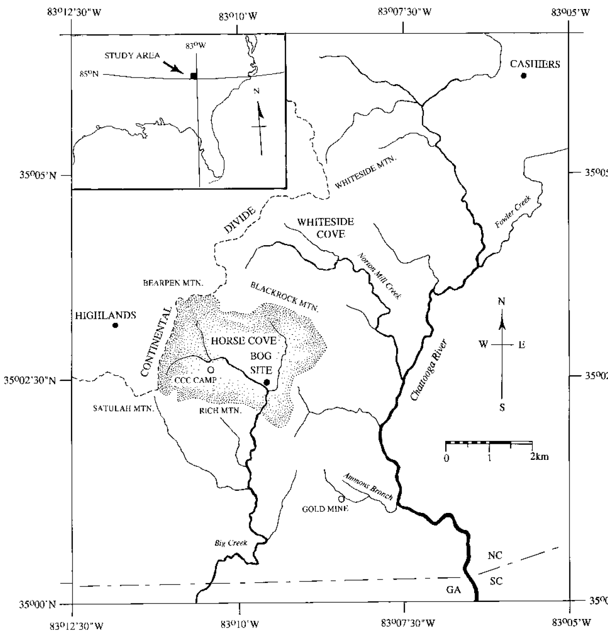

Figure 1. Horse Cove Bog in the Appalachian summit region, southern Blue Ridge Mountains, western North Carolina. Stippling defines the local watershed for Horse Cove along the eastern continental divide. Streams drain Horse Cove, flowing south, then east into the Chattooga River, then from the Savannah River to the Atlantic Ocean.

changes (Table 1). A total of 500 or more native pollen grains and spores was tabulated on systematic transects for each sample; charcoal particles were recorded in six size-class categories and were tabulated on the same transects as in the pollen counts. Number and geometric mean of total area of charcoal particles were calculated for each size class (Patterson et al. 1987) to determine cross-sectional area.

Results

Horse Cove Bog peat has been accumulating since 3550 years BP (radiocarbon years Before Present; Table 1). The upland pollen assemblage was generally dominated by oak and chestnut (each up to 35%, Fig. 2). Oak percentages remained nearly constant throughout the sequence. Percentages of chestnut pollen increased from an initial 7% to 36% by about AD 1000, then diminished to 20% to 25%. By about AD 1900, chestnut pollen declined to 14%. Pine pollen generally totalled 8% to 16%, with hickory represented by 1% to 6% of the upland pollen sum. Hemlock (*Tsuga*), sugar maple (*Acer saccharum*), beech (*Fagus grandifolia*), and butternut (*Juglans cinerea*) were most abundantly represented by pollen prior to the early 20th century. Grasses (Poaceae) reached 30% between about BC 2000 to 1500, then diminished to 4% to 10% of the upland pollen assemblage. Bracken fern (*Pteridium aquilinum*) had several prominent peaks in abundance. Ragweed (*Ambrosia*) was present prior to AD 1000 only in trace amounts, increased to 2% to 4% between about AD 1000 and 1830, and thereafter increased from 7% to 15% of the upland pollen. Herbs represented in the pollen record in pre-Columbian times included goosefoot (*Chenopodium*), plantain (*Plantago*), sumpweed (*Iva*), purslane (*Portulaca*), and maize (*Zea mays*). In historic times plantain, dock (*Rumex*), sump-

Table 1. Chronology for the Horse Cove Bog (Macon County, North Carolina) sediment sequence.

Midpoint sediment depth (cm) (depth range)	*Conventional radiocarbon age ±1 SD in yr BP**	*Calibrated calendar yr ±1 SD*	*Sediment depth interval (cm)*	*Time span in years*	*Sediment accumulation rate (cm/yr)*	*Deposition rate (yr/cm)*
0.0	Bog surface	AD 1995				
			4.0	65	0.062	16.3
4.0	*Castanea* decline	AD 1930				
			8.0	30	0.267	3.8
12.0	Historic logging	AD 1900				
			6.0	70	0.086	11.7
18.0	*Ambrosia* rise	AD 1830				
			1.5	405	0.004	270.0
19.5 (19–20)	510 ± 50	AD 1425				
			6.0	745	0.008	124.2
25.5 (25–26)	1330 ± 60	AD 680				
			6.0	2340	0.003	390.0
31.5 (31–32)	3370 ± 70	BC 1660				
			6.0	230	0.026	38.3
37.5 (37–38)	3550 ± 100	BC 1890				
			2.5	96	0.026	38.3
40.0	Base of sequence	BC 1986 (extrapolated)				

**Conventional radiocarbon dates are corrected by C^{13}/C^{12} ratios.*

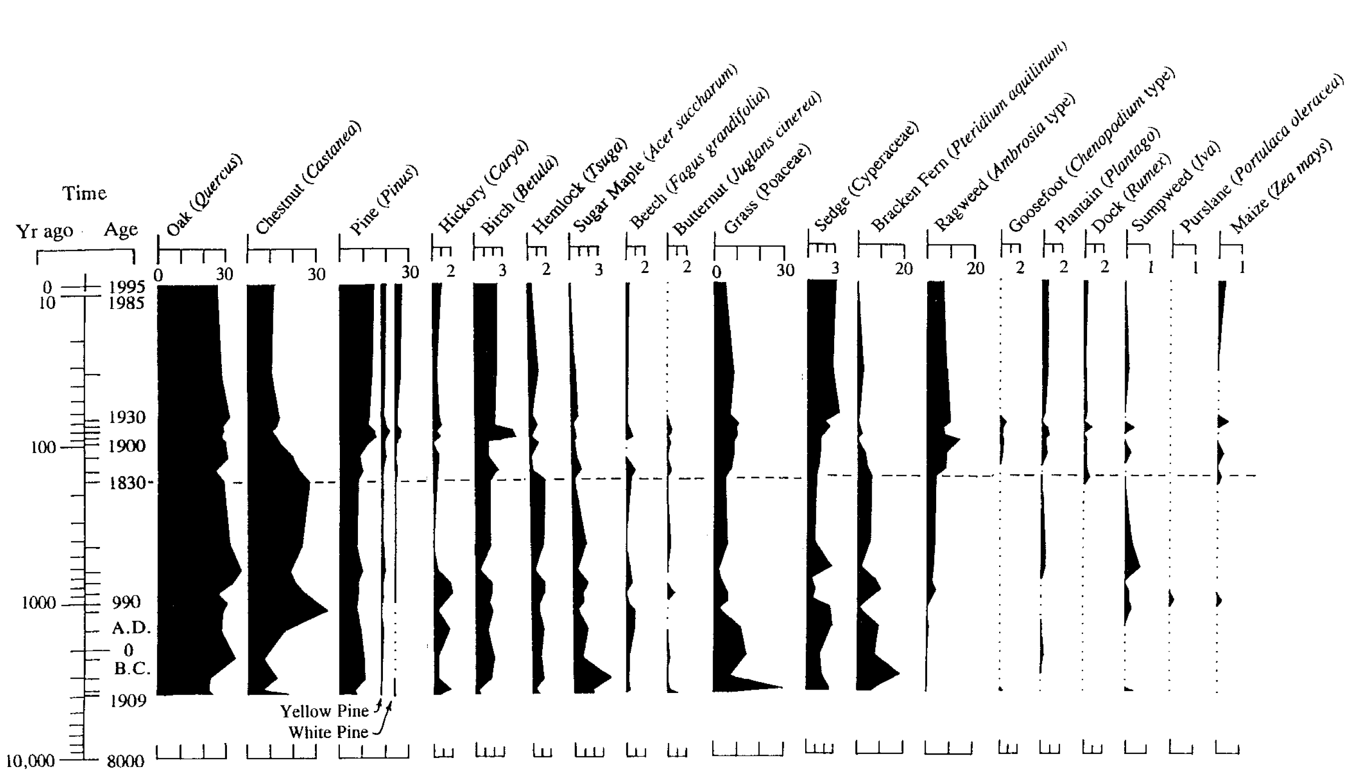

Figure 2. Selected curves for pollen grains and spores from Horse Cove Bog. Note the logarithmic vertical scale for the site chronology, based on calibrated calendar years before present (AD 1995). Percentages are based on the sum of pollen grains and spores of trees, shrubs, herbs, and ferns, excluding obligate aquatic plants. The horizontal dashed line at AD 1830 separates prehistoric and historic portions of the diagram.

weed, and maize were all consistently represented in the pollen record.

Prehistoric pollen accumulation rates (PAR) averaged an influx of 7941 grains/cm^2 of bog surface each year. The PAR were generally >50,000 grains cm^{-2} yr^{-1} after AD 1830. In prehistoric times charcoal accumulation rates (CHAR) ranged between 4 and 9 mm^2 cm^{-2} yr^{-1} (Fig. 3). Uncorrected values for historic CHAR rates ranged from 41 to more than 227 mm^2 cm^{-2} yr^{-1}. After AD 1830, corrected CHAR values (standardized based on the ratio of historic PAR to prehistoric PAR) averaged 7 mm^2 cm^{-2} yr^{-1} and were comparable with prehistoric CHAR, which averaged 6 mm^2 cm^{-2} yr^{-1}.

Discussion

From the pollen record, it appears that oak and chestnut have been dominant in the forests surrounding Horse Cove for the past 4000 years. Chestnut pollen has remained represented in the pollen record to the present, despite selective cutting and the decimation of American chestnut trees (*Castanea dentata*) by the fungal blight that struck the southern Appalachians in the early 1930s (Zahner 1994). The continued production of *Castanea* pollen is largely attributable to a second native species, chinquapin (*Castanea pumila*), which is locally abundant in the vicinity of Highlands today (J. D. Pittillo, personal communication; Zahner 1994).

A number of weedy herbs and cultigens, including goosefoot, plantain, purslane, sumpweed, and maize, that occurred in the Horse Cove Bog pollen record in pre-Columbian times are indicative of human activities (Yarnell 1976; Delcourt 1987). In historic times the pollen record included exotic Eurasian weeds such as dock.

Histograms of relative abundances of charcoal particles, tabulated by classes of cross-sectional area, illustrate changes in fire proximity to the bog (Fig. 3). Particles in the smallest area class (0.5–1 grids, 83–165 μm^2) were most likely derived from a broad region (>2 km). Charcoal in intermediate area classes (1–5 grids, 165–825 μm^2) probably came largely from fires on the restricted watershed surrounding Horse Cove Bog (stippled area in Fig. 1). Only those charcoal particles >50 μm in length and >5 grids (>825 μm^2) were produced by fires near the study site (Patterson et al. 1987; Clark & Royall 1995).

During the late Archaic cultural period (Fig. 3), local fires were less important contributors to the charcoal record (10%) than were watershed (55%) and regional (45%) fires. During the Woodland period, local fires increased to 30% of the charcoal record, with watershed and regional fires accounting for 50% to 55% and 20% to 30% of total cross-sectional area for charcoal particles,

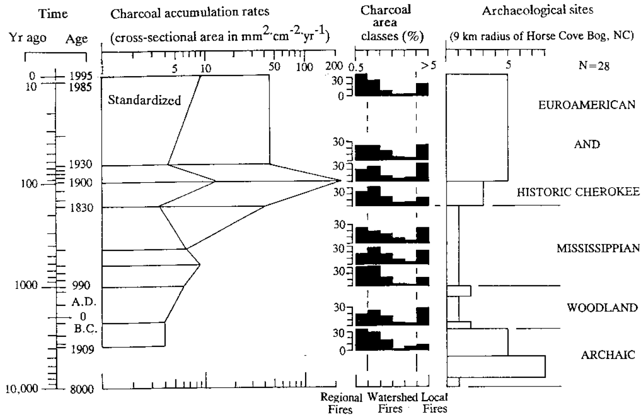

Figure 3. Horse Cove fire history over the past 4000 years. The charcoal accumulation rates from AD 1830 to 1995 are graphed as both calculated values and (smaller) standardized values that reduce the bias potentially introduced by historic forest clearance, sheetwash erosion of upland soils, and downslope transport of charcoal particles into Horse Cove Bog. The histograms of size classes for charcoal particles (graphed as percentage of total cross-sectional area) portray the relative contributions of charcoal from atmospheric inputs of regional fires (the size class 0.5–1.0 grid), from fires on nearby watershed slopes (size classes from 1.0–5.0 grids), and from local fires (largest size class of >5 grids, with charcoal particles also >50 μm in length). The archaeological sites identified within 9 km of the Horse Cove Bog site demonstrate local settlement by Native Americans throughout the past 10,000 years.

respectively. Mississippian times were characterized by incidence of local fires varying from 20% to 25% of the charcoal input. Mississippian-age watershed fires contributed 50% to 60%, and regional fires accounted for 18% to 25% of the charcoal. The historic Cherokee interval was characterized by 15% of charcoal from local fires, 24% from regional fires, and 61% from watershed-level fires. At AD 1900 coincident with historic Euro-American logging and slash fires, local fires accounted for 30% of the charcoal, with watershed fires contributing 48% and regional fires 22%.

High charcoal particle influx during the time of active fire suppression after AD 1930 is a consequence of (1) persistent local figures (set by lightening, accident, and arson; 20% to 25% of the charcoal); (2) watershed fires (40% to 50%); and (3) input from regional sources (25% to 35% of the charcoal particle influx, Fig. 3). High CHAR values during the time of fire suppression are thus in part an artifact of an expanded source area for fine-grained particulates since the regional landscape was opened by logging, conversion to agriculture, and urbanization. Locally high PAR values during this time interval include grains eroded from hillslopes after land clearance and increased pollen production on open landscapes.

Paleoecological results from Horse Cove Bog indicate that during most of the last 4000 years Native Americans played an important role in determining the composition of southern Appalachian vegetation through selective use of fire. Late Archaic peoples probably used fire for warmth and cooking, and they may have deliberately set fires, particularly on upper slopes of surrounding mountains to attract game animals such as white tailed deer (*Odocoileus virginianus*) and elk (*Cervus elaphus*) to grassy openings within the forest (Purrington 1983). Use of fire in late Archaic and Woodland times probably also promoted sprouting (Harmon et al. 1983), thereby increasing the abundance of chestnut and oaks growing in open groves with bracken and grass understory. Human-set fires likely would have spread to the ridge tops of nearby mountains, maintaining fire-adapted species of table mountain and pitch pines.

During the late Archaic, Woodland, and Mississippian times, human impact was concentrated within two areas of the landscape: (1) alluvial bottoms of major rivers and coves where temporary camps and villages were established and crops cultivated in garden plots and (2) upper slopes and ridge tops, where people hunted and gathered hickory nuts, acorns, and chestnuts seasonally. More mesic areas along the Blue Ridge escarpment and in north-facing lower slopes probably escaped presettlement fires. The pre-Columbian "baseline" of wildfire from Horse Cove demonstrates that prehistoric humans used fires that were focused on particular portions of the landscape and excluded from others. We infer that this regime of wildfire use was an intermediate-scale disturbance regime that promoted a heterogeneous mosaic of different vegetation types, some of which included fire-adapted species, and others of which included fire-intolerant species. We speculate that pre-Columbian Native American burning would have heightened the contrast across vegetational boundaries and increased beta and gamma landscape diversity.

If management goals include maintaining fire-adapted pines and certain oak species that are currently declining in the southern Appalachian Mountains because of active fire suppression, then future management tools clearly must include prescribed burning. To maintain both old-growth mesic hardwoods and fire-adapted pines within the same forest district, an optimal management plan would be based upon an understanding of the effects of different frequencies and intensities of fire applied to varying portions of the topographic-edaphic gradient and different areal extents of impact (Harmon et al. 1983). Old-growth mixed mesophytic forests will regenerate only under a disturbance regime that includes infrequent windthrow to open canopy gaps but that explicitly excludes fire. Promotion of Appalachian oak forests, including open "oak orchards" with grass and bracken fern understory, requires frequent ground fires such as may have been used by pre-Columbian Native Americans to maintain their hunting and gathering grounds. Furthermore, periodic crown fires along exposed ridge crests may be necessary for regeneration of fire-adapted endemic pines.

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