Holocene comment and reply

Charcoal evidence for Indian-set fires: a comment on Clark and Royall

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Abstract: Clark and Royall (1995) present a charcoal influx curve for Crawford Lake in southern Ontario and conclude that the Indians were responsible for a succession from beech to oak and pine throughout southern Ontario. We present an alternative hypothesis, that the 'Little Ice Age' caused the forest succession and that domestic fires and burning of stubble in agricultural fields were responsible for the charcoal record.

Key words: Charcoal, Ontario, Crawford Lake, forest fire, 'Little Ice Age', vegetation, human impact, climatic change.

Introduction

Clark and Royall (1995; hereafter C&R) suggest that Indian-set fires caused major changes in the forest landscape of southern Ontario. The landscape change itself is well known (see, for example, Burden *et al.*, 1986; McAndrews, 1988; McAndrews and Boyko-Diakonow, 1989; Campbell and McAndrews, 1991; 1993), and both Indian activity and climate change have been invoked to explain it. What C&R bring to the debate is a fossil charcoal abundance record from Crawford Lake.

The charcoal record shows one small prehistoric charcoal peak and one smaller historic charcoal peak; the period AD 1350–1650 shows a slightly higher background charcoal influx than either the preceding or following periods (their Figures 2–3). C&R interpret these data to indicate an increase in burning in the general region, with fire in the watershed of Crawford Lake at least at the time of the larger peak and possibly at the time of the later peak. C&R also suggest: (1) that the increase in fire was an increase in forest fire; (2) that the forest fires were due to Indian activity; and (3) that the forest succession from beech to oak and white pine (seen in the Crawford Lake and other regional pollen diagrams) was a result of this increase in fire and hence of Indian activity. Here we examine these interpretations and suggest an alternative.

The problem

Although C&R cite ethnohistoric accounts of Indian burning from the late 1700s referring to areas as far away as Florida, in the *Jesuit Relations* (Thwaites, 1896–1901), written in Ontario and Quebec in the early 1600s, there is only one mention of a landscape fire in southern Ontario, and that is a meadow fire set by the Jesuits themselves, apparently for fun. The foremost authority on the ethnohistoric literature of this region has found no ethnographic evidence for Indian-set forest fires (Heidenreich, 1971). Indeed, the Iroquoians lived in villages constructed of bark and wood poles; their structures would have been highly flammable, and a forest fire anywhere near their village would invite disaster.

C&R state that the background charcoal influx is composed of low atmospheric inputs from distant fires plus particulates borne by surface flow or redeposited during years with no local fire, and that the level of background charcoal varies directly with the frequency of peaks representing local fires. However, if redeposition is the more important process, then an increase in background level coinciding with an increase in peak frequency may not reflect a regional phenomenon but rather some resuspension from the local peak-charcoal influx events. The 1658 charcoal peak is in the historic period, well after Iroquoians had abandoned the area, and the single maize pollen grain coincident with the 1658 charcoal peak may be redeposited, as may be the charcoal forming the peak. The level of Crawford Lake fluctuated during the late Holocene, as indicated by erosional terraces both above and below the modern lake level (which is maintained in part by a logjam on the outlet stream); this would permit resuspension and redeposition of charcoal, pollen and other particulates.

The 1442 peak must represent a fire event. However, it could well be an ultralocal fire, perhaps even a bonfire lit on the ice in winter by fishermen. It may of course also be the product of a small forest fire in the watershed, but the fire would have had to be very small, as there is a community of cedars a few hundred metres east of the lake including a large number of individuals over 1000 years old with no fire scars (Larson and Kelly, 1991). The archaeological village about 100 m north of the lake was not destroyed by fire (W.D. Finlayson, pers. comm., 1994). The areas west and south of the lake are wetlands. C&R suggest that a charcoal peak of this magnitude must represent a fire within one hundred or so metres of the lake, but there scarcely seems room on the landscape to place a fire large enough to contribute materially to the vegetation succession.

The evidence that this peak is not an isolated event comes exclusively from the slight increase in background charcoal influx during the Indian period. This increase is statistically significant, but it could be partially redeposited charcoal from the 1442 event, or it could be from domestic fires and burning of field stubble, a practice documented in the regional ethnographic literature (Thwaites, 1896–1901).

The argument against domestic and stubble fires rests on the assumptions that about 10% of the wood in a fire is converted to charcoal, that about 1/1000 of the charcoal leaves the fire site as fragments larger than 50 μm, and that about 1% of the charcoal leaving the site in this size class eventually finds its way into the lake. By equations they do not present, C&R conclude that point sources would need to burn 10^4 to 10^6 t yr^{-1} of wood to produce the background signal observed during the Indian period. The calculation 29 $gm^{-2}yr^{-1}$ (from C&R Table 1)* 100 (for 100 m^2 of lake bottom, after C&R)* 100 (for lake deposition) * 1000 (for emission)* 10 (for charring) = 2900 t yr^{-1} or 2.9* 10^3 t yr^{-1} is orders of magnitude less than C&R's unexplained result.

Estimates of land-clearance rates for Iroquoian peoples range from 0.12 to 0.33 ha $person^{-1}yr^{-1}$ (Heidenreich, 1971; Sykes, 1980; Monckton, 1992). If the Crawford Lake village had a population of about 500, then some 60–165 ha of forest would be largely burned as fuel and slash each year during the occupation; other villages in the region would also have been using wood for fires and burning slash. Taking a round 100 ha yr^{-1} of burning as fuel and slash, we find that the prehistoric forest would need to have a standing biomass of only 29 t ha^{-1} to supply all the charcoal as domestic fires and slash fires. As a typical southern Ontario maple-beech stand today has 50–100 t ha^{-1} (Bonnor, 1985), this level of charcoal production could easily be supported by domestic and slash fires.

C&R compare their estimate of the total amount of fuel required to support the *entire* background flux by domestic fire with the amount of forest fire required to support only the *increase* in background flux between the pre-Indian and Indian periods. The number they use for the increased wood burning needed to sustain the increased charcoal flux (70 kg $ha^{-1}yr^{-1}$) does not appear to include the conversion of charcoal to wood, which makes the estimated increased fire consumption of wood closer to 0.7 t $ha^{-1}yr^{-1}$. If this amount is needed to support only the *increase* of 7 $gm^{-2}yr^{-1}$, then the amount required to support the entire background flux would be 2.9 t $ha^{-1}yr^{-1}$. Without considering wind direction, distance from source, drainage-basin characteristics, lake size (2.5 ha, not 1.5 as stated in C&R), and a multitude of other factors, it is not possible to evaluate the amount of fuel needed to produce a given charcoal flux. Any attempt to do so is misleading.

Finally, C&R conclude that it was this increase in fire activity that caused the succession of beech to oak and pine that occurs at Crawford Lake and at Second Lake (Burden *et al.*, 1986), which also shows evidence of local Indian occupation. However, beech pollen also declines rapidly at Found Lake (McAndrews, 1981), Tonawa lake (Campbell and McAndrews, 1991), and Barry Lake (McAndrews, 1984), and the decline is not coincident with Indian occupation at any of these sites. Indeed, the sites C&R specifically cite as *not* showing a rapid beech decline, Hams Lake and Nutt Lake (Bennett, 1987), do show a pronounced rapid beech decline, followed by an increase in oak and pine, the same as in Crawford Lake and virtually all other southern Ontario sites (Campbell and McAndrews, 1991).

Campbell and McAndrews (1993) present model simulations to explain the dynamics by which cooling may have effected the beech to oak and pine forest succession, and they consider the consequences of the cooling for carbon storage, assuming that the cooling was the driving force. Evidence that this was the case is presented in Campbell and McAndrews (1991), which C&R do not cite. Szeicz and MacDonald (1991) conclude that a particular vegetation formation in southern Ontario is not the result of Indian fire, and Campbell and Campbell (1994) show that Indian populations in southern Ontario were too small to affect the regional landscape in any significant way.

C&R criticize Campbell and McAndrews (1993) for using in the model a monotonic cooling starting in AD 1200. Gajewski (1988) has shown a cooling trend throughout the last millennium, Grimm (1981) shows cooling after AD 1500, and Clark (1988) has in the past cited Leonard (1986) as presenting a palaeoclimate record from the northern Great Plains (Leonard's site is actually in the Rocky Mountains) that shows a warm period from AD 1400 to 1600. In fact all available evidence essentially agrees that temperatures in the Great Lakes region peaked *c.* AD 1000–1200, with cooling thereafter (see, for example, Bernabo, 1981; Cermack, 1971), although brief warming episodes were embedded in the cooling trend. The use of a monotonic cooling starting in AD 1200 in Campbell and McAndrews (1993) was to demonstrate that a gradual monotonic cooling could have severe disequilibrium effects, not to match the 'Little Ice Age' climate of southern Ontario as exactly as possible.

Alternative explanation

A possible explanation for C&R's charcoal curve that we find more consistent with the facts runs as follows. The increase in background levels is due partly to reworking of charcoal from a single large event, partly to domestic fires, slash fires, and stubble fires, and perhaps to a very small degree to an increase in forest fire far to the north in the region of Algonquin Park (Cwynar, 1978). The single large event may be the result of a slash fire in a field near the lake shore; it occurs towards the end of the maize pollen period, which would have been the time of maximum expansion of fields around the village. The land immediately adjacent to the lake is of poorer quality than most of the land around the village and might not have been cultivated until close to the end of the economic life of that village site. The forest succession would have been due to climate cooling.

Alternatively, the single large charcoal flux event could have been due to a small forest fire (not more than a few hectares) near the lake. Such a fire need not have been set by Indians, either accidentally or on purpose; a cold winter or two (part of the climate cooling) could have produced plenty of dead wood to feed a lightning-ignited fire.

In either scenario, the prime mover for the forest succession is climatic cooling, not Indian-set fires. The fact remains that, as demonstrated by Campbell and McAndrews (1991), the forest succession found at Crawford Lake occurred with minor variations throughout southern Ontario, even in areas with no horticultural Indians; another succession consistent with cooling occurred farther north. The evidence presented by C&R for Indian-set fires consists of one sample of one varve at one site.

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