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FORUM

Does the absence of sediment charcoal provide substantial evidence against the fire and oak hypothesis?

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Introduction

Drs James Clark and Daniel Royall (1996) have recently discussed in this journal the evidence from sediment charcoal for fire regimes across a longitudinal gradient of northern hardwood-conifer forests in the north-eastern United States and southern Ontario. One of the study sites, called Devil's Bathtub, is presently dominated by *Quercus* (oak) forests and Clark and Royall used the lack of sedimentary charcoal production within this catchment to question the role of fire in oak recruitment in forests of the north-eastern USA. We have several concerns firstly about the use of this site to question the fire and oak hypothesis (Abrams 1992), and secondly about possible methodological limitations in using palaeoecological studies to reconstruct historical fire regimes. Here we outline what we perceive to be some of the challenges in reconstructing species assemblages and fire history in northern hardwood forests, with particular reference to the ecological role of surface fires in eastern US oak forests and whether they can (or cannot) be detected in the sedimentary charcoal record.

Results from the Devil's Bathtub

The Devil's Bathtub is a small (0.7-ha) steeped-walled kettle pond, located on the Till Plains in western New York on a coarse-textured soil. The site presently supports oak forest (Clark & Royall 1996; Clark *et al.* 1996) and has apparently been surrounded by beech (*Fagus grandifolia*) – sugar maple (*Acer saccharum*) forests since 8300 year BP following the transformation from *Picea* and *Pinus* forests. The oak forest within Devil's Bathtub has abundant sugar maple, red maple (*Acer rubrum*) and white ash (*Fraxinus americana*) in the understorey (Clark *et al.* 1996, personal observation). Clark and Royall found relatively high background levels of charcoal at Devil's Bathtub compared to other northern hardwood forests, but an absence of high frequency peaks that would indicate local fires. These data appear to contradict the idea that oak species require periodic fire to persist in forests in the north-eastern USA.

There are several important challenges facing palaeoecologists in the study of oak distribution and fire frequency that are left unresolved by Clark & Royall (1996). First, oaks are known for prolific pollen production relative to maple and beech (Graumlich & Davis 1993) and there may therefore be a tendency to over-estimate both the abundance of oak at a site relative to other hardwood species and the probability of finding fire evidence. A bigger challenge, however, is the difficulty in detecting low intensity surface fires in the sediment charcoal record as distinct from the regional background, a problem alluded to by Clark & Royall (1996). Clark *et al.* (1996) defend their interpretation of the low emission estimates from the Devil's Bathtub because of the clear charcoal peaks formed from surface and/or crown fires in *Pinus resinosa* forests in Minnesota and from slash-and-burn agriculture in mesic deciduous forests in southern Ontario. However, we do not believe that the charcoal emissions from either of these examples are analogous to that produced by the relatively incombustible litter found in oak forest understorey.

We believe that surface fire is the predominant type of burn in oak forests and that it results in inhibition of the reproduction of fire-sensitive, later successional species while leaving the mature oak trees unharmed. It is possible that the high levels of low frequency charcoal found at the Devil's bathtub site originated from fires in the adjacent oak forests and were not properly interpreted by Clark and Royall. For example, the charcoal record of a *Chamaecyparis thyoides* wetland in Massachusetts, USA, did not show evidence for known regional fires, and this suggests that most of the charcoal sediment, both high and low frequency, originated from local fires within the wetland (W. Patterson III, personal communication; Motzkin *et al.* 1993) Until the issue of charcoal emissions from low-intensity fires is resolved, we do not believe that one can state with a high degree of certainty that fires did not occur at Devil's Bathtub.

The present-day domination of the understorey at the Devil's Bathtub by maple and ash makes it very difficult to believe that periodic fire did not occur. The replacement of oak by maple and other hardwood species is a widespread phenomenon throughout much of eastern North America, which is often attri-

buted to fire-exclusion (Lorimer 1989; Abrams 1992). If maple and ash trees have the physiological ability to recruit in large numbers on the Devil's Bathtub site (i.e. the site is not an edaphic oak climax) then what disturbance factor other than fire could historically have prevented these species from replacing oak? It is difficult to perceive how wind-throw, by itself, could be responsible, especially since wind-throw and ice-storms may actually accelerate oak replacement by damaging the overstorey oaks and thus releasing later successional understorey individuals (Abrams & Scott 1989).

Clark & Royall (1996, page 379) state that 'Fire histories recorded by our method are most heavily influenced by the lake catchment, and more distant fires simply do not show'. The small steep-walled nature of the catchment at the Devil's Bathtub may also mean that the pollen data will be dominated by local vegetation patterns and may not be indicative of the broader region. A palaeoecological study of a wetland, located 35 km to the west of Devil's Bathtub and surrounded by beech-maple forest (Gehris 1971), indicated more recent declines in regional oak pollen, not apparent in the Clark and Royall data. Moreover, two large Seneca Indian communities, in which the uplands were cleared of trees with fire and chisels or girdling to promote blow-down, were located 8–15 km from Devil's Bathtub (Beale 1992; Dennis 1993). Considering that the Senecas occupied a site for 35–50 years, each episode of clearing a new site should have generated a pulse of atmospheric charcoal. Moreover, the Senecas burned their agricultural fields, some of which were several km in length, to rid them of weeds and insects as well as to promote soil fertility (Dennis 1993). The fact that little evidence for fire was recorded in the original land surveys following European settlement (Seischab 1990), referred to by Clark and Royall as supporting evidence of their own work, does not reflect the amount of burning that may have occurred during earlier Indian occupation. Omission of these important pre-European fire and land-use history events raises concerns about the significance of the Devil's Bathtub for palaeoecological reconstruction.

Conclusion

Clark and Royall have published two major papers describing the lack of fire in the hardwood forests at Devil's Bathtub and suggest that these data may contradict the fire and oak hypothesis. However, the hypothesis as outlined in Abrams (1992) was intended to describe the fire ecology of the vast oak forests found throughout southern New England, the mid-Atlantic region, the southern Appalachians, the mid-West and central Plains, that have persisted for thousands of years. It has been clearly stated that pre-European oak distribution in the northern hardwoods was limited, as was the occurrence of large-scale burning not associated with Indian activity, and that natural fires may have occurred only at intervals exceeding 1000 years (Lorimer 1977; Bormann & Likens 1979; Whitney 1986). While it is interesting that oaks may have dominated the tiny Devil's Bathtub catchment for most of the Holocene, it is an isolated island in a matrix of beech-maple forest which has a very low tendency for natural fires. Therefore, reporting that the Devil's Bathtub did not burn vis-à-vis the fire and oak hypothesis may be much ado about nothing. Ironically, vast expanses of pre-European oak-hickory (*Carya*) forest existed within 25 km of the Devil's Bathtub (Seischab 1990), and it is unfortunate that a suitable varved lake or bog within that region, which would allow a better evaluation of the role of fire in northern oak forest, was not studied by Clark and Royall.

A substantial number of palaeoecological studies indicate the occurrence of periodic fire in eastern US oak forests during the Holocene epoch (see Abrams 1992; Maenza-Gmelch 1997). Moreover, fire scar studies of ancient *Q. rubra* and pine stands in Ontario, Canada report a significant fire frequency before and after European settlement (Guyette & Dey 1995), indicating that at least some oak forests within the northern hardwood biome burned periodically (also see Davis 1985).

We are glad that Dr Clark and his associates are interested in looking for palaeocharcoal data in oak forests of eastern North America. However, we believe that the Devils' Bathtub site is a poor example in which to challenge the oak and fire hypothesis because of its isolated location within a region of beech-maple forest and its small size and physical features which seemingly limit charcoal and pollen input to the 0.7 ha catchment, rather than reflecting the broader region. The fire and oak hypothesis (Abrams 1992) was not originally intended to describe the palaeoecology of small oak populations within northern hardwood forests, which probably existed because of a combination of the extreme edaphic conditions and periodic fire. We look forward to seeing further studies of charcoal emission from low-intensity surface fires as well as sediment charcoal studies in more representative oak forests within the northern hardwood biome and further south in the true mixed-oak regions that will serve as a better test of the fire and oak hypothesis. Until these data are available, information on charcoal emissions will continue to be subject to a wide range of interpretation.

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