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R. B. Davis, T. E. Bradstreet and H. W. Borns, Jr.

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Note

REPLY TO R.J. MOTT (1977) REGARDING AN EARLY BOREAL FOREST IN NEW ENGLAND AND ADJACENT POSTGLACIAL CANADIAN AREAS

R. B. DAVIS, T. E. BRADSTREET, and H. W. BORNS, Jr., Department of Botany and Plant Pathology, Institute for Quaternary Studies, and Department of Geological Sciences, University of Maine, Orono, Maine 04469, U.S.A.

We would like to reply to MOTT (1977) who stated in this journal (p. 145) that «The influx rates determined by DAVIS *et al.* (1975) that led them to speculate on the absence of the spruce «Boreal Forest» period in Maine and northern New England in general, appear to be inaccurate because of the erroneous estimates for sedimentation rates.» We stated (p. 457) in regard to *Picea* pollen percentages that, «...spruce forest and tundra can produce similar percentage data...» and that this... «calls into question the interpretation of the lower levels of percentage diagrams from northern New England and maritime Canada.» Further, we suggested (p. 458) that the earliest postglacial forests in northern New England may have been a mixture of boreal *(e.g. Picea)* and temperate *(e.g. Pinus strobus)* tree taxa. As we shall attempt to demonstrate below, these «speculations» are justified.

The part of Mott's statement regarding erroneous «sedimentation rates» is unsupported, and Mott offers neither an explanation nor corrections for the supposed error(s). Furthermore, it is not clear which «sedimentation rates» he is referring to. Two possibilities are (1) the Moulton Pond core itself where we derived sediment accumulation rates by interpolation along a curve fitted to the ^{14}C dates (p. 437-438 and Fig. 2) and (2) Table I where we summarized pollen influx rates for various North American vegetation types based on data collected by three methods, viz. (a) pollen counts from Petri dish samplers, (b) cores, and (c) surface sediment samples. Regarding possibility (1), we have reviewed our data and cannot find that errors were made in execution of the stated methods. The risks inherent in curve fitting and interpolation should be obvious to all researchers, but we feel that in so doing we made the best use of our data. Regarding possibility (2), we comment only on method (c). The pollen concentrations in surface sediments, which we obtained from DAVIS and WEBB (1975), were converted to influxes by multiplying by «hypothesized sediment accumulation rates» (DAVIS *et al.,* 1975). In reality, the rates were not completely hypothetical, but were based in part on extensive experience in taking and dating short cores of lake sediments (*e.g.* DAVIS, 1967, 1974; DAVIS and NORTON, 1978) and examining a wide literature (reviewed in part by DAVIS, 1974; explained further by DAVIS *et al.,* 1975, Table 1). We used the term «hypothesized» to avoid exaggerated claims to accuracy. The selection of sediment accumulation rates also took into consideration the uncompacted nature of the upper cm of sediment. Sediment compaction curves based on water content (normalization to a constant accumulation rate of solids; DAVIS and NORTON, 1978) applied to net sediment accumulation rates for recent lake sediments (DAVIS and WEBB, 1975; and various subsequent literature) suggest that the rates used for these influx estimates were not unrealistic. At the present «state of the art», the degree of agreement between the influx rates derived by the three different methods (a - c, above) is as good as can be expected. To call the «sedimentation rates» «erroneous» is without basis, although improved data are needed (Mott offers none) as stated by MOTT and FARLEY-GILL (1978).

We will now discuss the nature of the first postglacial forests, first at Moulton Pond and then in the broader region. The mean influx rates (grains/cm^2/yr) which we gave (DAVIS *et al.,* 1975, Table 1) ranged for tundra from 200 to 1500, forest-tundra 1680 to 6620, and forest (various) 6800 to 46,800. In the Moulton Pond core, subzone **Id,** based on a single count with 35 percent NAP and estimated influx of 3800, represents a brief transition (less than a millennium) from a tundra period averaging 420 grains/cm²/yr (range 120-920) to a conifer-hardwood forest of temperate character averaging 18,650 (13,320-24,890). The **Id** spectrum differs from modern spectra from boreal forest regions (DAVIS *et al.*, 1975, p. 452 and Fig. 7). On these bases, we concluded that a closed boreal forest or closed spruce-dominated forest either had a very brief existence (perhaps missed due to the interval between subsamples from the core) or was absent in the vicinity of Moulton Pond.

High spruce pollen percentages characterized the tundra period at Moulton Pond as they do elsewhere in sediment covering this period in New England and nearby areas of Canada. At Moulton Pond, spruce pollen percentages in the tundra period average 27 percent and range from 11 to 64 percent. They are accompanied by substantial percentages of pine and birch pollen. The spruce percentages are similar to those from the modern boreal forests of eastern North America where surface sediments contain 36.6 ± 18.0 percent. The modern forest-tundra and tundra in eastern North America also produce high spruce percentages, viz. 49.1 ± 16.4 and 15.9 ± 7.7 percent, respectively (DAVIS and WEBB, 1975). These modern percentages are based on totals excluding the pollen of small shrubs and herbs except Cyperaceae, and therefore are slightly higher than if based on more inclusive totals.

What about the existence of a spruce-dominated, closed boreal forest in early postglacial time elsewhere in New England and adjacent areas of Canada? A review of the recent literature (examples cited below) leads us to the conclusion that the nature and duration of a closed «Boreal Forest» at that time varied considerably from place to place and that at the majority of sites most of the «spruce period» represents forest-tundra vegetation rather than a boreal forest. The initial vegetation following deglaciation was a tundra, and this was invariably followed by a period of open woodland and/or patchwork of forest and tundra, both covered by the term «forest-tundra.» The forest-tundra lasted from a few hundred years to as long as two millennia, depending on the area. The pollen spectra in this period are characterized by high percentages of *Picea,* but they do not represent a «Boreal Forest» similar to that which exists today. In addition to *Picea,* the forest-tundra also included *Populus, Pinus, Betula,* and *Alnus.* The probable great abundance of *Populus* is unlike today's forest-tundra in eastern North America. Similarly, farther west in southern Ontario MOTT and FARLEY-GILL recently (1978) found that the earliest vegetation with trees was a forest-tundra which persisted for about two millennia with no ensuing closed boreal forest.

The forest-tundra was followed by a closed forest. The earliest spectra which indicate this forest vary from site to site in their degree of similarity to spectra from modern boreal forest. Our interpretation of the earliest closed forest spectra (<10% NAP, and also, when available, influx of all terrestrial pollen of >6500 grains/cm²/yr) from Québec southeast of the St. Lawrence River and adjacent New England (MOTT, 1977; RICHARD, 1977) indicates mixed growth of *Abies, Pinus* spp. (incl. *P. strobus* at several sites), *Populus, Betula, Alnus, Picea,* and *Larix* at certain sites. The closest modern analogues are found in the northern parts of today's «Northeastern Transitional Forest» and in the southern fringes of the Boreal Forest (DAVIS and WEBB, 1975). In southwestern New Brunswick, about 130 km east-northeast of Moulton Pond, two diagrams by MOTT (1975) indicate (our interpretation) an absence of closed spruce dominated forest following the forest-tundra period. The first closed forests (zone 5-6 transition) were a mixture of *Populus, Abies, Betula, Larix, Picea* and possibly also *Quercus* and *Fraxinus,* and this vegetation was quickly replaced by *Pinus-Betula* dominated forests with certain additional temperate deciduous taxa. At MOTT and FARLEY-GILL's (1978) site in southern Ontario, the first closed forests were a mixture of deciduous and coniferous taxa dominated by pine species.

At sites elsewhere in the region, the pollen data indicate that the initial closed forests were more like today's boreal forests with a clear dominance of *Picea.* In northeastern Maine, DEEVEY's (1939) diagrams indicate a brief (no dates, but stratigraphically brief) initial forest dominated by spruce. The diagrams from nearby northwestern New Brunswick (TERASMAE, 1973) support a similar interpretation. In Nova Scotia (LIVINGSTONE, 1968; GREEN, 1976), a closed spruce dominated forest may have been of somewhat longer duration. In southern and central New England the «Boreal Forest» period lasted for a few hundred years to over a millennium (M. B. DAVIS, 1960, 1969; LIKENS and DAVIS, 1975; WHITEHEAD, in press; M. B. DAVIS, unpubl., pers. comm.).

In summary, the question raised by us (DAVIS *et al.*, 1975) is being answered by a growing literature which indicates that much of the so-called «spruce-period» in New England and nearby parts of Canada represents of forest-tundra vegetation. This was followed by mostly-closed forests which were similar in some places, but were not in others, to today's boreal forests. In some areas where it occurred, the spruce «Boreal Forest» phase was transitional, lasting less than a millennium, and was quickly succeeded by closed forests of temperate character.

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