NEOLITHIC FOREST CLEARANCE

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IT is the first approximation of the ecologist to relate the control of distribution of major vegetational types to major climatic types: only later does he advance to consider how human activities have interfered with and complicated the pattern determined in the first place by climate. The same relationship has held for the study of palæo-ecology by the methods of pollen-analysis. We have firmly established the general picture of forest movement across north-west Europe under the compulsion of changing climate, and now comes the phase when for the first time we seek to recognize, by pollen-analysis, the role of prehistoric man in changing the natural forest cover of Europe. We are brought to recognize this new phase by a recent publication of Johs. Iverson in the series of the Danish Geological Survey*, on "Land Occupation in Denmark's Stone Age".

Iverson begins with the thesis that Palæolithic and Mesolithic men were hunters and fishers, who modified very little the natural vegetation of the lands they so sparsely occupied, and indeed the application of the term 'forest culture' to the Mesolithic implies that the forest dominated man, and not the other way round. With the introduction of farmer culture to Denmark by the invasion of Neolithic man this state of affairs was radically altered, and Iverson seeks and finds evidence for this change in a striking series of pollen investigations. The dating of this change to the Neolithic period can sometimes be directly established; but more often it can be recognized from the pollen diagrams themselves. It is already well known that the Neolithic in Denmark falls in the middle of the oak-forest period in which oak, elm, and the linden together formed the high forest, with alder and birch in the wetter places and pine and birch in the drier. Iverson points out that pollen of the Ulmus (elm) in the middle of the oak period shows a conspicuous and consistent fall from uniform high to uniform low values. He has, by very laborious counts, shown that the far less frequent pollen of the ivy (*Hedera helix*) shows a very similar decrease at the same time, while the pollen of ash (Fraxinus) increases. This diminution in abundance of such a strongly Atlantic species as the ivy is considered by him to indicate the climatic change from the so-called 'Atlantic' to the 'Sub-boreal' period, a change agreed to fall very near the opening of the Neolithic in this part of Europe. There is no doubt that the fossil elm pollen in Britain gives every sign of coming from a tree with preference for an oceanic climate, and the sudden diminution of its frequency has been already recognized here, as in other parts of north-western Europe, as a trustworthy horizon.

Iverson now points out that in many Danish pollen diagrams, just above this clear climatically determined horizon, the pollen curves indicate a very sudden and peculiar change in forest composition. This is perhaps best shown at Ordrup Mose, where a layer of charcoal stratified into the marginal nekronmuds of a former lake give evidence of burning, and thus perhaps, indirectly, of human occupation. At this level the elements of the high forest, Quercus, Tilia, Fraxinus and Ulmus, undergo a distinct but temporary decline, while Betula reveals a transitory, Alnus a more lasting increase, in pollen frequency, and at the same time the Corylus (hazel) curve reaches a very pronounced maximum. Iverson assumes that these pollen-floristic changes "express the vegetational developments in a region where land-tilling people have occupied the land and cleared this dense primeval forest with axe and fire". The decline of the high forest tree-pollen curves is due to local destruction; the rise of birch, alder and hazel afterwards is due to the rapid regeneration of these species in cleared areas, partly from stumps and partly by their seeds, which, especially in birch and alder, facilitate quick dispersal.

This interpretation receives support from several directions. First is the actual charcoal layer at Ordrup. Second is the fact that at this level the *absolute* tree-pollen frequencies (per unit surface of prepared slide) fall suddenly to very low values and then slowly recover.

Thirdly, Iverson produces striking evidence from the examination of the non-tree pollen content of the lake deposits. Just above the charcoal layer the sum of the non-tree pollen increases suddenly just as one would expect by his hypothesis, but especial importance is attached to his identifications of the species contributing to this total. It had already been pointed out by Firbas that the pollen of cultivated cereals could in general be distinguished by its size and associated characters from that of other grasses, and Iverson shows that continuous though low amounts of cereal pollen are represented in the Ordrup profile above the level of sudden oak forest diminution. Along with this there begins a substantial and continuous curve for the pollen of Plantago, the common plantains, of the species *P. major* and *P. lanceolata*, which have always been very strongly associated with human disturbance of natural vegetation. In addition to this the pollen of Artemisia reaches high percentages, and Iverson suggests that this is probably due to *A. vulgaris*, which was a serious weed in Denmark until the practice of deep ploughing became possible. In several bogs of small size Iverson has been able to show the sudden minimum in the oak forest pollen curves, together with the associated rise of anthropochorus plants, forming an episode so "sudden and brief" in the pollen diagram that it can be taken as indicative of the vegetational succession after local occupation by man and only short-lived settlement. In the deposits of larger fiords or lakes the tree-pollen curves show less sudden disturbances, although the 'weed' and cereal pollen begin continuous curves at the usual level. It is reasonable to consider that pollen diagrams from such places reflect a generalized picture of a whole series of forest clearances over a large tract of countryside, and here, no doubt, it is much less easy to attribute the changes in pollen frequency to the single cause of human interference.

Iverson points out that when the initial phase of disturbance is past, the general forest composition shows little sign of permanent alteration until the beginning of the Early Iron Age. This constancy he is inclined to attribute to the type of forest exploitation practised by the Neolithic settlers, and he speculates that they may well have used the clearance fire to provide not only space for the cultivation of cereals, but also areas of rich herbaceous vegetation and tender tree and shrub shoots to serve for cattle grazing. It is recalled that similar employ-

* Landnam i Danmarks Stenalder (Land Occupation in Denmark's Stone Age). By Johs. Iverson. Danmarks Geologiske Undersøgelse II Række. No. 66. Pp. 68+9 plates. (Copenhagen, 1941.)

ment of clearance fires still continues in backward parts of Europe, and that the Danish archæologist G. Hatt had already indicated the probability that it was in use in prehistoric Denmark.

It follows naturally that if we accept the argument of Iverson thus far, we must expect to find that when the 'Sub-atlantic' climatic period began, no less important vegetational changes took place. For at this time not only the swift climatic 'deterioration' occurred, but also the establishment of a new people with iron implements and the permanent regular settlement associated with village culture. In fact, Iverson is able to demonstrate that the pollen diagrams and peat profiles do reflect such changes. There is the extensive water-logging of low-lying land and the formation of aquatic 'precursor' peat with *Scheuchzeria palustris* above the uniform and highly humified Sphagnum-Calluna peat of raised bogs, and there is the considerable extension of Fagus (beech) at the expense of Quercus (oak) in the pollen diagrams. Both these are climatic effects. In addition, there is a progressive forest destruction by human activity which is indicated by a further considerable increase in the pollen of herbaceous plants, and, in the heathy areas, by increase in the pollen of the ling, *Calluna vulgaris*. The pollen diagrams indicate that in the heath region of central Jutland it was not until the Early Iron Age that great and continuous areas of heath were formed, although some heath was doubtless produced by Neolithic and Bronze Age clearance, and even in Pre-neolithic times the woodlands were much more open than those on the heavier soils.

Iverson's most stimulating piece of research emphasizes what was already dimly recognized, that an *ecological* approach to the interpretation of the results of pollen-analysis is logical and profitable, and indicates that the pollen-analysis method has proved its flexibility by application to yet another aspect of post-glacial history. We may now look for confirmatory results in this special field from many other parts of Europe.

ANCIENT ASTROLOGY

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IN A.D. 1605 Sir Francis Bacon appended to the "Advancement of Learning" some prescriptions for posterity. These contain an injunction to construct "A Just Astrology". Bacon had previously assessed the then condition of this science in his main text. Like alchemy, astrology had a noble aim; like alchemy again, it had been more imaginative than rational; and, once more like alchemy, it needed the corrective and the purge. Astrology, as Bacon conceives it, is central and fundamental, for he defines it as "the real effects of the celestial bodies upon the terrestrial". This includes the action of the sun on the earth: without which there would be no astrology, because there would be no astrologers.

Posterity has obeyed Bacon in one way by sharpening and deepening its sense of absolute dependence on the sun. The cosmic course has made continuing human life possible by isolating the humble solar system in the vastness of space, and by placing the modest earth, with all its appropriate conditions, in nice adjustment to the solar rays. If the sun cooled down, mankind would freeze out; if it exploded into a fierce burst of radiation, the earth would become a great crematorium. If an invading body tore the earth too far away from the sun, or the sun from the earth, men would freeze; if it drove the earth and sun too near, or collided with the sun to make too fierce a furnace, men would burn. Invaders have far to come to reach an earth 4½ light-years away from the nearest star and very remote from the galactic depths. Though the importance of the sun is too obvious to be missed, the ancient mind probably grasped man's absolute dependence on it less completely than modern astronomy.

Plato's "Timæos" is very preoccupied with the sun as a measure of time, a revealer of number and a teacher of arithmetic. The moon, the planets and their motions share in the lessons. The Platonic Socrates, however, gives the sun its due in the "Republic" as the author of visibility, generation, nourishment and growth, though the sun itself is not generated. Modern astronomy, or, in Bacon's sense, astrology, does not confine celestial actions to the sun. The moon pulls more than the sun at the tides to produce their effects—on navigation, for example, or on some marine organisms. The cosmic rays still have their enigmas. If they do come partly from the stars and do act on genes, modern astrology will recognize some stellar influence. According to Aristotle's "De Cælo", the moving celestial bodies emit heat and light by rubbing against the air. The "Meteorologica" supplements this. Neither the moon nor any star gives out much heat: the moon is near but too slow, and the star is rapid but too far off. The sun is both swift enough and near enough to warm the earth well. Though the two passages claim little for non-solar influences, they do indicate how readily celestial bodies could be presumed to affect the earth. The ancient mind did, in fact, as ancient astrology shows, very liberally supplement the celestial action of the sun.

Greek science, including astronomy, began on May 28, 585 B.C.: Thales predicted an eclipse of the sun for that day, and Nature obligingly darkened a battle between the Lydians and the Medes. This statement is too dramatic to be literally true, but Thales and the eclipse conveniently date the still accepted origin of Greek science (and philosophy) in the sixth century B.C. Thales was lucky, as Heath notes, for the Babylonian period on which he depended is less reliable for solar than for lunar eclipses. In 2159 B.C. the Chinese astronomers Hi and Ho were unlucky. Thales predicted an eclipse and gained prestige; Hi and Ho did not predict an eclipse and were executed.

From Thales the current of science runs to one great decisive century of thought—the fourth century B.C., the century dominated by Plato and Aristotle. In drastic summary, and so far as possible from the scientific point of view, a mathematical tradition runs from the anti-experimental Plato and a second trend of thought runs from Aristotle. Mathematics had its hand in astronomy and astrology. Science reaches an acme in the third century. In mathematics it includes Euclid and Archimedes; in astronomy it includes Eratosthenes, who measured the earth's diameter very accurately, and Aristarchos, who anticipated the Copernican theory. Herophilos founded scientific anatomy and Erasistratos founded scientific physiology. Then science begins to run into relative, though recognizable, termini. In the first century B.C. Lucretius stores the fundamentals of atomism in his famous poem, "De Rerum Natura",