

## Thoughts Pertaining to the Glacial History of NE

A fundamental problem in the plant geography of America is the behavior of plants and plant ranges with relation to the glacial boundary. This problem has, over the past 25 years, given rise to a great deal of investigation and controversy.

The classical view, clearly stated by Darwin, is that as the continental glaciers advanced southward they drove the tundra and the boreal forest before them. It is presumed that this led to a sort of "compression" of natural vegetation types south of the glacial boundary, so that there would occur, south of the terminal moraines, great bands of tundra, boreal forest, and dislocated elements of the deciduous forest in eastern North America. It has been thought that as the ice receded, these great vegetational elements flowed back northward to cover the glaciated regions. It is presumed that the Alpine floras of the New England mountains were then made up from arctic elements that were "trapped" at high elevations and surrounded by boreal and deciduous forests.

Studies in western Europe suggest that something like this may have happened, at least so far as the tundra and boreal forest are concerned, with the near elimination of the deciduous forest elements. Remains of a tundra flora are commonly found, in western Europe, at the bases of post-glacial organic deposits.

In eastern North America, on the other hand, no authenticated tundra remains have ever been found in similar situations, and the post-glacial organic deposits seem to have started with boreal forest remains. Thus it would appear that the advance of the glaciers in eastern North America involved the actual destruction of the eastern American tundra flora except for a few species that now exist in the mountains of New England and the Maritime Provinces. When these relic floristic elements are examined, they are found to represent not only the flora of Eastern Arctic Canada, but also that of the Bering Straits region. Those with the latter relationship are separated from their northwestern relatives and isolated from them by thousands of miles. These facts

have led to the revival of Darwin's theory of persistence, and are presented in Fernald's well-known paper on the Persistence of Plants in Unglaci-ated Regions of Boreal America.

Fernald proposed that these isolated plants persisted on "nunataks" in the Gaspé region and Newfoundland, and possibly also on the Torngat Mountains and the mountains of New England. He proposed that these areas were not glaci-ated by the "Wisconsin" ice, and that in the last great interglacial period there were continuous ranges of these plants between the Northwest and the East.

In addition to the arctic species on the supposed nunataks, there are also species of modern temperate ranges. Some of these plants have their closest relatives in the Rocky Mountain region, while others represent the flora of the eastern coastal plain of the continent. In both instances the persisting plants are isolated and widely separated from their relatives.

Long-range dispersal in post-Pleistocene time is regarded as insuffi- cient to account for these disrupted ranges. There is a large amount of evidence in support of this.

Controversy in the problem has arisen primarily from two sources. One of these is among geologists who have refused to agree that the so-called nun- ataks were actually unglaci-ated. The other is in the field of biology, and insists that plants of temperate or southern affinities could not possibly have existed under the rigorous climates of nunataks surrounded by ice.

To accomplish the ranges in question, it seems necessary to establish the possibility of continuity between eastern and western elements, and between the floras of the Maritime Provinces and the coastal plain. There must also be time during which the continuity could be achieved.

The current concept of the Wisconsin glaciation, involving at least three separate advances of the ice, the Iowan, the Tazewell-Carey, and the Man- kato, with interglacial intervals during which the ice retreated far northward

or disappeared altogether, may afford the necessary conditions without its being necessary to go back to the Sangamon interglacial. It is not impossible that during the period between the Tazewell-Carey and the Mankato there was a tundra connection between the eastern mountains and the West.

If it should be possible further to prove that Mankato ice did not cover all of the Northeast, but left most of central and southern New England, the Maritime Provinces, and Newfoundland free of ice, then I think the problem might be solved. If these areas were free of ice during the Mankato, there may well have been also large sections of the continental shelf exposed, making it possible for coastal plain plants to migrate northward to Newfoundland.

There seems to me to be increasing evidence that most of this region was not covered by ice in Mankato time. The extent of congeliturbation seems to be too great to have been accomplished during the recessional stages of the Mankato glacier. In the White Mountains, for instance, I suspect that the Mankato ice was represented only by valley glaciers that occupied such cirques as Tuckerman's Ravine, and that the higher slopes are old surfaces that underwent intensive congeliturbation during all of Mankato time. I suspect also that the intense congeliturbation that is shown in southern and central New England indicates the same conclusion.

If these suppositions should prove to be correct, then the biological problem of getting the persisting plants through Mankato time ceases to be the difficult one of having them weather the rigorous climates of nunataks. It becomes necessary, rather, to get them through a period of intense congeliturbation. I do not believe the latter is impossible.

The absence of tundra remains in our peat bogs strongly suggests that the climate near the border of the ice was suitable for the growth of trees. During Mankato time it must have been a relatively ~~wet~~ climate to produce the amount of congeliturbation that is evident. The latter does not necessarily

involve a climate of extremely low temperatures throughout the year, but rather one in which the periods in spring and fall during which the diurnal temperature range crossed the freezing point were much longer than they are now. The climate in general, affected by great masses of Gulf air which seems to have been necessary to have produced the ice accumulation, could well have been suitable for the persistence of all of the relic plants. It seems to me that the principal difficulty for these plants would not have been climatic extremes so much as the physical instability of the soils caused by intense frost action. In order to persist, the plants would have had to show sufficient ecological amplitude with regard to soil instability. There would, of course, have been vast areas of outwash sand and gravel and river alluvium in which frost action would not have been great. The same would have been true of talus slopes in the mountains. These areas would have constituted "islands of relative stability" in the unstable tills which otherwise blanketed the region.

It has been pointed out that one of the characteristics of most of the persisting plants in the Northeast is that they now grow on the more unstable habitats. These habitats are on mountain talus, river gravels, sea beaches, and mountain table lands where frost action is still more or less intense.

Many of these plants may well have had somewhat wider ranges in the Northeast during Mankato time than they now have, occupying some of the unstable till surfaces. It is altogether possible, however, that the flora of such unstable soils in the neighborhood of the Mankato ice, particularly in its more southern areas, was made up of such elements in the native flora as were able to withstand the instability. There is some evidence that many of our existing native plants in these regions were capable of doing this. The flora on such unstable soils may have had the dwarfed appearance of tundra, but may have been made up primarily of species that have no relation to the present arctic tundra.