TWO PICTURES OF THE RECENT PAST

THE GENERAL CIRCULATION AT THE LAST (WÜRM) GLACIAL MAXIMUM. By H. C. WILLETT. *Geografiska Annaler, Vol. 32, Nos. 3-4 (1950) pp. 179-87.*

DIE VEGETATIONSZONEN DES NORDLICHEN EURASIENS WAHREND DER LETZTEN EISZEIT. By B. FRENZEL and C. TROLL. *Eiszeitalter und Gegenwart, Vol. 2 (1952) pp. 154-67.*

We cannot step backwards in time, which obstinately pursues its forward course. But in spite of this handicap, some of our contemporaries have made up their minds about the look of the world during the last glaciation. Three of them have recently published maps of that frigid epoch, and have written papers to explain their views. The first map, the work of Hurd C. Willett, shows what the climate was probably like; it is a map of pressure distribution, from which the skilled eye can reconstruct the prevailing weather of the northern hemisphere. The second comes from two distinguished German geographers, B. Frenzel and Carl Troll. It portrays the natural vegetation of Europe and Asia at the climax of the last glacial advance. I enjoyed super-imposing Willett's isobars on the Frenzel-Troll map, and have reproduced a small part of the combined result as Figure 1.

All three authors are modest in their claims. Willett (1950) says that his map is very tentative; he will be satisfied if it starts a discussion. He has been engaged for many years in a study of the general circulation of the atmosphere, more especially of its modern aberrations. Some of these aberrations seem to resemble conditions as they must have been in glacial epochs. Willett argues from these fluctuations of the modern climate back into the Pleistocene. He has drawn his map by a process of extended analogy, though he has been guided by far more than the analogy itself. The wisdom and experience of one of the foremost modern schools of meteorology has gone into this scientific dream, and it is entitled to respect and scrutiny.

Frenzel and Troll (1952) are equally diffident. They pay their respects to the work of Julius Büdel, who attempted a similar map for Europe only three years ago (1949), and to H. von Wissmann's (1938) well-known study of the Würm glaciation in China. They have acquired fresh data from the Soviet Union, an acquisition that makes possible a reliable map of vegetation from Atlantic to Pacific. The evidence upon which they drew comes mainly from the study of fossil pollen and plant fragments preserved in the peat-bogs, solifluction-deposits, and loess-layers of unglaciated Eurasia. They cite an impressive number of Russian sources, nearly all of which are quite recent.

I shall not question the validity of either map: clearly the devil's advocate is ruled out of court by the modesty of the papers' claims. Instead I shall ask this question: assuming that both maps are sound, and that they refer to the same moment in time, do they raise difficulties for one another when brought together?

I think they do; I believe that the climate shown by Willett ought to produce a distribution of vegetation different from the picture drawn by Frenzel and Troll. It is difficult, I must admit, to make the comparison direct enough for certainty. The Willett map refers to winter, whereas the climate of summer matters most in the study of vegetation. Nevertheless, Willett himself has given the clues by means of which we can visualize the summer climate. So we can proceed, bearing the difficulty in mind.

The difficulty starts in the Mediterranean, over which Willett shows a deep centre of low mean pressure, one of the most active of the cyclonic regions of the hemisphere. From this centre, he writes, ". . . storms probably travel either north and northeastward to feed the principal ice sheets, or more eastward, depending upon the fluctuating pattern of the general circulation". (1950 p. 182). He adds that in summer the storm tracks (and presumably the centre of low mean

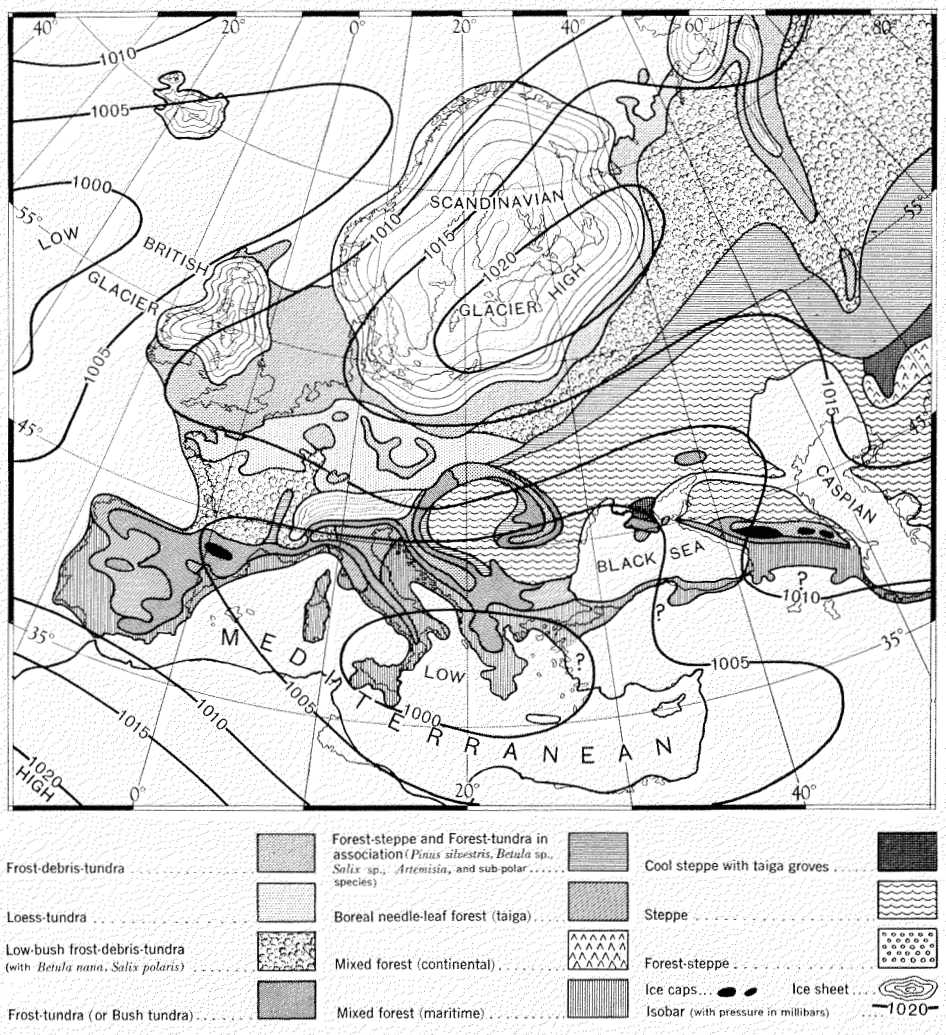

Fig. 1. Vegetation (after Frenzel and Troll) and winter pressure distribution (after Willett) at the climax of the last glaciation.

pressure) are shifted northwards towards the ice margin. This suggests that central and southern Europe, including the southern plains of Russia, were traversed in summer by eastward-moving cyclones, presumably with fairly warm, moist westerlies on their southern flanks. The cyclone tracks shown by Dorsey (in Flint, 1947, Plate 3) agree entirely with this view.

These facts imply an appreciable rainfall over the Mediterranean countries (which are now afflicted by a long summer drought) and over the plains of southern Russia. There is much evidence for such a pluvial period. We lack unequivocal proof that this humid epoch came at the climax of the last glaciation, though this is almost certain. The most striking evidence of the increased rainfall is offered by the lake levels in the numerous enclosed basins of the Mediterranean and Middle Eastern lands. Nearly all these basins show the unmistakable signs of high water levels; many that are now saline were fresh at some recent date, and possessed outlets to the sea.

Presumably this enhanced rainfall extended beyond the mountains of the Levant into central Asia, and ought, if we accept Willett's map, to have affected the Black,

Caspian, and Aral seas. There is plenty of evidence of high water levels from the Caspian, which had a brief connection with the Black Sea; the latter, moreover, was detached from the Mediterranean, draining to it via the Bosporus River. The Aral Sea covered an area one-third as great again as its present outline, and discharged for a long time to the Caspian through the Usboi (Flint, 1947, p. 477). Frenzel and Troll show a large expansion of the lake at the floor of the Tarim Basin. There is abundant evidence, in fact, that the pluvial regime extended far into the interior of Asia.

Yet the vegetation, if we accept the Frenzel-Troll evidence, remained droughty. The huge area of plains north of the Black Sea and the Caspian appear to have been covered by steppe; forest was confined to narrow galeria, that is strips along the rivers, and to a thin forest-steppe on the lower mountain slopes. We have this paradox: enough rainfall to create a large increase in run-off, and therefore high lake levels, but not enough to sustain forest. That the climate was warm enough for forest is hard to doubt. *Pinus silvestris* occurred in the combined forest-steppe/forest-tundra shown by Frenzel and Troll as running from the northern Ukraine in a broad belt through Gomel, Tula, and Kazan', well to the north of the region we are discussing. There seems to have been permafrost about as far south as the present Black Sea and Caspian north shores, but this would not have prevented forest growth: it does not do so today in Alaska, Mackenzie, and a large part of Siberia. Summer temperatures were probably between 50° and 55°F as far south as the 45th parallel, and possibly as high as 65°F in southern Turkistan. Very low rainfalls are adequate today to support coniferous forests at such temperatures. In the Mackenzie Valley an annual precipitation of 12 inches supports spruce forest on permafrost.

What, then, accounts for the treelessness of the steppes? We can suggest two hypotheses, and can quarrel with both of them:

(i) We might argue that the climate was in fact dry: that rain-shadow effects prevented the east-moving cyclones from producing heavy rain. The high level of the Caspian might have been due solely to the discharge of the Volga, carrying as it did much of the meltwater of the Scandinavian ice. But does this explain the prolonged expansion of the Aral Sea? Presumably this smaller lake was fed by the meltwaters from the expanded glaciers on the Hindu Kush. If these glaciers expanded, they could do so only with a substantial increase of snowfall from travelling cyclones, which again speaks for summer rain on the plains to the north.

(ii) Secondly, we could follow Carl Sauer (1952), and assert that a grassland climax is not a drought-indicator at all: he maintains that grasslands are confined to the plains of the world and reflect, perhaps, control by fire. The steppes of Russia in Würm days may have followed this pattern. Aurignacian hunters were living in the Crimea and the Ukraine, preying upon the subarctic mammals that roamed the steppes (Zeuner, 1950, p. 164). Did they use fire as a hunter's trap? And did they thus prevent the spread of trees? It seems unlikely: they were so few.

Probably the European students of the Pleistocene have an answer to this paradox: but it seems to need further discussion. I do not believe that a circulation like that depicted by Willett could give a climate dry enough in southern Russia for the survival of an open steppe. Yet the evidence of grassland cover, and even of loess accumulation, seems unshakable. Which view is right? F. KENNETH HARE

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