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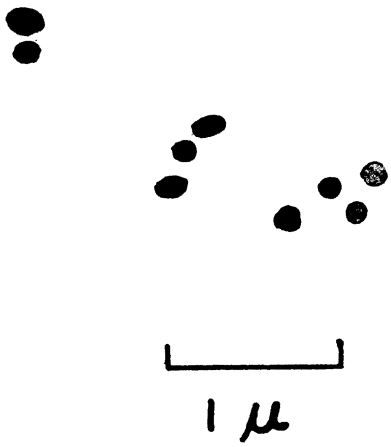

Figure 2. Meiosis I. Rule in 10 microns long

Thladiantha dubia Bunge. MINNESOTA: Cass Co.; yard of the Whittle Shop, near Whipholt, along Hwy. 34. Richard W. Pohl 9060 (ISC;A; BH).

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The Vegetation of the Glacial Border During the Wisconsin Maximum

L. J. Eilers[1]

Abstract: The climate of the glacial boundary during the Wisconsin maximum was generally cooler and moister than at present. There is some evidence that a frost climate prevailed for some time at the glacial margin, suggesting that a tundra-like vegetation existed there. Pollen profiles indicate that a *Picea-Abies* forest existed south of the glacial margin and probably extended up to it during periods of climatic amelioration.

Botanists interested in the evolutionary development of plants soon encounter the problem of their past distribution. Those studying the development of the midwestern flora must give major consideration to the fact that all of Iowa has been glaciated at least once and most of it several times during the Pleistocene epoch. A number of questions immediately arise. What happened to the existing flora during a glacial advance? What factors affected the nature and the distribution patterns of the vegetation during the maximum extent of the glaciations? What

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were the migration sequences and patterns as the plants repopulated the formerly-glaciated areas? How did these changing distribution patterns affect the evolution of the plants?

I have chosen to deal with the second of these questions: the problem of the distribution of plants near the glacial border in the midwest during a glacial maximum. Furthermore, I have limited this discussion to the Wisconsin stage. This glacial stage was the last to enter Iowa. Consequently, the associated fossil, climatic, and geological records are the most nearly complete. The Wisconsin stage was made up of several glacial advances and retreats (substages), but the evidence indicates similar climatic and vegetational conditions for all of them (1, 2). In this paper, then I am concerned with the conditions during a generalized glacial maximum.

Late Pleistocene Climate

The climate during the late Pleistocene is of interest because it affected the vegetation both directly and indirectly. The evidence is all secondary, but abundant, and a reasonably consistent picture of the general glacial and postglacial climate can be formed by integrating the various sources of information.

Studies of foraminifera fossils in deep sea cores indicate that the temperature of the surface water in the Atlantic and Caribbean oceans was approximately 11°F. colder during the last glaciation than at present (3, 4). Antevs, in a study of former snow lines and glacial moraines in the mountains of Colorado and New Mexico, deduced a mean temperature during the last glaciation 10°F. below that of today (26). Dillon studied the relationship between existing glaciers and present temperature isotherms and found that no existing ice sheet extends south of the 45°F. mean warm month isotherm. Combining this with the above and other data, he deduced that at the maximum extent of glaciation the mean temperature at the edge of the ice was 25°F. lower than present, and that this difference was reduced to about 5°F. at the equator (6).

Studies of microfossils from a large number of bogs in central United States show that *Picea-Abies* forests dominated this region during and for some time after the last glaciation (7, 8, 9, 10, 11, 12, 13, 14). This evidence also indicates that a moist, cool climate prevailed during glacial and early postglacial times.

Examination by Rosendahl of the macrofossils from a buried peat bog in Minnesota showed that the growth rings in buried spruce stems from the Peorian interglacial following the Iowan substage decreased in thickness toward the periphery (15). Rosendahl stated that "The progressive refrigeration of the climate of northwestern Minnesota is therefore indelibly recorded in the trees that grew there at the time of the last ice invasion."

Ruhe and Scholtes studied soil landscapes in relation to climatic and vegetational changes in Iowa (2). On the basis of fossil hemlock, yew, spruce, and larch wood found in buried soil produced a colder and moister climate during the several adduced a colder and more moist climate during the several advances of the Wisconsin glaciation. They also considered the occurrence of gleyed horizons in Iowa and Tazewell loess in southwestern Iowa as evidence of a humid climate during the later part of the Wisconsin age.

In considering the above generalized picture, it must be remembered that it is quite likely that local climate varied somewhat from place to place along the glacial border. In some places, perhaps, a glacial lobe may have been advancing, while in other places the ice sheet may have been stationary or even retreating.

Physiography of the Glacial Margin

During the maximum advance of an ice sheet, the landscape below the glacial margin was probably modified by valley trains or outwash plains in the lowlands. The uplands may have remained fairly stable except for the effects of increased moisture or possible solifluction, frost heaving, or other frozen-ground phenomena. Ponds and lakes were probably abundant and the glacier-margin streams were loaded with rock flour during the warm months.

There is scant evidence to determine if the ground at the glacial margin was perennially frozen in the midwest; however, periglacial effects have been adequately demonstrated in the eastern United States (16, 17). Smith found what seems to be abundant evidence of frozen-ground phenomena in the "Driftless Area" of southwestern Wisconsin. He states that "they are best explained as products of periglacial frost weathering, solifluction and frost heave during Wisconsin time" (18). Schafer found a limited number of locations in Jefferson and Van Buren counties in Iowa where the contact between a Kansan gumbotil and the over-lying loess has been involuted. He concludes that these deformations appear to be all attributable to periglacial conditions prevalent during a part of the Pleistocene (19).

Vegetation

If there was indeed a frost climate at the boundary of the glaciations in Iowa, it would undoubtedly have had a considerable effect on the vegetation. According to Sigafoos, "Congeliturbation . . . affects plants by: (1) burying them beneath soil, (2) damaging roots and stems by breaking or bending them, and (3) changing soil-water relations by moving the plants with respect to water table or by blocking surfacewater flow" (20).

Raup emphasizes that the timber line can be interpreted "as a zone of transition from relatively stable to unstable soils" (17). Flint also states, "As solifluction is most active today in treeless areas, it seems likely that the areas of intense solifluction in Europe and America were treeless when the process was most active" (1).

Arctic regions with perennially frozen soil are covered with tundra. There is little paleobotanical evidence for a tundra zone in Iowa, but several musk ox skulls have been uncovered in Iowa and adjacent states (21). These skulls are of a species which inhabits the tundra exclusively today (5). It has been suggested that fossils of tundra plants are absent from peat bogs because the tundra was displaced before the bogs were formed (12). Raup states that it is likely that many of the species making up the tundra vegetation at the glacial margin were plants from the native flora "whose ranges of tolerance are or were sufficient to allow them to survive the periglacial climate with its attendant instability of soil. They can be looked for among those that are closely related to or identical with species now having wide ranges in the north, or they may have included southern species that have northern biotypes which have since been lost"(17). Genera of plants which fit into this classification include *Equisetum, Salix, Alnus, Populus, Carex, Betula, Vaccinium, Rubus, Saxifraga, Papaver,* and several genera in the Poaceae and Asteraceae (20).

Braun believes that the bog plants with present distributions north of the glacial boundaries must have lived in bogs near or within the ice margin. She states that in northern latitudes bog plants are growing today over permanently frozen subsoil (22).

Studies of microfossils from peat beds south of the ice margin indicate that during the Wisconsin stage *Picea-Abies* forests extended from the east coast (23) to Iowa (10), and far into the south (24). During periods of climatic amelioration, these forests may have extended up the morainic debris covering the surface of the ice sheet, as occurs on Malaspina Glacier in Alaska (25).

Knowledge of the vegetation at the glacial border is still fragmentary and inconclusive. Additional paleobotanical evidence is needed before more definite conclusions can be drawn.

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Additions to the Moss Flora of Iowa

GARY L. SMITH[1]

Abstract. *Buxbaumia aphylla* Hedw. and *Climacium kindbergii* (R. & C.) Grout are reported for the first time from Iowa.

BUXBAUMIA APHYLLA

Buxbaumia aphylla Hedw. is one of the most unique and interesting of mosses. The mature plant consists of a roughened seta with rhizoids at its base surmounted by an oblique, asymmetric capsule of peculiar form (Figure 1). The gametophyte generation is a protonema, which may or may not persist as the sporophyte develops. A few poorly-formed leaves surround the sex organs.

The species is probably not so rare as its infrequent collection would indicate. It has been found in great numbers over a considerable area. It appears to be distributed widely but locally throughout the world. It is known in Europe, Asia, and Japan as well as in North America, where it ranges across the continent.

In late April, 1961, while collecting on the wooded bluffs overlooking the Mississippi River near McGregor, Iowa, I found eleven sporophytes of *B. aphylla* on a steep, shaded, north-facing

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