THE VEGETAL COVER OF THE DRIFTLESS CUESTAFORM HILL LAND:*  
PRE-SETTLEMENT RECORD AND POSTGLACIAL EVOLUTION  

Glenn T. Trewartha  
Department of Geography, University of Wisconsin  
*Pre-settlement Record*  

As the first white settlers found it, the flora of the Driftless Hill Land, both in types of plants and in the patterns of their distribution, showed predominantly the effects of Pleistocene glaciation. Two of the major plant formations of North America, the broadleaved or Alleghenian forest entering from the southeast, and the prairie entering from the southwest, were well represented, although the former was dominant. A third type, the northern coniferous and mixed forest, occupied a much smaller area and was concentrated along the northern and northeastern margins. These three great plant formations are not to be thought of as fitting together in the form of broad wedges bounded by relatively simple lines. On the contrary their zones of contact exhibit a complicated mosaic pattern with numerous peninsulas and outliers.

The vegetation maps of the Driftless Hill Land (Figs. 2 and 3) have been constructed from data compiled from the notebooks of the original government surveyors. For the region under analysis these surveys varied in time from 1832 for southwestern Wisconsin to 1855 in parts of Minnesota and northwestern Wisconsin. The source materials are available in the land offices of the state capitolts of the four states represented in the Driftless Hill Land.

For each government township of 36 square miles the government surveyor first established the four boundaries of the

*The region here designated as the Driftless Cuestaform Hill Land refers to that part of the inner basin of the Upper Mississippi unmantled by recent till sheets, where the local relief usually exceeds 250 feet. It is not identical with the well known Driftless Area although that region is largely included within its borders (Fig. 1).

Aid in completing this study has been received from research assistants subsidized by the University of Wisconsin, and from N. Y. A. students.
land unit by a linear traverse of 24 miles around its perimeter. This is known as the outer survey. Subsequently 60 miles of linear traverse inside of the township established the boundaries of the individual sections. For each mile of traverse, or one side of a section, the surveyor entered at the end of his notes comments concerning the lay of the land and the nature of the vegetation cover, even specifying the principal tree types, and often indicating the density of stand. A synthesis of these, as well as other data, was included in a colored sketch map of the township prepared by the surveyor and included in his notebook. When the notebooks were forwarded to the General Land Office in Washington D. C. engineers there prepared from the field notes township maps, scale two inches to a mile, on which certain major vegetation boundaries were indicated. Volumes containing copies of these original General Land Office plats are likewise available at the state land offices.

To facilitate copying the information from the surveyors' books, mimeographed work sheets were prepared each having on it the outline and section grid of one civil township, scale one inch to a mile. On the section lines of these sheets, by use of a digit and letter system of recording, were placed the data on native vegetation taken from the surveyors' notebooks and maps. Significant summary remarks by the surveyor concerning vegetation, surface configuration, settlements, etc., were noted on the back of each sheet. In the digit-letter legend placed on a section line, the first digit always indicated the primary form of vegetation, viz., woodland, grassland, brush, and swamp. Succeeding digits or letters represented particular species, usually trees, within the primary formation. These were arranged in order of importance. The completed work sheets were then fitted together into county units and boundary lines drawn around areas having similar vegetation characteristics. These areal subdivisions in simplified form and with slightly smoothed boundaries were later transferred to a map of the Driftless Hill Land, scale about 1/500,000. Due to the fact that the different surveyors were not equally proficient and careful in observing and recording the plant cover, the data for different townships are not of

---

2 Credit is due Robert Amaden, a graduate student in geography at the University of Wisconsin, for supervising the clerical work associated with collecting and plotting the data, and for constructing the manuscript map for Fig. 1.
uniform quality and therefore are not strictly comparable. This fact is borne out by the discrepancies to be observed along the margins of adjacent townships surveyed by different men.

An attempt was made to construct a map showing quantitatively by isarithms the dominance of particular tree species in various parts of the Driftless Hill Land. Recordings were made by quarter townships of the number of times particular trees were mentioned by the surveyor, on the assumption that the number of mentionings was directly proportional to the prevalence of the tree. The technique was unsuccessful and had to be abandoned, probably because the method required a degree of accuracy not inherent in the data, or because the above assumption concerning relationship between tree numbers and mentionings by the surveyor is incorrect. As finally developed the technique employed was less strictly precise and did not lend itself to drawing of isarithms, since numerical recordings were not made by unit areas. Instead, boundary lines were drawn around areas, irregular in outline and size, within which a certain combination of trees was dominant. Trees not mentioned on at least one fourth of the section-line traverses were usually omitted. The multitude of small areas representing slightly contrasting associations of trees finally required a considerable amount of combining and simplifying in the published map.

Fig. 2 showing distribution of the principal plant formations, together with certain major types of forest, indicates that the Driftless Hill Land is a part of the most northwestern extension of the Alleghenian hardwood forest. The western margin of the Driftless Hill Land's rough terrain fairly well coincides with the transition from hardwood forest on the east to prairie farther west. Within the hardwood area proper the larger prairies coincided with the crests of the broader rolling interfluves and adjacent upper portions of the bordering river bluffs. The latter sites have been facetiously labeled "goat prairies" by a botany graduate student engaged in a field study of them. This coincidence of prairie with the more extensive upland surfaces is sufficient to explain the relatively higher percentage of grassland, (1) south of the Wisconsin River, and (2) north of the Chippewa, in Wisconsin. On its northern and northeastern margins the hardwood forest gradually gives way to a mixed forest in
which conifers are prominent. This boundary as well is roughly coincident with that of the Driftless Hill Land. On the north the shift from hardwood to mixed coniferous-hardwood forest would seem normal for the latitude and largely climatically induced. The eastern vegetation boundary appears to be edaphic
in origin, conifers becoming more prominent on the sandy soils of the Cambrian Plain. Extensive areas of brush, and smaller ones of pure conifers, are conspicuous in the transition belt.

Figure 3 presents a more detailed analysis of woodland combinations and their distribution, more especially the deciduous forest. Within the hardwood forest the fact of oak dominance is most striking. On over one half of the total hardwood area oaks were the only trees mentioned by the surveyors. Where other species were present oak usually remained the most prominent tree. Only on some of the more extensive river bottoms, and in the oak-maple-linden-elm forest of Pierce, St. Croix, and Dunn Counties did oak recede from first position and, very occasionally, drop out of the woodland combination completely. From the standpoint of the vegetational history of the region it is very noteworthy that so much of the oak area was described as thin and scattered timber. Such a cover probably represented an intermediate stage in the evolution from prairie to woodland or vice versa. By some it was even spoken of as prairie rather than woodland. Thus certain early settlers in the lead region south of the Wisconsin River in Wisconsin and northwestern Illinois described it more than a century ago as a prairie land of which not more than one tenth was forested. Obviously much of the area designated on Fig. 3 as thin and scattered oak was considered by the settlers more prairie than forest.

Although the hardwood forest of the west central states is often labeled oak-hickory, the latter tree was not conspicuous in the Driftless Hill Land. Along the southern border of the region, in Illinois, there was the most extensive area of oak-hickory forest, and smaller scattered areas were present elsewhere.

Much more extensive were the areas in which maple,\(^2\) linden, elm, aspen, and ash were prominent trees. One such large area centered on Richland County, Wisconsin, just north of the Wisconsin River and extended out to the west, north, and east into Crawford, Vernon, Monroe, Juneau and Sauk counties. In this region, other than oak, sugar maple, linden, and elm were very prominent. Since maple as well as sugar tree was mentioned by the surveyors, one would infer that soft maple was likewise pres-

---

\(^2\) One cannot be certain at all times from the surveyors' notes what is meant by maple. In a large number of cases hard maple is designated as sugar tree, and where this is the case maple is understood to mean soft maple. But there are good reasons for believing that the term maple as recorded by some surveyors was used to include both the hard and soft varieties.
ent. Somewhat isolated from the larger unit just described, was a neighboring subarea located principally on the Baraboo quartzite monadnock, within the Driftless Area, but extending up to the Wisconsin end moraine.

Other relatively conspicuous centers of the above noted woodland combination were in, (1) Clayton and Fayette counties, Iowa, (2) northwestern Wisconsin in Pierce, eastern St. Croix, and western Dunn and Pepin counties, (3) south central Grant County, Wisconsin, and (4) Stephenson County, Illinois, and adjacent southwestern Green County, Wisconsin. There were other smaller widely scattered areas. In the northernmost of the centers mentioned, maple, especially sugar maple, appears to have been more prominent than oak. There is no striking coincidence between the areas of maple-linden-elm prominence and particular features of physical environment. The reasons for these “islands” in the midst of what is largely an oak woodland is not clear. It has been intimated that they may have been relics of a more extensive forest that found refuge in the Driftless Area during one or more of the periods of glacial advance. It may or may not be significant that in Iowa and in Sauk County (Wis.) the maple-linden-elm forest extended out to the Wisconsin moraine but not much, if any, beyond it.

A much less conspicuous hardwood combination was one in which aspen was associated with oak either as the first or second tree in importance. This type was usually in close juxtaposition to another somewhat different combination in which elm was either first or second in rank, with varying amounts of linden, ash, maple, and aspen. Forests with such tree combinations had principal centers in Wisconsin in (1) western Polk and adjacent parts of St. Croix counties, (2) northwestern Buffalo county, and (3) eastern Richland county.

Since the mixed hardwood-coniferous forest largely lay beyond the borders of the Driftless Hill Land, less attention has been given to its analysis. Assuming the surveyor’s observations to be a correct representation of cover, the mixed forest appears to have been composed of numerous contrasting combinations of species, most of the combinations covering no very extensive areas. With even the dominant trees varying within relatively small areas, it is not easy to subdivide the mixed for-
est into a relatively few groups each covering an area of some magnitude. In part the numerous tree combinations reflect the variety of regolith and drainage characteristics within the mixed-forest area.

Bordering the deciduous forest on the north and northeast in Barron, Polk, Chippewa, Eau Claire and Clark counties was a mixed forest in which white pine, birch, maple and oak appear to have been the dominant trees. Jack (black) pine, yellow pine, tamarack, hemlock, linden and aspen appear however in a variety of combinations. Within this forest it was the white pine and hemlock that were the most desirable timber trees and it was these that were early removed by the lumber companies. Farther south in Jackson, Monroe, Juneau, and Adams counties where the soils are more sandy, and extensive swamps prevalent, the less valuable forest contained more scrub oak, jack pine, and tamarack, although white pine remained one of the most widely dispersed species.

In their broader patterns of distribution the major soil types of the Driftless Hill Land, as recognized and mapped by the United States Department of Agriculture, roughly coincide with the principal vegetation and regolith combinations. Figure 4 was compiled chiefly from data in the state and federal county soil bulletins. Because of the discordance between federal and state soil terminology, harmonizing the published materials of different dates from the two sources required considerable adjustments and interpolations.

Postglacial Vegetation Changes in the Upper Mississippi Valley—Great Lakes Region

The vegetal cover of a region is dynamic, not static. The present-day distribution of floras depends not only upon the contemporary physical environment, but upon their earlier developmental history as well. Thus the pre-settlement vegetation mantle of the Driftless Hill Land, as of every other region, was the result of repeated advances and retreats of diverse floristic elements induced by environmental change or representing normal plant successions. The vegetation maps (Figs. 2 and 3) therefore represent only one stage in a long developmental history that is still continuing. In most instances, however, current
advances and retreats of floras are too slow to permit of observing them first hand, so that conclusions must be drawn from historical and other indirect evidence. Three of the most valuable types of contemporary evidence concerning vegetation migrations are: (1) the successional relations of the species near the margins of their ranges, (2) the presence of relic species, or relic plant colonies, in unique edaphic environments, and (3) the floral stratigraphy and pollen profiles of peat bogs.

Up to the present time no comprehensive study of the vegetational history of the Driftless Area has been made and only such a study will reveal whether, as some suggest, that region may have been ecologically unique in the northern Middle West. At no period of glacial advance was the Driftless Area an island entirely surrounded by ice, and therefore completely cut off from nonglacial regions farther to the south. Such isolation however was practically complete during the Kansan stage of glaciation, while during the Nebraskan and the first Wisconsin stages the Driftless Area was the northern end of a bulbous peninsula much constricted farther south. At other times of ice advance it was part of a broader peninsula or deep enclave thrust into the ice front. Not once, but several times, therefore, the Driftless Area would appear to have experienced a type of periglacial climate perhaps unique on this earth, and one in which the degree of refrigeration seemingly should have been more intense and long continued than in the broad unglaciated region lying south of the general ice front. At the same time however it at least was not overridden by ice with consequent annihilation of plant life, and so in spite of its refrigeration, may have served as a temporary refuge for certain sorely pressed floral types retreating before the advancing glaciers.

Such a region as the Driftless Hill Land permits of some interesting speculation relative to the effects of its marked periglacial climates upon vegetational forms. Occasional and very incidental observations within the Driftless Area of loess resting upon residual regolith with no intervening humus layer are suggestive. A careful and systematic study of a large numer of loess profiles might yield significant information concerning the character of interglacial, intraglacial, and postglacial climates and floras. Fernald points out that the Driftless Area has a con-
siderable number of remarkable endemics and is a definite center for plants of a limited range which were able to survive there during Wisconsin glaciation, but after the last retreat of the ice withdrew to more hospitable locations. Fassett has discovered that within the Middle West a number of relics are confined to the Driftless Area, while others less confined, center on it in a significant manner. Thus the Aconite (Monkshood) of the Middle West is isolated within the Driftless Area or close to its margins and appears to have been saved from extermination by the asylum offered during ice advance by this unglaciated spot. Being conservative, the plant has not advanced any distance into glaciated territory since the retreat of the ice. Miner’s Lettuce (Montia Chamissoi) grows only in our western mountains and on two hillsides of the Driftless Area. The Jack Oak (Quercus ellipsiodalis) appears to have survived glaciation in the Driftless Area and during post-Pleistocene times has spread out from that center in all directions. This by no means exhausts the list of endemics but it at least suggests a line of evidence that appears somewhat contradictory to that suggested by the loess profiles. Too little data are at hand however upon which to make a judgement. A more thorough analysis of the several kinds of evidence will be necessary in order to establish the nature of the interglacial and post-glacial floras of this unique region.

With the data that are available one can do little better than assume that the Driftless Area experienced, in different degrees perhaps, a great many of the large-scale vegetation changes characteristic of the Upper Mississippi-Great Lakes region during post-Pleistocene times. As a general theory it is assumed that with the advance of the continental ice climatic changes were induced along its front that led tundra, conifers, and broad-leaf forests to retreat ahead of it and then follow back in its wake as it melted. What the specific changes of climate were that produced continental glaciation, and in turn were generated by it beyond the ice front, is not clear. There is some evidence to show that the ice advanced over standing and probably living

---

8 See papers by Hansen; numbers 16, 17, 18 in bibliography.
forests in which the annual rings showed a marked decrease in rate of growth only during the last 12 years before death occurred.\textsuperscript{6} On the other hand in certain Florida peat bog deposits, buried diatoms have been found that belong to a well known group characteristic of bogs and glacial lakes in Canada, northeastern United States, and northern Europe. Many of these ancient forms at present occur no farther south than New England. By some paleo-ecologists this has been taken as indicating that the diatoms were deposited during the climax of Wisconsin glaciation, when the cooling effects of the ice were extended as far south as Florida. Paleo-ecologists in Europe have evidence that treeless tundra bordered the Riss (third glaciation) and Würm (fourth glaciation) ice in belts 100 to 450 kilometers wide.\textsuperscript{7} It is difficult to understand how the northern one-half to two-thirds of the North American continent could have been covered with ice without producing a marked refrigerating effect upon the lands to the south, and more especially upon such an engulfed region as the Driftless Area. Still, the evidence is not entirely corroborative and the whole problem of the climatic effects of continental glaciation beyond the ice front warrants a careful analysis of the numerous peat deposits south of glacial limits.

Sears\textsuperscript{8} outlines four important stages through which hypothesis concerning post-glacial climates and vegetation changes have passed:

1. Vegetation retreated southward before the advancing glaciers and later, with the melting of the ice, returned to a relatively stable equilibrium.

2. The Blytt-Sernander hypothesis assumed a series of climatic fluctuations involving both temperature and precipitation. Five periods are recognized: pre-boreal, boreal, Atlantic, sub-boreal, and sub-Atlantic, of which the first, second, and third are continental or dry in character. The fourth or Atlantic period was thought of as warm and humid and represented a climatic optimum, while the sub-Atlantic period represented a return to

\textsuperscript{6} Wilson, L. R. The Two Creeks Forest Bed, Manitowoc, Wisconsin, Wis. Acad. Sci., Arts, and Letters, 27, 1932, pp. 31-46.
\textsuperscript{8} Op. cit., pp. 43-44.
more humid conditions. In this country, Sears has been the principal protagonist of the Blytt-Sernander hypothesis as applied to conditions in North America.

3. The Anderson hypothesis denied the reality of the second dry, or sub-boreal, period in the Blytt-Sernander scheme and instead maintained that a gradual climatic deterioration, from the Atlantic period down to the present time, has taken place.

4. According to Von Post three major subdivisions of post-glacial climate are to be recognized: (1) a period of increasing warmth, (2) a period of maximum temperature, and (3) a period of decreasing temperature. Smaller fluctuations in one or more of the climatic elements may have occurred within these principal periods, but they are extremely difficult to recognize. Sears, although not discarding the Blytt-Sernander hypothesis, admits that this simpler one has considerable merit in that it is broad enough to permit of modification and refinement, and yet does no violence to facts as they are at present known.

Geothermal measurements in the deep copper mines of Calumet, Michigan, tend to corroborate the Von Post hypothesis of post-glacial climatic changes. These measurements suggest that the last glacial retreat was followed, perhaps after several thousand years, by a period distinctly warmer than the present. This in turn was succeeded by a slightly cooler climate persisting until rather recent times.9

Evidence from Analysis of Modern Floras

Based entirely upon a study of present-day floras, Gleason10 has presented a broad outline of post-glacial vegetation changes in middle western United States. (1) At the time of greatest advance of Wisconsin ice the associated semiarid climate resulted in a narrow and interrupted strip of coniferous forest bordering the front of the ice, and broadening northward in the Driftless Area where some shelter was provided by the deep valleys. Relics of this boreal vegetation are still to be found in the Driftless Area coincident with such edaphically dry sites as rocky hill slopes, sand and gravel terraces, and exposures of

sandstone. The subhumid conditions may have caused vegetational belts to shift as much as 400 miles eastward from what they are at present so that western Illinois was perhaps exclusively prairie. (2) The mild dry xerothermic period of early post-Wisconsin led to a northward expansion of the coniferous forest and a further extension eastward of the prairies in the form of a wedge (Prairie Peninsula) between the northward

Diagram:

- **Northern Lake Forest**
  - SF
  - Legend:
    - F - Fir
    - G - Grassland Complex
    - Hw - Hardwood, except Oak

- **Central Deciduous**
  - O & Hw
  - Legend:
    - O - Oak
    - P - Pine
    - S - Spruce

- **Northeastern Oceanic**
  - SF
  - Legend:
    - O - Oak
    - P - Pine
    - S - Spruce
expanding conifers on the north and the deciduous forests to the south. It was at this time that the prairies moved into southern and western Wisconsin occupying the exposed uplands where the warm dessicating winds in summer, the cold dry winds of winter, and the deficient snow cover were adverse to maintenance of forest. (3) A retardation and eventual stop of the advance of the prairie upon the northward retreating conifers, followed by an advance of the southeastern deciduous forest to the north and west upon the Prairie Peninsula, resulted from a climatic change in the direction of increased rainfall. The deciduous forest advance was participated in by two successional series, a xerarch series chiefly oak and hickory on the uplands, and a hydrarch series (oak, elm, ash, walnut, maple, cottonwood, and others), along the valleys. Gradually the xerarch forests of the bluffs encroached laterally upon the interfuwe upland prairies, more and more isolating the prairie colonies. Such was the condition in the Driftless Hill Land when the Indian appeared. Simultaneously with increase in moisture and the advance of the deciduous forest, changes took place in the prairie flora. The xerophytic western species withdrew from the eastern prairie extension, or left relic colonies behind in distinctly xerophytic habitats. Thus developed an eastern peninsula of the prairie distinct from that of the western plains. (4) With the advent of the Indian came the introduction of a new element in the vegetational environment, viz: the prairie fire. Through the destruction of the young seedlings on the margins of the forest, and the more susceptible mature trees as well, the previous advance of the deciduous forest was turned into a retreat. Gradually the forest was pushed back toward the bluffs and the area of prairie expanded. By this means there came into existence the open park-like condition known as the “oak openings”, and in places the so-called barrens, characterized by a sparse growth of hazel brush, scrub oak, and wild plum. (5) The arrival of white settlers and the subsequent development of agriculture gradually reduced the effectiveness of forest fires as a factor in vegetation distribution. Once more, therefore, the deciduous forests began their advance, along the stream courses and at right angles to them, and have continued down to the present time except as thwarted by cultivation and pasturage.
The Driftless Area east of the Mississippi gives one the impression of being densely forested at the present time, yet the first settlers of a century and more ago spoke of it as dominantly prairie. Chandler, a resident of Galena, Illinois, during the third decade of the 19th century, estimated that only one tenth of the lead region in the Driftless Area of what is now southwestern Wisconsin and northwestern Illinois was covered with timber. Estimates by other eyewitnesses ranged from 10 to 20 percent. This same mining area was described by Keating (1823) as "presenting the waved appearance of a somewhat ruffled ocean; it is covered with a dry short grass", above which rose the higher knobs visible 30 miles away. These same knobs are now concealed by forest.—the country is still prairie with tufts of inferior timber", according to Col. Charles Whittlesey writing in 1832. Except along the Mississippi most of the timber in the lead area was so small as to make it unfit for construction of large buildings and large importations of lumber are reported at Galena as early as 1842.

Evidence from Peat Bogs

The most recent and perhaps discriminating method for tracing post-glacial changes in vegetation and climate is by statistical analysis of pollen blown from adjacent trees and other plants, that has been preserved in the organic sediments of peat bogs. The idea was originated by G. Lagerheim of Sweden during the first decade of the last century, while credit for development of working methods goes to L. Von Post of the Geological Survey of that country. Much successful work of a paleoecological nature has been done in Europe following this method, less in the United States. Indeed in the latter region it is all confined to the period since 1930, and most of it to the last 5 years.

A cylindrical type of borer is used to obtain samples of peat at intervals of six inches to a foot throughout the different levels

---

of the bog. Several slightly different methods are employed for treating the samples in preparing them for microscopic examination, the purpose of which is to free the pollen grains from the peat fibers. One hundred fifty to 200 pollen grains are usually counted and identified for each level sampled. Contrasts in size, shape, markings, etc., are employed in identifying the pollen species.

Analysis of the botanical literature reveals that at least 75 to 80 bogs in northcentral and northeastern United States and adjacent Canada have been studied by the pollen-profile method. For purpose of regional analysis these bogs have been located on
TABLE I

Percentages of Principle Pollens for Four Driftless Area Bogs
(Data from Hansen)

1. Tamarack Creek Bog (Trempealeau Co.)

<table>
<thead>
<tr>
<th>Depth in Ft.</th>
<th>12½</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1½</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fir</td>
<td>58</td>
<td>41</td>
<td>49</td>
<td>28</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Spruce</td>
<td>25</td>
<td>31</td>
<td>40</td>
<td>42</td>
<td>30</td>
<td>26</td>
<td>13</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Pine</td>
<td>6</td>
<td>13</td>
<td>5</td>
<td>11</td>
<td>27</td>
<td>46</td>
<td>31</td>
<td>32</td>
<td>28</td>
<td>34</td>
<td>44</td>
<td>41</td>
<td>44</td>
</tr>
<tr>
<td>Oak</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>6</td>
<td>19</td>
<td>20</td>
<td>29</td>
<td>36</td>
<td>37</td>
<td>36</td>
<td>38</td>
<td>32</td>
<td>36</td>
</tr>
<tr>
<td>Mixed deciduous</td>
<td>5</td>
<td>7</td>
<td>2</td>
<td>9</td>
<td>12</td>
<td>5</td>
<td>17</td>
<td>18</td>
<td>22</td>
<td>13</td>
<td>12</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Birch</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>4</td>
<td>7</td>
<td>9</td>
<td>5</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Grasses</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

2. Mormon Coulee Bog (La Crosse Co.)

<table>
<thead>
<tr>
<th>Depth in Ft.</th>
<th>12½</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1½</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fir</td>
<td>20</td>
<td>17</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Spruce</td>
<td>24</td>
<td>23</td>
<td>12</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Pine</td>
<td>39</td>
<td>48</td>
<td>49</td>
<td>43</td>
<td>36</td>
<td>29</td>
<td>32</td>
<td>34</td>
<td>38</td>
<td>34</td>
<td>16</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Oak</td>
<td>6</td>
<td>8</td>
<td>24</td>
<td>26</td>
<td>32</td>
<td>41</td>
<td>42</td>
<td>37</td>
<td>34</td>
<td>33</td>
<td>32</td>
<td>31</td>
<td>29</td>
</tr>
<tr>
<td>Mixed deciduous</td>
<td>3</td>
<td>2</td>
<td>7</td>
<td>17</td>
<td>20</td>
<td>22</td>
<td>21</td>
<td>12</td>
<td>11</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Birch</td>
<td>7</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td>8</td>
<td>3</td>
<td>1</td>
<td>8</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Grasses</td>
<td>2</td>
<td>2</td>
<td>9</td>
<td>12</td>
<td>23</td>
<td>23</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22</td>
</tr>
</tbody>
</table>

3. Hub City Bog (Richland Co.)

<table>
<thead>
<tr>
<th>Depth in Ft.</th>
<th>12½</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1½</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fir</td>
<td>20</td>
<td>30</td>
<td>15</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Spruce</td>
<td>28</td>
<td>30</td>
<td>30</td>
<td>25</td>
<td>9</td>
<td>6</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Pine</td>
<td>20</td>
<td>26</td>
<td>28</td>
<td>43</td>
<td>40</td>
<td>48</td>
<td>42</td>
<td>34</td>
<td>34</td>
<td>33</td>
<td>41</td>
<td>34</td>
<td>10</td>
</tr>
<tr>
<td>Oak</td>
<td>4</td>
<td>4</td>
<td>11</td>
<td>12</td>
<td>19</td>
<td>18</td>
<td>25</td>
<td>35</td>
<td>32</td>
<td>31</td>
<td>30</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Mixed Deciduous</td>
<td>5</td>
<td>2</td>
<td>12</td>
<td>14</td>
<td>20</td>
<td>19</td>
<td>22</td>
<td>23</td>
<td>25</td>
<td>22</td>
<td>22</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Birch</td>
<td>2</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Grasses</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

4. Wisconsin Dells Bog (Juneau Co.)

<table>
<thead>
<tr>
<th>Depth in Ft.</th>
<th>14</th>
<th>13</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spruce</td>
<td>1.2</td>
<td>2.5</td>
<td>1.2</td>
<td>1.7</td>
<td>1.0</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pine</td>
<td>29.0</td>
<td>31.0</td>
<td>28.3</td>
<td>33.5</td>
<td>38.6</td>
<td>33.0</td>
<td>37.1</td>
<td>31.6</td>
<td>30.0</td>
<td>43.0</td>
<td>40.1</td>
<td>33.3</td>
<td>33.5</td>
<td>34.4</td>
</tr>
<tr>
<td>Hemlock</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.4</td>
<td></td>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
<td>0.5</td>
<td>1.5</td>
<td>1.6</td>
<td>1.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Larch</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.4</td>
<td></td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oak</td>
<td>21.0</td>
<td>24.0</td>
<td>22.0</td>
<td>22.5</td>
<td>22.0</td>
<td>28.5</td>
<td>26.5</td>
<td>30.5</td>
<td>32.0</td>
<td>14.0</td>
<td>25.0</td>
<td>22.0</td>
<td>15.2</td>
<td>17.5</td>
</tr>
<tr>
<td>Beech</td>
<td>20.0</td>
<td>17.0</td>
<td>15.0</td>
<td>10.0</td>
<td>12.0</td>
<td>10.0</td>
<td>12.0</td>
<td>13.0</td>
<td>12.0</td>
<td>11.0</td>
<td>17.0</td>
<td>26.0</td>
<td>16.0</td>
<td></td>
</tr>
<tr>
<td>Maple</td>
<td>2.0</td>
<td>3.5</td>
<td>1.5</td>
<td>6.5</td>
<td>6.0</td>
<td>4.5</td>
<td>7.5</td>
<td>7.0</td>
<td>8.5</td>
<td>11.0</td>
<td>6.5</td>
<td>9.5</td>
<td>8.5</td>
<td>14.0</td>
</tr>
<tr>
<td>Linden</td>
<td>0.4</td>
<td>0.5</td>
<td>0.3</td>
<td></td>
<td>0.2</td>
<td>0.8</td>
<td>0.7</td>
<td>0.3</td>
<td>1.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hickory</td>
<td>0.2</td>
<td>0.5</td>
<td>1.2</td>
<td></td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.4</td>
<td>0.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walnut</td>
<td>0.1</td>
<td>0.3</td>
<td>0.6</td>
<td>0.6</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.3</td>
<td>0.4</td>
<td>0.3</td>
<td>0.4</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Elm</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Willow</td>
<td>0.2</td>
<td>1.7</td>
<td>2.6</td>
<td></td>
<td>0.2</td>
<td>0.4</td>
<td>0.6</td>
<td>2.6</td>
<td>2.2</td>
<td>0.4</td>
<td>0.1</td>
<td>0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ericaceae</td>
<td>0.2</td>
<td>0.2</td>
<td>0.5</td>
<td>0.2</td>
<td>0.5</td>
<td>0.2</td>
<td>0.2</td>
<td>0.5</td>
<td>2.2</td>
<td>3.7</td>
<td>2.5</td>
<td>5.5</td>
<td>4.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Grasses</td>
<td>3.9</td>
<td>1.0</td>
<td></td>
<td>0.2</td>
<td></td>
<td>0.2</td>
<td></td>
<td>0.2</td>
<td>0.1</td>
<td>0.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compositae</td>
<td>5.0</td>
<td>5.0</td>
<td>4.4</td>
<td>3.0</td>
<td>3.0</td>
<td>1.1</td>
<td>2.1</td>
<td>2.5</td>
<td>3.9</td>
<td>1.7</td>
<td>3.2</td>
<td>1.9</td>
<td>2.4</td>
<td>1.1</td>
</tr>
</tbody>
</table>
difficult and generalizations are somewhat provisional in character. In spite of this weakness of the data, however, certain general inferences can be made. Without much chance of rebuttal, there appears to be a distinct regional pattern in the pollen profiles.\textsuperscript{16} In the following paragraphs are summarized some of the more important generalizations which can be made from a study of eastern North American pollen profiles (Fig. 6), more especially those of four bogs located within the Driftless Area.

There is little or no evidence of tundra in the bottom strata of North American peat profiles. According to Sears this does not necessarily preclude a tundra stage, for the basins in the till plain in which peat eventually accumulated may have been filled with detached ice blocks until the northward advancing coniferous forest had surrounded them. Or the tundra period may have been followed by such dry climate as to prevent peat formation. It seems unlikely however that bog basins within the Driftless Area could have been occupied by ice during, or at least long after, glaciation and yet there is an entire absence of tundra pollen in the lower strata of all four Driftless Area bogs studied.\textsuperscript{17} In spite of direct evidence being absent, many paleo-botanists are still of the opinion that the ice front was bordered by a tundra zone, possibly a much narrower one than in Europe.

At the bottoms of practically all of the bog profiles (except those not possessing older strata) in northeastern United States and southeastern Canada, and south as far as north central Illinois, central Indiana, and central Ohio, pollens of subarctic conifers, chiefly fir and spruce, dominate. This is not so clearly the case in the profiles from the four Driftless Area bogs. Only the most northern one shows a strong preponderance of fir and spruce at the lowest level. In Hub City Bog fir and spruce are the most important species but pine is likewise strong (Table I). Mormon Coulee Bog shows pine with the highest percentage at the lowest level although fir and spruce are likewise prominent, while in the fourth bog pine is the only important conifer and deciduous species likewise show high percentages. These data


\textsuperscript{17} Hansen, Henry F. Postglacial Vegetation of the Driftless Area of Wisconsin, Am. Midland Nat., 21, 1939, pp. 732-762.
may indicate that an initial forest of fir and spruce was already waning and being replaced by a pine-deciduous forest in the region of the three most southerly bogs when their first strata were laid down. Another suggestion is that these three bogs were relatively late in point of origin and consequently do not so clearly indicate the existence of this earlier forest.

Other types of pollen replace fir and spruce in the upper two-thirds or three-fourths of the characteristic profile for northeastern United States. It is in this part of the generalized profile that evidences of regional differentiation become more marked, profiles of different bogs show greater variability, and interpretations of the data by different workers are less in agreement. In northern Wisconsin and Minnesota the decline of fir and spruce pollen is followed by an increase in pine and later by hardwoods, chiefly oak, although pine remains dominant. The crest of oak coincides with the low point for spruce and fir. Toward the top of the profile as hardwoods wane, spruce and fir show an increase (Fig. 6).

Farther south in the present deciduous area (Northcentral Illinois, southern and western Wisconsin, central Indiana, and Ohio) after the early spruce-fir dominance there is a rapid increase in pine followed shortly by an equally rapid increase in oak and other hardwoods. The upper three-fifths of the profile is dominantly of this latter type with a small percentage of pine persisting. Significantly, perhaps, pine shows a slight increase at the extreme top of the profile. A grassland complex, beginning about half way up the profile, comes to a crest and dies out again some distance below the top (Fig. 6). Profiles from the Driftless Area show a larger proportion of pine than is indicated in the more generalized pattern described above.

Typical of the northeastern states and adjacent parts of Canada is a profile which resembles that of northern Wisconsin and Minnesota in its succession of spruce-fir and pine and in the dominance of conifers, but differs in that spruce-fir remains more important and pine less important throughout. Oak shows a crest as it does in the northern lake states, while hardwoods other than oak are relatively more important, and are more important than pine near the top of the profile (Fig. 6).
It will be useful now to turn to the interpretations of these pollen profiles. In all probability the climatic change associated with glacial retreat was of a greater degree than any that have occurred subsequently. The replacement of fir and spruce by pine is taken by some as evidence that the climate was becoming drier and perhaps warmer, and of pine by oak as indicating a warm maximum. The increase of spruce-fir in the upper parts of the northern profiles contemporaneous with the disappearance of oak, and in the northeastern states with the increase of more northerly hardwoods, suggests a waning of the warm-dry maximum. Other workers, although admitting that the replacement of spruce-fir by pine suggests a waning of the glacial climates, believe that all changes above the coniferous level are purely the result of local succession and do not require a postulation of climatic change. The increase in spruce toward the top of the profiles may be the result of increased filling of the basins and their invasion by black spruce.18

The profile of the central deciduous area with its shift from an early spruce-fir and pine forest to a later dominance of hardwoods, especially oak, suggests an increase in temperature which reached a xeric climax with the grassland crest. The subsequent decline of grass and slight increase in pine suggests a return to cooler and moister conditions. Some workers, on the other hand, think the evidence for climatic change, after the shift from coniferous to deciduous forest, is dubious.

It becomes fairly obvious that there are two points of view regarding pollen profiles and their interpretation. One group, following the lead of Sears, sees in the record for eastern North America “certain remarkably consistent, fairly synchronous, and long-time trends—which are difficult to explain on the basis of purely local changes.” This group strongly favors a climatic interpretation and one that involves a number of significant climatic variations within postglacial times. Within the second group of workers are those who would ascribe all postglacial vegetation changes to purely normal local succession, and others who admit of a postglacial warming resulting in a shift from coniferous to deciduous forest, but see little in the pollen record

to require postulation of climatic fluctuations since that major change.

Bibliography

(Starred references deal specifically with bogs of the Driftless Area)


36— Climatic change as a factor in forest succession. Journ. of Forestry 31, 1933, pp. 934-942.


Madison, Wisconsin,
November, 1939.