POLLEN ANALYSIS OF INTERGLACIAL PEATS OF IOWA

by

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INTRODUCTION

In Iowa there are a number of locations from which fossil materials of the Pleistocene period have been collected. Several papers have been published which describe these interglacial deposits and their plant remains.[2] Most of the plant materials described were coniferous and the conclusion has developed that interglacial ages in this state were uniformly cool. Nielsen [3] discusses Aftonian interglacial material from Minnesota. He finds chiefly coniferous materials but draws no general conclusions about the vegetation for the whole Aftonian interval. Voss [4] has described Yarmouth and Sangamon materials from Illinois. Further reference to his work will be made later in this paper.

In this paper the results are reported of studies of fossil pollen preserved in interglacial peats from the state of Iowa. Percentages of various kinds of pollen found at successive depths in the peat are taken to represent the composition of the vegetation nearby at the time each layer of peat was formed.

The evidence of pollen analysis indicates that the coniferous materials described by earlier workers must have come from near the beginning or end of the interglacial interval and that in the middle part of the interval a vegetation very much like the present was probably developed.

Although it is well known that pollen may be transported for long distances in the air it seems likely, if those distant contributions were in any considerable numbers, that successive layers of peat materials would show little variation in pollen composition. On this assumption it follows that changes in pollen composition necessarily represent

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2 Beyer, S. W., Evidence of a Sub-Aftonian Till Sheet in Northeastern Iowa: Proc. Iowa Acad. Sci., Vol. IV, pp. 58-62, 1897.
Finch, G. E., Drift Section at Oelwein, Iowa: Proc. Iowa Acad. Sci., Vol. IV, pp. 54-58, 1897.
Macbride, Thos. H., A Pre-Kansan Peat Bed: Proc. Iowa Acad. Sci., Vol. IV, pp. 63-66, 1897.
Calvin, Samuel, Interglacial Deposits of Northeastern Iowa: Proc. Iowa Acad. Sci., Vol. V, pp. 64-70, 1898.
Savage, T. E., A Buried Peat Bed in Dodge Township, Union County, Iowa: Proc. Iowa Acad. Sci., Vol. XI, pp. 103-109, 1904.

3 Nielsen, E. L., A Study of a Pre-Kansan Peat Deposit: Torreya, Vol. XXXV, pp. 53-56, 1935.

4 Voss, John, Pleistocene Forests of Central Illinois: Bot. Gaz., Vol. XLIV, pp. 808-814, 1933.
———, Forests of the Yarmouth and Sangamon Interglacial Periods in Illinois: Ecology, Vol. XX, pp. 517-528, 1939.

changes in local flora. Likewise, grass pollen, in the absence of much tree pollen, may be assumed to represent upland grassland vegetation rather than swamp grasses of the bog surface even though the genera of grasses represented cannot be determined.

In no case is it to be implied that the pollen record from a particular peat deposit necessarily represents the entire interglacial time. Peat formation may have begun long after the opening of the interglacial age and may have closed at any time. In addition, the plowing action of an advancing ice sheet may have erased any amount from a small part, or none, to the major portion or all of the record. If one is fortunate enough to get a series which indicates climatic change it may be possible to put it, at least tentatively, in its place in the interglacial time.

Materials and Methods

During the summer of 1931 the writer visited all of the places from which interglacial peat deposits had been reported in Iowa. In several instances the peat deposits could not be located. Collections were made from all deposits found.

The common practice in sampling post-glacial peats for pollen analysis is to take samples at intervals of 6 inches or more. It is obvious that interglacial peat deposits must have been greatly compressed by the ice sheet and load of glacial till with which they have been covered so that a smaller interval between samples is advisable in order to get results as informative as possible. Accordingly, the interval between samples was reduced to 2 inches in interglacial material, the sample consisting of a rough cube of peat approximately 2 inches on a side. In the graphs the figures designating the samples represent the distance of the bottom edge of the sample from the top surface of the peat.

These samples were subjected to the standard treatment for deflocculating the peat and separating the pollen grains, using 10 per cent, or weaker, KOH and centrifuging the material to concentrate the pollen. In all cases where the frequency of pollen on the microscope slide was high enough to warrant it the materials were studied with the high, or 4-millimeter objective lens of the microscope and identification of the pollen was checked by reference to it with the oil-immersion lens. Certain of the deposits were low in pollen content. To facilitate counting, these slides were surveyed with the low power,

or 16-millimeter objective lens of the microscope and the identity of the pollen was checked with the oil-immersion lens. Sears'[5] key and drawings and the drawings of Meinke[6] as well as slides of fresh pollen were used in determining the forms found. Structures resembling grains of grass pollen but lacking the characteristic single germinal pore of grass were encountered at certain levels. These were not counted as pollen. The pollen grains counted in the individual slides ranged from 7 to 209. The low figure represents study of the whole area of a slide while the higher figures were usually obtained from a small part of a slide. Conclusions are based only on counts of approximately 100 or more pollen grains for each level.

Acknowledgments

The thanks of the writer are due to Dr. H. S. Conard of Grinnell College, to Dr. R. B. Wylie, and to Dr. H. A. Mattill, of the State University of Iowa for laboratory space and use of apparatus; to Dr. P. B. Sears of Oberlin College, for encouragement, advice and technical assistance, both in the course of the study and in the preparation of the manuscript; and to Dr. Geo. F. Kay, former Director of the Iowa Geological Survey, whose interest has made possible this study.

The Pleistocene Period

The present classification of the Pleistocene period for Iowa[7] is given below.

Epoch (series)	Ages (stages)		Substages	
	Glacial	Interglacial	Glacial	Interglacial
Eldoran	Wisconsin	Recent	Mankato Iowan	Peorian
Centralian	Illinoian	Sangamon		
Ottumwan	Kansan	Yarmouth		
Grandian	Nebraskan	Aftonian		

5 Sears, Paul B., Common Fossil Pollen of the Erie Basin: Bot. Gaz., Vol. LXXXIX, pp. 95-106, 1930.

6 Meinke, H., Atlas und Bestimmungsschlüssel zur Pollenanalytik: Bot. Arch., Vol. XIX, pp. 380-449, 1927.

7 Kay, G. F. and Leighton, M. M. Eldoran Epoch of the Pleistocene Period: Bull. Geol. Soc. Am., Vol. XLIV, pp. 669-673, 1933.

Interglacial Peats of Iowa

Only two interglacial ages, the Aftonian and the Sangamon are represented by interglacial peat exposures in Iowa although many instances of peat from the Yarmouth have been reported in well records from the southeastern part of the state.

Of the six exposures of interglacial peat discussed in this paper five are of the Aftonian interval and one is placed, on stratigraphic evidence, late in the Sangamon age.

One of the Aftonian beds is near Oelwein, in Fayette county, eastern Iowa; two are near Denison, Crawford county, western Iowa; and two are in Union county near Thayer and Afton, in the southwestern part of the state.

The Sangamon bed is in Louisa county, in southwestern Iowa, not far from the town of Wapello.

THE OELWEIN PEAT

Near Oelwein, in Fayette county, eastern Iowa, Beyer [8] discovered a bed of Aftonian peat in a railroad cut in 1896 or 1897. In this cut, the banks of which have since slumped, he reported a discontinuous peat bed ranging up to 4 feet in thickness. The writer attempted to reach the original face of the cut by digging trenches through the slumped material. One of these trenches reached the peat, a layer about 16 inches thick, brown with considerable clay intermixed. Although Macbride [9] mentions moss leaves below and fragments of wood above which were not altered in form, no macroscopic plant parts were found at this place. Two series of samples were collected from the peat, one from each side of the face of the trench, perhaps 15 to 18 inches apart. It is recognized that this furnishes only a minimum of material for pollen analysis but it was all that was available under the circumstances.

The four upper samples, representing 8 inches of section, were of cocoa brown peat, easily crumbled, non-calcareous; not at all coal-like and with a large proportion of silt mixed with the vegetable material. They were moderately high in pollen content.

The four lower samples were of grayish-brown, silt-like material of texture similar to upper part and bearing little or no pollen.

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8 Beyer, S. W., Evidence of a Sub-Aftonian Till Sheet in Northeastern Iowa: Proc. Iowa Acad. Sci., Vol. IV, pp. 58-62, 1897.

9 Macbride, Thos. H., A Pre-Kansan Peat Bed: Proc. Iowa Acad. Sci., Vol. IV, pp. 63-66, 1897.

It perhaps should be emphasized that although the trench reached the peat, the thickest part of the deposit according to Beyer's [10] report was not found.

TABLE Ia
Oelwein Peat, Series "A"

Kinds of pollen	Percentages at different depths							
	2″	4″	6″	8″	10″	12″	14″	16″
Conifers								
Abies	4	2	5	2		—	—	
Larix	3	1	1	—		—	—	
Picea	24	23	41	38		25	—	
Pinus	29	35	36	46	No pollen	51	(100)	No pollen
Tsuga	1	—	—	—		—	—	
Monocots								
Cyperaceae	—	1	—	—		—	—	
Gramineae	16	6	1	2		6	—	
Sparganium	1	—	—	—		—	—	
Dicots								
Carya	—	1	—	—		—	—	
Platanus	—	1	—	1		—	—	
Quercus	19	29	15	11		14	—	
Unknown	4	2	2	1		4	—	
No. of pollen grains counted	140	178	147	132	0	49	1	0
Pollen frequency per sq. mm.	2.4	2.2	3.7	2.5	0.0	0.4	0.004	0.0

TABLE Ib
Oelwein Peat, Series "B"

Kinds of pollen	Percentages at different depths							
	2″	4″	6″	8″	10″	12″	14″	16″
Conifers								
Abies	1	—	1	1	—	—	—	—
Larix	—	—	2	—	—	—	—	—
Picea	25	11	23	15	(11)	29	(33)	—
Pinus	27	30	36	37	(78)	51	(67)	—
Monocots								
Gramineae	6	9	7	1	—	1	—	—
Potamogeton	—	1	—	—	—	—	—	—
Typha	—	—	—	—	—	1	—	—
Dicots								
Betulaceae	—	—	1	—	—	1	—	—
Platanus	1	1	1	—	—	2	—	—
Quercus	39	49	28	44	—	13	—	—
Unknown	2	1	2	4	(11)	2	—	(100)
No. of pollen grains counted	191	165	162	145	9	101	'3	1
Pollen frequency per sq. mm.	5.8	6.3	3.5	2.2	0.06	0.73	0.01	0.007

Tables 1a and 1b show the percentages of all kinds of pollen found at each level in the two series of samples taken from the Oelwein peat bed.

10 *Op. cit.*

Figure 1 is a graphic representation of the relative importance of the principal forms present in each level. The figures used are a

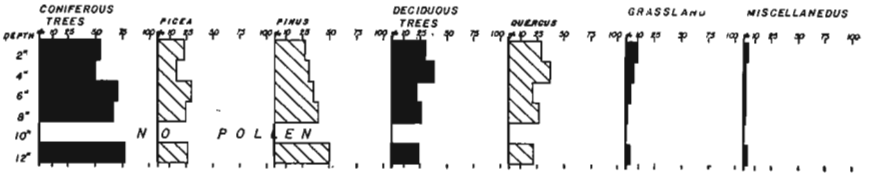

FIG. 1. — Oelwein Peat. Percentages of each group of fossil pollen are indicated along the top and the depth in inches at the left. The percentages used are based on a summation of the number of each kind of pollen found at corresponding levels in Series "A" and "B" from this peat.

summation of the number of pollen grains found at corresponding levels of the two series. In this figure and all other text figures of this paper the genera and families are grouped as follows:

Coniferous	*Deciduous*	*Grassland*	*Miscellaneous*
Abies	*Acer*	Gramineae	Unknown
Larix	Betulaceae	Compositae	*Rumex*
Picea	*Carya*	Amaranthaceae-	Cyperaceae
Pinus	*Fagus*	Chenopodiaceae	*Sparganium*
Tsuga	*Fraxinus*		*Typha*
	Juglans		*Salix*
	Platanus		*Potamogeton*
	Quercus		*Juncus*
	Tilia		

In addition, each diagram shows the percentage of *Pinus*, *Picea*, and *Quercus* in separate columns. These are crosshatched to indicate that they are different from the solid black columns.

Neither the 16-inch level nor the 14-inch level contained enough pollen to be significant. The 12-inch level, although the pollen frequency was not high still affords significant numbers of grains. Pine appeared to be the dominating form here, and there is a considerable quantity of spruce and some oak. The complex suggests the mixed forest of northern Minnesota.

At the 10-inch level again there was insufficient evidence but the 8-inch level appears to be much the same as the 12-inch. Oak gained a little at the expense of pine. At 6 inches oak was unchanged, total conifers were practically unchanged but the proportion between pine and spruce was altered.

In northern Minnesota spruces now occupy the wet soils, pine the somewhat dryer locations and oak the exposed hillsides. *Thuja* is found in the bogs. A slight increase in moisture might cause an increase in the area of wetter soils and account for the increase in spruce.

A second possibility is that an increase in spruce resulted from invasion of bog areas as water levels lowered during a dryer period or following the filling of the open bog with peat.

In the next level, the 4-inch, the strong increase in oak and the loss in number of spruce pollen suggest a definite loss of moisture supporting the second possibility suggested above. This may have been the culmination of a cycle of drying and moderate warming which began in the 6-inch level.

This peat might be interpreted either as the gradual warming of an early interglacial or possibly as the fluctuating climate of the waning interglacial age.

Such a brief amelioration of climatic conditions toward the end of the interglacial age has been reported by Jessen and Milthers [11] for the last two interglacial ages in Denmark and northwest Germany and by Premik and Piech [12] for the penultimate interglacial in Poland. A similar late interglacial amelioration is faintly suggested by Trela's figures for the Hamarnia peat in Poland.[13]

The 2-inch level suggests a fluctuation toward glacial conditions, either a return of cooler climate briefly in the early interglacial or the end of the interglacial age. Spruce pollen had regained part of its losses, pine had changed but little, oak was receding.

THE CRAWFORD COUNTY PEAT BEDS

In Crawford county in west-central Iowa there are two interglacial peat exposures, both Aftonian in age.

The smaller of these, described by Kay and Apfel,[14] is exposed in the bank of a small creek about 3 miles north of the town of Ricketts, about 20 miles from Denison. It is referred to here as the Ricketts bed.

The other, called here the Denison bed, was discovered by Kay [15] in 1931 in a cut along the paved road west of the town of Denison. It lies in the SE1/4 of sec. 32, Goodrich township and the NE1/4 of

11 Jessen, K. and Milthers, V., Stratigraphical and Paleontological Studies of Interglacial Freshwater Deposits in Jutland and Northwest Germany: Danm. Geol. Unders., Ser. II, No. 48, pp. 1-379, atlas with Plates 1-40. 1928.

12 Premik, J. and Piech, K., Zur Kenntnis des Diluviums im Süd-Westlichen Mittelpolen: Ann. de la Soc. Geol. de Pologne, Vol. VIII, Pt. 2, pp. 1-132, 1932.
Sears, Paul B., Glacial and Postglacial Vegetation: Bot. Rev., Vol. I, pp. 37-51, 1935.

13 Szafer, W., The Oldest Interglacial in Poland: Bull. Acad. Pol. Sci. et Lett., B *I*, pp. 19-50, 1931.

14 Kay, G. F. and Apfel, E. T., The Pre-Illinoian Pleistocene Geology of Iowa: Iowa Geol. Survey, Vol. XXXIV, pp. 1-305, 1929.

15 Kay, G. F., Personal Communication.

TABLE IIA

Denison Peat, Series "A"

Kinds of pollen	Percentages at different depths																				
	2″	4″	6″	8″	10″	12″	14″	16″	18″	20″	22″	24″	26″	28″	30″	32″	34″	36″	38″	40″	42″
Conifer																					
Abies	5	2	8	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Larix	8	2	4	1	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	2
Picea	23	10	24	13	2	2	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—
Pinus	15	4	21	20	3	—	—	—	—	1	1	—	1	—	—	—	—	—	—	—	4
Tsuga	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Monocots																					
Cyperaceae	1	1	—	—	1	—	1	—	3	2	2	—	—	1	—	—	—	—	—	—	—
Gramineae	29	62	39	59	80	86	95	86	76	63	68	82	91	66	(50)	(100)	—	—	—	—	90
Sparganium	1	—	2	1	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—
Dicots																					
Acer	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—
Amaranthaceae-Chenopodiaceae	—	1	—	—	—	2	—	—	—	—	—	1	2	1	—	—	—	—	—	—	—
Betulaceae	1	—	—	1	2	2	—	1	3	3	4	3	—	1	—	—	—	—	—	—	—
Carya	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Compositae	1	1	—	—	1	—	—	—	1	3	1	1	1	—	—	—	—	—	—	—	2
Fagus	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—
Fraxinus	—	—	—	—	—	—	1	—	—	2	—	1	—	—	—	—	—	—	—	—	—
Juglans	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—
Platanus	2	2	—	1	4	2	—	4	2	3	4	4	—	—	(50)	—	—	—	—	—	—
Quercus	11	5	—	1	7	6	3	4	5	11	10	1	1	4	—	—	—	—	—	—	2
Rumex	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—
Tilia	—	1	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Unknown	5	9	4	2	2	1	1	5	9	9	8	7	2	24	—	—	—	—	—	—	0
No. of pollen grains counted	209	184	136	149	114	126	120	135	119	176	134	132	128	102	2	7	0	0	0	0	50
Pollen frequency per sq. mm.	5.59	5.58	0.86	5.64	2.47	2.2	3.03	5.15	2.58	2.76	1.69	1.82	1.04	1.93	—	0.036	0.0	0.0	0.0	0.0	0.15

sec. 5, Denison township. (SE1/4, sec. 32, T. 84 N., R. 40 W. and NE1/4 sec. 5, T. 83 N., R. 40 W.)

The peat in these two beds is very much alike although the Ricketts peat is a much shallower deposit than the Denison bed. The plant material is much compressed, dark brown to black, containing only a little silt, appearing unlaminated when wet but separating or flaking with comparative ease when dry. The Ricketts peat shows laminations in the bed in some parts.

TABLE IIB
Denison Peat, Series "B"

Kinds of pollen	Percentages at different depths						
	2″	4″	6″	8″	10″	12″	14″
Conifers							
Abies	9	9	16	20	1	1	—
Larix	1	2	3	5	1	1	1
Picea	9	2	3	2	—	1	—
Pinus	7	4	8	9	1	—	—
Tsuga	—	—	—	1	—	—	—
Monocots							
Cyperaceae	15	15	10	16	9	13	—
Gramineae	32	33	36	28	68	67	94
Sparganium	1	—	—	—	—	—	—
Dicots							
Acer	—	1	1	1	—	—	1
Amaranthaceae-Chenopodiaceae	—	1	—	—	—	1	1
Betulaceae	6	6	7	6	2	3	—
Compositae	2	1	1	1	—	3	—
Platanus	—	1	3	2	2	1	1
Quercus	7	6	3	1	1	3	1
Salix	1	10	1	2	2	1	—
Unknown	10	9	9	7	13	6	2
No. of pollen grains counted	149	140	146	176	166	162	169
Pollen frequency per sq. mm.	2.82	1.78	6.32	3.33	5.03	6.14	8.54

Tables 2A, 2B and 2c show percentages of different pollens at each level of the three series of samples from the Denison bed. This peat is exposed in the bank on both sides of the paved road for a total distance of about 50 yards. Series "A" comes from the north bank and series "B" and "C" from the south bank of the road, "B" about 5 yards east of "A" and "C" about 25 yards west of "B".

Description of the Peat

Denison "A"

2″– 4″ dark brown peat, little silt
4″– 6″ cocoa-brown peat, more silt
6″–12″ gray-brown peat, considerable silt

12″–14″ darker gray-brown peat, less silt
14″–30″ very dark brown (almost black) peat, scarcely any silt
30″–34″ gray with brownish spots and streaks, somewhat mud-like contains some organic material
34″–36″ like above but with less of the organic matter
36″–38″ no brownish streaks or organic material
38″–40″ similar to 36″–38″
40″–42″ similar to 36″–40″, but with some spots of peaty material

The deepest level of Series "A," the 42-inch depth, was very low in pollen content, affording only 50 grains on the whole studied area of the microscope slide, or a pollen frequency of only 0.1535 pollen grains per square millimeter. However, 90 per cent of these 50 pollen grains were grass pollen so it seems safe to assume that these represent the major part of the vegetation.

Samples from levels of 40 inches to 30 inches were also very sparse in pollen, in fact no pollen at all was found in any of these except the 30- and 32-inch levels where only 2 and 7 grains respectively were found on the slide. At the 28-inch and 26-inch levels, however, the pollen frequency rose abruptly to 1.93 and 1.04 pollen grains per square millimeter and remained high thereafter except in one level. The cause for the failure of pollen preservation in these levels while peat formation was going on is not known although absence of pollen from grassland peat is not uncommon.

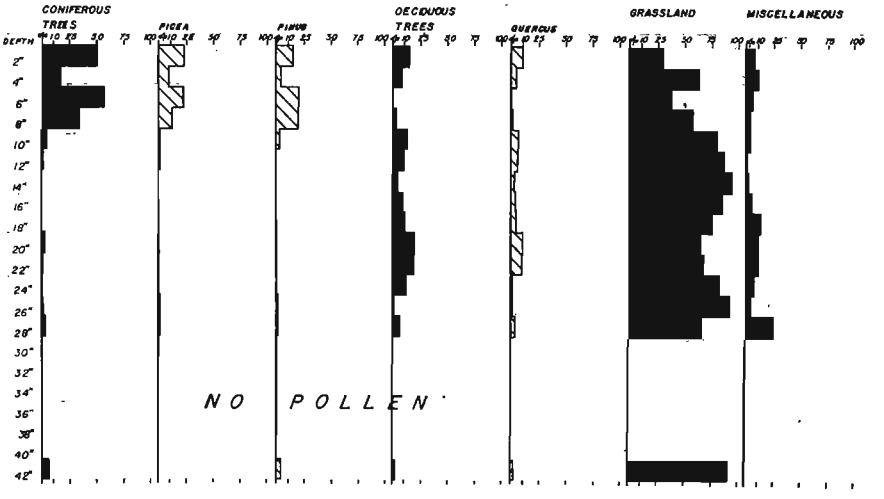

FIG. 2. — Denison Peat, Series "A". Percentages of each group of fossil pollen are indicated along the top and the depth in inches at the left. Levels 30 inches to 40 inches inclusive were devoid of pollen.

TABLE IIc

Denison Peat, Series "C"

Kinds of pollen	Percentages at different depths													
	3″	6″	8″	10″	12″	14″	16″	18″	20″	22″	24″	26″	28″	30″
Conifers														
Abies	2	5	15	16	3	6	4	8	—	2	1	1	—	—
Larix	1	—	1	1	3	1	1	4	—	—	—	—	—	—
Picea	1	—	34	29	1	4	1	2	—	—	—	—	—	—
Pinus	1	5	14	19	2	3	7	1	—	1	—	—	—	—
Tsuga	—	—	—	—	—	—	—	1	—	—	—	—	—	—
Monocots														
Cyperaceae	1	1	5	5	7	6	13	4	2	8	10	7	—	2
Gramineae	55	33	11	13	66	63	58	61	90	74	83	79	98	96
Juncus	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Sparganium	4	1	—	—	—	1	—	—	—	—	—	—	—	1
Typha	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Dicots														
Amaranthaceae-Chenopodiaceae	—	—	—	—	1	—	1	—	—	1	—	—	—	—
Betulaceae	7	6	3	3	1	3	4	8	2	2	4	3	—	2
Carya	—	—	—	—	—	1	—	—	—	—	—	—	—	—
Compositae	1	—	1	2	1	1	—	—	—	—	—	1	—	—
Fagus	—	4	—	—	—	—	—	—	—	—	—	—	—	—
Fraxinus	—	1	—	—	—	—	—	—	—	—	—	—	—	—
Platanus	1	2	1	—	1	—	1	1	1	2	1	3	—	—
Quercus	14	26	10	5	8	7	6	3	4	5	2	5	—	—
Salix	1	1	1	—	1	1	1	1	—	4	2	1	—	—
Unknown	12	17	7	6	7	5	5	6	2	2	—	2	2	2
No. of pollen grains counted	130	145	169	172	153	174	144	146	192	172	251	157	111	121
Pollen frequency per sq. mm.	2.46	4.39	4.27	6.52	5.8	4.39	3.64	2.77	14.55	8.69	19.02	6.95	4.2	2.62

Figure 2 is a graphic representation of the major vegetation groups as shown in the "A" series from this bed. The grassland formation was dominant at the lowest level. There are no data between 42 inches and 28 inches but above that the grassland continued to play the leading role up to the 8-inch level where although grasses still appear to have been dominant, conifers were present in sufficient numbers to be recognized as an important part of the vegetation.

According to Sears [16] the absence of pollen between the 28- and 42-inch levels is excellent confirmation of a grassland maximum, since the accompanying climate is notoriously bad for pollen preservation. The low organic content of the sediment at this level is likewise in keeping.

Oaks had brief increases at the 22-inch and 20-inch and at the 12-inch and 10-inch strata, but do not appear to have been of major importance at any of those places.

At the 6-inch level coniferous pollen was most abundant, about equally divided between pine and spruce, grass pollen was abundant and the pollen of deciduous trees was completely absent.

The next stage, the 4-inch, seems to indicate a warmth fluctuation with slight increase in oak and other deciduous forms and large increases in grasses. One might conclude that this stage was probably also dry since most of the gain has been in grass pollen. The top sample, or the 2-inch, indicates a return of coniferous forms, particularly spruce.

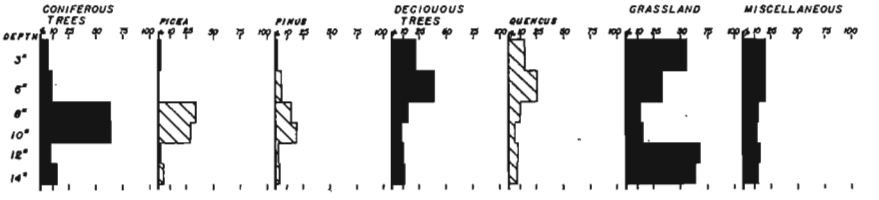

FIG. 3. — Denison Peat. The upper levels of Series "C" — Percentages of each group of fossil pollen are indicated along the top and depth in inches at the left. The 3- and 6-inch levels here are thought to correspond to the 4-inch level of the preceding figure in which coniferous pollen gives way to oak and grass for a brief period.

Figure 3, in which the upper levels of Series "C" are illustrated, seems to indicate (the 3-inch and 6-inch levels) that the climatic amelioration shown in the 4-inch level of Series "A" was of somewhat longer duration and that oaks and other deciduous trees were of considerable importance in that period. Peat corresponding in age to the

16 Sears, P. B., Personal Communication, 1940.

2-inch level of Series "A" seems to be absent in this series. Possibly it was graded away by the advancing ice sheet.

The similarity between the pollen figures for the lower levels of the Oelwein bed and the upper levels of the Denison peat suggests that these beds may represent a nearly continuous series. On the other hand if one regards the Oelwein beds as representing an early part of the interglacial then there must have been considerable lapse of time between the close of the Oelwein record and the beginning of peat accumulation at the Denison bed. In any case it seems likely that the Denison peat represents the climax vegetation of the Aftonian interglacial interval.

TABLE III
Ricketts Peat

Kinds of pollen	Depth in inches					
	2″	2″	4″	4″	6″	6″
	Percent	No. of grains	Percent	No. of grains	Percent	No. of grains
Conifers						
Picea	—	—	—	—	1	1
Monocots						
Gramineae	71	5	81	26	93	92
Sparganium	—	—	6	2	1	1
Dicots						
Acer	—	—	3	1	—	—
Betulaceae	—	—	—	—	1	1
Compositae	—	—	—	—	1	1
Platanus	—	—	3	1	2	2
Quercus	—	—	6	2	1	1
Unknown	29	2	0	0	0	0
No. of pollen grain counted		7		32		99
Pollen frequency per sq. mm.		0.27		0.81		3.0

Table 3 shows quantities and percentages of different pollens at each level of the Ricketts bed. Although only the 6-inch or deepest level provides enough pollen grains to furnish a basis for reliable conclusions, it seems probable that the whole bed represents but one phase, the grassland, of the interglacial interval. The spores found were almost exclusively grass pollen, which represented about 89 per cent of all the pollen found in all parts of the bed.

THE UNION COUNTY PEAT BEDS

In Union county, which lies 75 to 80 miles south and east of Crawford county, are found two exposures of interglacial peat, one near Thayer and the other in Dodge township north of Afton. Both are of the Aftonian interglacial interval.

The Thayer bed is exposed in the bank of a road cut along the paved highway about half a mile west of the town of Thayer. The peat here is light brown, contains considerable silt and strikingly resembles that of the Oelwein bed. There follows a detailed description of the profile.

0″– 4″ cocoa brown peat showing some oxidation and containing considerable silt
4″– 6″ cocoa brown color, somewhat grayish, less oxidation
6″– 8″ as above but not grayish, still less oxidized
8″–12″ cocoa brown peat, some silt
12″–14″ as above, but somewhat grayish
14″–16″ darker cocoa brown
16″–18″ as in 12″–14″

Three series of samples were obtained from this peat bed. Two were but 4 inches in depth, the third was 18 inches deep. Tables 4a, 4b, and 4c, show the percentages of each kind of pollen found at each level in these samples.

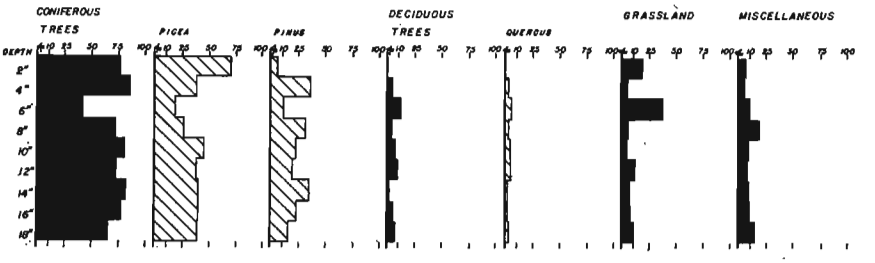

FIG. 4. — Thayer Peat, Union County, Series "C." Percentages of each group of fossil pollen pollen are indicated along the top and the depth in inches at the left. Figures for the 2-inch, 4-inch, and 14-inch levels are based on a small number of pollen grains and should not be regarded as conclusive.

Figure 4 is a diagram of the percentages of the major plant groups in the "C" series. In this diagram the 2-inch, 4-inch, and 14-inch levels are sparse in pollen. They are included in this diagram for the sake of completeness, but are not to be regarded as conclusive because they are based on a small number of pollen grains. If the series "A" and "B" could be correlated with the 2- and 4-inch levels of Series "C" it would be possible to add these levels together to make a significant figure. It seems likely, however, judging from the pollen frequencies and percentages, that the "A" series corresponds to the 6- and 8-inch levels of series "C" and that the "B" series corresponds to the 4- and 6-inch levels of "C." (See Tables 4a, 4b, 4c.)

TABLE IVA AND IVB
Thayer Peat, Series "A" and "B"

Kinds of pollen	A		B	
	Percentages at different depths			
	2″	4″	2″	4″
Conifers				
Abies	6	9	28	4
Larix	1	3	—	1
Picea	35	33	35	17
Pinus	13	17	24	30
Tsuga	—	1	—	—
Monocots				
Cyperaceae	5	5	3	6
Gramineae	20	10	4	18
Juncus	2	—	—	—
Sparganium	1	—	—	1
Typha	—	—	—	1
Dicots				
Amaranthaceae-Chenopodiaceae	—	—	—	1
Betulaceae	2	5	—	4
Compositae	—	—	—	1
Fagus	—	1	—	1
Platanus	1	—	—	1
Quercus	6	3	2	7
Unknown	10	12	4	8
No. of pollen grains counted	128	138	68	158
Pollen frequency per sq. mm.	1.21	1.9	0.18	1.28

TABLE IVc
Thayer Peat, Series "C"

Kinds of pollen	Percentages at different depths								
	2″	4″	6″	8″	10″	12″	14″	16″	18″
Conifers									
Abies	—	11	10	12	10	12	2	11	10
Larix	—	—	1	1	2	2	4	2	—
Picea	71	39	19	27	46	39	41	41	40
Pinus	6	37	12	32	23	20	35	24	16
Monocots									
Cyperaceae	—	—	1	10	3	—	—	3	5
Gramineae	12	5	37	5	5	11	7	8	10
Sparganium	—	—	—	1	—	1	2	—	5
Typha	—	—	1	—	—	—	—	—	—
Dicots									
Acer	—	—	1	—	—	—	—	—	—
Amaranthaceae-Chenopodiaceae	6	—	—	—	—	—	—	—	1
Betulaceae	—	2	4	1	2	2	—	2	2
Compositae	—	—	1	—	—	1	—	—	—
Fagus	—	—	—	—	1	—	—	—	1
Platanus	—	—	1	—	—	2	—	1	1
Quercus	—	2	5	3	4	5	2	2	3
Rumex	—	—	—	—	—	—	—	—	1
Tilia	—	—	1	—	—	—	—	—	—
Unknown	6	5	8	8	6	7	7	7	4
No. of pollen grains counted	17	57	147	158	128	133	46	121	116
Pollen frequency per sq. mm.	0.04	0.35	1.11	2.99	2.15	1.83	0.46	1.83	0.93

The climatic significance of this deposit is less clear than that of the Denison peat. Coniferous pollen was predominant throughout the peat bed. At the 6-inch level grassland forms and deciduous trees show a material increase but are not important in the two upper levels.

It seems likely that this peat was formed at about the same time as the Oelwein peat. Both show a brief amelioration of climate in the upper levels with a subsequent degradation, both show a similar pattern of pollen frequency and a similar group of pollen percentages.

TABLE V

A comparison of pollen frequencies from the "A" series of the Oelwein peat and the "C" series of the Thayer peat. The significance lies in the similarity of pattern of increases and decreases of the pollen frequency rather than in direct correspondence of figures.

Pollen frequency per sq. mm.			
Oelwein "A"		Thayer "C"	
		0.04	2″
		0.35	4″
2″	2.4	1.11	6″
4″	2.2	3.0	8″
6″	3.7	2.2	10″
8″	2.5	1.8	12″
10″	no pollen	0.46	14″
12″	0.4	1.8	16″
14″	0.004	0.9	18″
16″	no pollen		
18″	no pollen		

The Dodge township bed was described in 1904 by T. E. Savage.[17] In the bank of a small stream tributary to the Grand river, the peat is exposed considerably above the water line.

The peat-containing material has a total thickness of about 10 feet but the actual amount of peat is very much less. In this bed there are thin layers of carbonaceous material separated by thick bands of fine sand. The peat here is much less consolidated than the other interglacial peats, and the plant parts are considerably less altered, particularly in the upper layers. In the lower part of the bed the peat is more compact and plant materials are more difficult to recognize though they are not altered and consolidated as they are in the Denison and Ricketts peats. Moss plants, conifer leaves and stems of water plants are conspicuous.

Table 6 shows the kinds of pollen and the percentage of each kind found at each 6-inch level of the "B" series from this peat bed. Because of the scarcity of pollen, which makes the significance of figures from this peat somewhat doubtful, only every third sample was studied.

17 Savage, T. E., A Buried Peat Bed in Dodge Township, Union County, Iowa: Proc. Iowa Acad. Sci., Vol. XI, pp. 103-109, 1904.

TABLE VI

Dodge Township Peat Bed, Series "B"

Kinds of pollen	Percentages at different depths																			
	2″	6″	12″	18″	24″	30″	36″	42″	48″	54″	60″	66″	72″	78″	84″	90″	96″	102″	108″	114″	120″
Conifers																					
Abies	3	5	7	17	22	11	33	No Pollen	9	19	9	—	16	8	14	—	26	17	—	21	27
Larix	—	5	1	—	—	—	—		—	—	—	—	—	4	—	—	5	—	—	—	—
Picea	41	42	50	50	28	11	44		36	38	64	22	44	31	50	50	16	11	—	36	33
Pinus	14	16	6	8	22	14	—		9	31	9	22	26	39	7	25	32	28	71	36	37
Tsuga	—	—	—	—	—	—	—		—	—	—	—	2	—	—	—	—	—	—	—	—
Monocots																					
Cyperaceae	1	—	1	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Gramineae	30	21	24	17	11	18	22		9	6	—	33	10	8	7	13	5	28	14	—	—
Potamogeton	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	5	—	—	—	—
Sparganium	—	—	—	—	—	—	—		—	—	—	—	—	—	14	—	—	—	—	7	—
Typha	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Dicots																					
Amaranthaceae-Chenopodiaceae	1	—	—	—	—	—	—		—	—	9	—	—	—	—	—	5	6	—	—	—
Betulaceae	—	—	2	—	6	4	—		—	—	—	—	—	4	—	—	—	—	—	—	—
Carya	—	—	—	—	—	—	—		—	—	—	—	—	4	—	—	—	—	—	—	—
Celtis	—	—	—	—	—	32	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Compositae	—	—	1	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Fagus	—	—	—	—	—	—	—		—	—	—	—	—	—	7	—	—	—	14	—	—
Platanus	—	—	1	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Quercus	1	5	1	—	—	5	—		—	—	—	6	—	4	—	—	—	—	—	—	3
Rumex	1	—	1	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Salix	—	—	1	—	—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
Unknown	8	5	7	8	11	5	0		36	6	9	17	2	0	0	13	5	11	0	0	0
No. of pollen grains counted	78	19	136	12	18	56	9	0	11	16	11	18	50	21	14	8	19	18	7	14	30
Pollen frequency per sq. mm.	0.2	0.05	0.48	0.03	0.05	0.14	0.02	0.0	0.03	0.04	0.03	0.05	0.13	0.07	0.04	0.03	0.05	0.05	0.02	0.04	0.08

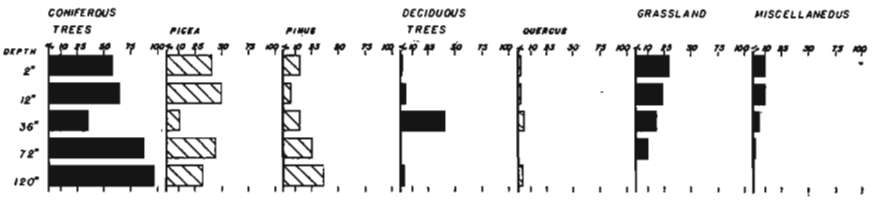

FIG. 5. — Dodge Township Peat, Union County, Series "B." Percentages of each group of fossil pollen are indicated along the top and the depth in inches is shown at the left. Figures are based on the following number of pollen grains per level: 2-inch, 78; 12-inch, 136; 30-inch, 56; 72-inch, 50; and 120-inch, 30. Ony the 12-inch level is based on a sufficient number of pollen grains to insure relative accuracy though other figures may be regarded as suggestive.

Figure 5 is a diagram of the percentages of pollen of various vegetation units found at certain levels of the "B" series from the Dodge township peat deposit. Figures showing the quantity of pollen on which these percentages are based are listed below the figure. Only one of these levels, the 12-inch, furnishes enough pollen to give a reliable guide to the composition of the vegetation. However, the other levels shown, with the exception of the 120-inch level, which is added only because it is the lowest one of the bed, all contain 50 or more grains of pollen and, although they cannot be regarded as throughly establishing a picture of the vegetation, they may be looked on at least as suggestive.

The general trend of vegetation change which these figures suggest is a slow disappearance of conifers and their replacement by grassland. The 30-inch level does not fit the picture. In this sample were found a quantity of spores resembling *Celtis* pollen, giving rise to the high percentage of pollen from deciduous trees in this level. No more pollen of this kind was found in the peat deposit.

The picture at the 12-inch level, the only one which we may regard as entirely reliable, is of a coniferous forest in which spruce was dominant. Small quantities of pine and fir were also present. Grassland forms were moderately abundant.

The percentages of the 2-inch level, based on 78 grains of pollen, showed strong increases in pine and grass pollen suggesting the beginning of a dryer period which may have led to the grassland formation as shown in the Denison peat.

Interpretation of the Aftonian in Iowa

From the evidence of the pollen preserved in peats of Aftonian age in widely separated parts of Iowa, that interglacial age must have been

of long duration. Such changes of vegetation as are indicated could scarcely have been accomplished in a short period.

In western Iowa (Crawford county) it seems probable on the evidence of the pollen, that a climatic condition and vegetation considerably like the present were reached. There is no indication of a long deciduous climax at any time in the series. In southwest Iowa (Union county) the evidence for a prairie condition is less convincing, if not entirely lacking. However, it seems doubtful if the peat series here can represent the same time period as that in Crawford county. It is not likely that conifers would remain dominant here throughout the interglacial period while, only 75 miles to the northwest, a prairie vegetation flourished.

In eastern Iowa (Oelwein) much the same situation is found as in the southwestern part of the state and again it seems probable that the peat series here represents but a part of the interglacial time. While it is not absolutely impossible, on the evidence, that coniferous forests remained here throughout the Aftonian it seems more probable that a prairie vegetation was developed either preceding this peat deposit or following the cessation of the peat record.

It seems likely to the writer that the Dodge township peat in Union county represents the earliest deposit of peat in this group, that the Denison and Ricketts peat beds are next in age and separated from the Dodge township bed by a hiatus of unknown length and that the Oelwein and Thayer beds were formed during the last part of the interglacial age, although these deposits may be nearly contemporaneous with the Dodge township peat.

If the first hypothesis is true the Aftonian vegetation of Iowa was first coniferous. Conifers were directly succeeded by grassland without the development of a deciduous phase although postglacial studies in northern Iowa have shown a well developed period of deciduous tree vegetation there.[18] The coniferous period was probably of considerable length and the grassland climax was of very long duration. As the interglacial period waned, grassland was succeeded by oak in the eastern part of the state although at the same time oak played a very insignificant part in the southwestern part of the state.

Oak dominance was of short duration. Conifers quickly succeeded the oak in both peat deposits and continue dominant to the end of the

18 Lane, G. H., A Preliminary Pollen Analysis of the East McCulloch Peat Bed: Ohio Jour. Sci., Vol. XXXI, pp. 165-171, 1931.

interval except for a short time represented by peat near the top of the sections at Oelwein and Thayer, during which temporary increases of grass and oak pollen suggests that there may have been a brief amelioration of the climate near the end of the interglacial interval.

On the second hypothesis above, oak would show a larger development in eastern than in western Iowa during the coniferous-grassland transition. Other conclusions would be the same except that the record would be assumed to close soon after the interglacial age began to wane.

It is to be hoped that further discoveries of Aftonian peat may be made in other parts of Iowa so that a complete series of records from all parts of the state can be developed.

The Sangamon Interglacial Age

Near Wapello, Louisa county, Iowa, along the old highway as it rose out of the Iowa river bottom, a road cut exposed a bed of peat approximately 20 inches thick at its greatest part. On the whole the peat is quite homogeneous. It is non-fibrous throughout and somewhat laminated. The color in the upper samples to 6 inches is dark brown, in the 8-, 10-, and 12-inch levels it becomes almost black, at 14 and 16 inches it is again a dark brown and changes again to brownish-black in the lowest levels. These colors were determined in the dry condition.

This peat lies at the bottom of an eroded depression in the Illinoian gumbotil plain so it probably had its origin quite late in the Sangamon interglacial age. It is covered by 10 to 15 feet of loess deposits.[19]

Tables 7a, 7b, and 7c record the percentages of each kind of pollen found in three series of samples taken from this peat bed.

The figures represent about what one would expect in peat formed late in an interglacial interval. A great many forms are present but in small quantities, and the vegetation was predominantly coniferous.

This material contrasts with the Sangamon peat described by Voss[20] and Fuller [21] in the abundance of pollen, in the large number of genera

19 Kay, G. F., Personal Communication.
20 Voss, John, Pleistocene Forests of Central Illinois: Bot. Gaz., Vol. XCIV, pp. 808-814, 1933. ———, Forests of the Yarmouth and Sangamon Interglacial Periods in Illinois: Ecology, Vol. XX, pp. 517-528, 1939.
21 Fuller, G. D., Interglacial and Postglacial Vegetation of Illinois: Trans. Illinois State Acad. Sci., Vol. XXXII, pp. 5-15, 1939.

TABLE VIIA

Sangamon Interglacial Peat, Series "A"

Kinds of pollen	Percentages at different depths									
	2″	4″	6″	8″	10″	12″	14″	16″	18″	20″
Conifers										
Abies	1	1	1	1	1	1	1	3	7	5
Larix	3	2	1	1	4	1	1	—	—	—
Picea	13	5	24	38	47	50	15	33	16	19
Pinus	63	27	45	47	39	23	6	48	62	37
Tsuga	—	—	—	—	—	—	—	1	—	1
Monocots										
Cyperaceae	—	—	—	—	—	—	—	9	—	—
Gramineae	16	43	22	6	2	20	13	5	5	7
Dicots										
Acer	—	5	1	2	3	—	—	—	—	—
Betulaceae	—	1	1	—	—	—	52	—	—	4
Compositae	—	—	—	—	—	—	—	—	—	2
Fagus	—	—	1	—	—	—	—	—	—	—
Platanus	—	4	1	1	1	—	—	—	—	6
Quercus	2	—	4	3	1	3	3	1	7	3
Salix	—	—	—	—	—	—	—	—	—	1
Unknown	3	12	1	2	3	3	10	1	3	14
No. of pollen grains counted	103	110	160	122	128	159	173	201	134	115
Pollen frequency per sq. mm.	0.68	1.67	2.42	1.68	3.23	4.82	17.47	30.45	13.54	3.48

TABLE VIIB

Sangamon Interglacial Peat, Series "B"

Kinds of pollen	Percentages at different depths								
	2″	4″	6″	8″	10″	12″	14″	16″	18″
Conifers									
Abies	—	—	1	4	9	7	14	12	11
Larix	—	—	—	—	2	4	—	—	—
Picea	3	6	9	25	44	24	42	41	21
Pinus	25	14	21	37	29	16	20	37	62
Tsuga	—	—	—	—	2	—	—	—	—
Monocots									
Cyperaceae	—	—	—	1	—	—	—	—	—
Gramineae	17	43	43	9	5	12	5	1	—
Typha	—	1	—	—	—	—	—	—	—
Dicots									
Acer	3	—	—	3	—	—	—	—	—
Betulaceae	—	—	—	1	2	—	2	—	—
Compositae	—	—	1	—	2	—	—	—	—
Fraxinus	—	—	1	—	—	—	—	—	—
Juglans	—	—	—	—	—	1	—	—	—
Lysimachia	—	—	—	—	—	1	—	—	—
Platanus	8	2	—	1	—	1	2	—	—
Quercus	33	23	22	15	5	14	9	1	1
Unknown	11	11	3	6	2	20	6	9	6
No. of pollen grains counted	36	111	102	144	128	100	100	123	120
Pollen frequency per sq. mm.	0.26	1.68	1.55	2.88	6.46	0.99	2.16	9.32	9.19

TABLE VIIc

Sangamon Interglacial Peat, Series "C"

Kinds of pollen	Percentages at different depths					
	2″	4″	6″	8″	10″	12″
Conifers						
Abies	1	1	7	4	4	1
Larix	1	1	1	1	—	1
Picea	24	5	55	25	44	34
Pinus	37	10	21	54	42	57
Monocots						
Gramineae	28	27	12	5	7	5
Dicots						
Amaranthaceae-Chenopodiaceae	—	1	—	—	—	—
Betulaceae	—	45	1	2	—	—
Platanus	1	1	—	—	—	—
Quercus	4	5	—	5	3	5
Rumex	—	—	—	—	1	—
Unknown	4	4	3	3	0	2
No. of pollen grains counted	174	165	87	248	110	187
Pollen frequency per sq. mm.	4.49	8.33	0.24	25.05	1.25	5.31

represented, and in the large fluctuations of deciduous and grassland pollens shown in the upper levels of series "A" and "B".

A comparison of the percentages of various genera among the three series suggests that the "A" series contains both the oldest and the youngest material of the peat bed. Large numbers of the pollen of deciduous trees, especially oak, and of grasses which appeared in the upper four samples of the "B" series may be correlated with the 6- and 4-inch levels of series "A". Grassland forms showed their highest values in these levels of series "A" although oak was much less abundant here than in the "B" series. It is difficult to account for these differences since these series were collected within a few feet of each other. High counts of Betulaceae pollen appeared in the 14-inch level of the "A" and in the 4-inch level of the "C" series. If one calculates the percentages of other forms separately from the Betulaceae pollen these levels show no great differences from adjacent levels in each series.

Figure 6 is a graph of the major vegetation groups as shown in the "A" series. In the 14-inch level of this graph Betulaceae pollen has been excluded in calculating the percentages.

Coniferous dominance was practically complete except for two times represented by the 14- and 12-inch levels and the 6- and 4-inch levels. In the lower level grassland pollens were in significant numbers while in the upper one both grassland forms and deciduous tree pollen in-

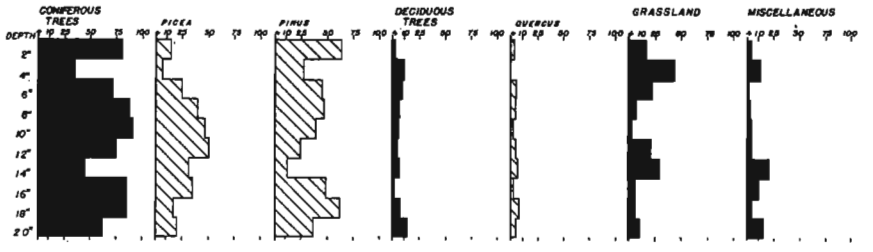

FIG. 6. — Sangamon Peat, Series "A." Percentages of each group of fossil pollen are indicated along the top and depth in inches at the left. In the 14-inch level the percentages have been recalculated, excluding Betulaceae pollen.

creased materially. If, as is suggested above, the upper four levels of series "B" may be correlated with the 6- and 4-inch levels of the "A" series then the rôle of deciduous forms at this stage may have been more important than this graph shows.

The 20-inch level, which shows slightly larger amounts of grassland and deciduous tree forms, may represent the end of a third fluctuation.

It would appear that climatic conditions toward the end of the interglacial interval fluctuated considerably. The uppermost of these peaks of grassland and deciduous tree pollen may represent the same sort of brief climatic amelioration as was noted above toward the end of the Aftonian interglacial period. The work of Jessen and Milther,[22] in which this feature appears so prominently, was on peat of the last interglacial in Europe which may be contemporaneous with the Sangamon in this country.

There is, however, no positive evidence that this peat was formed at the very end of interglacial time. The high values of grassland and oak pollen are accompanied by considerable pine and some spruce. These might be interpreted as a mixed oak-pine savannah at some earlier stage in interglacial time. However, the absence of such forms from Voss'[23] long series of materials from nearby stations in Illinois would lead one to doubt this conclusion. It seems more likely that the Iowan peat is more recent than the Illinois beds and consequently that it developed quite late in Sangamon time.

22 Jessen, K. and Milthers, V., Stratigraphical and Paleontological Studies of Interglacial Freshwater Deposits in Jutland and Northwest Germany: Danm. Geol. Unders., Ser. II, No. 48, pp. 1-379, atlas with Plates 1-40, 1928.

23 Voss, John, Pleistocene Forests of Central Illinois: Bot. Gaz., Vol. XCIV, pp. 808-814, 1933.

Summary

1. Interglacial peat materials from six widely separated locations in Iowa have been examined for fossil pollen and the percentages of different genera represented have been computed. One of the six deposits belongs to the Sangamon (last) interglacial age, the other five are Aftonian (oldest interglacial) in age.

2. The Aftonian materials seem to represent two or three separate phases of the interglacial interval. The oldest peat appears to be that from the Dodge township bed in Union county. A coniferous vegetation gradually changing to grassland is indicated. The Oelwein and Thayer peat may be nearly contemporaneous with the Dodge township peat. In that case, oak was of greater importance in eastern Iowa than in the southwestern part of the state during the transition from conifers to grassland. A grassland climax shifting toward oak and coniferous genera is recorded in the upper layers in the Denison peat. The closing part of the interglacial interval may be represented in two beds, the Oelwein and the Thayer peat. Both show dominant coniferous forms but with brief advances of oak and grass pollen shortly before the end of the peat record. The record ended with increasing coniferous forms.

3. Noteworthy in the evidence are the absence of important numbers of oak or other deciduous forms in the succession from conifers to grassland; the long dominance of grassland; the development of more oak in eastern than in western Iowa during the closing part of the ice-free time; and the appearance of a brief amelioration of climate shortly before the end of the interglacial interval.

4. The single peat bed from the Sangamon probably represents only a short time toward the end of the interglacial interval. The vegetation represented is mostly coniferous but small quantities of a number of other genera are present. Sharp fluctuations of climate are indicated. The coniferous forms were dominant except near the top of the peat where grass and oak were in majority for a short time. This brief amelioration of climatic conditions was succeeded by new increases of coniferous forms and the record ended with coniferous dominance.

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