2. *The* Arctic Flora *of the* Cam Valley *at* Barnwell, Cambridge.

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A section in Pleistocene gravels at Barnwell, Cambridge, was described by Prof. Marr & Miss E. W. Gardner in 1916.[1] They drew attention to the occurrence there of peat-seams yielding definite plant-remains, which were submitted to the late Clement Reid for identification. His preliminary report, showing the Arctic nature of the flora, was incorporated by Prof. Marr in a paper read before the Geological Society[2]; but, unfortunately, death prevented Mr. Reid from undertaking the full examination of the beds which he had, no doubt, intended to make.

I lately had the opportunity of investigating the Barnwell pit, and the examination of fresh material revealed the existence of a far larger fossil flora than was suspected originally. The records of such Arctic floras in low latitudes are few, and in the present instance a number of plants identified had not been recognized previously in the fossil state. It was thought desirable, therefore, that the results of this fuller study should be placed on record, in order that they might be available to other workers in the same field.

Owing to the great kindness of Mrs. E. M. Reid, I was able to use the unique collection of recent seeds made by Mr. Reid in his lifetime, and that collection (referred to as the Reid Collection throughout this paper) was the standard for all my systematic work.

As the stratigraphical details were dealt with in 1916,[1] no full account of the beds is given here, but the accompanying section, drawn to scale, should serve to make clear the respective positions of the different seams examined (fig. 1, pp. 6–7).

These seams were composed of broken and matted fragments of stems, of leaves and of bark, together with fruits and seeds. In some the peat was coarse, consisting largely of thick twigs of willow and birch, as in Seam X. In others the vegetable remains were finer, and leaves, which were often much worn, predominated, as in the lowest seam or in the middle seam above the Tramway. Yet others, for example the four

[1] Geol. Mag. 1916, p. 339.
[2] Q. J. G. S. vol. lxxv (1919–20) p. 204.

parallel seams, were poor in leaves and twigs, but very rich in small seeds and in tiny black galls.

To what cause such differences were due is uncertain. If there were a seasonal cause, no definite seasonal sequence could be made out, owing to the irregular mode of occurrence of the seams. Perhaps, however, the variation merely depended on the capacity of the water for carrying a load at the time of formation of any particular seam, and this view was supported by the fact that a thick peat-layer, which occupied a definite stream-channel at the eastern end of the section, was composed almost wholly of the coarsest and heaviest vegetable remains; in it twigs were very abundant, but seeds and leaves were scarce. However these variations were caused, it was clear that the Barnwell seams represented accumulations of vegetable débris washed from various parts of the river-basin; there was no indication that the peat was in the position of growth.

If we judge by the botanical evidence, climatic and ecological conditions remained the same in the Cam basin throughout the accumulation of the seams. Hence the plants obtained from each horizon may be regarded as representing one and the same flora; but, lest future work should give a new significance to such differences as existed between the floras of individual seams, these floras are enumerated separately in an appendix to this paper.

The plants enumerated on pp. 8–10, including those identified by Mr. Reid,[1] constitute the Barnwell Flora up to date.

Generally speaking, the species to which the fossils belonged were determined, but occasionally a plant could be referred to its genus only, either because of the inevitable incompleteness of the Reid Collection, or on account of the bad state of preservation of the specimens. Plants believed to be unrecorded previously in the fossil state were noted, but the literature of the subject is so scattered that records of some fossils may possibly have been overlooked.

A careful study of the plant-lists showed that the flora consisted of several groups of plants which were dependent for their existence upon special climatic and ecological factors; with the view of obtaining an idea of the flora, as a whole, these plant-groups, rather than the individual species themselves, are described.

[1] J. E. Marr, Q. J. G. S. vol. lxxv (1919–20) p. 226.

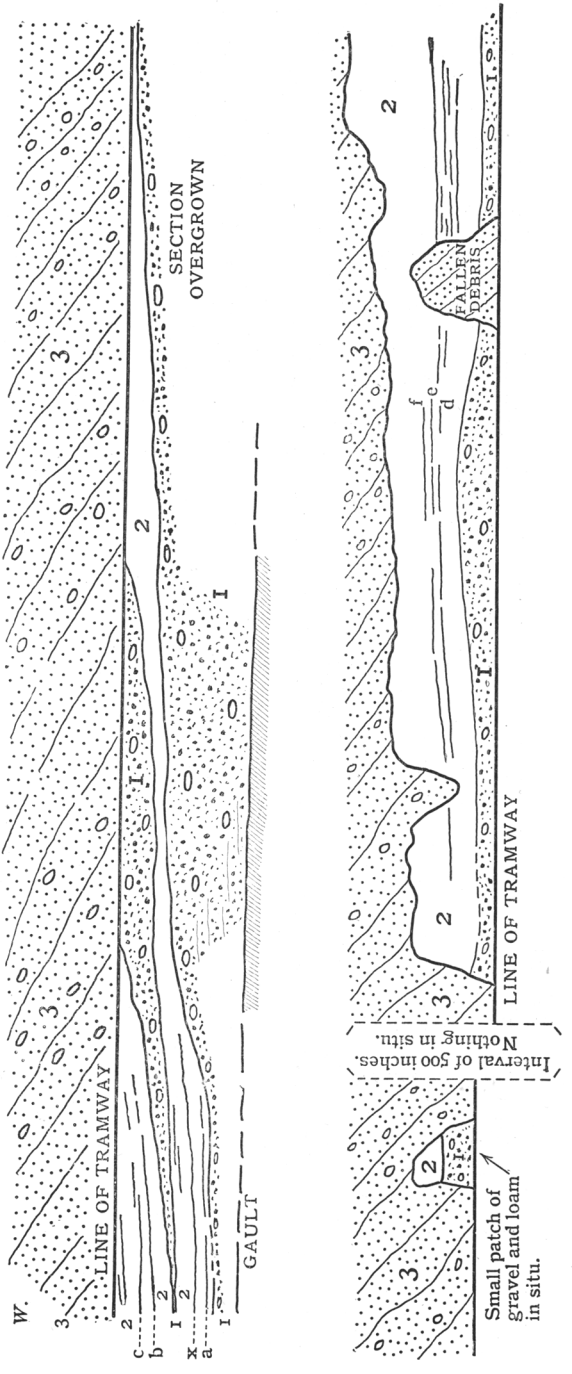
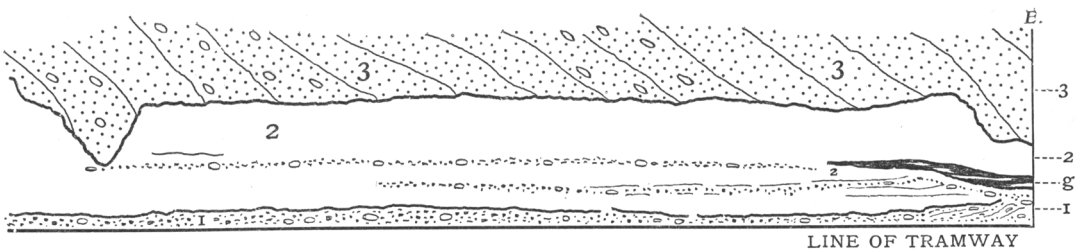


Fig. 1.—*Section in the northern face of the brickpit, Barnwell Station, as exposed in June 1920.*



Length represented in section = 1500 inches. Scales, vertical & horizontal = 1 : 80.

1 = Gravel *in situ*; 2 = Loam or sand yielding peat; 3 = Disturbed gravel, not *in situ*.

Peat-seams are represented by heavy lines in the loam. Seams were too numerous for all that were actually present to be shown on so small a scale.

a = Lowest seam below the Tramway.
b = Seam X below the Tramway.
c = Four parallel seams below the Tramway.
d = Lowest seam above the Tramway.
e = Middle seam above the Tramway.
f = Top seam above the Tramway.
} Seams from which material was examined by the Author.

x = Seam from which material was examined by Clement Reid, and subsequently by the Author.

g = Small channel, clearly marked out by a peaty layer, which yielded no leaves, few seeds, but abundant twigs and bits of bark.

[The letters in the central column denote the relative abundance of different species in the deposit. C = very common, c = common, f = frequent, s = scarce. Actual numbers are given where one or two specimens only were found. Where the word 'exotic' occurs in the third column, it signifies that the plant in question is not indigenous in Britain at the present day. L. stands for Linnæus throughout.]

Thalictrum alpinum L.	C	Recorded also from the Lea Valley in late Glacial beds.
Thalictrum minus L.	s	
Batrachium hederaceus L.	c	Recorded from the Lea Valley.
Batrachium spp.	...	
Ranunculus aconitifolius L.	C	Exotic. Not previously recorded fossil. Doubtfully identified with *R. amplexicaulis* L. by Mr. Reid,[1] but the examination of fresh material showed that it really agreed with *R. aconitifolius*.
Ranunculus Flammula L.	s	Recorded doubtfully from the Lea Valley.
Ranunculus Lingua L.	s	Recorded from the Lea Valley.
Ranunculus repens L.	s	
Ranunculus bulbosus L.	s	
Papaver alpinum L.	1	Not previously recorded fossil.
Fumaria sp.?	...	
Draba incana L.	c	Represented by carpels. Recorded from the Lea Valley.
Cochlearia officinalis L.	2	Represented by carpels. A *Cochlearia* was recorded from the Lea Valley, but the species was undetermined.
Helianthemum sp.	1	
Viola palustris L.	2	Recorded from the Lea Valley.
Silene cælata Reid	f	An extinct plant. Recorded from the Lea Valley.
Lychnis sp.	...	Exotic.
Arenaria sedoides L.	f	Not previously recorded fossil.
Arenaria biflora L.	1	Exotic. Not previously recorded fossil.
Arenaria gothica Fries	1	Not previously recorded fossil. In Britain now found only on Ingleborough.
Arenaria sp.	2	
Stellaria sp.?	...	
Caryophyllaceæ	1	Seed.
Geranium sp. x	C	
Geranium sp. y	1	Carpel. Exotic.
Linum Præcursor Reid	c	Recorded from the Lea Valley. An extinct plant.
Potentilla Anserina L.	c	Recorded from the Lea Valley.
Potentilla argentea L.	1	
Potentilla alpestris Hall	1	Not previously recorded fossil.
Potentilla fruticosa L.	1	
Potentilla Tormentilla Neck.	c	= *Potentilla erecta* L. Recorded from the Lea Valley.
Rubus sp.	1	
Dryas octopetala L.	s	Leaves.

[1] J. E. Marr, *loc. cit.*

Myriophyllum spicatum L.	f	Recorded from the Lea Valley.
Hippuris vulgaris L.	c	Recorded from the Lea Valley.
Saxifraga oppositifolia L.	f	Leaves, fruits, and shoots. Recorded fossil on the Continent, but not in this country.
Scabiosa sp.	1	Exotic.
Campanula sp.	1	Exotic.
Vaccinium uliginosum L.	s	Leaves.
Gentiana cruciata L.	1	Exotic.
Menyanthes trifoliata L.	C	Recorded from the Lea Valley.
Bartsia sp.	1	Nearest to *B. alpina*, but only half as large as that species.
Ajuga reptans L.	1	
Primula scotica Hook.	1	Not previously recorded fossil.
Primula sp.	1	Exotic.
Armeria arctica Wallr.	C	Recorded from the Lea Valley.
Rumex maritimus L.	1	
Polygonum viviparum L.	f	Recorded fossil from Saxony, but not previously from this country.
Salix cinerea L.	1	Leaf.
Salix repens L.	C	Leaves. Recorded from the Lea Valley.
Salix Arbuscula Fries	c	Leaves.
Salix Lapponum L.	c	Leaves. Recorded from the Lea Valley.
Salix herbacea L.	2	Leaves. Recorded from the Lea Valley.
Salix Polaris Wahl.	2	Leaves. Exotic.
Salix reticulata L.	2	Leaves. Recorded from the Lea Valley.
Betula nana L.	C	Fruits, male catkins, and leaves abundant. Recorded from the Lea Valley.
Carpinus Betulus L.	1	Recorded from the Lea Valley.
Sparganium simplex Hudson	1	
Sparganium minimum Fries	1	Recorded from the Lea Valley.
Potamogeton heterophyllus Schr.	c	Recorded from the Lea Valley.
Potamogeton Zizii Roth	s	Not previously recorded fossil.
Potamogeton obtusifolius M. & K.	f	Recorded from the Lea Valley.
Potamogeton filiformis Nolte	C	Recorded fossil from Denmark.
Potamogeton densus L.	f	
Potamogeton spp.	...	
Zannichellia pedunculata Reich.	f	Recorded from the Lea Valley.
Naias marina, var. *intermedia* A. Braun.	1	Identification kindly confirmed by Dr. Rendle.
Eleocharis palustris R. & S.	c	Recorded from the Lea Valley.
Eleocharis uniglumis Link	f	
Rhynchospora sp.?	1	
Scirpus lacustris L. (?)	1	Recorded from the Lea Valley.
Eriophorum polystachion L.	1	Not previously recorded fossil.
Eriophorum latifolium Hoppe	1	
Carex capitata L.	c	Exotic. Not previously recorded fossil.
Carex arenaria L. (?)	2	
Carex divisa Hudson	1	
Carex vulpina L. (?)	1	
Carex lagopina Wahl.	s	Not previously recorded fossil.
Carex Goodenovii Gay	C	This species was at first identified with *C. incurva* Lightfoot by Mr. Reid,[1] but the examination of more material has since proved it to be *C. Goodenovii*.

[1] J. E. Marr, *loc. cit.*

Carex atrata L. (?)	s	Not previously recorded fossil.
Carex ustulata Wahl.	f	Not previously recorded fossil.
Carex capillaris L.	s	Not previously recorded fossil.
Carex glauca Scop. ?	s	Badly preserved.
Carex flava L.	l	
Carex rostrata Stokes	f	Recorded from the Lea Valley.
Carex spp.	C	These were among the most characteristic fossils of the deposit. They are well represented in all northern and Arctic floras.
Isoëtes lacustris L.	s	Recorded from the Lea Valley.
Selaginella spinulosa A. Braun	f	Macrospores. Not previously recorded fossil from this country,
Chara sp.	C	Nucules. Recorded from the Lea valley.

(*a*) The Arctic-Alpine Group.

There are many Barnwell fossils the modern representatives of which appear both in Temperate and in Arctic regions. When found in the Temperate Zone they occur only on upland moors and on mountain-slopes, where some are plants of wide distribution, growing throughout extensive elevated tracts, while others are of a more extreme type found only in limited areas at considerable altitudes. These extreme forms are members of the scanty flora of the mountain-top detritus, or of the open plant-associations of the higher slopes; generally, they form cushions and tufts upon exposed rock-surfaces. Yet others occupy the more sheltered damp ledges on mountain-summits, or flourish in ravines or along mountain stream-banks. When growing in Arctic regions, these same plants are no longer confined to Alpine situations, but flourish at sea-level. In many cases they extend far beyond the Arctic Circle, and some of them are counted among the most widely distributed of Arctic species, occurring in all Arctic countries.

These plants form a striking element in the Barnwell Flora, since they constitute 42 per cent. of the whole, having regard only to those fossils in which the specific, as well as the generic, determination was made. They are as follows:—

Thalictrum alpinum L.
Ranunculus aconitifolius L.
Papaver alpinum L.
Draba incana L.
Cochlearia officinalis L.
Arenaria sedoides L.
Arenaria biflora L.
Potentilla alpestris Hall.
Potentilla fruticosa L.
Dryas octopetala L.
Saxifraga oppositifolia L.
Vaccinium uliginosum L.
Primula scotica Hook.
Armeria arctica Wallr.
Polygonum viviparum L
Salix Arbuscula Fries.
Salix Lapponum L.
Salix herbacea L.
Salix Polaris Wahl.
Salix reticulata L.
Betula nana L.
Potamogeton filiformis Nolte.
Eriophorum polystachion L.
Carex capitata L.
Carex lagopina Wahl.
Carex atrata L. (?).
Carex ustulata Wahl.
Carex capillaris L.
Selaginella spinulosa A. Braun
Isoëtes lacustris L.

(*b*) The Group of Plants of Wider Distribution.

In addition to the markedly Arctic or Alpine plants of the preceding group, other fossils were identified with species which have a wider geographical distribution, although their range is more limited towards the north. In the Temperate Zone, these plants are common in lowland situations, but they also flourish on higher ground. The plants identified include species which now characterize such varied habitats as water, marsh, meadow, and heath. They are as follows:—

Ranunculus Flammula L.
Ranunculus repens L.
Ranunculus bulbosus L.
Viola palustris L.
Potentilla Anserina L.
Potentilla Tormentilla Neck.
Myriophyllum spicatum L.
Hippuris vulgaris L.
Gentiana cruciata L.
Menyanthes trifoliata L.
Salix repens L.
Sparganium simplex Hudson.
Sparganium minimum Fries.
Potamogeton heterophyllus Schreber.
Potamogeton Zizii Roth.
Eleocharis palustris R. & S.
Eleocharis uniglumis Link.
Scirpus lacustris L. (?).
Carex arenaria L. (?).
Carex Goodenovii Gay.
Carex flava L.
Carex rostrata Stokes.

(*c*) The Southern Element.

A small number of the Barnwell plants were forms which have an even more restricted northern range at the present time, and these were designated the 'southern element' in the flora. The majority of them are now found as far north as about 63° lat. N., but in one or two cases they extend only to Denmark or to the extreme south of Scandinavia. This southern element is as follows:—

Ranunculus Lingua L.
Ajuga reptans L.
Carpinus Betulus L.
Potamogeton obtusifolius M. & K.
Potamogeton densus L.
Zannichellia pedunculata Reichberg.
Naias marina, var. *intermedia* A. Braun.
Carex vulpina L. (?).
Carex divisa Hudson.

It is difficult to account for the presence of such plants as *Carpinus Betulus* and *Potamogeton densus* in association with the Arctic species previously enumerated. But the majority of the plants forming this southern element had seeds too delicate in character to have survived from an earlier deposit; and, since their preservation was of exactly the same type as that of the Arctic plants from Barnwell, they were probably contemporary with the Arctic species. Perhaps the difference in altitude between the low-lying tract of the plain around Barnwell, and the more elevated ground in the higher reaches of the river, was sufficient to differentiate between the conditions in the two areas to such an extent that, while on the Chalk hills the most Arctic species could grow, in the lowlands the southern element could find an habitation.

(*d*) The Calcareous-Soil Group.

Considering that there was a Chalk outcrop in the upper reaches of the Cam, comparatively close to Barnwell, it is not surprising to find that the flora included plants of a definitely calcicole type. These were :—

Thalictrum minus L.
Papaver alpinum L.
Arenaria gothica Fries.
(?) Helianthemum sp.
(?) Linum Præcursor Reid.
Dryas octopetala L.
Gentiana cruciata L.

The plants *Helianthemum* and *Linum Præcursor* are placed here tentatively, for the recent species of *Linum* and *Helianthemum* thrive best on a calcareous soil, and the unidentified rock-rose and the extinct linseed may perhaps have shared this character.

(*e*) The Estuarine Group.

The presence of the following plants at Barnwell suggests tidal influence :—

Rumex maritimus L.
Zannichellia pedunculata Reichberg.
Naias marina, var. *intermedia* A. Br.
Eleocharis uniglumis Link.
Carex arenaria L. (?).
Carex divisa Hudson.

With the possible exception of *Zannichellia pedunculata*, no single plant in this list can be regarded as affording incontrovertible evidence of tidal influence; but, when we consider the group as a whole, the marine tendency of all these plants does seem to afford cumulative evidence of such a factor. The suggestion of marine influence is not unreasonable, in view of the previous history of the Fenland: for, even at the present time, a very small estuarine flora still survives far inland in the county of Cambridge, and this element must have been larger before the comparatively modern system of drains and sluices controlled the inflow of tidal waters.

It would appear, therefore, that the Barnwell Flora owed its complexity to the admixture, in a single deposit, of leaves and seeds from various parts of the river-basin. It included remains of Arctic and Chalk plants which were transported some little distance before they were incorporated in the peat-seams, and were therefore usually represented by but few specimens except in the case of the larger and tougher seeds. There were also plants from the low-lying tract bordering the Fenland, where tidal influence was probably felt.

The facts here stated, which were made apparent by the study of a particular flora, have a bearing on the whole question of peats in river-gravels. Considering that plants from several ecological units must necessarily have been mixed together in any river-gravel in which a flora is preserved, considerable variation between

any two such fossil floras is to be expected, even if they were actually contemporary; for it could rarely happen, in the case of two rivers, that the areas drained supported exactly the same plant-formations in precisely the same proportions.

Difference, then, in detail, must almost always be expected, though, naturally, two contemporary floras so differing may still bear the stamp of the more general conditions under which they flourished—such, for instance, as the climatic conditions. Comparison, with the view of establishing the relative age of two floras, seen in such close perspective as in the case of those from the Pleistocene, is therefore difficult; and the difficulty is increased by the fact that in any two cases conditions of preservation may have varied, so that whereas, in the one instance, certain delicate forms were preserved, in the other, on the contrary, they were destroyed before fossilization could take place. Further, an inadequate study of one or of both of two deposits may mean that characteristic forms escaped notice, and this risk should always be borne in mind in any attempted comparison, however much material was examined; for the fossil content frequently differs in richness from seam to seam, and it must sometimes happen that the investigation of one more sample of peat would reveal the presence in a flora of plants previously unrecorded.

All that can be said safely, therefore, in comparing two Pleistocene floras is that both, say, are Temperate, or both Arctic, so that they may have been contemporary. This is essentially true of the Lea and Cam-Valley Floras, both of which yielded Arctic plants, and both of which, judging by stratigraphical evidence, appear to have been of Upper Palæolithic date.

The late Clement Reid, in a note mentioned previously,[1] suggested the contemporaneity of these two floras on the grounds that:

(*a*) there was a correspondence in the plant-assemblages, and that

(*b*) not only did the same species occur, but the same Arctic species were missing.

Recent evidence does not accord with these statements, for, beyond the fact that both floras were Arctic, yielding certain of the same widely-distributed Arctic and Temperate forms, there appears to be no close correspondence between the two plant-assemblages, as will be shown subsequently. Moreover, some of the Arctic species which were supposed to be absent from the two areas were found lately at Barnwell, illustrating once more the fact that inferences based on negative evidence are always liable to modification as the result of subsequent discovery.

This being borne in mind, some conclusions in regard to the differences between the floras have been deduced from the available evidence. But the fact that these conclusions are purely tentative cannot be too strongly emphasized, for at any moment further research may render them untenable. First, then, while the flora

[1] See J. E. Marr, Q. J. G. S. vol. lxxv (1919–20) p. 227.

in both cases was almost equally large, there was an amazing number of plants represented in either list that were not recorded in the other one—in fact, only about thirty species, or roughly a third of the plants known to occur at Barnwell, were common to the two deposits (see the floral list). Further, different families were represented in the two cases: thus, out of a total of twenty-seven families in each locality, the following from Barnwell were not found in the Lea Valley: Papaveraceæ, Fumariaceæ (?), Cistaceæ, Geraniaceæ, Saxifragaceæ, Dipsaceæ, Campanulaceæ, Ericaceæ, Scrophulariaceæ, and Primulaceæ; while these from the Lea Valley were unrecorded at Barnwell: Portulaceæ, Leguminosæ, Umbelliferæ, Caprifoliaceæ, Valerianaceæ, Compositæ, Solanaceæ, Chenopodiaceæ, Urticaceæ, and Alismaceæ. The apparent absence in the Barnwell peat of Composites which were represented in the Lea Valley by several different species is rather curious, in view of the present abundance and wide distribution of the members of that family, and in view also of the preservation at Barnwell of numerous delicate seeds.

Another difference brought out by a study of the floral lists is that the Arctic character of the flora was far more pronounced at Barnwell than in the Lea Valley, for in the former locality 42 per cent. of the plants were Arctic and Alpine species, as against 22 per cent. in the latter area. Similarly, the number of plants not now indigenous in Britain (chiefly Arctic and Alpine species) was greater at Barnwell, and included the following:—

Ranunculus aconitifolius L.
Papaver alpinum L.
Silene cælata Reid. (Extinct.)
Lychnis sp.
Arenaria biflora L.
Geranium sp. *y*.
Linum Præcursor Reid. (Extinct.)
Scabiosa sp.
Campanula sp.
Gentiana cruciata L.
Primula sp.
Armeria arctica Wallr.
Salix Polaris Wahl.
Carex capitata L.
Carex ustulata Wahl.

In the Lea Valley this class of plants was considerably smaller, consisting of

Silene cælata Reid. (Extinct.)
Lychnis sp.
Linum Præcursor Reid. (Extinct.)
Potentilla cf. *nivalis*.
Armeria arctica Wallr.

The occurrence of the extinct plants *Silene cælata* and *Linum Præcursor* in both localities is not necessarily a proof that the peat-beds were contemporary; for, given suitable conditions, these species would have been preserved in deposits formed at any point along their time-range.[1]

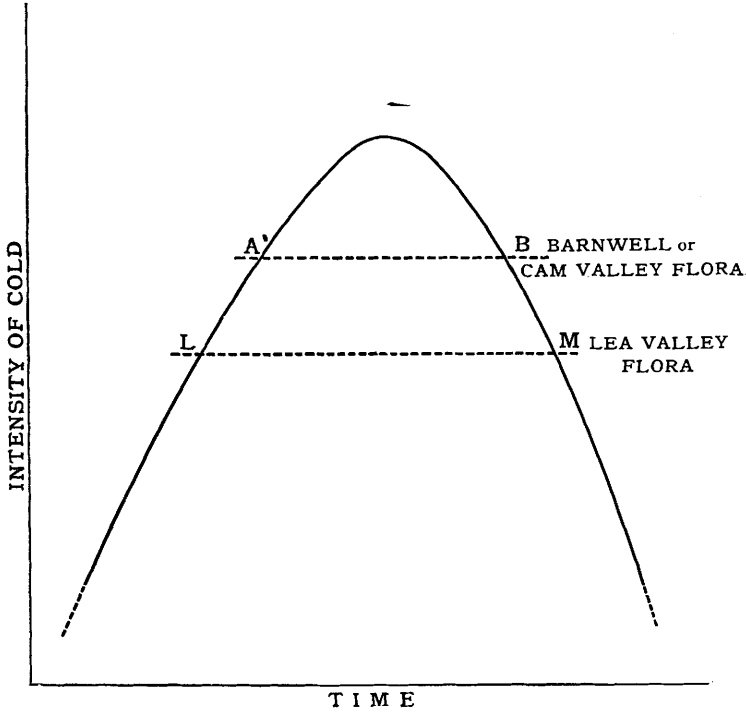
Again, the calcareous-soil element was more clearly defined in the Barnwell Flora than in that of the Lea Valley, and this constitutes another difference between them.

[1] That is, during the existence of the genera, from their evolution to their extinction.

A definite cause must have underlain such differences, and therefore the question arises: 'To what can they be attributed?'

Supposing that the two floras were separated by a considerable interval of time, that alone would probably have accounted for their dissimilarity, and this would have been the case had they lived during different cold periods. On this hypothesis, the Barnwell plants might have co-existed approximately with the Arctic

Fig. 2.—*Curve representing the relative positions of the Cam and Lea-Valley Floras, based on the theory that the former lived nearer the climax of a cold period than the latter.*



flora of Hoxne; but the botanical evidence alone is insufficient to justify such a conclusion, more especially as a considerable number of years have elapsed since the Hoxne Flora was investigated, while the stratigraphical evidence which places the Barnwell gravels fairly late in the Pleistocene renders this interpretation improbable.

If, on the other hand, the two Arctic floras lived within the same cold period, their differences might be partly explained by supposing that the Cam-Valley Flora existed whan the cold was near its climax, while the Lea-Valley Flora lived when it was less

marked: wherefore, of the two floras, that from the Cam Valley would naturally show the more pronounced Arctic features. Hence, if the two were supposed to lie on a curve, so drawn that ordinates represent intensity of cold and abscissæ represent time, the Cam-Valley Flora would lie at a higher point on the curve than the Lea-Valley Flora.

Thus A or B (fig. 2, p. 15) would represent diagrammatically the relative position of the Cam-Valley Flora if the Lea-Valley Flora were supposed to lie at L or M on the curve. If L were its position, the Cam-Valley Flora would be the younger of the two, whether it were represented by A or B, and similarly if M were its position, then the Cam-Valley Flora would be the older.

Another possible explanation of the more striking character of the Arctic element at Barnwell is based on the theory, previously suggested, that the most Arctic plants grew on the high ground upstream. But the high ground, which both in the Lea and in the Cam Valleys was formed by Chalk, was near to Barnwell, in the Cam Valley, while it lay much farther away from Ponders End in the Lea Valley; thus seeds from the upland tract had a good chance of incorporation in the peat-seams at Barnwell, whereas in the Lea Valley they were more liable to be destroyed during transport.

The relative distance between the peat-beds and the Chalk uplands in the two localities would also explain why the calcareous element as well was better represented at Barnwell than at Ponders End.

Perhaps, if the suggestion that the floras lived during the same cold period be correct, both the causes indicated here may have helped to produce a certain individuality in the plant-beds of the two areas.

Though it is possible, then, to regard the floras as contemporary, the evidence yielded hitherto by the plants is insufficient to justify any definite conclusion, and, at present, it looks as if the testimony afforded by other lines of research must be awaited for the final solution of the problem.

I desire to take this opportunity of thanking Mrs. Reid for generously allowing me to use the magnificent Reid Collection, and for the assistance which she willingly gave me while I was at work on these beds. My thanks are also due to Prof. J. E. Marr, F.R.S., who kindly gave me every facility for working in the Sedgwick Museum. I am further deeply grateful to Miss G. L. Elles, D.Sc., for reading and criticizing this paper in manuscript, and for all the ungrudging help and encouragement which she has always afforded me.

Appendix I.

Notes on Certain Species recorded at Barnwell.

Salix repens.

This plant was represented at Barnwell by its leaves, and, if we judge by their abundance, it must have occupied considerable areas. As it is a chalk-hating (calcifuge) plant, it may either have lived in the lowland tract where the beds below the Chalk were exposed, or it may have occupied areas covered by gravels of some thickness, higher up-stream, on the Chalk outcrop.

Draba incana and Cochlearia officinalis.

These two Crucifers are well-known instances of plants which flourish in Arctic-Alpine situations, but also along sea-coasts. Since however, they are very common and widely-distributed Arctic plants, it seems probable that their presence in the Barnwell Flora was due to climatic conditions rather than to tidal influence, wherefore they are classed with the Arctic, and not with the estuarine plants in this paper.

Appendix II.

The Barnwell Flora, showing the Distribution of the Fossil Plants through the Different Seams.

The following abbreviations are used for the seams examined :—

Lowest	= The lowest seam in the section.	In the section below the tramway.
x	= The lowest seam but one in the section. This was the seam examined by Mr. Clement Reid, several additions to his list have since been made.	
X	= A seam above the gravel-wedge.	
4 Parl.	= Four thin, closely-associated, parallel seams above the gravel-wedge.	
M.A.T.	= The middle one of three seams at the point indicated in fig. 1, pp. 6–7.	In the section above the tramway.
T.A.T.	= The highest of three seams at the same point.	

This terminology was employed in labelling the actual specimens, which have been deposited in the Sedgwick Museum.

Species recorded.	Seams. Lowest.	x.	X.	4 Parl.	M.A.T.	T.A.T.	Comment on Specimens.
Thalictrum alpinum L.	×	×	×	×	×	×	
Thalictrum minus L.	...	...	...	×			
Batrachium hederaceus L.	...	×	×	×	×		
Batrachium spp.	...	...	...	×	×	...	Several species. Not in the Reid Collection.
Ranunculus aconitifolius L.	...	×	×	×	×	×	In various stages of preservation, seen in the recent specimens after treatment by boiling and then rubbing to a varying extent, in order to simulate the conditions of fossilization.
Ranunculus Flammula L.	...	...	...	...	×		
Ranunculus Lingua L.	...	?	...	...	×		
Ranunculus repens L.	...	?	×				
Ranunculus bulbosus L.	...	×					
Papaver alpinum L.	...	...	...	...	×	...	The fossil had all the characters of *Papaver alpinum*, but was slightly larger than seeds of that species from the only gathering in the Reid Collection.
Fumaria sp.?	...	...	...	...	×	...	Not in the Reid Collection.
Draba incana L.	×	×	×	×			
Cochlearia officinalis L.	...	...	...	...	×		
Helianthemum sp.	...	...	×	...	...	...	The outer skin of the seed had perished during fossilization.
Viola palustris L.	...	×					
Silene cælata Reid	×	×	×	×			
Lychnis sp.	...	×	...	...	...	...	Not in the Reid Collection.
Arenaria sedoides L.	...	...	×	×	...	×	
Arenaria biflora L.	...	...	×				
Arenaria gothica Fries	...	...	...	...	×	...	The seed broke after identification, the remains were mounted and deposited with the other specimens in the Sedgwick Museum.
Arenaria sp.	...	...	...	×	...	...	Preservation good, but the species was not represented in the Reid Collection.
Stellaria sp.?	...	...	...	...	×	...	Not in the Reid Collection.
Caryophyll seed	...	×					
Geranium sp. x	×	×	×	×	×	×	The characters of this species were found scattered throughout the genus *Geranium*. Species not in the Reid Collection.
Geranium sp. y	...	...	×	...	...	...	Carpel. Nearest to *G. sanguineum*, but smaller than that species. Not in the Reid Collection.
Linum Præcursor Reid	×	×	×	×			
Potentilla Anserina L.	...	×	×	×	×		
Potentilla argentea L.	...	...	×				
Potentilla alpestris Hall	...	...	...	×	...	...	The thin prolongation seen on one side in the recent seed is broken in the fossil, probably a natural result of fossilization.
Potentilla fruticosa L.	...	...	×	...	...	...	Hairs (or their bases) preserved at the broad end of the seed.

Species recorded.	Seams.						Comment on Specimens.
	Lowest.	x.	X.	4 Parl.	M.A.T.	T.A.T.	
Potentilla Tormentilla Neck.	×	×	×	×	×		
Rubus sp.	...	×	...	...	...	...	Badly preserved.
Dryas octopetala L.	...	...	×	...	×		
Myriophyllum spicatum L.	...	×	...	×	×		
Hippuris vulgaris L.	...	×	×	×	×	×	
Saxifraga oppositifolia L.	...	...	...	...	×	×	
Scabiosa sp.	...	...	...	×	...	...	Not in the Reid Collection.
Campanula sp.	...	...	...	×	...	...	Not in the Reid Collection.
Vaccinium uliginosum L.	×	..	...	...	×	×	Leaves. The lower epidermis was destroyed, showing the spongy tissue and often the upper epidermis also. Leaves of the recent plant were prepared for comparison by soaking and rubbing.
Gentiana cruciata L.	...	...	...	×	...	...	Surface-striations were closer than those in the majority of recent seeds examined, but fell within the range of variation of the species. In allied species also a similar range of variation was observed.
Menyanthes trifoliata L.	×	×	×	×	×	×	The outer surface of the seeds was often partly destroyed.
Bartsia sp.	...	...	×				
Ajuga reptans L.	×						
Primula scotica Hook.	...	...	...	...	×		
Primula sp.	...	...	...	...	×	...	Not in the Reid Collection.
Armeria arctica Wallr.	×	×	×	×	×	×	A few undeveloped specimens showed crowded pollen-grains in the calyx.
Rumex maritimus L.	...	...	×				
Polygonum viviparum L.	...	×	×	...	...	×	The specimens were usually broken, though all showed the distinctive ornamentation. The original determination was based on a good and complete specimen.
Salix cinerea L.	...	×					
Salix repens L.	×	×	×	×	×	×	
Salix Arbuscula Fries	×	×	...	×	×	...	In many cases the hairs on the leaves were well preserved.
Salix Lapponum L.	×	×	×	...	×		
Salix herbacea L.	...	×	...	...	×		
Salix Polaris Wahl. (?)	...	...	...	...	×	×	
Salix reticulata L.	...	×	...	×			
Betula nana L.	×	×	×	×	×	×	
Carpinus Betulus L.	...	×					
Sparganium simplex Hudson	...	...	...	×			
Sparganium minimum Fries	...	×					
Potamogeton heterophyllus Schreb.	×	×	×	×			
Potamogeton Zizii Roth	...	...	×	×	×		
Potamogeton obtusifolius M. & K.	...	×	...	×	×		
Potamogeton filiformis Nolte	×	×	×	×	×		
Potamogeton densus L.	×	×	×	×			
Potamogeton spp.	×	...	×	...	×	...	Several species. Not represented in the Reid Collection.
Zannichellia pedunculata Reichb.	×	...	×	×			

Species recorded.	Seams.						Comment on Specimens.
	Lowest.	x.	X.	4 Parl.	M.A.T.	T.A.T.	
Naias marina, var. *intermedia* A.Br.	...	...	...	×			
Eleocharis palustris R. & S.	...	×	×	×	×	×	
Eleocharis uniglumis Link	...	...	×	×	×		
Rhynchospora sp.?	×	...	...	...	...	...	Not in the Reid Collection. Badly preserved.
Scirpus lacustris L. (?)	...	...	...	...	×	...	Badly preserved.
Eriophorum polystachion L.	...	...	...	×			
Eriophorum latifolium Hoppe	...	...	...	×			
Carex capitata L.	×	×	×	×	×	×	
Carex arenaria L. (?)	×	...	×		...	...	Badly preserved.
Carex divisa Hudson	...	...	...	×			
Carex vulpina L. (?)	...	×					
Carex lagopina Wahl.	...	...	?	×	×	...	The fossils were very slightly larger than the recent specimens, which were not fully developed, also their surface-sculpture was a trifle coarser than that of the recent seeds. In other respects, however, including the character of the utricle, the fossils and recent specimens agreed exactly.
Carex Goodenovii Gay	×	×	×	×	×	×	One specimen had a complete utricle, and many had part of the utricle preserved.
Carex atrata L. (?)	×	...	...	×	×	...	Badly preserved.
Carex ustulata Wahl.	?	...	×	×	×	×	
Carex capillaris L.	?	...	×	×	×		
Carex glauca Scop. (?)	...	...	...	×	×	...	Badly preserved.
Carex flava L.	...	...	...	...	×	...	Slightly less cuneate than specimens in the Reid Collection, but agreeing with the recent seeds in every other respect.
Carex rostrata Stokes	...	...	...	×			
Carex spp.	×	×	×	×	×	×	Numerous, but as a rule badly preserved. Many species not represented in the Reid Collection.
Isoëtes lacustris L.	...	×					
Selaginella spinulosa A. Braun	×	×	×	×	×	×	
Chara sp.	×	×	×	×	×	×	
89 species, representing 27 families.	29 species.	42 species.	43 species.	49 species.	47 species.	20 species.	

Discussion.

Prof. J. E. Marr congratulated the Author upon the valuable addition which she had made to our knowledge of the Pleistocene geology of Cambridge. He called attention to the occurrence of unworn implements of Upper Palæolithic age on a terrace somewhat north of Barnwell, and at a height less than that of the plant-bearing deposits. This proved that the plant-deposits were formed prior to the end of Upper Palæolithic times. The occurrence of *Zannichellia* in these beds was by him unexpected, and probably complicated the question as to various earth-movements in later Pleistocene times.

Mrs. E. M. Reid said that the Author's work was most valuable. She agreed with the Author that the botanical evidence threw no light on the absolute age of the Arctic floras of the Cam and Lea Valleys, but that it did throw light on their relative ages, and showed that these were not identical. She had been led to this view by comparing the two Arctic floras with the Temperate floras which preceded (Cromerian) and succeeded (present day) the Glacial Period. The two Arctic floras, as known, contain almost the same number of species; but, whichever comparison is made, the Lea-Valley flora is seen to contain about half as many again of Temperate forms as the Cam-Valley flora. This shows that the Cam-Valley flora lived nearer to the maximum of cold than the Lea-Valley flora, but does not show whether the Lea-Valley flora was earlier or later. Of the 145 known Cromerian species, only 16 are found in the Cam-Valley flora, a definite indication that the Cromerian flora was mostly exterminated in Southern Britain, and must have survived outside our islands. A great deal is now known of these Arctic floras. With the return of warmth they were driven to higher latitudes and higher altitudes; some species reached both, some only one or the other, and some neither: the latter were exterminated. In the speaker's view, plant life has been driven to and fro, and up and down the mountains, by stress of climate. If we can but follow its migrations, we shall have a most valuable botanical time-record, by which to trace changes of climate. If such a record is ever made (and the speaker saw no reason why in the future it should not be made), it would be by the aid of such reliable and valuable work as that done by the Author.

Prof. W. J. Sollas expressed his satisfaction in learning that Prof. Marr's discovery of the *Dryas* Bed at Cambridge had led to such valuable results, and congratulated the Author on a remarkable contribution to our knowledge of the Pleistocene flora. We owe to Dr. and Mrs. Clement Reid an ancillary branch of investigation which is bearing excellent fruit, and it is most fortunate that a Cambridge botanist has appeared to continue its cultivation.

It was to be hoped that the *Dryas* flora is confined to a single horizon. Whether it really was so or not might be still an open

question. In Scandinavia it seemed to be constant in its appearance at the close of the last Glacial episode, during the later stages of the emergence which followed upon the *Yoldia* depression, and in Gotland it occurs along with *Zannichellia polycarpa* below the deposits of the *Ancylus* lake. Prof. Marr's discovery of Palæolithic implements at a higher level than the plant-bed provided a new problem, and showed the necessity for further investigation. The Author had furnished a firm basis of fact; subsequent enquiry might increase, but could not diminish its value.

The Author thanked those present for the kind reception given to her paper. In reply to Prof. Sollas, she regretted that, up to the present, no comparison with the Pleistocene floras of the Continent had been made. She ventured to differ from Mrs. Reid as to the extermination of the Temperate flora by the cold; for, although the Cromerian species found in the Lea and Cam floras were few, the species recorded from the Cromerian would constitute but a small proportion of the Temperate flora then living, and there was no dearth of Temperate species in these two Arctic beds, for such constituted 78 and 58 per cent. of these floras respectively. A certain element comprising the more southern forms was doubtless exterminated; but, pending further discoveries, she felt that the presence of so large a proportion of Temperate species associated with the Arctic species pointed to the fact that, far from being exterminated, much of the flora was able to endure the changed conditions, and to live on side by side with the Northern invaders.