TRANSACTIONS

OF THE

Norfolk and Norwich

NATURALISTS' SOCIETY

PRESENTED TO MEMBERS FOR

1931–32

VOL. XIII.—PART III

EDITED BY MISS A. M. GELDART

NORWICH
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JANUARY, 1933

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1.—Precedence will be given to papers dealing with local Natural History.

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The Norfolk and Norwich Naturalists' Society has for its objects—

1. The practical study of Natural Science.

2. The protection, by its influence with landowners and others, of indigenous species requiring protection, and the circulation of information which may dispel prejudices leading to their destruction.

3. The discouragement of the practice of destroying the rarer species of birds that occasionally visit the County, and of exterminating rare plants in their native localities.

4. The record of facts and traditions connected with the habits, distribution, and former abundance or otherwise of animals and plants which have become extinct in the County; and the use of all legitimate means to prevent the extermination of existing species, more especially those known to be diminishing in numbers.

5. The publication of Papers on Natural History contributed to the Society, especially such as relate to the County of Norfolk.

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1897	Kerrison Colonel E. R. A., C.M.G., D.L., Birds Place, Buxton, Norwich
1925	Kerrison Mrs., Birds Place, Buxton, Norwich
1912	Ketton-Cremer W. C., Felbrigg Hall, Norfolk
1931	Ketton-Cremer R. W., Felbrigg Hall, Norfolk
1926	Kimberly Mrs.. M.Sc., "Constantia," Elm Grove Lane, Norwich
1898	Knight Edward, Keswick Old Hall, Norwich

L

1930	Lance Capt. H. W., Burnham Norton Lodge, King's Lynn
1926	Lane D. H., Framingham Pigot, Norwich
1931	Lawfield F. W., 219, Hills Road, Cambridge
1932	Leake Mrs., The Gables, South Wootton, King's Lynn
1926	Leconfield Lady, Petworth House, Petworth, Sussex
1921	le Strange C., Hunstanton Hall
1909	Leicester The Right Hon. the Earl of, G.C.V.O., C.M.G., *V.P.*, Holkham

Elected

1899 Leney F., Castle Museum, Norwich
1931 Liddell-Grainger Capt. H. H., Ayton Castle, Berwickshire
1931 Liddell-Grainger Lady Muriel, Ayton Castle, Berwickshire
1927 Lister Dr. S. R., Terrington Lodge, King's Lynn
1923 Livesay Surg.-Capt. A. W. B., R.N., St. Andrew's Hospital, Thorpe, Norwich
1922 Livesay Mrs., St. Andrew's Hospital, Thorpe St. Andrew
1922 Lloyd Capt. L., Taverham Mill, Norwich
1925 Lloyd Mrs., Taverham Mill, Norwich
1899 Long S. H., M.D., F.Z.S., M.B.O.U., *Hon. Mem., Hon. Sec.*, 31, Surrey Street, Norwich
1907 Long Mrs. S. H., 31, Surrey Street, Norwich
1919 *Long Miss E. M., 31, Surrey Street, Norwich
1923 Long G. S. B., St. Giles Plain, Norwich
1921 Lucas Baroness, Woodyates Manor, Salisbury

M

1924 MacKenzie Miss G., The Cottage, Ingworth, Norwich
1923 *Macpherson A. Holte, 21, Campden Hill Square, Kensington, W.8
1931 Maidment Dr. F. N. H., Harleston, Norfolk
1905 Mann Sir Edward, Bart., Thelveton Hall, Norfolk
1931 Maples Ashley K., 33, London Road, Spalding, Lincs.
1906 Marriott F. W. P., 11, Queen Street, Norwich
1931 Marshall E. H., 5, Council House St., Calcutta
1931 Marshall W. K., Radburne Estate Office, near Derby
1892 Marsham Major H. S., Rippon Hall, Marsham, Norfolk
1931 Martin A., Keswick Hall, Norwich
1912 Mason A., Willow Lane, Norwich
1911 Master George, M.D., Bury St. Edmunds
1893 Mayfield A., F.L.S., Mendlesham, Stowmarket
1926 McCall C. Home, Upper Flat, San José, Mount Rd., Hastings
1922 McKenna Mrs. Reginald, 70, Pall Mall, S.W.1
1926 McLean Colin, Humbletoft, East Dereham
1926 Meade Miss P., Croxton, Thetford
1898 Meade-Waldo Edmund G. B., Stonewall Park, Edenbridge, Kent
1928 Miller O. T., "Heathcote," Norwich Road, Fakenham
1923 Minns Mrs. E., Hammond's Wood, Frensham, Surrey
1932 Moore R. F., 3, Unity Street, Cambridge
1923 Moppe Lewis E. van, Cliffside, Overstrand
1929 Morley C., Monk's Soham House, near Framlingham, Suffolk
1924 Mortimer Ernest, The Red House, Wrentham, Suffolk
1922 Mountfield Miss M., Horsford, Norwich
1929 Moxey Llewellyn
1920 *Mullens Major W. H., Westfield Place, Battle, Sussex
1921 *Murton Mrs., Cranbrook Lodge, Cranbrook, Kent

N

1926 Nash J. E., 37, Mulgrave Road, Dollis Hill, London N.W.10
1922 Nevill Rev. R. W., Old Catton Vicarage, Norwich
1926 Nevill Mrs. R. W. ,, ,, ,, ,,
1925 Neville Sir R. J. N., Sloley Hall, Norfolk
1931 Nevill Capt. G. A., The White Lodge, Swanton Morley, East Dereham
1930 Nevill Capt. G. H., Swanton Morley, Norfolk

Elected

1911 Newman L. F., St. Catharine's College, Cambridge
1889 Nicholson W. A., *Hon. Mem.*, 5, Mill Hill Road, Norwich
1915 Nightingale S. R., Scratby Hall, Great Yarmouth
1926 Norfolk and Norwich Library, Norwich
1932 Norgate Mrs., Cranworth, Shipdham, Norfolk
1919 Norgate Philip, Swanington, Norfolk
1915 Norwich Public Library
1927 Notcutt R. F., Woodbridge

O

1927 O'Donnell O., Great Fransham, East Dereham
1914 Oliver F. W., D.Sc., F.R.S., *Hon. Mem.*, *V.P.*, Ballard's Barn, Limpsfield Common, Surrey
1930 Owen Miss F., 80, Mundesley Road, North Walsham

P

1889 Page G. W., Walsingham, Norfolk
1919 Pain Percy, Dersingham, King's Lynn
1913 Paine Rev. N. W., Great Melton Rectory, Norfolk
1919 *Palmer Mrs. P. Hurry, " Red Roofs," North Drive, Great Yarmouth
1912 Parker H., Lyncroft Road, Pakefield, Lowestoft
1921 Parker R. E., Marlingford, Norwich
1873 Partridge Rev. W. H., M.A., " Breckles," Leed Street, Sandown, I. of W.
1889 Patterson Arthur H., *Hon. Mem.*, Ibis House, Lichfield Road, Gt. Yarmouth
1920 Patteson Mrs. F. E., Great Hautbois House, Norfolk
1932 Patteson Miss, Great Hautbois House, Norfolk
1911 *Payler Donald, The Museum, Birmingham
1923 Peed John, Aylsham
1926 Percy Lord William, D.S.O., Catfield Hall, Norwich
1925 Petrie Mrs., The Dower House, Heydon, Norwich
1926 Phillippo G., 7, St. Philip's Road, Norwich
1925 Pilch R. G., 45, Grosvenor Road, Norwich
1930 Podmore R. E., Maynards, Matfield, Kent
1931 Potts F. A., Trinity Hall, Cambridge
1931 Pratt Alfred, The Cottage, Cliff Avenue, Cromer
1932 Preedy Mrs., 49, The Close, Norwich
1919 Preston Sir E., Bart., Beeston Hall, Norwich
1900 Preston F., 66, The Close, Norwich
1913 Purdy T. W., Woodgate, Aylsham
1925 Purnell Mrs. Ralph, 12, Claremont Road, Norwich
1887 Pycraft W. P., A.L.S., F.Z.S., British Museum (Natural History), London, S.W.

R

1929 Ramage H. P., Ridgemont, Carrow Hill, Norwich
1928 Raywood W., 13, Upper King Street, Norwich
1930 Reeves Derek L., Honingham Hall, Norwich
1925 Reeves Hugh, Honingham Hall, Norwich
1930 Reynolds Miss J., Clipston House, Church Road, Watford
1924 Richmond H. W., F.R.S., King's College, Cambridge
1925 Ringrose B., Farley, Harbridge Green, Ringwood, Hants.
1924 Rippingall Neale F., Langham, Norfolk
1911 Rising A. P., The Manor House, Ormesby, Great Yarmouth

Elected

1908 Riviere B. B., F.R.C.S., F.Z.S., M.B.O.U., Woodbastwick Old Hall, Norwich
1908 Rogers Commander F. S., R.N., Ingham New Hall, Norwich
1909 Rogers Rev. Henry, Coltishall Hall, Norwich
1908 *Rothermere Rt. Hon. Lord, Hemsted Park, Cranbrook, Kent
1897 *Rothschild Rt. Hon. Lord, F.Z.S., Tring, Herts.
1922 Rounce G. H., The Pines, Park Road, Cromer
1930 Rowell George, 15, The Close, Norwich
1902 *Ruggles-Brice Mrs. R., Keswick Hall, Norwich
1906 Rumbelow P. E., 27, Rodney Road, Great Yarmouth

S

1929 Sainty Miss O., West Runton, Cromer
1931 *Salisbury Prof. E. J., D.Sc., F.L.S., *President*, Willow Pool, Radlett, Herts
1930 Scratchley Lt.-Col. V. H. S., D.S.O., The Parsonage, West Newton, King's Lynn
1925 Sewell P. E., Dudwick House, Buxton, Norwich
1929 Shaw A., Bixley, Norwich
1922 Shepheard Dr. Samuel, Aylsham
1930 Shilcock Miss Joan R., "Maryland," Sheringham
1930 Simpson Miss W., Geldeston Lodge, Geldeston, Norfolk
1919 Smith Col. H. F., Didlington Hall, Norfolk
1915 Smith Mrs., Ellingham Hall, Bungay
1891 Smith W. R., Harleston, Norfolk
1917 Sowels Miss, The Rookery, Thetford
1922 Spalding G., 9 ,St. Stephen's Street, Norwich
1911 Spurrell J. T., Manor House, Newton St. Faiths, Norwich
1923 Spurrell Miss M., Manor House, Newton St. Faith's, Norwich
1923 Spurrell Miss P., Manor House, Newton St. Faith's, Norwich
1925 Steers J. A., St. Catharine's College, Cambridge
1921 Stimpson Edward, Sall Moor Hall, Reepham, Norfolk
1932 Stone Miss I., 42, Sandringham Road, Norwich
1922 Sumpter Dr. B. G., Brancaster Staithe, King's Lynn
1896 Sutton W. Lincolne, F.I.C., Eaton, Norwich

T

1931 Talbot Sir Gerald, K.C.V.O., C.M.G., O.B.E., Burnley Hall, Somerton, Norfolk
1931 Tate Mrs., Lenwade House, Near Norwich
1921 Taylor Dr. Mark R., 338, Winchester Road, Southampton
1878 Taylor Shephard T., M.B., The Mount, Edgefield, Melton Constable
1921 Thain D., West Somerton, Norfolk
1931 Thomas J. F., Bowden House, Seaford, Sussex
1886 Thouless H. J., "Southernhay," Wroxham
1929 Tillett Miss I., 2, Claremont Road, Norwich
1896 Tillett Wilfrid S., 2, Claremont Road, Norwich
1920 Todd Lt.-Col. Eardley, Mundham House, Brooke
1902 Todd R. A., B.Sc., The Retreat, Elburton, Plymouth
1932 Todd Mrs., Mundham House, Brooke, Norfolk
1923 Tomes Lady, Mannington Hall, Norfolk
1910 Tracy N., 3 King Street, King's Lynn
1925 Tucker B. W., 9, Marston Ferry Road, Oxford
1906 Turner Miss E. L., F.L.S., H.M.B.O.U. *Hon. Mem.*, 13, Storey's Way, Cambridge
1927 Turner Edgar, "Kuruman," Walberswick

Elected	
	U
1923	Upcher Rev. E. C. S., Weybourne Rectory, Norfolk
1921	Upcher H. E. S., The Gables, Upper Sheringham
1930	Upcher Mrs. H. E. S., The Gables, Upper Sheringham
	V
1917	Vincent James, Hickling, Norfolk
	W
1923	Walter Mrs. Cyril, Old House, Drayton, Norwich
1923	Waterfield Miss, Attlebridge, Norfolk
1923	Waterfield Miss Penelope, Attlebridge, Norfolk
1928	Watson J. B., c/o Barclays Bank Ltd., Surbiton, Surrey
1926	Wemyss Major, Bryn House, Wroxham
1927	Wemyss Mrs. ,, ,,
1923	Wenn Miss, Ingham, Norfolk
1931	Wheeler G., Tatterford Rectory, Fakenham, Norfolk
1883	*Whitaker Joseph, F.Z.S., Rainworth Lodge, Mansfield
1922	Willett W. L., Paddock Wood, Kent
1913	Williams Miss Margaret, 8, The Close, Norwich
1929	Wilson Mrs. Gerald, Saxlingham Nethergate, Norwich
1930	Wing J. Sladen, 21, Cheyne Gardens, Chelsea, S.W.3
1909	Witherby H. F., M.B.E., F.Z.S., 326, High Holborn, W.C.
1928	Wood M. S., M.D., Woodland House, Windermere
1931	Woolley Miss, B.Sc., Blyth Secondary School, Norwich
1923	Woolsey G. E. W., Old Catton, Norwich
1907	Wormald Hugh, M.B.O.U., Heathfield, East Dereham
1922	Wortley Francis, Half-Year, West Runton, Norfolk
1929	Wortley Roger, "Seathwaite," Sheringham
	Y
1915	Yarmouth Free Library, The, Great Yarmouth

TOTAL

Honorary Members	5
Life ,, ...	28
Ordinary ,, ...	364
	397

The Treasurer in Account with the Norfolk and Norwich Naturalists' Society.

Year Ending 30th April, 1932

I. GENERAL ACCOUNT

Dr.

1931–32.	£	s.	d.
To Balance from 1931	66	9	9
,, Subscriptions	184	19	6
,, Sale of "Transactions"	1	4	4
,, ,, "Flora of Norfolk"	0	7	0
,, Interest on War Stock and Consols	11	0	0
,, Donations to Publication Fund	4	5	0
,, Excursion Secretary	0	18	0
,, W.B.P.F. Subscriptions	6	6	0
,, Withdrawn from Savings Bank	35	0	0
,, Proceeds of Sale of 31 War Savings Certificates	35	5	3
,, ,, ,, 64 ,, ,,	93	1	4
,, Income Tax repaid	4	15	4
	£443	11	6

Cr.

	£	s.	d.
By "Transactions,"	119	9	0
,, Postages	18	13	3
,, Printing	4	5	3
,, Library Rent	6	6	0
,, Expenses of Meetings, Teas, etc.	5	1	9
,, Fire Insurance	0	13	6
,, W.B.P.F. Re-fund of subscriptions	6	6	0
,, The Norfolk Naturalists Trust for Alderfen Broad Purchase Fund	50	0	0
,, The Norwich Museum Committee for The Norfolk Room Fund	105	0	0
,, Books	16	5	9
,, Legal Charges for reclamation of Income Tax	1	1	0
,, Placed on Deposit at Barclays Bank	100	0	0
,, Balance on Current a/c at Bank	10	10	0
	£443	11	6

Examined and found Correct,
(Signed) W. A. NICHOLSON,
May, 1932

II. LIFE MEMBERSHIP FUND

1931–32.	£	s.	d.	1932		£	s	d.
To Balance from 1931 ...	38	18	6	April 30	By Transferred to General a/c ...	35	0	0
,, Bank Interest ...		7	9		,, Balance in Savings Bank ...	6	16	3
,, Interest on War Loan ...	2	10	0					
	£41	16	3			£41	16	3

Examined and found correct,
(Signed) W. A. NICHOLSON.

III. DEPOSIT ACCOUNT

1931-32	£	s.	d.	1932		£	s.	d.
To Balance, Capital from 1931 ...	24	0	9	April 30	By Purchase of £108 18s. 2d. 4 per cent. Consolidated Stock ...	104	0	9
,, Bank Interest ...		10	5		,, Balance at Barclays Bank ...	20	10	5
,, Transferred from General a/c ...	100	0	0					
	£124	11	2			£124	11	2

Examined and found correct,
(Signed) W. A. NICHOLSON.

List of Investments and Assets

		£	s.	d.
£300	£155 6s. 10d. 5 per cent. War Stock 1929-49 at cost ...	150	18	1
	£191 1s. 10d. 4 per cent. Consolidated Stock, at cost ...	166	9	7
	£108 18s. 2d. ,, ,, ,, ,, ...	104	0	9
	Balance in Savings Bank ...	6	16	3
	Balance on Deposit Account at Barclays Bank ...	20	10	5
	Balance on Current Account at Barclays Bank ...	10	10	0
		£459	5	1

Phot. E.J.S. *Natural size*

Lizard Orchid, Orchis hircina

ADDRESS

I

The EAST ANGLIAN FLORA: A Study in comparative Plant Geography

By Prof. E. J. Salisbury, D.Sc., F.L.S.

Being the Presidential Address delivered April 26th, 1932

With Plates I—VIII, three text figures and 106 *Maps*

Contents

INTRODUCTION AND GENERAL FEATURES

The especial object of this address is to consider the more characteristic features of the East Anglian Flora and to enquire as to how far the presence of its components can be correlated with the conditions of the present or with the environmental factors of the past. In so doing I make no apologies for extending our enquiry beyond the limits of Norfolk itself since the county boundaries have been determined by historical and political considerations and do not correspond to limits of biological importance. A still more pertinent consideration is that, however natural the delimitation of our area may be, the significance of its plant population can only be appreciated in relation to that of Britain as a whole and of the entire European Flora of which it forms a part.

Enquiry into the causes of the geographical distribution of species is essentially a comparative and extensive study, which often itself furnishes clues to the requirements of individual species; but nevertheless the ultimate elucidation of the facts usually demands an intensive study of the biology of the different species combined with experimental culture.

To no department of knowledge have Natural History Societies in general contributed more in the past than to the study of geographical distribution, and their members could do much in the future to further our accurate knowledge of the biology of individual species, without which the underlying causes of their more detailed distribution must remain obscure.

At the outset we may remind ourselves that the occurrence of a species in a particular part of England, and not in another, may be an accident of dispersal rather than an indication of especial fitness for the area in occupation. Furthermore, the absence of one species may be of equal significance to the presence of another, provided we can be sure that for both species there have been equal opportunities for invasion and establishment. Information of this character can for most plants, however, be acquired only by the deliberate introduction of wild species beyond their existing range. The strong objection which some students of geographical distribution have to such introductions, whilst it may have some sentimental justification, cannot be defended on scientific grounds, though it is of course essential that such introductions should be properly recorded.

Experimentation of this character can alone afford us definite data as to the capacity of species to exist beyond their present limits, and may also yield information as to whether the limiting factors are climatic, edaphic, or biotic.

The importance must be stressed of distinguishing between the occurrence of species in natural plant communities and their occurrence where the environmental conditions, particularly with respect to the pressure of competition, have been directly or indirectly disturbed. The great majority of the published records of the rarer species lose much of their value because the environment and plant community in which they were discovered have not been stated. We all know that many alien species are to be met with, year after year, on rubbish heaps, by waysides and on cultivated ground where human activities maintain an open community and preclude the degree of competition which exists in the closed communities of undisturbed vegetation. Such data have their scientific value, but this is probably little more, though certainly no less, than that obtaining from the deliberate culture of wild species in gardens. This does furnish us with information as to the climatic tolerance of a species and may, and often does, enable us to discover that species grow in nature where they must and not where they will. For, in the absence of competition, species often flourish exceedingly under conditions very different from those in which they occur in the wild state; the natural inference being that these favourable conditions are still more beneficial to their natural competitors.

The association of species with " open " communities only does not, however, necessarily imply the alien character of the species in question. It has too often been assumed that the occurrence of a species chiefly in arable land, roadsides, disturbed soil, etc., necessarily implies its adventive character. But it should be emphasised that many so-called weeds are probably natural constituents of the earlier open phases of the succession in perfectly natural conditions. In this connection one may cite the occurrence of Corn Salad (*Valerianella olitoria*), Chickweed (*Stellaria media*), Groundsel (*Senecio vulgaris*) on the early phases of dune systems, although these species are more usually associated in our minds with the artificial conditions of arable land and gardens, roadsides and railway embankments. It is perhaps more likely that many such species have extended their range of occupation to these artificial habitats than that they have emigrated from such artificial homes to the natural loci. Even in those instances where a species is found at the present time in artificial habitats alone, it by no means follows that this is not an outcome of the restriction or obliteration of its former natural habitats. In the more sophisticated areas of the earth's surface the control exercised over natural forces necessarily involves a great reduction in the area of land slides, erosion-fans and the like. To-day, many admittedly native species characteristic of the woodland marginal flora find suitable conditions in the hedgerow which is the representative, usually artificial, of the natural scrub margins which have well-nigh disappeared from the edges of our woodlands and, indeed, in highly agricultural districts these hedgerows furnish the only sanctuary for woodland species. The time may be not far distant when the hedgerows of S.E. England will be the sole stations for some of these marginal species, yet, because thus confined to an artificial habitat, botanists of the future would be in error in supposing these species to be aliens. Many species natural to the early stages of succession are intolerant of severe competition, which is here at a minimum ; and such species find an equally favourable environment in the early phases of colonisation of rubbish shoots, waste ground, and cultivated soils. Further, it must be emphasised that many English species are at or near their geographical limit, so that the balance in the struggle for supremacy between species is easily weighted, in one direction or another, by factors that towards the centre of a species range might have little or no effect.

Species towards the boundaries of their geographical range exhibit two extreme types of occurrence. Some, as might perhaps be normally expected, become gradually more rare as they reach their climatic limits. Such are exemplified in the British Flora by the northern shingle-beach species *Mertensia maritima*, towards its southern limit ; or by the southern species *Matthiola sinuata*, *M. incana*, and *Polycarpon tetraphyllum* of sand-dunes at their northern limits. Or, again, amongst woodland species by the southern *Euphorbia hiberna* and *Ruscus aculeatus*; amongst aquatics by *Damasonium stellatum*, all these at their northern limits for Europe which they attain in Britain.

By contrast with such definite diminution towards the limit of a species' range we may note the abundance of the northern *Cornus suecica* at its southern limit at the Hole of Horcum in Yorkshire ; the dense growth of the woodland Oxlip (*Primula elatior*) at its western limit in East Anglia and of

Physospermum cornubiense at its northern limit in Buckinghamshire. The last named is the more striking since the northern limit of this species on the continent is northern Spain.

The Perennial Glasswort (*Salicornia perennis*), the Dorset Heath (*Erica ciliaris*), and the Cornish Heath (*Erica vagans*) alike illustrate similar abundance at the limit of the species range. How can we explain this apparent contradiction? It is always rash to generalise with regard to species which differ in so many respects as to their more detailed ecological requirements and biotic associates; but it is not without significance that the species which become gradually more rare as they approach their geographical limit are not infrequently characteristic of habitat conditions where the pressure of competition is manifestly not severe owing to the open communities they frequent. On the other hand, those species which are abundant at their geographical limits are often social species of relatively advanced phases of succession characteristic of more closed plant communities. It may be suggested that where the species is abundant at or near the climatic limit of its range, this may often be due to its benefiting by a reduction in the pressure of competition, either through elimination of the competitors or diminution of the vigour of these competitors to a much greater degree than that of the species in question. Moreover, the decreased reproduction by seeds often shewn not only by southern species at their northern limit but also by northern species at their southern limit, is commonly accompanied by an increased rate and vigour of vegetative multiplication. This is well seen in the case of *Rubus arcticus* which rarely fruits even in southern Sweden and never, so far as I am aware, when cultivated in this country, but its vegetative vigour is such that it may well be placed in the English gardener's *Index expurgatorius*. Similarly the southern *Ulmus campestris*, which according to the late Dr. Henry fruits freely in the high central plateau of Spain, shews with us great vegetative vigour but only produces fertile seed very exceptionally and sparsely in hot seasons. M. Beyle (1928) has called attention to a number of species which do not fruit in northern Germany, and in the case of some (e.g. *Acorus*) the temperature factor is evidently involved.

The increasing rarity of a species not subject to appreciable competition is probably the natural outcome of increasing unfavourability of the climatic factors upon the vegetative vigour of the species, its reproductive capacity, etc. In the presence of any significant competition the species could not under such circumstances survive, but in the absence of competition it may still persist with diminishing frequency and vigour. This is strikingly illustrated by *Mertensia maritima* at its most southerly station for Britain on the shingle bank at Blakeney. Here there is rarely more than a single individual in any one season occupying an area otherwise bare of vegetation. On more than one occasion the single individual has been destroyed by burial under shingle in severe storms. Nevertheless the species reappears as a consequence of the survival of an occasional seedling presumably arising from seed previously buried and exposed by the same storm that had destroyed its parent. It can scarcely be doubted, however, that such tenuous survival would not be possible if competition were added to the other unfavourable factors of the habitat.

Those species which belong to the more advanced stages of plant successions where the community is more or less closed cannot survive beyond the limit where their vigour and frequency is adequate to withstand the competition pressure, and hence their diminution at the climatic limit will tend to be abrupt rather than gradual. If, further, the climatic depression of their competitors be greater than their own, a temporary increase in frequency may occur under suitable edaphic conditions and thus accentuate the abruptness of the species' diminution at its climatic limit.

Both extremes of marginal occurrence are represented in the East Anglian Flora. The gradual diminution is exemplified, as already mentioned, by *Mertensia maritima*, by *Dianthus prolifer*, by *Gastridium lendigerum* and *Trifolium suffocatum*. It may be noted that both the last named species, in the south of England, attain locally to a considerable degree of abundance where the edaphic conditions are especially favourable. All the species mentioned are characteristic of more or less open phases of the plant succession. The other extreme, the abrupt limitation, is represented by such plants as *Primula* *elatior, Frankenia lævis,* and *Salicornia perennis.* All of these, which are present in considerable abundance at their limit, are members of the more advanced stages of succession and grow in close association with other species. Between these two extremes are many species which, like *Silene conica* and *Medicago minima,* are neither markedly rare nor yet abundant towards their climatic limit and occupy partially closed communities. Whilst in general the competitive factor appears to explain the differences observed, it must nevertheless be emphasised that the hypothesis advanced does not appear to cover the facts of distribution in every case. In illustration of such discrepancies we may cite *Statice reticulata* which is a salt marsh species of a relatively early phase in the succession, yet we find it growing with considerable frequency on the Norfolk coast and in some localities in great abundance. It is, however, noteworthy that the exceptional vigour and abundance of this species in certain "lows" at Blakeney Point and particularly at Scolt Head is associated with the almost complete absence of competition, whereas in other "lows" where the competition is more severe, the plants of *Statice reticulata* are both fewer in number and much smaller in size.

The view here advanced can therefore be stated in these terms :—*The later the stage of succession to which a species belongs* (*i.e., the more closed the community*) *the more abundant will that species tend to be towards the climatic limit of its range, which will in consequence tend to be abrupt, especially if the species be a social one.*

The abundance of the various tree species which are at or near their climatic limits in Great Britain, and which amounts to almost pure dominance in their respective edaphic conditions, may be regarded as a further illustration of this generalisation.

It is, however, a necessary corollary to the foregoing statement that, since it is assumed that competition plays so large a part in determining frequency and abundance at the limit of a species' range, the degree to which this operates will depend both on the nature of the species as regards susceptibility to competition and on the nature of its competitors. The degree in which species vary as to their tolerance of competition is largely, though perhaps not entirely, indicated by the phase of succession to which they belong. But the nature of the competitors will depend not only on their climatic and edaphic limitations, but also on the respective facilities for their dispersal. Since reproduction by seed is often markedly diminished towards the geographical limits (and dispersal by vegetative means is often very precarious except over short distances) the accidents of dispersal may often play a considerable part in determining the abundance of particular species.

Apart from these general considerations it will be necessary, before passing to the more detailed consideration of the East Anglian Flora, to examine briefly the past history and present character of the environment which this part of England presents.

In common with the rest of England north of the Thames valley East Anglia was subject to glaciation during the Pleistocene. The stratigraphy of the Glacial deposits in our area has been admirably summarised by Prof. Boswell in a recent paper (Boswell, 1931). He concludes that there have been four Glacial periods in East Anglia. One corresponding to the Norwich Brick-earth; a second, which formed the Chalky-Jurassic Boulder Clay and which was followed by the most important interglacial period, probably corresponding with the Mindel-Riss interglacial of the Continent and characterised by implements of derived Mousterian and Acheulian types.

The third Glaciation formed the Chalky Boulder Clay; and the fourth the Hunstanton Boulder Clay corresponding to derived Upper Aurignacian and possibly Lower Magdalenian types of human artifacts. The river alluviums corresponding to the advent of Neolithic Man represent the temperate period which succeeded this last glaciation. East Anglia was thus apparently subjected to a series of glaciations with one prolonged and marked climatic amelioration following the second glaciation, during which a temperate flora was re-established. At Hoxne, Suffolk, where the succession of strata was worked out by Clement Reid (Rep. Brit. Assoc. 1896, pp. 400-415, 1897, and J. Reid Moir. Proc. Prehist. Soc. East Anglia, Vol. V., pp. 137-165, 1927), it seems clear that hardy species (such for example as *Rubus idæus*, *Ceratophyllum demersum*, *Sparganium ramosum*, and *Scirpus lacustris*, which occur in all but the most recent of the plant bearing zones) could probably have survived throughout the successive climatic changes, but it must be emphasised that an examination of the Drift Map of East Anglia shews practically the whole of Norfolk, Suffolk and the greater part of Essex as far as Epping and Chelmsford on the south, and Swaffham, Thetford, Linton and Stevenage on the west, to be occupied either by Boulder Clay or, as in the north-east of Norfolk, by Glacial Drift. It is hence highly probable that the whole of this area was in one or other glaciation covered by ice. Any suggestion therefore that an appreciable number of the present-day species comprise survivors of the preglacial Flora is too speculative to be seriously considered until some positive evidence in support of their perglacial character is forthcoming, accompanied by evidence as to the probability of an unglaciated area which might have served as an adequate sanctuary.

In the reaction from the view that the whole of the Flora of these islands was destroyed by the Pleistocene glaciations we must avoid too facile an acceptance of the theory of persistence. Whilst, however, it is improbable that any appreciable proportion of even the hardy species survived in East Anglia itself it is very likely that, as Woodhead (1929) has suggested, arctic and alpine types may have survived on " nunataks " in other glaciated areas, and quite probably a considerable number of the more hardy species in the unglaciated southern part of England. From such survivors of the pre-glacial Flora re-colonisation would naturally take place in the areas gradually exposed by the receding ice sheet and, in view of what we know respecting the importance of priority of occupation in relation to competition, the widespread distribution of many of these hardy types may well owe not a little to the advantage they derived from immigration into unoccupied ground. When we bear in mind the vast territory that was thus gradually exposed and the considerable area of moranic deposits that must have fringed the extensive European ice front throughout the pleistocene glaciations, we cannot but realise that this must have been the heyday of the plants of open communities and may well have been the chief period, not only of their evolution, but also of their geographical extension. It is not improbable that this was the primary home of species which to-day are mainly, if not exclusively, associated with the artificial conditions of cultivated and disturbed soil. The numerous microspecies of *Capsella bursa-pastoris* agg. and *Senecio vulgaris* agg., all normally self-fertilised, would be peculiarly fitted for success in climatic conditions unfavourable for insect pollination as are the parthenogenetic and apogamous *Alchemillas, Antennarias* and *Hieraciums* of the arctic and alpine conditions of to-day.

The fact that *Picea excelsa* and *Trapa natans*, which have been recorded in the pre-glacial Cromer Forest Bed from several localities in Norfolk, (c.f. Clement Reid, The Origin of the British Flora) have vanished from our Flora is testimony to the rigour of the subsequent climatic conditions. But having regard to what has already been said as to the probable extent of the ice sheet in East Anglia, it is hardly surprising that there are scarcely any plant remains, so far as I am aware, which can be definitely assigned to the actual period of a glaciation. A single exception is afforded by the record of *Salix polaris* at Beeston, near Sheringham, which appears to have been actually in the lowest part of the Boulder Clay. Perhaps also the zone containing *Hippuris vulgaris* and *Salix polaris* at Mundesley and that containing *Betula nana, Salix polaris, Hippuris vulgaris, Potamogeton and Carex sp.* should also be included. But it is clear that the majority of the so-called glacial plant beds, as we should expect, correspond to land surfaces immediately before or subsequent to a period of glaciation, being situated either immediately above or below the glacial beds themselves. The so-called late-glacial bed at Hoxne in which Clement Reid recorded *Salix myrsinites, S. herbacea*, and *S. polaris*, together with a number of other species, chiefly of a hardy temperate character, would appear from Prof. Boswell's stratigraphy to belong to the period of climatic oscillation between the first and second Glaciations and certainly not to the period of glaciation itself. Such horizons therefore represent transition floras which can thus give us no idea from their composition as to how rigorous the climatic conditions may have been at the height of the respective glaciations that they precede or follow. Wilmott (1931) has pointed out the possibilities of error in the determination of *Salix polaris*, which is the only species (in these alleged glacial beds) not present in the British Isles to-day. Nevertheless other species present, such as *Betula nana* and *Salix herbacea*, are dwarf species intolerant of competition which are only found in this country in situations, such as high altitudes furnish, which simulate the rigour of the arctic where they find their chief home. The evidence for the climatic conditions rests on the much surer foundations of the widespread occurrence of boulder clays, coastal pack ice, etc., though the occurrence of biological types, such as *Arctostaphylos Uva-ursi* and *Betula nana* in Devon, and the record of the definitely arctic *Ranunculus hyperboreus* in the Isle of Wight have a real significance and cannot be dismissed as lightly as Mr. Wilmott would have us believe. Prof. Seward, in discussing the Pleistocene glaciation and its effect on the distribution of plants, has recently (Seward 1931) called attention to the growth of warm climate species in juxtaposition to the foot of a recent glacier and, from analogy, has suggested the possibility of the temperate flora having survived not far distant from the ice front in glacial times. The analogy, though suggestive, is, however, hardly valid since the area occupied by a modern glacier is in no way comparable with the vast extent of the ice sheet in glacial times, and hence the effect on the climate of adjacent land in the two cases would be of an entirely different order.

What proportion of the hardy species which extend to-day into the arctic may have persisted throughout the Pleistocene, our evidence is clearly not adequate to assess; that more may have survived the later and less severe glaciations is quite probable, but there is no scientific justification for assuming such survival for any of the definitely southern members of our Flora, nor would such survival materially aid in overcoming difficulties in explaining existing distribution. What, however, may have been of the first importance were the climatic fluctuations during the Pleistocene and Neolithic periods. For the study of plants in cultivation, in the presence and absence of competition, has shewn that plants can survive under conditions much further from the optimum than those necessary for successful invasion. What applies to edaphic and biotic factors doubtless applies also to the climatic environment, so that we can, I think, justifiably assume that each marked change in the climatic conditions would have facilitated the invasion of Britain by species having particular climatic limitations. Once established, these species would withstand considerable climatic change, especially if adverse climate were ameliorated by the interaction of local topographical and edaphic conditions, a point to which we shall return. Thus the successive glaciations would facilitate the invasion of arctic and alpine types, some of which have survived the warmer and drier intervals in situations where the altitude, or the soil, or both, permitted. Thus the present distribution of the alpine *Cherleria sedoides* and *Gentiana verna* or of the northern and arctic *Salix herbacea*, *S. reticulata*, *Saxifraga oppositifolia* and *Saxifraga cernua* (only on the summit of Ben Lawers) are rendered comprehensible if (as Forbes first suggested) they are assumed to be survivors from a glacial period when their area of occupation was more extensive and their establishment facilitated. The arctic element is doubtless the more ancient and represents species which were driven south with the onset of the first glaciation, but it is significant that these are not present on all mountain summits, but only where the soil conditions are peculiar. This is particularly noticeable on Lawers where the schist, to which most of the arctic types are confined, probably owing to its physical more than its chemical characteristics, has enabled these species to endure there the subsequent climatic oscillations and the conditions of to-day. The peculiar flora of the "Sugar Limestone" of Teesdale, of the dry sandy heaths of Dorset and Suffolk, of the Mountain Limestone of North Wales, of the Serpentine of Cornwall, are further examples of the association of local species with special edaphic conditions upon which their survival, in the face of competition, presumably depends. The occurrence in these islands of *Gentiana verna* (N.W. Yorks; Durham; Westmorland: Cumberland) and *Cherleria sedoides* (Scotland only, from Perth northwards) is particularly significant as to the past climatic conditions, for, at the present day, these are both species of the mountains of southern Europe which were almost certainly their original home. On the Continent *G. verna* occurs in central and southern Europe and in Asia in the west and north, whilst *C. sedoides* is confined to the Pyrenees, the Alps, and the Carpathian Mountains. Their northward migration during the cold period and subsequent disappearance from the intervening lowlands is the obvious explanation of their present discontinuity, but this inevitably demands climatic conditions in northern France far different from those of to-day, and argues a modification of the climatic conditions during the most severe glaciation very far south of the limits of the ice-sheet itself. The fact that one of these species (*G. verna*) grows almost at sea-level on the coast of Galway does not, as Wilmott has suggested (loc. cit.), really invalidate its use as a climatic indicator. The case is the converse of the occurrence of maritime species near the summits of some mountains and bears witness to the fact that the climatic complex of the sea shore may have much in common with that of a mountain habitat and, given the requisite combination with particular soil conditions, a species may be equally at home in either environment. *G. verna* in its lowland stations in Galway grows on limestone or sand-dunes. The latter, I have elsewhere pointed out, have much in common with definitely calcareous soils, not only because of the shell fragments, but also by reason of the physical properties. We might therefore possibly have found this species likewise persisting, *under peculiar edaphic conditions*, between its British stations and the mountains of southern Europe, but since nowhere does this plant occur throughout this extensive area, it is in the highest degree improbable that conditions, other than the climatic ones known to favour its occurrence, could have enabled the species to bridge this wide gap. In these two cases there seems no reason to doubt that identical ecotypes occur in both Scotland and the Alps.

Just as the arctic climate of the glacial epoch rendered possible the spread of these arctic and alpine species, so too the dry continental type of climate which supervened in post-glacial times probably enabled continental species to migrate into these islands. These in their turn have persisted in areas rendered possible as sanctuaries by the combination of local climate and soil. Later, when the post-glacial continental dry conditions gave place, in the Atlantic period, to a moist oceanic climate, the invasion of Britain by species characteristic of oceanic conditions was facilitated, and these in their turn have persisted, especially in such communities as woodlands where favourable climatic and edaphic factors are accentuated by the biotic conditions. The fossil record is too incomplete to afford us either confirmation or denial of this hypothesis of successive invasion by different geographical elements as facilitated by climatic fluctuation, but the presumptive evidence is so strong in favour of this explanation for the present distribution of the arctic and alpine element that it is not unreasonable to suppose a similar explanation for the other elements; for these, though the fossil evidence is less satisfactory, exhibit similar restriction to areas having definite environmental conditions.

Nevertheless we must recognise that the discontinuity of distribution which many species now present is witness only to the efficacy of purely local conditions in determining survival, and though such discontinuity may often be due to the relic nature of the species it may be but a tribute to the efficiency of long-distance dispersal. The vagaries of distribution are, for example, well illustrated by the occurrence in Norfolk of *Physarum carneum*, a species of Mycetozoon only recorded elsewhere from the Cheyenne mountains and from Portugal (c.f. Howard, 1928, p. 394).

We can recognise in the British Flora the following geographical elements mainly based upon the areas in which they characteristically occur on the Continent :—

(*a*) The Alpine Component. (Species characteristic of the Alpine area).

(*b*) The Northern Component. (Elements with a northern trend in their distribution).

- (1) The Arctic Element. (Species characteristic of Arctic regions).
- (2) The Northern Element. (Species characteristic of Northern Europe).
- (3) The Continental-Northern Element. (Species of Northern and Central Europe). These grade into the Northern Continental Element, and the inclusion of certain species in one or the other element is a matter of opinion.

(*c*) The Southern Component. (Elements with a southern type of distribution).

- (4) The Southern Element. (Species characteristic of

Southern Europe, exclusive of the Mediterranean Element).

(5) The Mediterranean Element. (Species whose chief centre of distribution is the Mediterranean region).

(6) The Continental Southern Element. (Species chiefly found in central and southern Europe).

(*d*) The Oceanic component. (Elements with a definite western trend in their distribution, apparently preferring oceanic conditions).

(7) The Western Element. (Species characteristic of Western Europe).

(8) The Southern-Oceanic Element. (Species characteristic of Western and Southern Europe).

(*e*) The Continental component. (Elements chiefly occupying Central Europe and apparently favoured by Continental climatic conditions).

(9) The Steppe Element. (Continental species characteristic of Steppe communities).

(10) The Continental Element. (Continental species exclusive of [9]).

(11) The Northern Continental Element. (Species chiefly occupying Central and Northern Europe).

(*f*) The Western Central Component.

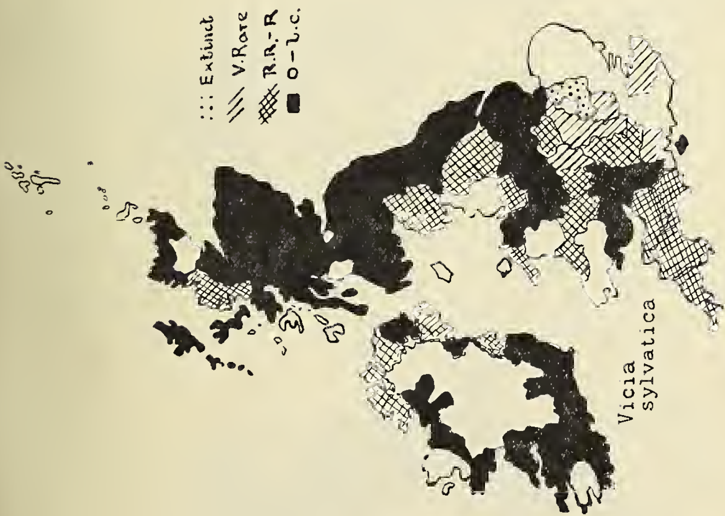
(*g*) The Endemic Component.

(*h*) Recent Immigrants.

(*i*) The Generally-Distributed Component.

It should be emphasised at once that the terms " Southern," " Northern," " Western," etc., as used here, are not employed in the sense that some of them were used by H. C. Watson, as referring to the distribution of the species within these Islands (Watson, H. C. *Cybele Britannica* 1847) ; and it is to avoid confusion that I have therefore employed the terms " Western " and "Continental" which respectively correspond, in part, to Watson's " Atlantic " and " Germanic " types. At the time when Watson wrote the *Cybele* the continental distribution of the members of our flora was less well known than now and the then existing data not readily accessible, so that his somewhat parochial treatment was perhaps inevitable ; but the clue to this local distribution must clearly be sought in the entire range of the species and its environmental preferences

Map 3



Map 4

Maps 5, 6 & 7

Map 5

Map 6

Map 7

It will be noted that all these species are rare, or very rare, in East Anglia, and that most occur with greater frequency in Ireland than in England. The percentage frequencies represent the percentage of vice-counties and counties in England and Ireland respectively in which the species has been recorded and is clearly a measure of frequency, but not of abundance. These figures shew that the only species, except the dubious *E. variegatum,* which has not a wide distribution in England is *Mertensia maritima.*

(2) The Northern Element

Of definitely Northern types, other than arctic species, there are six species, together with three Rubi, which should probably be included here. They are as follows :—

	Frequencies in East Anglia	Percentage frequencies in England	Ireland	Scotland
Antennaria dioica ...	v.r.	70%	97.5%	97.6%
Carex pulicaris ...	f.c.	100%	100%	100%
Goodyera repens (Map 6) ...	v.r.	8.4%	Absent	53.6%
Lycopodium clavatum ...	r.	88%	67.5%	90%
Menyanthes trifoliata (Pl. VII)	c.	99.5%	100%	100%
Parnassia palustris ...	l.c.	67.6%	82%	97.6%
Rubus Lindleyanus ...	...	...	...	Present
Rubus Rosaceus ...	...	...	...	Present
Rubus Schlechtendalii ...	...	...	...	Present

It is noteworthy that the species which have the widest distribution also attain the highest altitudes, whilst *Goodyera repens,* which is absent from Ireland, only attains 1000 feet, in Scotland.

Considering the northern and arctic types collectively, three are more or less common, the remainder either rare or very rare. All but two are species of wide distribution in Britain, and the exceptions attain their southern limit in Norfolk. These are *Mertensia maritima,* which has its most southern station for Britain on the shingle-beach at Blakeney Point, and *Goodyera repens,* for which five Norfolk stations have been recorded. We may note that *Stellaria nemorum* which, though definitely northern in Britain (Map 5), has but a slight northern trend on the continent, attains its southern limit in Lincolnshire. These three species furnish examples of the three types of southern boundary in Britain. *Goodyera repens* has an oblique southern limit in a N.W.-S.E. direction (Map 6), that of *Mertensia maritima* is approximately East and West (Map 3), whilst the southern boundary of *Stellaria nemorum* is oblique in the N.E.-S.W. direction. The last is a species of moist woodlands, whilst the first is a species of dry woodlands. One may suggest that the differing direction of their oblique margins is indicative of the fact that, though both are northern types, the one (*S. nemorum*) is a slightly oceanic northern type, whilst the other (*G. repens*) is more of a continental species. Indeed, as we shall see in other elements, the obliquity of the margin of distribution in Britain, with its marked contrast between the oceanic character of the west and the relatively continental climate of the east, is indicative of the preferences of species in these respects. As the sequel shews, similar distinctions can be recognised amongst other geographical elements. The British Islands do in fact present us with a considerable range in temperature between North and South and of rainfall between East and West. As so many species attain their climatic limits in these islands, the change from a rather continental climate in the east to the oceanic conditions in the west and the warm conditions in the south and south-west giving place to cooler conditions as we pass north-eastwards, enables us to judge, by the greater extension on one side or the other, what aspect of the climatic complex preponderates in its influence on the distribution of a given species. In this connection it is, however, important to recognise that the east and west of England differ in other respects than the meteorological. The east is relatively more cultivated than the west, it is in general more densely populated, and whilst the east is frequently calcareous or exhibits soils rich in nutrient salts, the soils of the west are often siliceous in character and relatively poor in electrolytes. Again, whilst the east is prevailingly lowland the west is largely upland. But despite all these complications, which might be thought to invalidate any conclusion, the number of species involved is sufficiently large and the species so varied in their edaphic and habitat requirements that analysis is rendered possible.

(3) The Continental—Northern Element

Of the species with a northern and central European distribution, eight are represented in our area. These are shewn in the accompanying table.

TABLE III. Continental-Northern species in East Anglia

	Frequencies in East Anglia	Percentage frequencies in England	Ireland	Scotland
Comarum palustre (Map 8)	l.c.	85.8%	100%	100%
Gentiana campestris... ...	r.r.	83%	75.2%	95%
Lathyrus palustris (Map 9)	r.r.	29%	35%	2.4%
Oxycoccus vulgaris	r.	64.8%	85%	70.7%
Peucedanum palustre (Map 7)	l.c.	22.5%	Absent	? 2.4%
Silene noctiflora Pl. VII. D.	f.c.	72%	25%	17%
Stellaria glauca (Map 10) ...	l.c.	73%	55%	29.2%
Vicia sylvatica (Map 4)	(?Extinct)	73%	57.5%	83%

It may be supposed from the northern and central European distribution of these species on the Continent that they are markedly tolerant of continental climatic conditions, and two of them (*Peucedanum* and *Silene noctiflora*) are in fact more characteristic of the drier eastern side of England. *Lathyrus palustris* does not occur in Scotland, but, though present in Ireland, it is found in some twelve counties and vice-counties on the east side of England, as compared with only six on the west.

Many of the arctic species, at the present day, have a circumpolar distribution and, having regard to the much more favourable conditions for plant life in the arctic regions in preglacial times, it is reasonable to suppose that they had their origin in the north and were driven southwards *pari passu* with the increasing severity of the climatic conditions as the Pliocene gave place to the Pleistocene. The arctic types present on the mountains of southern Europe bear witness to the extent of the migration thus initiated. Moreover, the area of the ice-sheet in the arctic regions during the maximum glaciation renders it probable that, despite nunataks and similar sanctuaries, many of the species which had their origin within the arctic circle may only owe their presence in the arctic regions to-day to re-immigration as the ice-sheet once more contracted towards the pole.

It has been shewn by Turesson that some apparent glacial relics are ecotypes of probably much more recent origin (Turesson, 1927 and 1931), and Gurney has called attention to the fact that the occurrence of the northern Crustacean *Canthocamptus cuspidatus* associated with the northern Planarian *Polycelis cornuta* in a spring at Holt Lowes in Norfolk, though both cold water species, cannot be regarded as glacial relics (Gurney, 1929, p. 569).

The changed climate during the Glacial epoch, which rendered possible the occupation of the European plains by northern types, also made possible the northward migration of southern alpine types, such as *Cherleria sedoides, Gentiana verna,* etc. Hence it is not always possible to differentiate between the alpine species which have invaded the arctic, and the arctic species which have invaded the alps. Nevertheless, though an alpine species may find an even more congenial home in the arctic than in its place of origin, a circumpolar distribution is strong presumptive evidence for the northern origin of a species. We have recent fossil records from eastern England of *Betula nana* and perhaps *Galium boreale* from the base of the first glacial, at Beeston; of *Betula nana, Salix myrsinites, Salix herbacea, Salix polaris, Scirpus pauciflorus* and ? *Carex incurva* from between the first and second glaciations at Hoxne; of *Salix polaris* from Mundesley; and *Salix polaris* and *Betula nana* from Ostend. Even if the alleged *Salix polaris* be in reality another northern willow, it is evident that arctic types were at one time or another widely spread in East Anglia, but of the species cited not one survives to-day. Of the northern and arctic types in the existing flora (excluding the northern *Rubi*, the distribution of which cannot be accurately assessed) only one does not occur in America. It is therefore probable that these circumpolar types have immigrated, either directly or indirectly, from the north in early post-glacial times.

Why have these species survived? With the object of testing the causes of restriction of such arctic types the writer has cultivated the following in a lowland garden:—*Juncus biglumis, Thalictrum alpinum, Cerastium alpinum, Salix reticulata, Salix herbacea,* and *Saxifraga oppositifolia.* The two first could be grown quite successfully under conditions which ensured a continuous supply of soil moisture. The remainder, when grown under the same conditions, were liable to "damp off" after frost, although capable of withstanding very low temperatures when grown in well-drained soil. Under the latter conditions these species can be grown for years provided the surrounding air is not too dry.* Thus in lowland

*The presence of the Alpine species *Gentiana verna* on the sand-dunes of Galway and of the arctic species *Dryas octopetala* also almost at sea-level on the limestone (c.f. A. G. More, Cybele Hibernica pp. 111 and 238, 1898) further illustrate this capacity to flourish in lowland situations on well drained soils in a humid climate.


Comarum
palustre
O.-C. RR-R.
V.R.

Map 8


Lathyrus
palustris
L.C.-L.f.
R-R.R
V.R \\, Extinct :::

Map 9

Map 10

habitats such plants are liable to be killed by the early spring droughts. If these species experimented with are representative, it would then appear that the northern types are limited mainly by the moisture relations of the soil or the air, though competition factors certainly play a part. The poor fruiting of some northern types in southern gardens further suggests that they are probably " long-day " plants and that, as between situations of appreciably different latitude, photoperiodism may come into play as a limiting factor to reproduction and maintenance of the race. Of the sixteen arctic and northern types of our area no less than eight are marsh plants, species thus normally tolerant of high soil moisture, and in such situations the relative aridity of lowland habitats at certain seasons is minimised. These, as might be expected, include the most frequent and southernmost types in lowland habitats. Paradoxical as it may appear, *Mertensia maritima* can perhaps be placed in the same category, since the internal dew formation in the shingle which it occupies and the water stored in its succulent leaves ensure it against excessive drought. The remaining species comprise four woodland types (three *Rubi* and *Goodyera repens*), *Antennaria dioica*, a heath plant, now probably extinct, and the two species of *Lycopodium* which are probably diminishing. *Lycopodium clavatum* is extinct in Suffolk, Berks, Herts, Warwick and Oxford, and has diminished in Leicester, Bucks., Kent and Hants. *Lycopodium Selago* (Map 2) is extinct in Berks., Bucks., Oxford, Leicester, Worcester, N. Somerset and probably Kent. The northern element would thus appear to be an ancient and diminishing constituent of the East Anglian flora, even the marsh species sharing in the general diminution of plants of damp habitats in England as a whole (Salisbury, E. J. The Waning Flora of England, Trans. S. E. Union of Scientific Societies 1927, pp. 35-54).

The author so far succeeded in cultivating *Lycopodium Selago*, in a lowland garden in Oak humus, that in the year following its introduction the plant produced numerous sporangia and subsequently a terminal rosette of bulbils. The plant nevertheless died abruptly, following a prolonged dry period. It is probable, then, that the Lycopodiums, though not marsh plants, have, like these, shewn marked diminution owing to the lowering of the permanent water table and, taken in conjunction with experience of other northern and arctic species, this suggests that dryness of the air, or of the soil, or of both, may in general be the most detrimental factor to northern types. In this connection it should be noted that Turesson found that the alpine race of *Poa alpina* in Scandinavia has a high water requirement, in contrast with the lowland race the water requirement of which is low (G. Turesson. 1927).

If this is true, then it is scarcely surprising if the northern and arctic species persisted at low levels through the " Atlantic Period " since, even though the temperature was probably appreciably higher, the humidity was higher also. Further, if the submerged forests correspond to this period of maximum climatic amelioration, then the isostatic elevation of the land, which they attest, though only sixty to eighty feet (c.f. G. Slater, in " Handbook of the Geology of Great Britain," London 1919), would increase the efficacy of the upland sanctuaries. Assuming that these northern and arctic types are mostly relics from glacial times, it is less easy to understand their persistence through the warm and dry " Boreal Period," and, therefore, the presence of this element in the lowlands at the present day may well represent a recolonisation, either from the highest altitudes or from the European continent, at some time subsequent to the " Boreal Period," when the humidity had again increased, perhaps even as recently as the cold moist period of Sub-Atlantic times. Such a comparatively recent origin of the lowland stations might account for the widespread persistence of these species, despite the rather abnormal character of their present environments. In any case there can hardly be any question that the northern flora is diminishing in the southern and eastern counties, and a recent visit to certain localities in North Wales, after an interval of twenty years, revealed an appreciable elevation of the lower limit of some arctic species which may be further evidence of this retreat, although the human factor is doubtless in part responsible.

If there be any correlation in this component between age and area it would appear to be negative rather than positive. For the most pronouncedly arctic species in the British Flora were probably the earliest immigrants after the retreat of the ice, even if not present during the glacial epoch

Fig. 1

Fig. 1

Mean Max Temperature Aug.-Oct.

Mean Max. Temperature Aug.-Oct.

itself; yet the majority of these are the very species which are most restricted in their area of occupation.

(*c*) The Southern Component

(4) The Southern Element

The species included here, regarded as southern without qualification, are those characteristic of the south European region, but excluding the more definitely Mediterranean types and those species which, though southern, are also of pronouncedly central European or western character in their distribution. Of southern species in this restricted sense there are in Britain as a whole some twenty-two species, whilst a further fifteen species exhibit a central European trend. Of this total of thirty-seven species, there occur in East Anglia eighteen or 48.6%. The proportion of those having a slight central-European trend being the higher. They are as follows :—

Table IV. Southern Species of East Anglia (exclusive of Mediterranean types)

		Habitat	Northern limit for Britain.
Adonis autumnalis (S&C) ...	r.	Dry cornfields	Edinburgh as casual
Althæa officinalis (S&C)	r.	marshes	Clyde isles
Antirrhinum majus (S)	alien	walls	
Calamintha nepeta (S)	r.r	Dry banks	North Lincoln
Carex strigosa (S)	r.	woods	Cumberland
Cystopteris fragilis (S)	v.r.	Old walls	Shetlands
Dianthus prolifer (Map 12) (S&C) ...	v.r.	Sandy soil	Norfolk
Gnaphalium luteo-album (S) ...	r.	Sandy soil	S.W. Yorks.
Hippocrepis comosa (S&C) ...	v.r.	Chalk pasture	Kincardine
Hydrocotyle vulgaris (S&C) ...	c.	Marshes	Shetlands
Iberis amara (Map 13) (S&C) ...	r.	Wood margins on Chalk	S. Lincoln
Lythrum hyssopifolium (Map 16 (S)	Extinct	Marshes	Stafford
Papaver argemone (S&C) ...	r.r.	Cornfields	Hebrides
Polypogon monspeliensis (S) ...	v.r.	Sandy shores	Kincardine
Rumex pulcher (S&C)	l.c.	Dry places	N.W. Yorks.
Salvia pratensis (Map 11) (Pl. III)	v.r.	Chalk pasture	S.E. Yorks.
Smyrnium olusatrum (S)	c.	littoral	Dumbarton
Specularia hybrida (S&C)	r.r.	Cornfields on chalk	Cheviotland

Two of these southern species attain their northern limit in Norfolk, and two others in Lincolnshire. The remaining species shew varying degrees of northward extension, two even occurring as far as the Shetlands. Three of the species are marsh plants, but the remaining species, with the one exception of *Carex strigosa*, are plants of dry habitats where the character of the soil compensates for climatic deficiencies. It will, however, be convenient to defer consideration of the significance of the distribution of these species until the other southern elements have been considered.

(5) The Mediterranean Element

Fifteen Mediterranean species occur in East Anglia, representing approximately 40 per cent. of the Mediterranean plants of Britain. The species represented are the following :—

TABLE V. The Mediterranean Element of East Anglia

			Northern limit for Britain.	
Bromus madritensis	v.r.	Fields (Casual)	As casual, Fife	+
Carduus pycnocephalus v. tenuiflorus	l.c.	Dry banks near Sea	Elgin	+
Centaurea solstitialis	r.	Lucern fields		–
Delphinium ajacis	r.	Cornfields	Caithness	+
Demazeria loliacea	l.c.	Shingle	Hebrides	+
Festuca ambigua	r.	Sandy soil	Norfolk	–
Filago spathulata	r.	Sandy soil	Norfolk	+
Frankenia lævis (Map 19) ...	l.	Shingle-lows	Norfolk	–
Gastridium lendigerum (Map 14)	v.r.	Sandy soil	Norfolk	–
(Inula crithmoides)	Extinct	Shingle	Wigtown	+
Linum angustifolium	r.	Dry sandy or or chalky soil	N.E. Yorks.	+
Salvia verbenaca	c.	Dry places near Sea	E. Ross	+
Spergularia atheniensis ...	v.r.	Sandy soil	Suffolk only	–
Statice reticulata (Map 18) ...	l.c.	Salt marshes	Lincoln (if not Ext.)	–
Suæda fruticosa (Map 17) ...	l.c.	Shingle beaches	N.E. Yorks.	–
Teucrium scordium (Map 80)	v.r.	Marshes	N.W. Yorks.	+

+ = Recorded from Ireland. – = Absent from Ireland.

Of these Mediterranean species four, and perhaps five, (if *Statice reticulata* be extinct in Lincolnshire) have their northern limit for Britain in Norfolk, whilst three more extend as far as Yorkshire and the remainder into Scotland.* Seven of these species which occur in Ireland are also those with an appreciable northward extension. In addition to the above *Antirrhinum calycinum*, a Mediterranean species found in Portugal, Spain, S. Italy and North Africa, was found in Norfolk by the Rev. R. Forby. This is a close ally of *Antirrhinum orontium*, of which the genetics have been studied by Miss Saunders (E. R. Saunders, A Study of *Antirrhinum orontium*. Hereditas, pp. 17-24, IX. 1927) and is distinguished by its larger

* It is suggestive of one cause of the restricted distribution of these species that *Frankenia laevis* produces few fertile seeds in its natural habitats in Norfolk and, if grown on ordinary soil, flourishes vegetatively but fails to flower (c.f. Dymes, 1927).

Maps 11, 12, 13 & 14

Map 11

Map 12

Map 13

Map 14

Map 15

Map 16

Map 17

Map 19

flowers, which are white with coloured striæ. A red flowered strain was bred by Miss Saunders, but this differs from *A. orontium* in the more or less glabrous character of the stem. All the Mediterranean species occupy habitats that are either physically or physiologically dry.

It is not in any degree probable that these Mediterranean species represent ancient relic types from a remote warm period. If the set of the surface currents during the autumn period of seed dispersal be considered it will be found that these pass from the straits of Gibraltar up the English Channel and impinge upon the coast of Norfolk. The means of recent introduction is thus at hand, and special local conditions render that introduction effective. In relation to this it should be noted that from a study of the Bryophytic flora Cardot (1930) concludes that the Mediterranean element was introduced into Britain after the Glacial epoch and does not represent survival from either preglacial or interglacial times.

(6) The Continental-Southern Element

Under this heading are included species which are definitely Central European as well as south European, and constitute a transition group between the definitely southern on the one hand and the definitely continental types on the other. They form an appreciable portion of the British Flora numbering about ninety-five species, of which no less than sixty-six, or about 70 per cent., occur in East Anglia.

TABLE VI. The Continental-Southern Element

			British Northern limit.	General direction of limit.	Ireland.
Aceras anthropophera ...	v.r.	Chalk pasture	S.W. Yorks.	(*a*)	/
Ajuga Chamæpitys	(Camb.)	Chalk pasture	Cambridge	(*a*)	/
Arenaria tenuifolia (Map 20)	r.	Dry fields	Linlithgow N.W. York	(*p*)	–
Arum maculatum... ...	c.	Woods	N. Perth	(*p*)	–
Atropa belladonna ...	r.	Chalk woods	Cheviotland N. Durham	(*p*)	/
Bryonia dioica	f.	Woods	S. Northumberland	(*a*)	/
Bupleurum rotundifolium (Map 22) (Pl. VII, C) ...	r.	Fields	Kirkcudbright	(*a*)	–
Butomus umbellatus* ...	r.r.	Aquatic	N. Perth	(*p*)	–
Calamintha officinalis ...	l.c.	Dry banks	Cumberland	(*p*)	\
Centaurea Calcitrapa ...	r.	Dry fields	Norfolk	(*In*)	/
Cheiranthus Cheiri ...	l.c.	Old walls	Caithness	(*In*)	\
Chenopodium ficifolium	r.	Cult. gr.	Selkirk	(*a*)	/
Colchicum autumnale ...	r.	Wet woods	Cumberland	(*p*)	–

* Butomus umbellatus has recently been recorded from Finland where, however, it remains sterile c.f. J. Montell, 1927).

			British Northern limit.	Ireland.	General direction of limit.
Daphne laureola	f.	Woods	Durham	(*a*)	/
Diplotaxis tenuifolia ...	r.	Waste ground	Ayr	(*a*)	–
Dipsacus sylvestris ...	r-l.e.	Woods	N. Perth	(*p*)	–
Euphorbia amygdaloides	l.c.	Woods	Cheviotland	(*p*)	/
Filago gallica ...	r.	Dry ground	Suffolk	(*a*)	/
Fœniculum vulgare ...	r.r.	Cliffs	Antrim	(*p*)	–
Fumaria capreolata ...	f.c.	Fields	Shetlands	(*p*)	–
Galanthus nivalis ...	r.r.	Woods	Elgin	(*a*)	/
Galeopsis ladanum ...	r.r.	Fields	Aberdeen	(*p*)	/
Galium anglicum (Map 25)	r.	Walls	Norfolk	(*a*)	/
Geranium lucidum ...	r.r.	Walls	Caithness	(*p*)	/
Geranium pyrenaicum ...	r.r.	Waste gr.	Elgin	(*p*)	/
Glaucium luteum ...	l.c.	Shingle	Kincardine	(*p*)	/
Helociadium nodiflorum	c.	Ditches	Shetlands	(*p*)	/
Herniaria glabra (Map 24)	l.f.	Sandy soil	Lincoln S.	(*a*)	/
Inula pulicaria (Map 15)	r.	Wet places	Merionith	(*a*)	/
Isatis tinctoria	v.r.	Fields	Cambridge	(*a*)	/
Lathyrus aphaca (Map 23)	r.	Fields	Flint	(*a*)	–
Lathyrus hirsutus ...	r.	Waste gr.	Edinburgh	(*a*)	/
Lathyrus nissolia ...	r.	Grassland	S.E. Yorks.	(*a*)	/
Leucojum æstivum (Map 21)	r.	Wet woods	Suffolk E.	(*In*)	/
Linaria cymbalaria ...	r.r.	Walls	Caithness	(*In*)	–
Linaria spuria	r.	Fields	Lincoln N.	(*a*)	/
Lithospermum purpureo-coeruleum	r.	Woods	Denbigh	(*a*)	/
Lonicera caprifolium ...	c.	Woods	throughout	(*p*)	–
Lotus tenuis	f.	Dry places	E. Sutherland	(*p*)	/
Lotus uliginosus	c.	Meadows	Hebrides	(*p*)	–
Luzula maxima ...	r.r.	Woods	Almost throughout	(*p*)	–
Mentha rotundifolia ...	r.	Waste gr.	Forfar	(*In*)	/
Narcissus pseudo-narcissus	r.r.	Woods	Cheviotland	(*a*)	/
Oenanthe lachenalii ...	l.c.	Marshes	Hebrides	(*p*)	–
Ophrys apifera	l.c.	Chalk pasture	Lanark	(*p*)	\
Ophrys aranifera (Pl. II)	v.r.	Chalk pasture	Denbigh	(*a*)	/
Orchis hircina (Map 69) (Pl. I)	v.r.	Chalk pasture	Lincoln	(*a*)	/
Orchis pyramidalis ...	l.c.	Chalk pasture	Mull	(*p*)	–
Ornithogalum pyrenaicum	v.r.	Woods	Norfolk	(*a*)	/
Orobanche picridis ...	r.	Pastures	Norfolk	(*a*)	–
Orobanche reticulata ...	r.	Chalk pasture	Yorks	(*a*)	/
Oxalis corniculata ...	r.r.	Waste gr.	N. Aberdeen	(*a*)	/
Plantago coronopus ...	f.c.	Sandy gr.	Shetlands	(*p*)	–
Ruscus aculeatus ...	r.r.	Woods	?Caithness	(*In*)	/
Salix purpurea	r.r.	Riversides	Caithness	(*p*)	–
Silaus pratensis	l.c.	Meadows	Fife	(*a*)	–
Silene anglica	r.r.	Dry ground	Elgin	(*p*)	–
Spiranthes autumnalis ...	r.r.	Chalk pasture	Westmorland	(*p*)	–
Tamus communis ...	f.c.	Woods	S. Northumberland	(*a*)	–
Torilis nodosa	f.c.	Dry banks	Ross E.	(*p*)	/
Trifolium medium ...	r.r.	Pastures	Orkneys	(*p*)	–
Trifolium scabrum ...	r.	Sandy soil	Kincardine	(*p*)	/
Tulipa sylvestris	r.	Pastures	Fife	(*a*)	/
Valerianella auricula ...	o.	Fields	Fife	(*In*)	/
Viburnum lantana ...	r.	Chalk scrub	N.E. Yorks.	(*a*)	/
Vicia lutea	v.r.	Dry places	Kincardine	(*a*)	/
Vinca minor	r.r.	Woods	Caithness	(*a*)	/

(*p*) = present. (*a*) = absent. (*In*) = Introduced.

/ = General direction of Northern limit in Britain is from the S.W.—N.E. – = General direction of Northern limit is from E. to W. \ = General direction of Northern limit is in the S.E.—N.W. direction.

Map 20

Map 21

Bupleurum rotundifolium

Map 22

Lathyrus aphaca

Map 23

Phot. E.J.S. $X\frac{3}{4}$

Spider Orchid, Ophrys aranifera

Phot. E.J.S.

Chalk down with Cratægus scrub and Salvia pratensis

Photo E.J.S.

Pasque flower, Anemone pulsatilla

Map 24

Map 25

Of these sixty-seven species no less than forty (60 per cent.) agree in having a diagonal north-eastern limit in England, attaining a more northerly station on the east than on the west. The frequency and very marked character of this feature in so many instances calls for explanation and is probably indicative of definite climatic preferences (c.f. later).

The Flora of East Anglia is interesting as including a number of species which here attain their northern limit for Britain. Of those which belong to the southern component, and which shew this feature, nine attain their northern limit in Norfolk, two in Suffolk, two in Cambridgeshire, whilst four more extend into Lincolnshire. In addition, one species of the Continental-Southern element, namely *Typha minima*, formerly occurred at Wicken Fen, its only known British locality (c.f. Gilmour, 1931).

It is a noteworthy feature that so many of the southern species in the British flora as a whole exhibit a comital and vice-comital distribution, which is mainly south of a line extending from the Wash in the east to the Bristol Channel on the west. It should be emphasised that, apart from the common factor of association in many instances with relatively dry habitats (a frequent feature of southern types since in such environmental conditions the climatic complex is ameliorated), the species in question are characteristic of diverse plant communities and of various soils. Moreover, these conditions extend beyond the range which the species occupy. As illustrating the diverse types shewing such distribution we may instance *Iberis amara*, which is a calcicole; whereas *Herniaria glabra* is a silicicole. *Dianthus prolifer* will, however, grow equally on both calcareous or siliceous soils of a dry character. Other examples might be cited, and in almost every case apparently suitable habitats could be instanced beyond the existing range of the species.

It is true that twelve per cent. of these southern species are calcicoles in this country (c.f. E. J. Salisbury, The significance of the Calcicolous Habit., Jour. Ecol., Vol. VIII, P. 202,-215, 1920) and that the major part of the calcareous soils of Britain are in the south-eastern area. But that we are not therefore warranted in attributing the restriction of these species to this region to soil factors alone, or even as the master factor, is shewn by the extension of equally calcicolous species, more tolerant, however, of oceanic conditions, over most of western Britain. Thus *Orchis pyramidalis* and *Spiranthes autumnalis*, though more local in the west of England, are almost as widespread as on the eastern side and have an approximately horizontal northern limit, with a northward extension on the west as great as on the east. Still more striking is the distribution of the Bee Orchid (*Ophrys apifera*), especially as contrasted with *O. aranifera*, which even exhibits a diagonal northern limit in the N.W.-S.E. direction. All these three calcicolous orchids occur in Ireland and their wide distribution in the west is partly a consequence of the calcareous character of sand dunes (c.f., E. J. Salisbury, The soils of Blakeney Point. Annals of Botany Vol. XXXVI, pp. 391-431, 1922), and in this connection it is of interest to note that the markedly calcicolous mollusc *Pomatias* (*Cyclostoma*) *elegans* also extends as far northwards on the west as on the east (c.f. Roebuck Memorial Number, Jour. Conchology, Vol. 16, Pl. VII, 1921; and A. E. Boycott, Oecological notes, Proc. Malacological Soc. Vol. XIV, p. 128, 1921). It is clear, then, that the distribution of calcareous soils is inadequate to explain the restriction, even of the calcicolous species, to the south-east of England.

Either these southern species have not yet attained their possible range, or the limiting factors are climatic rather than the direct consequence of either soil conditions or biotic influences. The more southerly limit on the west, as compared with the east, is in harmony with the preference of many of these species for dry habitats. Their extension into southern Britain, like the extension of some of them into southern Scandinavia, (e.g., *Dianthus prolifer, Herniaria glabra* c.f. Sterner l.c.) is made possible by their association with situations that are rendered arid both by the physical features of the soil and by topography. Together these diminish the effect of humid climatic conditions and enable the species concerned to extend towards the north and west. Such edaphic factors will, however, diminish in their ameliorating efficacy as the humidity of the climate increases.

If this hypothesis is correct, it follows that in passing from the drier conditions of the east to the humid conditions of the west the northward range should diminish. As already pointed

Average hrs. sunshine
from May to August

■ Over 6.5 to 7.5 hrs.sun per day

⊞ Over 6.0 to 6.5

|||| Over 5.5 to 6.0

Fig. 2

out, this is actually the case and results in a general diagonal S.W.-N.E. trend for the northern limit in Britain.

If further confirmation were needed it is to be found in the fact that the northern limit in Europe as a whole for many of these southern types has the same S.W.-N.E. trend (c.f. R. Sterner, The Continental element in the Flora of S. Sweden, Geografiska Annaler, H. 3-4, 1922). Moreover, Matthews, in his interesting analysis of the species confined to England and Wales, furnishes a map shewing the concentration of the 266 species involved, many of which are southern continental types, and the general diagonal character of the limits of equal concentration are obvious (Matthews J. R., The Distribution of Plants restricted to England and Wales, Ann. Bot. p. 283, 1923). It is noteworthy that of the species here considered exhibiting this obliquely north-eastern limit over 68 per cent. are absent from Ireland. A fact which suggests that this absence is not due to inefficient dispersal, but to climatic intolerance of the extreme oceanic conditions in Ireland which soil factors are inadequate sufficiently to ameliorate. On the other hand, those species which do not shew any appreciable differences in their northern limit on the east and west sides of Britain, and may therefore be presumed to be tolerant of oceanic conditions, are well represented in Ireland, 66 per cent. being present (18·species in Ireland, 6 species absent).

Nevertheless, it should be noted that the relation to the climatic complex, though sufficiently obvious, does not shew a simple correlation with the usually recorded meteorological data, whether of rainfall or of temperature considered either as annual or monthly means, or from the point of view of their extremes. It is, however, perhaps significant that the region of England south of the line from the Wash to the Bristol Channel is approximately the area of maximum sunshine (Fig. 2); and, if we exclude those regions where the rainfall is high, the correspondence of sunshine duration with the distribution of these southern species becomes very close, particularly if the sunshine during the summer months is alone considered. This is very striking if we compare the distribution maps for the more restricted southern species with the map for hours of bright sunshine per day during August (c.f. Meteorological

Office Book of Normals Section III, p. 139, 1920). In view of the importance of sunshine, especially to southern species, for the formation of flowers and fruit it may well be that the limiting factor for further northward and westward extension is set by the power of adequate reproduction by seed (in this connection c.f. p. 236). Our interpretation is strengthened rather than weakened when we turn to the southern species which are normally associated with damp habitats. The range of these will clearly not be so markedly affected by higher rainfall as such; and these do in fact extend to varying limits on the west, which may even be more northerly than the limit on the east, but, for those of more limited range, still within the area of relatively high summer sunshine.

TABLE VII

Distribution	Species absent from Ireland.	Species present in in Ireland.
Limit North of Moray Firth	2 spp. (8.3%)	22 spp. (91.7%)
Limit in mid Scotland (Between Moray Firth and Firth of Forth)	7 spp. (35%)	13 spp. (65%)
South Scotland	8 spp. (57%)	6 spp. (43%)
North England (Limit N. of Humber)	177 spp. (63%)	10 spp. (37%)
Limit in England south of the Humber	21 spp. (100%)	0 spp. (0%)

A perusal of the distribution data with respect to Ireland shews another interesting feature. Taking the entire Southern Component of the East Anglian flora and grouping them according to their northward extension (c.f. Table VII), we see that there is a steady decrease in the proportion of species which occur in Ireland as we pass from the species with an extended northward range in Britain to those with a restricted range. In general it is true that the more extended the range northwards the more the species tends to extend westwards. This is in conformity with the conclusion of Lutz (Bull. Amer. Museum., Nat. Hist. pp. 335-366) that there is a high correlation between the east-and-west extent of a species and its north-and-south range. Two explanations are possible. Either that the differences in range are a real expression of differences in climatic tolerance, or that they are an indication of differences in the rate of dispersal and furnish examples of the relation between age and area. That the former is the more probable explanation is indicated by the fact that the differences in range in Britain correspond in general with the differences in climatic tolerance exhibited by these species on the continent. Further, some of the more restricted species have a more efficient means of dispersal than those which extend into Ireland, and pairs of comparable species can be cited, such as *Salvia pratensis* and *S. Verbenaca*, *Ophrys aranifera*, and *O. apifera*, of which one is restricted and the other has a wide range, although the dispersal mechanism must be practically identical. But the strongest argument in favour of the dominance of the climatic factor in determining the limits of these species, is to be found in the correspondence of the direction of these limits in Britain with the climatic preferences as evidenced by their range in Europe.

Analysis of the southern component according to the type of habitat and the degree of northward extension furnishes the following percentages :—

TABLE VIII

S. England. 100%	N. England.	S. England.	N. Scotland.	No. of Spp.
Damp habitats	66%	50%	53%	15
Woods	99%	45%	45%	11
Calcareous Soils	92%	25%	0%	15
Sandy Soils	55%	33%	33%	9
Other dry Soils	87%	56%	34%	23
Other habitats	84%	77%	81%	26

These data shew that the rate of diminution is greatest for the calcicolous species which are unrepresented, so far as East Anglian plants of this group are concerned, in the north of Scotland. But the species of sandy soil shew an even greater initial diminution, though, having regard to the small number of species involved, no great importance can be attached to these proportions. It should, however, be noted that the diminution is generally most marked for the species of dry habitats, which in total number 47, or nearly 48 per cent. of the entire southern component. On the other hand, if we exclude the miscellaneous class (chiefly arable, waste ground, etc.) the lowest rate of diminution is shewn by the damp habitat species. Since these latter might be expected to be least affected by the increasing humidity directly, the contrast between the damp habitat and dry habitat species in this respect would appear to lend further support to the view that the diminution is an outcome of increasing climatic unfavourability. The following southern species are stated by Nicholson to have become extinct in Norfolk: *Lythrum hyssopifolium, Salvia pratensis, Erodium moschatum, Inula crithmoides.* The disappearance of the two last, which are littoral species, and of the second which is a very conspicuous plant, is probably to be attributed to the increased pressure of the human factor and cannot be regarded as indicative of a diminished climatic or edaphic suitability. The extinction of the relatively inconspicuous *Lythrum hyssopifolium*, which grows in situations that are wet in winter but dry in summer, may be due to a lowering of the water-table in Norfolk as elsewhere in England.

(7) The Oceanic Component

The West European Element in the East Anglian Flora

The extreme West-European species in the British Flora constitute a group of distribution types which includes the so-called Lusitanian element with a distribution restricted mainly to the Iberian Peninsular, Brittany, the Cornish peninsular and the west of Ireland. This group numbers some twenty-three species. Of this total two only are met with in East Anglia, viz., *Ulex nanus* and *Ulex Gallii*. Both species have a continental distribution from Spain and Portugal to France and Britain. *Ulex Gallii* in France has its northern continental limit in Normandy and is restricted to the maritime departments. *Ulex nanus* has a more extended range with the Seine inferieure as its northern limit and tending eastwards almost as far as the Rhone. In the British Isles this difference in the continental distribution of these species is reflected in their respective western limits. For whereas *Ulex Gallii* extends into Ireland and is there widespread, *Ulex nanus* is absent from Ireland. The former species is most abundant in the south-eastern counties, whilst *Ulex Gallii*, though present in the east of Britain, is only common in the west. In East Anglia *U. nanus* is occasional to frequent and is found both in the western drier vice-counties as well as in the eastern moister vice-counties of Norfolk and Suffolk. *Ulex Gallii*, on the other hand, is confined to the eastern portions of these counties and is nowhere in the east of England more than rare.

In view of these facts with regard to the continental and English distributions it is very significant that the one should be common in Ireland and the other absent. Both have similar seeds and probably depend on precisely the same agencies of dispersal. Except that *U. Gallii* is probably more tolerant of calcareous soils, these two closely allied species are almost identical in their edaphic requirements and occupy similar communities. It is therefore most probable that the absence of *U. nanus* from Ireland is not due to its failure to reach Ireland, but to unsuitability of the climatic conditions. The case of these two congeners is so striking that it throws considerable doubt upon the commonly adopted explanation of the absence of species from Ireland as due to failure of the agencies of dispersal. Further, as we have already seen in the southern component, the absence of species from, or their presence in, Ireland is generally correlated with the climatic preferences of the species as indicated by its continental range.

The absence of *Euphorbia portlandica* is noteworthy, since suitable dune areas are abundantly provided in that part of East Anglia where the climate shews the nearest approach to oceanic conditions. Its absence, and that of the remaining Lusitanian types, may, with a considerable degree of certainty, be attributed to climatic conditions alone.

When we turn to the west European species in which the oceanic distribution is less marked, the representation in the East Anglian Flora, as might be expected, is very different. The British Flora as a whole includes about sixty-nine such species and of these thirty-nine are present in our East Anglian Flora. Naturally the degrees of restriction to western Europe in this western element exhibit a wide range. Some species, such as *Scilla nutans*, *Genista anglica* (Map 26), *Anagallis tenella* (Map 27), *Erica cinerea*, *E. tetralix*, etc., although definitely western in their geographical distribution, do nevertheless by their extension towards Central Europe display a considerable degree of tolerance for continental climatic conditions. Others, such as *Corydalis claviculata*, *Sedum anglicum*, *Verbascum virgatum*, etc., are more markedly oceanic and constitute transitional types, as regards distribution, to the Lusitanian element just considered. Here again the absence of certain species is noteworthy. Thus, the markedly western *Agrostis setacea*, a grass of sandy heaths, is absent, although suitable edaphic conditions are well represented and these indeed constitute the habitat of a closely allied grass, namely *Apera* (*Agrostis*), *spica-venti*, which is a continental species occupying a similar " niche," but with different climatic requirements. Other absentees, noteworthy because their absence cannot be attributed to the absence of suitable soils, are *Orobanche hederæ* and *Daucus gummifer*. The rarity of *Wahlenbergia hederacea* (Map 36), *Luzula Forsteri*, and *Ranunculus Lenormandi* is also significant. Of the western species present in East Anglia most are of wide distribution in the British Isles. The complete list of western species present in East Anglia is given in Table IX. It will be noted that some of these, despite their west-European distribution, have a definitely eastern distribution in Britain. Thus *Glyceria Borreri*, *Salicornia perennis* (*radicans*), and *Spartina stricta* belong to Watson's " Germanic " group, suggesting affinity with the South-Western species which, whilst shewing a preference for oceanic conditions, are intolerant of the restricted sunshine associated with the more extreme oceanic climate.

Table IX. West-European species present in East Anglia

Species.	Frequency in East Anglia.	Eng.	Watson's Type.	Frequency in Ireland.	Habitat.
Anagallis tenella (Map 27)	f.c.	99%	Btsh.	100%	Marsh
Anchusa sempervirens ...	r.	?	Eng.	27.5%	Waste groun
Anthemis nobilis ...	r.	70%	Eng.	52.5%	Dry heaths
Barbarea præcox	r.	?	?	22.5%	Waste groun
Carex arenaria	l.c.	97% of Litt.	B.	90% of Litt.	Sandy soil
Carex binervis	r.r.	99%	B.	100%	Dry heaths
Carex trinervis	v.r.	?	G.	25%	Wet sandy so
Carex punctata (Map 40)	v.r.	14%	Atl.	12%	Damp Littor
Cerastium pumilum ...	v.r.	31%		0%	Heaths
Cirsium anglicum ...	f.	69%	Sctsh.	100%	Wet places
Conopodium denudatum	l.c.	97%	B.	100%	Woods
Corydalis claviculata ...	l.c.	84%	B.-Atl	15%	Woods
Crambe maritima ...	v.r.	62% of Litt.	E.	33% of Litt.	Shingle beac
Crithmum maritimum (Map 28)	v.r.	64% of Litt.	Atl.	80% of Litt.	Shingle beac
Erica cinerea	l.c.	96%	B.	97.5%	Heaths
Erica tetralix	l.c.	98.6%	B.	100%	Damp heath
Erodium maritimum (Map 31)	r.	46.4%	Atl-E	27.5%	Littoral
Genista anglica (Map 26)	l.c.	91.5%	B.-E.	0%	Damp heath
Glyceria (Sclerochloa) Borreri (Map 29) ...	r.	19.7%	Germ.	7.5%	Salt marshes
Glyceria maritima ...	c.	59% of Litt.	B.	100% of Litt.	Salt marshes
Glyceria procumbens ...	r.	39%	E.-G.	0%	Salt marshes
Hypericum elodes (Map 37)	l.c.	79%	Atl-E.	62.5%	Bogs
Lastræa æmula	v.r.	34%	Atl.	92.5%	Gogs

Species.	Frequency in East Anglia.	Eng.	Watson's Type.	Frequency in Ireland.		Habitat.
›idium heterophyllum Smithii)	l.c.	97%	B.-E.	65%		Hedge-banks
:ula Forsteri (Map 32)	v.r.	42%	E.	0%		Woods
riophyllum alterniflorum		77%	B.	92.5%		Ponds, etc.
ıanthe crocata ...	r.r.	90%	B.E.	85%		Stream-sides
roselinum segetum ...	r.	47%	E.	0%	–	Damp chalky soil
ıunculus hederaceus ...	f.	100%	B.	100%		Ponds
ıunculus Lenormandi	r.	70%	E.	32.5%		Ponds
›hanus maritimus /Iap 42)	v.r.	44.7% of Litt.	Atl.	56% of Litt.		Sea Cliffs
›us affinis	o.	?	?			Woods
:ornia perennis ...	l.c.	32% of Litt.	Germ.	0%		Salt marshes
a nutans	c.	98.6%	B.	100%		Woods
·phularia aquatica ...	c.	97%	E.	95%		Stream-sides
ım anglicum (Map 30)	l.c.	48%	Atl.-B	75%		Shingle
:tina stricta ...	r.	15.5%	Germ.	0%		Salt-marshes
.phytum tuberosum...	r.	21%	Int. Scot.-abs			Woods
;ium humifusum [ap 33)	v.r.	33.8%	E.-G.		–	Chalky heaths
: europæus	c.	100%	B.	100%		Heaths
ıascum virgatum ...	r.	1.5%?	Atl-E.		–	Gravelly soil
ı Curtisii (Map 52) ...	r.	35%	Atl.	50%		Dunes
lenbergia hederacea ap 36)	v.r.	62%	Atl.	17.5%		Woods

No less than ten of these species have a more or less marked western distribution in Britain. *Carex punctata* has its northern limit for eastern England in Suffolk, where it is very rare. Apart from this station its eastern limit extends from Kirkcudbright to S. Hampshire (Map 40). In Ireland it is confined to Cork and Kerry. *Crithmum maritimum* also has its nothern limit on the east coast in Suffolk, but extends into the Hebrides on the west. In Ireland, with the exception of the north-east, it extends all round the coast (Map 28). *Erodium maritimum* has a similar distribution with its northern limit extending from Wigton on the west to Norfolk on the east (Map 31). *Hypericum elodes* is more generally distributed but, except for its rare occurrence in east Yorkshire, its limit is again a diagonal one extending from the Hebrides to Norfolk (Map 37). *Lastræa æmula* probably owes its western distribution in Britain more to increased frequency of the boggy habitats it frequents than to the direct effect of climatic conditions. In suitable habitats it extends into E. Yorkshire, the eastern border counties, Perth and the Orkneys. *Raphanus maritimus* occurs very rarely on the east coast from N.W. Yorkshire southwards, extending on the west as far as the Hebrides (Map 42). *Sedum anglicum* is present on the east coast of Scotland and only exhibits a slight western tendency (Map 30). *Viola Curtisii* has its eastern limit from Cheviotland to Dorset, except for its East Anglian occurrences in Breckland (Map 52). *Wahlenbergia hederacea* is markedly western in Britain and only extends on the east as far as S. Essex (Map 36).

It is thus evident that the west European element in the East Anglian Flora can, with respect to their distribution in Britain, be placed in two categories, viz. :—(*a*) Those which are widely dispersed and which constitute about three quarters of the total; (*b*) those which exhibit a definite western trend in Britain itself and which mostly present a geographical limit which passes diagonally from East Anglia in a north-westerly direction. These species may be conveniently referred to as the *Diagonally-Western* Group. The greater extension of these species on the west, as compared with the east, cannot be attributed to the absence of the appropriate communities or soils in the north-eastern area, since suitable conditions are as frequent there as further south. Furthermore, the population factor cannot be invoked since these species occur in the south-east, where the human factor is most intense; whereas the north-east and the west present comparable conditions in this respect, although the species in question are present in the one and not in the other. It is clear then that we must attribute this diagonally-western distribution to climatic causes. The fact that a whole group of species shew this same feature is very significant, the more so since in the case of *Carex punctata, Crithmum maritimum* and *Erodium maritimum,* the East Anglian stations are in the nature of outliers from the main area of occupation and are situated in the damper eastern vice-counties. The higher rainfall of this area and the presence of the large expanses of water are responsible, doubtless, for the fact to which this distribution bears testimony, that the climatic conditions are here relatively oceanic in character as compared with the east of England generally, and particularly contrast with the dry and continental conditions in the adjacent area of west Suffolk and Cambridge.

It is noteworthy that these west European species, when considered from the point of view of the moisture relations of

Map 26 Genista anglica

Map 27 Anagallis tenella (Continental distribution after Ludi)

Sclerochloa Borreri

Map 29

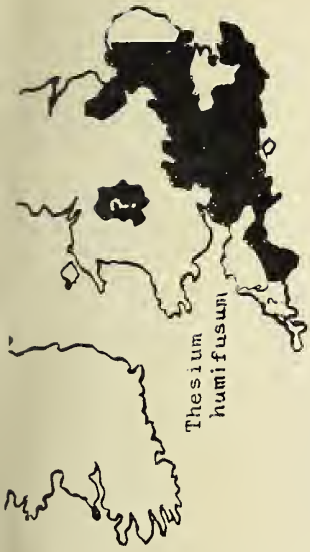
Crithmum maritimum

Map 28

Map 30

Map 31

Maps 32, 33, 34 & 35



Thesium humifusum

Cicendia filiformis

Map 35

Luzula Forsteri

Juncus acutus

Map 34

Map 36

Map 37

V.R.
Ex

Map 38

Carex punctata

Trifolium suffocatum

Map 41

Scirpus Savii.

Map 39

Map 43

Brassica oleracea

Map 42

Raphanus maritimus

Phot. E.J.S. $X\frac{1}{2}$

Wood Rush, Luzula Forsteri

Phot. E.J.S. $X\frac{1}{2}$

Oxlip, Primula elatior

Phot. E.J.S. X¼

Fen with Orchis incarnata and Cirsium anglicum

the habitat, fall into two rather strikingly extreme types of habitat. Seventeen, or over 43 per cent. of the total, occur in damp or wet habitats of one type or another and therefore in situations where the edaphic conditions tend to ameliorate the ill effects of high temperatures and low precipitation, of which species, characteristic of oceanic climatic conditions, might be intolerant. So too the woodland species, which number six or 15.3 per cent., occupy a habitat where the climatic conditions are far less extreme than in the open, and in this connection we may note that *Wahlenbergia hederacea* is confined to damp woodlands in the drier conditions of the east of England, but is found in the open on damp heaths in the moister climate of the west. Thus we see that 59 per cent. of the total west-European species grow in situations where the full effect of the climatic conditions of East Anglia are minimised. It is therefore the more surprising to find that thirteen species, or a third, representing all but three of the remaining species, are definitely associated with dry types of soil, which seems paradoxical, in view of their association with oceanic conditions. It should, however, be noted that, whereas many of the damp habitat species are frequent or common, the dry habitat species are with three exceptions rare or very rare. One may suggest then that, unlike some southern types, these species are not associated with sandy, or gravelly soil, or shingle, because of their dry character, but because of other physical qualities of the soil, such as good aeration or because they here escape undue competition. But, not being highly xerophytic types, (the succulents *Crambe maritima*, *Crithmum maritimum*, *Sedum anglicum*, are probably all dependent upon internal dew formation in the shingle), it is not unlikely that a more or less oceanic climate is essential for their welfare on these dry soils. Such an interpretation of the facts is strengthened by the much greater frequency of several of these species in the west of England.

It should be noted that several of these West-European species are definitely associated with soils which are not only deficient in, and sometimes totally devoid of, carbonates, but also with soils which are usually deficient in exchangeable calcium and often of high acidity. Such species as *Erica cinerea*, *E. tetralix*, *Anagallis tenella*, *Hypericum elodes*, *Genista* *anglica*, and *Ranunculus Lenormandi* afford examples, and it is possible that the climatic limitations of these species are in part indirect, in the sense that their particular soil requirements are realised in temperate regions, only under oceanic climatic conditions.

The prevailingly " diagonally western " limit of the western species offers a striking contrast with the " diagonally eastern " limits of so many of the members of the southern component, and this contrast is perhaps the most convincing testimony to the significance of these limits as expressions of specific requirements.

(8) The Southern Oceanic Element

The species included here are characteristic of southern and western Europe and, though their segregation from the southern component is somewhat arbitrary, they would seem to be more appropriately considered as part of the Oceanic component; since, though exhibiting a definite southern tendency, a more or less oceanic climate seems to be the dominating factor in their distribution. The absence from Scotland of fifteen, out of a total of thirty-two species in this category, sufficiently attests to their southern tendency in Britain. Of those which occur in Scotland, several only reach the southern Scottish counties (e.g., *Helminthia echioides*, Map 53, *Statice binervosa*, Map 60). The oceanic character is clearly shewn by the number of species which occur in Ireland, namely, twenty-seven, or nearly 82 per cent. Five of these species actually exhibit a greater frequency in Ireland than in England, and this wider distribution not only emphasises further the climatic preferences of this group, but, taken in conjunction with the fact that eight species which occur in Ireland do not occur in Scotland, points again to the presence in, or absence from Ireland, as determined in most cases at least by climatic preferences, and not by the efficacy, or rate, of dispersal. The two species which just extend into Scotland occur in 17.5 per cent. and 30 per cent., respectively of the Irish counties and vice-counties.

It is evident then that the distribution of these species is not a consequence of their possible recent arrival during the Atlantic Period, but must be attributed mainly to climate. It seems therefore surprising that, having regard to the rather continental character of the East Anglian climate, so many of these species should be represented. In this connection it is necessary to appreciate the striking contrast which is afforded by the climatic conditions of the eastern portion of East Anglia, particularly the area of the Broads, and the south-western area occupied by the Breckland heaths (c.f. Map Fig. 3). It is this climatic contrast, accentuated by soil differences, which is responsible for the richness of the East Anglian Flora and the juxtaposition of oceanic and continental types. This climatic segregation within our area is reflected in the Sphagnaceous flora. Eight species of Sphagnum are recorded from V.C. 27, six from V.C. 25 and V.C. 28, only five from V.C. 26 and none from Cambridge. (J. B. Duncan, Census Catalogue of British Mosses, 2nd Ed., 1926.) Similarly for the mollusca : whereas 110 and 111, species respectively have been recorded from E. Norfolk and E. Suffolk, only ninety-four and ninety-eight have been found in W. Norfolk and W. Suffolk. (Boycott. 1911.)

TABLE X. Species of Southern and Western Europe (Southern Oceanic types) in the East Anglian Flora.

cies.	Frequency in E.A.	Habitat.	% Freq. in England.	% Freq. in Ireland.
opyrum junceum	l.c.	Shingle	76% of Litt.	76% of Litt.
opyrum pungens (Map 45)	l.c.	Shingle	57% of Litt.	32% of Litt.
a maritima	r.r.	Shingle	87% of Litt.	100% of Litt.
ssica oleracea (Map 43) ...	4.	Cliffs	30% of Litt.	0%
itriche obtusangula ...	r.	Aquatic	69%	40%
ex extensa	r.	Salt marsh	78% of Litt.	94% of Litt.
ora perfoliata (Map 46) ...	r.	Calc. past.	86%	67.5%
ndia filiformis (Map 35)	v.r.	Sandy heaths	12.7%	7.5%
yledon umbilicus (!Suffolk)		Walls and cliffs	69%	97.5%
nasonium stellatum (Map 48)	(Extinct)	Ponds	21%	absent
horbia paralias (Map 44)	v.r.	Dunes	65% of Litt.	60% of Litt.
uca uniglumis (Map 50)	v.r.	Sandy shore	46.8% of Litt.	20% of Litt.
ninthia echioides (Map 53)	r.r.	Dry places	89%	20%
ericum androsæmum lap 55)	r.	Woods	90%	100%
fœtidissima (Map 54) ...	r.r.	Woods	72%	57.5%
cus acutus (Map 34) ...	v.r.	Dune-slacks	36% of Litt.	20% of Litt.
icago maculata (Map 47)	r.r.	Dry banks	65%	10%
lotus altissima	r.r.	Waste ground	94%	25%
iola millegrana (Map 35)	r.r.	Damp heaths	80%	50%
unculus Baudotii ...	r.r.	Ditches	65%	40%
unculus parviflorus ...	r.r.	Dry soil	84.5%	17.5%
na maritima	l.c.	Salt marshes	63%	57.5%
pus Savii (Map 39) ...	r.	Damp heaths	28%	65%
ice binervosa (Map 60) ...	l.c.	Salt marshes	55% of Litt.	48% of Litt.

Species.	Frequency in E.A.	Habitat.	% Freq. in England. in	% Freq. in Ireland.
Statice Humile (rariflora) (Map 61)	l.f.	Salt marshes	49% of Litt.	84% of Lit
Tillæa muscosa (Map 48) ...	l.f.	Damp heaths	12%	absent
Trifolium glomeratum (Map 58)	r.r.	Gravelly heaths	28%	5%
Trifolium maritimum (Map 51)	r.	Salt marshes	53% of Litt.	absent
Trifolium subterraneum (Map 59)	r.r.	Gravelly heaths	60.5%	2.5%
Trifolium suffocatum (Map 41)	v.r.	Sand dunes	34% of Litt.	absent
Trigonella purpurascens (Map 56)	r.r.	Gravelly banks	45%	15%
Urtica pilulifera (Pl. VII B)...	v.r.	?Ex. Waste gr.	1.4%	absent
Averages of frequency for species common to England and Ireland			63.4%	46.6%
Average all English sp.			56.5%	

That the extension of many of these species to Ireland is an indication of a greater range of climatic tolerance, is attested by the higher average frequency of these in England as compared with those absent from Ireland. The species represented grow in a great diversity of environments, and both dry and moist habitats are represented, alike in the species confined to Britain and in those extending to Ireland. The three species *Scirpus Savii* (Map 39), *Juncus acutus* (Map 34), and *Cicendia filiformis* (Map 35), all of which occupy most sandy habitats, are of exceptional interest as shewing a diminishing range, in the order named, both in Britain and in Ireland. All three species are entirely absent from the eastern side of Britain north of the Thames estuary, except for their East Anglian stations, and all are absent from West Suffolk. *Radiola millegrana* (Map 38), however, a species of similar habitats, has a wide range both in Britain and in Ireland, although often extremely local in its distribution and depending for its persistence on special topographical and microclimatic conditions. It is notably less abundant in the eastern counties than in the western, and is probably a diminishing species already extinct in Cambridgeshire, Bedfordshire, and Hertfordshire. Of the two woodland species *Hypericum androsæmum* (Map 55), and *Iris fœtidissima*, we may note that the former tends to grow on siliceous soils and the latter on calcareous soils. *Iris fœtidissima* (Map 54) certainly has a more continuous range, but there is no indication of the diagonally S.W.-N.E. limit

Agropyrum pungens

Map 45

Euphorbia paralias

Map 44

Map 47

Map 46

Tillaea muscosa

Map 49

Damasonium stellatum

Map 48

Map 50

Map 51

Map 52

Viola Curtisii

Map 53

Helminthia echioides


Hypericum
androsaemum
Rather Rare
Rare

Mep 55


Iris
foetidissima
Ex.

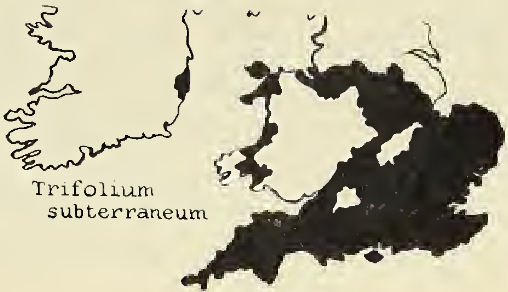
Map 54

Trigonella ornithopodioides

Medicago maculata

Trifolium glomeratum

Map 58



Trifolium subterraneum

Map 59

Statice binervosa

Map 60

Statice rariflora (humile)

Map 61

which is so marked a character of the continental-southern calcicoles. So too the calcicole *Chlora perfoliata*, though absent from the non-calcareous north-eastern part of Ireland and from four of the Welsh counties, has nevertheless as extended a range on the west side of Britain as on the East (Map 46). The six West-European littoral species common to East Anglia and Ireland all exhibit a similar distribution, although two (*Statice binervosa* Map 60, and *S. Humile* Map 61) are salt-marsh plants; one, *Euphorbia paralias* (Map 44), is characteristic of the dune face, *Festuca uniglumis* of sandy shores, whilst the Sea Cabbage (*B. oleracea* Map 43) is a cliff plant, *S. binervosa* and *F. uniglumis* (Map 50) both shew a marked N.W.-S.E. limit in Britain.

The presence in this group of no less than five leguminous plants, all characteristic of dry gravelly or sandy habitats, is a striking feature. The species are *Trigonella purpurascens* (Map 56), *Medicago maculata* (Map 57), *Trifolium subterraneum*, (Map 59), *Trifolium glomeratum* (Map 58) and *Trifolium suffocatum* (Map 41). In the order named they shew a diminishing range in Britain and, except for transposition of the third and fourth, the same order holds for Ireland from which the last species is absent. All these five species are very low-growing plants and may well be restricted to such situations, by reason of the relative immunity they enjoy, in these very arid situations, from undue competition; but their capacity to grow in such places may well be conditional on the climate being of a sufficiently oceanic character, particularly with respect to adequate humidity and not too severe a winter (all these species are winter-annuals).

Of the southern oceanic species of East Anglia which do not occur in Ireland, three are species of wet habitats, viz., *Trifolium maritimum* (Map 51), *Damasonium stellatum* (Map 48) and *Tillœa muscosa* (Map 49), and therefore it is unlikely that their distribution, which is chiefly in the south-east of England, is limited by the higher humidity of the west and north. Neither is it probable that temperature is the master factor, since in this respect the east is more favourable than the west. It is more probable that the amount of sunshine is the master factor involved, influencing the distribution mainly by its effect on reproduction (c.f.p 236). If this be the true explanation, then we can understand why damp and dry habitat species, a few species which require an oceanic climate as well as the majority of those associated with a continental climate, alike may shew this same type of south-western limitation in the British Isles. *Damasonium stellatum* has become extinct in five counties or vice-counties and has diminished in four others. *Trifolium maritimum* is also a diminishing species. *Radiola millegrana* has become extinct in two counties and has appreciably diminished in another. These extinctions correspond with the diminution of damp habitat species in general. Of the other representatives of this element *Beta maritima, Trigonella purpurascens,* and *Urtica pilulifera* (this species was once plentiful at Lowestoft, Henslow and Skepper, 1860 p. 75) have become extinct in two counties: *Chlora perfoliata, Iris fœtidissima,* and *Ranunculus parviflorus* in one. These facts are, however, probably not indicative of any general tendency for this element to diminish, except in so far as drier conditions tend to diminish the oceanic character of the climate. Of the other elements of the "Oceanic Component" eight species have shewn extinction or diminution in one or more of the English counties, and of these six are damp habitat species and the other two are littoral species. The former are to be attributed to lowering of the water-table, the latter to human interference.

Braun-Blanquet (1923 p. 129) has called attention to the diminution in frequency of these Oceanic types towards their eastern limits, and to the fact that the range of a number of them is tending to retreat westwards rather than to extend eastwards. His conclusion, that the Atlantic types are not of very recent origin, appears justified, and their western restriction cannot be attributed to these species not having yet attained to their climatic limit. Matthew's study of the Anglo-Irish species in the British Flora (1926), which largely comprises oceanic types, has shewn that on the Continent these chiefly occupy the south-west, and on other grounds Braun-Blanquet (l.c.) also regards South-Western Europe as the probable home of these plants.

Of the 102 species comprising the Southern Component of the East-Anglian flora almost all are definitely lowland types. Only six species namely *Arum maculatum* (1200), *Galeopsis* *ladanum* (1050), *Geranium lucidum* (1850), *Luzula maxima* (3000), *Orchis pyramidalis* (1050) and *Salix purpurea*, have been recorded from altitudes of over 1000 feet in England (A. Wilson, 1931). The general uniformity in this respect is clearly correlated with the southern climatic preferences of these species.

(e) The Continental Component

To understand the occurrence of the continental species it is necessary to study somewhat closely the distribution of rainfall in East Anglia. This distribution, as already noted, is markedly unequal, and three regions can be distinguished with respect to precipitation. The first, in the east and north-east, of which Norwich is the approximate centre, extends from Ipswich, Yarmouth and Cromer on the east, to Sudbury, Hawkedon, Ixworth, Swaffham and Sandringham on the west. In this area the total annual rainfall ranges from 24-ins. to 28-ins., and in the northern half is in general over 26-ins. In marked contrast with this moderate rainfall is the low rainfall of the belt of country extending from the Wash over the Breckland heaths to the coast from Felixstow to Shoeburyness. Here the annual precipitation is usually from 21-ins. to 24-ins. and may be as low as 18.4 ins., which is the lowest recorded mean for the British Isles. Data over a period of years are not available for the heart of the Breckland area, where it is probable that the amount of precipitation is lower than the data available from the stations at its margin indicate. The published data for Thetford suggest that the line of demarcation between the low and higher rainfall areas may be comparatively abrupt. Thus, in Thetford itself the mean annual rainfalls for Ford Street Gardens (44-ft. altitude) and the Waterworks are 23.4 and 23.8 ins. respectively. (The latter station is at an altitude of 165-ft., which accounts for the higher rainfall.) At Kilverstone Hall, less than two miles N.E. of Thetford and at an altitude of 70 ft., the mean annual rainfall is only 21.7 ins. A further area of low rainfall is furnished by the coastal strips of the north and south-east where mean precipitations of about 23 ins. are the rule (c.f. British Rainfall for 1930). The accompanying map (Fig. 3) shews that these coastal strips are in reality extensions of the larger low-rainfall area which more or less enclose the area of higher rainfall.

The striking disparity between the precipitation in these two regions is accentuated by several factors, of which the chief is the sandy character of the soil in the dry area where the soil, owing to the coarse size of the soil particles has, apart from the organic content, a low water-retaining capacity; whereas the soil in the area of higher rainfall is often, from its fine-grained clayey texture, or high organic content, or both, very retentive of the water it receives. We have no available data respecting the humidity of the air in the two regions, but it is probable having regard to the large areas of standing water in the neighbourhood of Norwich, that differences in this respect still further accentuate the differences in available water supply for the vegetation in the two areas. Furthermore, and this is probably of considerable importance, the lowest annual rainfalls are mainly the consequence of reduced precipitation during the winter months. Comparison of the monthly means for Bury St. Edmunds, Norwich, England as a whole, and Wales shews that, in the order named, there is not only an increasing total precipitation, but also that this is mainly the outcome of increase during the winter months when evaporation is low. Thus we may conclude that the sandy area, shewn dotted in the accompanying map, Fig. 3, is considerably drier than the rainfall data alone suggest. It therefore follows that the conditions obtaining on these sandy heaths are definitely continental in character as regards humidity.

When we turn to the influence of temperature the same juxtaposition of a region of relatively continental character in the west of our area and a more oceanic climate in the east is again indicated. For the purpose of this comparison we may take Cambridge as typical of the dry low rainfall belt, and Yarmouth as typical of the eastern area. In the accompanying table (Table XI) the extremes of temperature and rainfall for these towns and for other parts of the British Isles of similar latitude are quoted from the official books of Normals. It will be at once evident that the climate of Cambridge is definitely continental, whereas that of Yarmouth is somewhat more oceanic than that of Oxford. The minimum

Fig. 3. Map of East Anglia, shewing rainfall distribution and occurrence of species. Figures represent av. rainfall in inches

temperature recorded at Yarmouth is 22° of frost, whereas at Cambridge 32° of frost have been recorded.

TABLE XI. Extremes of Temperature (°F.) and Rainfall (mm.) for various stations.

ation.	Longtitude.	Min. Temp.	Max. Temp.	Range	Degrees of Frost.	Min. Rain.	Max. Rain.
erry	10°15 W.	20	81	61	12	1078	1756
ublin	6°15 W.	13	87	74	19	422	980
nglesey	4°39 W.	17	86	69	15	610	1431
xford	1°16 W.	6	95	89	26	380	912
mbridge ...	0°8 E.	0	96	96	32	308	795
armouth ...	143 E.	10	89	79	22	494	1122

The general amelioration of the climatic conditions as we pass westwards from Cambridge is to be expected, but the almost abrupt change to oceanic conditions on the east is as surprising as the magnitude of the change itself. It is therefore significant that, though we have markedly oceanic species in the east of our area, already dealt with, on the sandy heaths of our area where the soil conditions accentuate the definitely continental type of climate, we find the characteristic species are mostly plants of steppe conditions, chiefly found in areas where the climatic conditions are markedly continental. These, whilst usually capable of withstanding severe cold when the conditions are dry, are often very intolerant of cold humid conditions which obtain in the midlands during the spring. Several of the more characteristic species, such as *Silene conica*, *Teesdalia nudicaulis* and probably *Medicago minima*, are winter annuals; others, such as *Silene otites* and *Veronica spicata*, are winter green perennials. *Medicago falcata* is, I gather from Dr. Mills, a hemi-cryptophyte. It is probably the dry character of the winter months and the high summer temperature and amount of sunshine that limit these species to the continental area. In this connection it is necessary to recognise that extreme conditions as to sunshine, temperature, and humidity, are often of more importance than the means.

For several years the writer has cultivated the continental steppe species *Silene conica* on sandy loam at Radlett, Hertfordshire. This species is a winter annual and the soil where the plants grew was left undisturbed, the seedlings germinating in abundance each autumn. From the autumn of 1928 to that of 1930 the number of self-sown plants steadily increased, and in the summer of 1931 there were more plants and probably a much larger output of seed than in any of the previous years. Laboratory tests of the seed produced in the summers of 1929 and 1930 shewed the germination capacity to be very high, the average of a large number of tests being over 98 per cent. In the summer of 1931, however, although the amount of seed produced appeared to be larger than ever, not a single self-sown seedling appeared in the autumn.* Fortunately seed had been again collected and this, when tested in the laboratory, shewed a maximum germination of only 0.5 per cent.

I am much indebted to Sir John Russell for supplying me with the meteorological data recorded at Rothamstead (the nearest Station to Radlett which records the sunshine) for the appropriate periods of 1930 and 1931. If we consider the whole period from the beginning of flowering to the shedding of the seed, i.e., the months of May, June, July and August, the number of hours of sunshine was respectively 909.1 and 729.7 ; the rainfall was 9.012 ins. and 13.108 ins., whilst the mean temperatures were 57°.3 and 56°.2 F. The most significant months for the seed production of *Silene conica* are, however, probably June and July, for which the hours of sunshine were 450.4 and 372.8 ; rainfall 3.63 ins. and 4.56 ins. ; temp. 59.1 and 58.6 These totals shew, what is even more obvious from the weekly data, that there was but little difference in the two seasons as regards temperature ; and the difference in respect to rainfall, though appreciable, would, from the period of its incidence in 1931, in all probability, be beneficial rather than the reverse. The difference in the two seasons as regards the number of hours of sunshine is however very striking, and the deficiency in this respect during 1931 may well account for the failure of *Silene conica* to produce good seed. It is not, indeed, improbable that the failure of many southern and continental types to produce a crop of fertile seed, except in abnormally sunny years, may depend on an inadequate supply of radiant energy, especially of short wave-length.

Recently O. H. Volk has given an account of the ecology

*A certain number of seedlings appeared in September, 1932, after disturbance of the soil, probably from buried seeds of 1930 or earlier years, shewing that this species may in this way survive an unfavourable season.

of the vegetation of the sandy area of the Upper Rhine valley, in which the striking resemblance of the plant communities, as to species in the two areas, is obvious. Amongst the more characteristic species common to both may be cited *Silene otites, S. conica, Medicago minima, Artemisia campestris, Teesdalia nudicaulis, Scleranthus perennis, Holosteum umbellatum,* and *Veronica verna.* (O. H. Volk, Zeitsch f. Botanik B.24, pp. 81-185 1931).

Stomps had previously suggested as a cause of the floristic resemblance that these East Anglian species owe their presence to the fact that they are relics from the former valley of the Rhine and thus represent a remnant of what was at one time a continuous distribution. Prestwitch, Harmer, Van Steen and others have advocated the view that, in the transition period between the Pliocene and the Pleistocene, when the North Sea was mainly land, the Rhine followed a course through East Anglia entering the area of present land-surface near Walton and, passing through Essex and Suffolk, emerged at Cromer. It must be noted, however, that the Chillesford sands, which Harmer considers to have been formed by the distributary of the ancient Rhine delta (F. W. Harmer, Proc. Geol. Assoc. Vol. XVII, pp. 451-479, 1902), are late Pliocene overlain by Clay; whereas the sandy soils of Breckland, which these plants now occupy, are of Post-glacial origin and possibly derived from the ancient dunes which occupied the former south-eastern margin of the Wash (c.f. Map in E. P. Farrow. On the Ecology of the Vegetation of Breckland). The lack of continuity in time and space between the siliceous habitats weakens the force of the argument for the persistence of these species. Furthermore, the resemblance of these Rhenish communities to those of Breckland, though so striking, is not more so than to the siliceous grasslands of the Vexin Francais described by Allorge (P. Allorge. Les Associations, Vexin Francais pp. 342, Nemours 1922) in which *Veronica verna, Silene otites, Artemisia campestris, Teesdalia nudicaulis, Holosteum umbellatum, Medicago minima* and *Veronica triphyllos* also occur on siliceous soils ; whilst *Herniaria glabra, Agrostis spica-venti, Medicago falcata, Muscari racemosa* and *Phleum Boehmeri* are found in the same region where the soil is more calcareous. The communities described both by Volk and Allorge which shew the closest resemblance to those of the Breckland heaths are characterised by the dominance of *Corynephorus canescens*, which is also a feature of the East Anglian continental element, although here, almost, but not entirely, littoral in its occurrence (Photo, Pl. VIII). It is, therefore, noteworthy that in the Corynephoretum described by Braun in the Cevennes we find a similar group of species (J. Braun, Les Cevennes Meriodionales, pp. 208, Geneva, 1915).

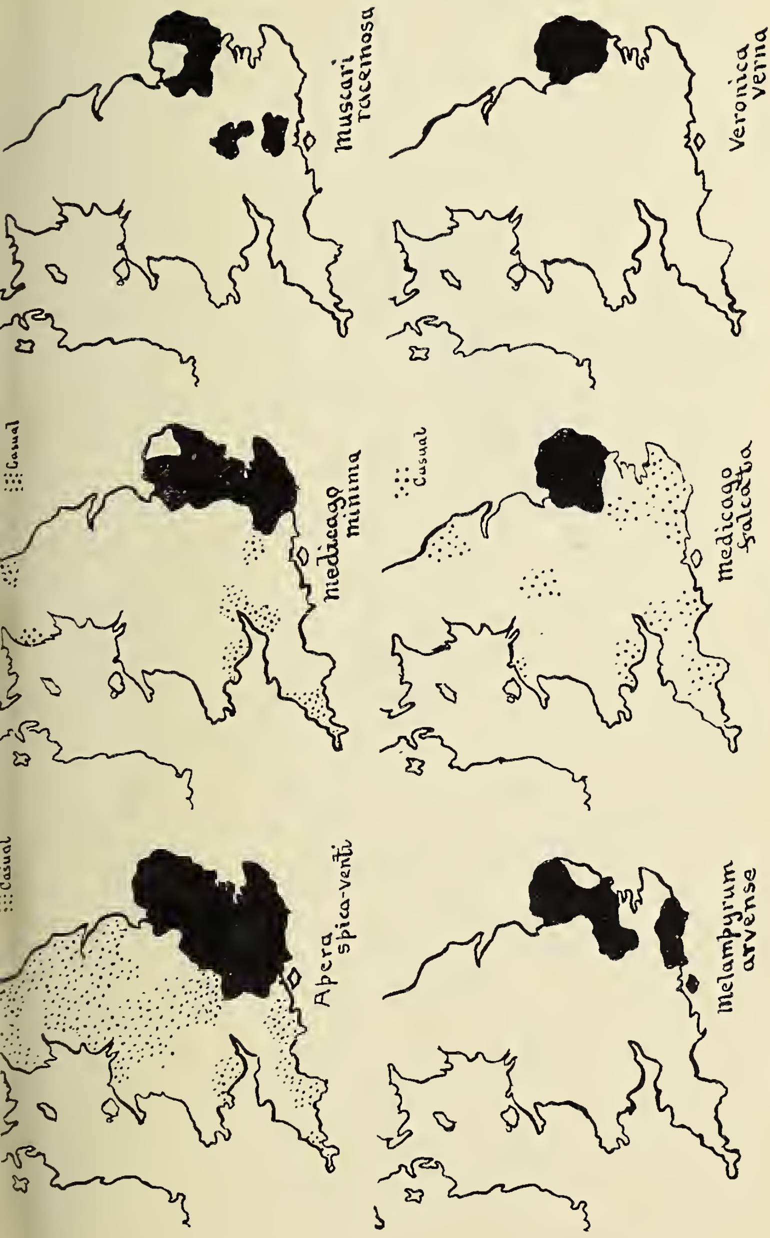
It is evident, then, that the floristic resemblances to which Stomps attaches such importance are of ecological, rather than historical, significance. Further, we may point out that one of the species to which Stomps calls attention, viz., *Silene otites*, is represented in our area by a strain which, according to Newton, agrees most closely with plants from Denmark (W. F. C. Newton, Genetical Experiments with *Silene otites* and related species, Journal of Genetics pp. 109-120, Vol. XXIV, 1931). Stomps' hypothesis involves survival from preglacial times, a view which is also accepted by Wilmott (l.c.) ; but, quite apart from any difficulties of climatic tolerance, it has already been pointed out that the major part of East Anglia was glaciated and rendered edaphically unsuitable for these psammophiles. It is only the more recent post-glacial covering that has provided the suitable conditions for these plants. It is not improbable that their immigration was as early as the Boreal Period, when the continental climate favoured the formation of loess and wind born sand and the colonisation of this country by species characteristic of continental conditions. Their survival since that period has only been rendered possible by the peculiar combination of local climatic and edaphic conditions.

(9) The Steppe Element

Table XII. Steppe Species in the East Anglian Flora

Species.	E. Anglia	% Freq. in Eng.	* Freq. in in Ireland.	Habitat.	Wats T
Agrostis spica-venti (Map 62) ...	l.c.	32.4%	absent	Sandy soil	Germ
Arnoseris pusilla	r.	27%	absent	Sandy soil	Ger-l
Artemisia campestris	v.r.	5.6%	absent	Sandy soil	Germ
Corynephorus canescens (Pl. VIII)	l.f.	9.8%	absent	Sandy soil	Germ
Dianthus deltoides	r.	63%	absent	Dry heaths	Eng-
Eryngium campestre ...	Extinct	14%	casual	Dry heaths	
Holosteum umbellatum (Pl. VIIA)	Ext.	1.4%	absent	Dry heaths	Germ
Hypochœris glabra ...	r.r-l.c.	62%	2.5% v.r.	Sandy soil	Ger-

Maps 62, 63, 64, 65, 66 & 67



Map 67

Map 66

Map 65

Map 69

Map 68

Trifolium ochroleueum

Scleranthus perennis

Silene conica

Sonchus palustris

Map 73

In the first and third map the solid black indicates frequent; cross-hatching indicates rare; diagonal shading indicates very rare.

Silene otites

Map 74

	E. Anglia	% Freq. in Eng.	* Freq. in in Ireland.	Habitat.	Watsonian Type.
licago falcata (Map 66) ...	r.	7%	absent	Sandy heaths	Germ.
licago minima (Map 63) ...	l.f.	14%	absent	Sandy heaths	Germ.
ampyrum arvense (Map 65)	v.r.	11.2%	absent	Cornfields	Germ.
nchia erecta	r.	83%	absent	Dry heaths	Eng.
scari racemosa (Map 64) ...	v.r.	8.4%	absent	Sandy soil	Ger.-l.
his ustulata	v.r.	63%	absent	Dry pastures	E.-G.
eum bœhmeri (Map 68) ...	l.	10%	absent	Sandy heaths	Germ.
entilla argentea	l.c.	67.6%	absent	Dry heaths	Eng-Ger.
ranthus perennis (Map 71) ...	r.	7%	absent	Sandy heaths	Eng.-Ger.
ecio campestris	r.	33.8%	absent	Chalk downs	Eng.
li libanotis ... (Camb.)	v.r.	5.6%	absent	Chalk downs	Ger.-l.
ne conica (Map 72) (Pl. VIII)	.lr.	14%	absent	Sandy soil	Ger.-Eng.
ne otites (Map 74)	l.r.	5.6%	absent	Sandy soil	Germ.
sdalia nudicaulis	l.c.	77.4%	12.5%	Sandy heaths	B.-E.
onica spicata	v.r.	7%	absent	Chalky heaths	Eng.-I.
onica triphyllos	v.r.	8.4%	absent	Sandy fields	Germ.
onica verna ...(Map 67) ...	v.r.	5.6%	absent	Sandy heaths	Germ.

esdalia nudicaulis occurs plentifully in certain sandy habitats in Ireland (c.f. Praeger).

In his account of the Continental Element in the flora of South Sweden, Rikard Sterner shews that there, too, it is the combination of local climate and soil conditions which enables such species as *Phleum Boehmeri* and *Veronica spicata* to extend their range into southern Scandinavia (Geografiska Annaler H.3-4 1922).

Of the steppe species which occur in East Anglia only two occur rarely as probable natives in Ireland, whilst some of those with a very high frequency in England, such as *Mænchia erecta* and *Potentilla argentea*, are entirely absent. *Dianthus deltoides* has been found in two Irish counties as an escape. Most of these species are absent, or rare, even in the west of England and belong to the Watsonian Germanic type. It is thus evident that the distribution in Britain is mainly limited by climatic factors, but that the occurrence of the more extreme steppe species is dependent upon the combination of suitable edaphic and climatic conditions is shewn by the map giving the distribution of Mean Annual rainfall for a number of stations in East Anglia and the distribution of the sandy heaths, together with the distribution of some of the more characteristic species, Fig. 3. It is evident that these occur exclusively where there is a combination of low rainfall with soil of a very porous character.

That the absence from Ireland of so large a proportion of this

Element, namely twenty-two species, or just over 88%, is due to environmental factors is indicated by the respective frequencies of Continental species common to both England and Ireland (Table XIII). Of these latter there are twenty-four; and twenty of these show a higher frequency in England, the remaining four comprise three damp habitat species and one Heath species. For the total twenty-four species the average frequencies are 78.7% for England and 57.1% for Ireland. Thus just over ninety per cent. of the continental species of East Anglia show a diminution westwards, amounting to entire absence from Ireland in 44.2%.

Of other groups, besides the higher plants, central European species are represented in East Anglia. For example, the Mid-European Syrphid Fly, *Chilosia globulipes* Beck, is found in Suffolk, and *C. fasciata* Egger, a species of mid- and southern-Europe, extends from Kent to Cambridgeshire (Fordham 21). Breckland is also the home in this country of *Dianthcia irregularis, Agrophila sulphuris, Lithostega griseata, Spirodes sticticalis* and the beetle *Diastictus vulneratus.*

TABLE XIII. The Continental Element in the East Anglian Flora (Exclusive of Steppe spp.)

Species.	Freq. in E. Anglia.	% Freq. in Eng.	Ireland.	Habitat.	Watsonian Type.
Acorus calamus	f.	48%	absent	Marshes	Eng.
Allium vineale	r.	93%	40%	Dry soils	Brit.
Anemone Pulsatilla (Map 76) ...	r.r.	26.7%	absent	Chalk downs	Ger.
Antirrhinum Orontium	r.r.	66%	7.5%	Dry fields	Eng.
Aspidium aculeatum	l.c.	97%	92%	Woods	Brit.
Astragalus glycyphyllos	r.	69%	absent	Woods	Brit.
Bupleurum tenuissimum	r.	39.6%	absent	Dry banks	E.-G.
Carpinus Betulus	r.r.	54%	absent	Woods	E.-G.
Centunculus minimus	r.	80%	40%	Moist sand	E.-B.
Dipsacus pilosus	r.r.	74.6%	absent	Moist woods	E.-G.
Epipactis palustris	l.c.	87.3%	75%	Marshes	E.-B.
Fritillaria meleagris	r.	36.6%	absent	Wet meadows	Eng.
Gagea lutea	r.	49%	absent	Moist woods	I.-B.
Galeobdolon luteum	l.c.	91.5%	10%	Woods	Eng.
Galeopsis speciosa	r.r.	76%	52.5%	Fields	Scot.-B
Genista tinctoria	r.	98.6%	absent	Heaths	Eng.
Gentiana germanica (Map 79) ...	18%		absent	Downs	Ger.
Geranium Phæum	r.	62%	25%	Woods	
Hypericum montanum	r.	70%	absent	Dry woods	Eng.
Lamium hybridum	r.r.	86%	65%	Fields	Brit.
Liparis Lœselii (Map 78)	r.	12.7%	absent	Bogs	Ger.
Lonicera periclymenum	o.	100%	100%	Woods	Brit.
Malva rotundifolia	c.	98.6%	57.5%	Waysides	Br.-En

Map 75

Map 76

Malaxis paludosa

Map 77

Liparis Loeselii

Map 78

Gentiana germanica

Map 79

Teucrium scordium

Map 80

Map 81

Utricularia intermedia

Map 83

Utricularia minor

Map 82

X 7/16

Euphrasia Pseudo-Kerneri

Phot. E.J.S. X $\frac{3}{8}$

Fen with Liparis Loeselii

Fig. A. Holosteum umbellatum; B. Urtica pilulifera; C. Bupleurum rotundifolium; D. Silene noctiflora; E. Menyanthes trifoliata

Species.	Freq. in E. Anglia.	% Freq. in Eng.	Ireland.	Habitat.	Watsonian Type.
ione pedunculata ...	? Extct. from	Recorded 11%	absent	Salt marshes	Ger.
ıanthe Phellandrium ...	... l.c.	73%	87.5%	Ditches	Eng.-Ger.
:his incarnata	...r.r-l.c.	73%	100%	Marshes	Brit.
›opteris montana ...	... r.	93%	75%	Wet heaths	Brit.
ıithogalum nutans ...	... r.	7%	absent	Woods	Eng.
›banche major	... r.r.	90%	12.5%	Heaths	Eng.
ygonum minus ...	... r.	73%	57.5%	Wet places	Eng.
ygonum mite	... r.	42%	12.5%	Wet places	Ger.
ercus sessiliflora ...	... f.	85.5%	absent	Woods	Brit.
ıunculus Lingua ...	... f.	91%	75%	Marshes	Brit.
sa rubiginosa	... f.c.	80%	70%	Hedges	Eng.
sa spinosissima ...	... r.r.	84.5%	95%	Dry heaths	Brit.
mex Hydrolapathum ...	... c.	91.5%	92.5%	Riversides	Eng.
on amomum (Map 47)	... f.	79%	absent	Wood-margins	Eng.
ıchus palustris (Map 73)	... v.r.	17%	absent	Marshes	Ger.
·bus torminalis	... r.	73%	absent	Woods	Eng.
:atiotes aloides	... l.c.	25%	7.5%	Dykes	G.-E.
ifolium ochroleucum ... (Map 70)	r.-l.c.	20%	absent	Dry pasture	Ger.
ymus chamædrys ...	... r.r.	42%	27.5%	Dry heaths	Brit.
ronica montana ...	... r.	93%	95%	Damp woods	Brit.

The members of the continental component shew a continuous series with regard to the extent of their range in Britain, from those like *Hypochaeris glabra* and *Teesdalia nudicaulis* which extend into Scotland and Ireland (though doubtfully native in the latter country), through species with a wide distribution in England only, such as *Mœnchia erecta* and *Sison amomum* (Map 47), to species, as for instance *Apera spica-venti*, *Medicago minima* (Map 63), *Muscari racemosa* (Map 64), *Melampyrum arvense* (Map 68), *Medicago falcata* (Map 66) and *Veronica verna* (Map 67), which shew increasing restriction to the east of England. Matthews, in his valuable cartographic analysis of the British Flora (Matthews' 1923), has suggested that East Anglia may represent the centre of immigration of the members of this element into this country. Whilst this is not in itself improbable, it must not be lost sight of that, as we have seen, the presence of these species in East Anglia is adequately accounted for by a peculiarly favourable combination of soil and climate; and in this connection it should be noted that, of the definitely continental types which occur in the British Flora as a whole, only about fourteen per cent. are not found in East Anglia, and these are nearly all very rare and local in their English distribution (e.g. *Arabis turrita*, *Cephalanthera rubra*, *Leucojum* *vernum, Orchis militaris, Phyteuma spicata,* etc.). Whilst, therefore, it is quite probable that these species may have first entered East Anglia from the Continent and subsequently spread, their presence here cannot be adduced in support of such a view. The varying extent beyond the confines of East Anglia, does however, raise the question as to whether their ranges in Britain represent differing degrees of tolerance for the more oceanic conditions of the west and north, or whether these varying ranges are due to different rates of spread or different times of immigration. In other words, are these differences in range an outcome of the time factor or of the environment ?

Two types of evidence support the view that the causes are ecological rather than temporal. Firstly, it should be noted that some of these species, e.g. *Apera spica-venti, Medicago minima* (Maps 62 and 63) definitely occur as temporary casuals beyond the area of their permanent occupation, so that for these the opportunity of further extension has already offered, and their lack of persistence must clearly be attributed to unfavourability of the environment. Secondly, most of these species exhibit a decreasing abundance as the western and northern peripheries of their ranges are approached. If the existing distributions of these species were but an expression of the efficiency of dispersal in relation to time, the respective species might at the peripheries of their ranges shew a low frequency, i.e. the species might be quite local in its occurence ; but the abundance should be similar to that which the species exhibits in the east of England. A striking exception to this generalisation is the occurrence of several of these continental species in Dorset, exhibiting an abundance comparable to that in East Anglia. But the Dorset heaths where they occur probably also have a low rainfall and certainly exhibit a soil of extreme porosity and aridity.

(11) The Northern Continental Element

The species belonging to this element are characteristic of central Europe, but with a definite northern tendency. It is evident that their separation from the continental-northern element is somewhat arbitrary, as the two groups taken together show gradations from those in which the continental

Tussocks of Corynephorus canescens

Silene conica

preference is the more marked to those in which the northern tendency predominates. But, though opinions may differ regarding certain species, this does not invalidate conclusions regarding the elements as a whole.

The first and most prominent feature of this group is the very high proportion of aquatics or species of damp habitats. Out of the total of thirty species these number no less than twenty-one. Further, of these wet habitat species, only five are absent from Ireland, whereas five of the nine species of other habitats are absent, and two more of these are only found in a single Irish county. The damp habitat species similarly preponderate in Scotland, and of the species present in the different countries the average percentage frequency is 42.9% for England, 42.8% for Ireland and nearly 63% for Scotland. In other words, members of this group, when they extend beyond England, tend to occur with slightly lower frequency in Ireland, but even more frequently in Scotland.

TABLE XIV. Table Northern Continental Species of East Anglia.

Species	Percentage frequencies for Eng.	Ireland.	Scot.	Habitat.	Watsonian Type.
gelica sylvestris	100%	100%	100%	Damp woods	British
ragalus danicus (Map 75) ...	38%	2.5%	53.7%	Downs and Dune	Ger.
amagrostis stricta	4.2%	10%	9.8%	Bogs	
npanula patula (Map 94) ...	42%	absent	absent	Copses	English
ex canescens	73%	2.5%	90%	Bogs	British
ex disticha	86%	100%	68%	Marshes	English
ex elongata	29.6%	2.5%	absent	Damp places	English
rex ericetorum	4%	absent	absent	Heaths	Ger.
rex filiformis	39.4%	57.5%	58.5%	Marshes	British
rex limosa	19.7%	62.5%	70.8%	Bogs	Scottish
ex paradoxa	14%	5%	2.4%	Marshes	English
ysosplenium alternifolium ...	74.6%	absent	56%	Wet places	British
uta virosa	36.6%	40%	46.3%	Wet places	British
tillaria meleagris	36.6%	absent	absent	Wet meadows	
tiana amarella	93%	80%	56%	Downs and Dune	British
tiana Pneumonanthe ...	45%	absent	absent	Wet heaths	English
minium monorchis	32%	absent	absent	Downs	Ger.
pericum hirsutum	87%	10%	63%	Chalky woods	British
pericum quadrangulum ...	98.6%	85%	83%	Damp places	Eng.-Br.
trœa uliginosa (Map 81) ...	11.3%	absent	absent		
nosella aquatica	62%	5%	12%	Aquatic	Ger.-Eng
torella lacustris	80%	90%	92%	Aquatic	British
laxis paludosa (Map 77) ...	41%	30%	56%	Bogs	British
lampyrum cristatum ...	15.5%	absent	absent	Calcareous woods	Ger.
rola rotundifolia	28%	2.5%	39%	Woods	Scot-Ger.
es nigrum	86%	absent	61%	Wet woods	Interm.

Species	Percentage frequencies for Eng.	Ireland.	Scot.	Habitat.	Watsonian Ty
Sedum rupestre	19.7%	30%	absent	Dry places	Engli
Utricularia intermedia (Map 83)	15.5%	60%	70%	Aquatic	Britis
Utricularia minor (Map 82) ...	66%	97.5%	80%	Aquatic	Britis
Utricularia ochroleuca	8.5%	5%	57%	Aquatic	Britis
Average frequencies ... Av.	42.9%	42.8%	62.6%		
Total species	30	21	21		

Since the species common to the three countries mostly occur in wet habitats, their tolerance for the moist climatic conditions of the west and north is scarcely surprising. A high summer temperature is apparently essential for the fruiting of *Utricularia*, and it is possible that this applies also to other members of this group.

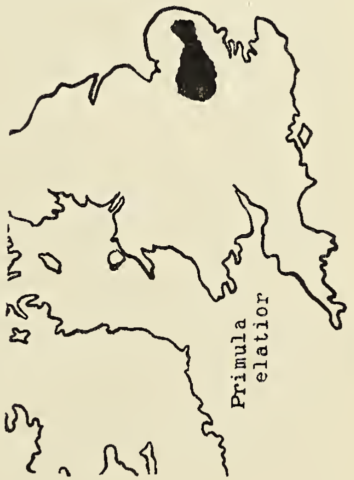
The drier habitat species have very varying ranges. That of *Melampyrum cristatum* is of the same restricted type as those of more strictly continental species. *Campanula patula* has a wide range in England (Map 94), whereas *Limosella aquatica*, (Map 81), *Cicuta virosa* and *Carex limosa*, in the order named, have an increasing range in Scotland.

It is of interest to compare the distributions of continental species with those of northern-continental types occupying the same habitats. Thus, if we compare the distribution of the Continental *Liparis Loesilii* (Map 78 and Pl. VI) with that of *Malaxis paludosa* (Map 77), both orchids of similarly very wet bogs; or, to instance the other extreme, the Continental *Anemone Pulsatilla* with the northern-continental *Astragalus danicus*, (Map 75), we find a similar relation, despite the disparity of conditions, which again emphasizes the minor rôle played by the edaphic factors in determining the major features of geographical distribution.

Attention may be called to the fact that several of these northern-continental species are shy fruiting plants, except in favourable seasons; and a number of them have an effective alternative in vegetative reproduction. This is notably the case for the Utricularias, but vegetative spread is also a salient feature of *Astragalus danicus*, the various Carices, *Cicuta virosa*, *Hypericum quadrangulum*, *Limosella aquatica*, *Littorella lacustris*, *Sedum rupestre* and *Pyrola rotundifolia*. The erratic appearance of *Limosella* is apparently dependant

Map 84

Map 85



Map 86

Map 87

upon the drying of the seeds present in the mud (c.f. Salisbury, 1921), whilst *Littorella lacustris* only flowers as the "land-form," reproducing entirely by runners when submerged (Arber, 1920 p. 232). The advantages of a continental climate with its hot dry periods is therefore obvious in the case of these particular species, but the vegetative propagation of the one and the prolonged dormancy of the seeds in the other (*Limosella*, although exhibiting a strawberry-like vegetative multiplication, is an annual) enable these species to have an extended northern and western range.

The importance of the temperature factor is also shown by the northern continental Utricularias. Dr. Robert Gurney has furnished evidence that the flowering of members of this genus is associated with high temperatures (and perhaps exceptional sunshine) in the early part of the year (R. Gurney *Utricularia* in Norfolk, Trans. Norfolk and Norwich Nat. Soc. Vol. XI., pp. 259-266, 1922) ; a conclusion which is strengthened by the observations of F. C. Gates on *Utricularia resupinata* in North America, who finds a correlation between the flowering of this species and high summer temperatures (F. C. Gates, Heat and the flowering of *U. resupinata*, Ecology Vol. X. p 353).

(f) The Western-Central Component

This is an ill-defined group of few species which have their main home in western and central Europe, and would appear to be favoured by climatic conditions of an intermediate character between continental and oceanic extremes. The ill-defined character of this element would scarcely justify its separation, were it not that species of this geographical provenence are not infrequently characterised by a markedly local distribution. In the East Anglian Flora the following species are perhaps appropriately placed in this category :—

Table XV. Species of W. Central Europe.

	English % Frequency.
Apium inundatum	98.6%
*Carum bulbocastanum (Map 87)	7%
*Cirsium tuberosum (Map 85)	5.6%
Drosera intermedia	59%
*Genista pilosa (Map 84)	9.8%
Hypericum humifusum	100%

	English % Frequency.
Hypericum pulchrum	98.6%
Malva moschata	100%
Ornithopus perpusillus	97%
*Primula elatior (Map 86) (Pl. IV)	11.2%
Scirpus fluitans	90%

All of the four species marked (*) are very local in their distribution, but, whereas *Primula elatior* (Pl. IV, Map 86) and *Carum bulbocastanum* (Map 87) are restricted to a few adjacent counties, *Cirsium tuberosum* and, still more *Genista pilosa*, exhibit a striking discontinuity of range in this country. Miller Christy has pointed out the close correlation in the distribution of the Oxlip and the area occupied by the chalky Boulder-clay (Christy 1922); and the apparently erratic character of many distributions may, in reality, be connected with very local changes in soil and climate, which only intensive study of the biology of the species and of the habitat conditions can elucidate. Drude (1912) has commented upon the occurence of west-central European types in Great Britain and emphasized the apparent capriciousness of the selection which are represented in the British Flora. Nevertheless, he concludes that all this makes very much more the impression of ordered distribution than of chance invasion. Some of the species cited above have, it will be noted, a wide distribution in England; but it should be emphasised that though Coste (Flore de France) gives these as species of western and central Europe, their inclusion here is less certain than that of the local species just cited.

(g) The Endemic Component

The relatively facile immigration into Britain, which the colonisation by continental types from the Glacial epoch to the present day attests, implies a similar facility for emigration to the Continent of new species or varieties which may have arisen in the past within the British Isles. The very small number of British endemics, either of specific or lower taxonomic rank, (probably less than twenty-five, inclusive of sub-species and varieties) may therefore be but a small proportion of those which have originated in Britain. On the other hand, this small number may not be the outcome of loss of endemic status, by emigration of new types produced in the more remote past, but may be a true indication of the slow rate of origin of such, which the relatively short period that has elapsed since the Pleistocene has been inadequate to furnish in greater numbers.

If former British endemics existed to-day, which have now extended to the Continent, we should certainly expect to find them amongst the more extreme oceanic types presenting an appreciably lower frequency on the Continent than in Britain. *Oenanthe fluviatilis* fulfils these conditions in a striking degree. It has been recorded in thirty-two English counties and vice-counties (Map 89), whilst on the Continent it is very rare, being confined to west Jutland and a few locations in Germany(near Colmar, Metz and Illingen). This species may well be of British origin, but it is perhaps unique in its exemplification of these features. As already noted, the Oceanic component as a whole bears no indications of recent origin and is tending to diminish rather than to extend its range.

If then, as seems probable, the rate of production of new types be slow, it might seem reasonable to suppose that those elements which have been longest in occupation of this country would be the most prolific in endemic types. But such a probability is only capable of being tested if the new forms, produced by members of each element, exhibited a distribution in Britain of a corresponding character. But that such an assumption is far from being true is shewn by the interesting case of *Cirsium eriophorum*, of which three sub-species are recognised. The sub-species *vulgare* has a range extending from Holland and southern France to eastern Germany and Poland. Beyond the westward range of this sub-species we have the sub-species *britannicum* (Map 90), which is endemic to Britain and is found from East Anglia to Somerset, Pembroke and Durham ; whilst on the eastern limit of the sub-species *vulgare* the sub-species *decussatus* has a range through Poland and part of Continental Russia (c.f. Map page 871 Vol. VI, Hegi. Flora Von Mittel Europa). It is most probable that the wide-ranging sub-species *vulgare* has given rise both to the endemic western type on the one hand and, on the other, to the markedly continental sub-species *decussatus* ; but, whichever be the parental stock, the non-conformity of the climatic tolerance in these three allies, evinced by the absence of overlap in their ranges, shews that new types may have different climatic demands from the stock from which they are derived. The majority of British endemics (about two thirds) are western in their distribution, whilst about a quarter are northern types. Only four have an eastern distribution, whilst one other of general distribution in England and one southern type also occur in East Anglia. The endemics found in East Anglia are as follows :—

TABLE XVI. Endemic British Types present in East Anglia.

Bromus interruptus Druce. South-Eastern (Map 88).
Cirsium eriophorum sub-sp. *Britannicus* Petrak. General (Map 90).
Euphrasia anglica Pugsley. Southern (Map 92).
Euphrasia Pseudo-Kerneri Pugsley. South-Eastern (Map 93).
Polygala Babingtonii Druce. Southern.
Ulmus sativa Mill (*U. Plottii*). Eastern (Map 91).

It is extremely improbable that any of these endemics represent plants of an erstwhile wider distribution that have become extinct, except in Britain. Therefore, it is noteworthy that these autochthonous types present the same categories of distribution as shewn by species which have immigrated from without. *Bromus interruptus* exhibits the diagonally south-eastern type (c.f. Map 88), with a northern limit extending diagonally from S.E. Yorkshire to Somerset; and the distribution of *Euphrasia Pseudo-Kerneri* is of the same character (c.f. Map 93 and Pl. VI) (c.f. Pugsley 1930. *Ulmus sativa* Mill (*U. Plotii* Druce) (c.f. Moss 1912) have the distribution of a continental species (Map 91). The aquatic *Oenanthe fluviatilis* (Map 89), in common with some continental-southern types of wet habitats, has a distribution which, though mainly south-western, has a more or less horizontal (E. to W.) northern limit. *Euphrasia Anglica* is a southern type, whilst *Cirsium eriophorum* sub-sp. *britannicus* extends almost throughout England (Map 90); but its greater frequency on calcareous soils in the west than in the east is of interest in relation to what has been already noted as to its distributional relation to the sub-species *vulgare*.

Amongst the endemics not represented in East Anglia there are examples of the western type (e.g. *Aconitum anglicum* c.f. Stapf. in Bot. Mag. T. 9085, 1926) and of the northern

Map 88

Map 89

Map 90

Map 91

Map 92

Map 93

(e.g. *Cochlearia Scotica* and *Carex Sadleri*). The probability is, therefore, far greater that the distribution of these endemics is mainly determined by climatic factors than that these depend in any appreciable degree upon either their place of origin or their rate of dispersal.

(h) Recent Immigrants

The distributions of species which are known or suspected to have been introduced into Britain in modern times have many features of interest. Primarily, they afford evidence as to the rate of spread of species, and since they include representatives of various types of dispersal, they provide a means of estimating as to whether the rate of spread and the direction of migration show any marked correlation with the type of dispersal mechanism. Secondly, such recent introductions are of great importance as shewing whether the spread of species is more readily effected in one direction than another. Moreover, since for the more recent immigrants the location of their first introduction into Britain probably corresponds with the first recorded stations, it is possible to judge as to whether the centre of dispersal affects the type of distribution in Britain. In other words, whether the area at present occupied by a species, either recent or ancient, can be taken as any indication of the direction of its immigration.

In the following list the undoubted and probable alien species are listed in the order of the earliest available record. (In most cases taken from W. A. Clarke, First Records of British Flowering Plants, 1900). These dates, so far as the early nineteenth century and perhaps the latter part of the eighteenth century, probably correspond roughly to the date of first introduction. The earlier dates have only a very limited value as guides to the length of time which the species has been in the country. Nevertheless, considered as a whole, the order may be taken as a sufficiently close approximation to the sequence of their immigration or introduction into Britain. In the columns on the right of the table the number of comital and vice-comital divisions in which the species has been recorded is given. Here we may note that some of the annual species are very impermanent, and the numbers cited have only a general significence. Nevertheless, allowing for all such possible sources of error, it is at once apparent that there is no definite correlation between the area occupied by individual species and the time of their occupancy of the country. It is true that *Aegopodium podagraria*, which has been in this country from the sixteenth century, is found throughout the British Isles but this is now probably also true for *Veronica Tournefortii* (*Buxbaumii*), which did not appear till 1825. A more valid comparison can, however, be made, since in the genera *Senecio* and *Impatiens* two species with quite comparable methods of dispersal have been introduced into this country at different dates. Actually *Senecio viscosus*, first recorded in 1660, has a more extended range than *S. squalidus* which is first recorded over a hundred and thirty years later; but both occur in Ireland, and actually the distribution of these species in Britain corresponds with their continental range, for whereas *Senecio viscosus* is perhaps native as far north as Belgium, *Senecio squalidus* is of Mediterranean origin. The two species of *Impatiens* (Maps 100 and 101) shew the reverse relation, since the more recently recorded species has the wider range. But here, too, the difference of range in Britain corresponds with the occurrence of these species in Europe and America respectively. *Impatiens parviflora* is a native of Siberia, whereas *Impatiens fulva* has its chief area from Nova Scotia and Oregon to Florida and Missouri, although extending along the western limit as far as Alaska. The two species of *Claytonia*, both quite recent introductions, occur in Britain in almost the same number of comital and vice-comital divisions; but *Claytonia alsinoides* also occurs in Ireland. Both are natives of Western North America, but *Claytonia alsinoides* has a more northerly range from Alaska to South California, as compared with *C. perfoliata* which extends from British Columbia to Mexico. It is therefore significant that *C. alsinoides* has a more northerly limit in Britain (viz. The Orkneys) than its congener (Elgin); and that, whereas *C. perfoliate* attains its greatest abundance on the Surrey heaths, *C. alsinoides* is most abundant in the north. It is clear from the distribution of these and other recent additions to our flora (c.f. *Matricaria suaveolens*, *Veronica Tournefortii*, Maps 102 and 106) that not only is the range in Britain apparently unconnected with the time of occupancy, but also that the area colonised shews little if any relation to the location of the first introduction, as judged by the earliest record. On the contrary, as we have already seen, the range observed appears to be correlated with the native provenance, even in the case of species whose sojourn in Britain has been relatively short. A striking feature of these recent acquisitions, in which they exhibit a contrast to most of those long-established in this country, is the rather discontinuous character of their geographical distribution. This suggests that the spread of a species does not usually radiate gradually from a single centre, but that, either there is multiple introduction from abroad, or the spread from the original locality is commonly discontinuous, though from each centre thus established more or less continuous spread may ensue. It would therefore appear extremely unlikely that the area occupied by a species, or any group of species, can be taken as a criterion of the direction of their immigration.

TABLE XVII. Introduced species

rd.	Species.	Comital and Vice-comital occurrences in Britain.					
		1-20	21-40	41-60	61-80	81-100	101-112
	Oenothera biennis	–	–	50	–	–	–
	Mercurialis annua	–	–	53	–	–	–
	Aegopodium podagraria ...	–	–	–	–	–	112
	Erysimum cheiranthoides	–	–	–	73	–	–
	Camelina sativa	–	–	45	–	–	–
	Scrophularia vernalis (Map 96)	–	32		–	–	–
	Urtica pilulifera	–	25 (?Ex.)		–	–	–
	Linaria Cymbalaria ...	–	–	–	–	88	–
	Senecio viscosus (Map 97) ...	–	–	–	69	–	–
	Erigeron canadensis (Map 95)	–	–	40	–	–	–
	Antennaria margaritacea ...	–	21	–	–	–	–
	Malva pusilla	–	32	–	–	–	–
	Crepis taraxacifolia ...	–	–	–	64	–	–
	Oxalis corniculata	–	35	–	–	–	–
	Centranthus ruber	–	–	43	–	–	–
	Cynosurus echinatus ...	–	38	–	–	–	–
	Coronopus didymus ...	–	–	–	62	–	–
	Senecio squalidus (Map 98)	–	31	–	–	–	–
	Juncus tenuis	–	–	43	–	–	–
	Euphorbia Cyparissias ...	–	34	–	–	–	–
	Petasites fragrans	–	37	–	–	–	–
	Euphorbia virgata	–	26	–	–	–	–
	Lepidium Draba (Map 99)	–	33	–	–	–	–
	Impatiens fulva (Map 100)	–	22	–	–	–	–
	Veronica Tournefortii (Map 102)	–	–	–	–	–	100
	Mimulus guttatus (Map 103)	–	–	–	–	89	–
	Claytonia alsinoides (Map 104)	–	–	43	–	–	–
	Bromus arvensis	–	40	–	–	–	–
	Elodea canadensis	–	–	–	–	87	–

First Record.	Species.	Comital and Vice-comital occurrences in Brita					
		1.20	21-40	41-60	61-80	81-100	101
1849	Poterium polygamum ...	–	–	43	–	–	
1852	Melilotus indica ..., ...	–	–	46	–	–	
1852	Claytonia perfoliata (Map 105)	–	–	45	–	–	
1858	Impatiens parviflora (Map 101)	–	27	–	–	–	
1871	Matricaria suaveolens (Map 106)	–	–	–	77	–	
1872	Geranium versicolor ...	–	24	–	–	–	
1872	Sisymbrium pannonicum ...	–	–	–	–	96	
1883?	Azolla filiculoides	?9	–	–	–	–	
1887	Prunella laciniata	9	–	–	–	–	

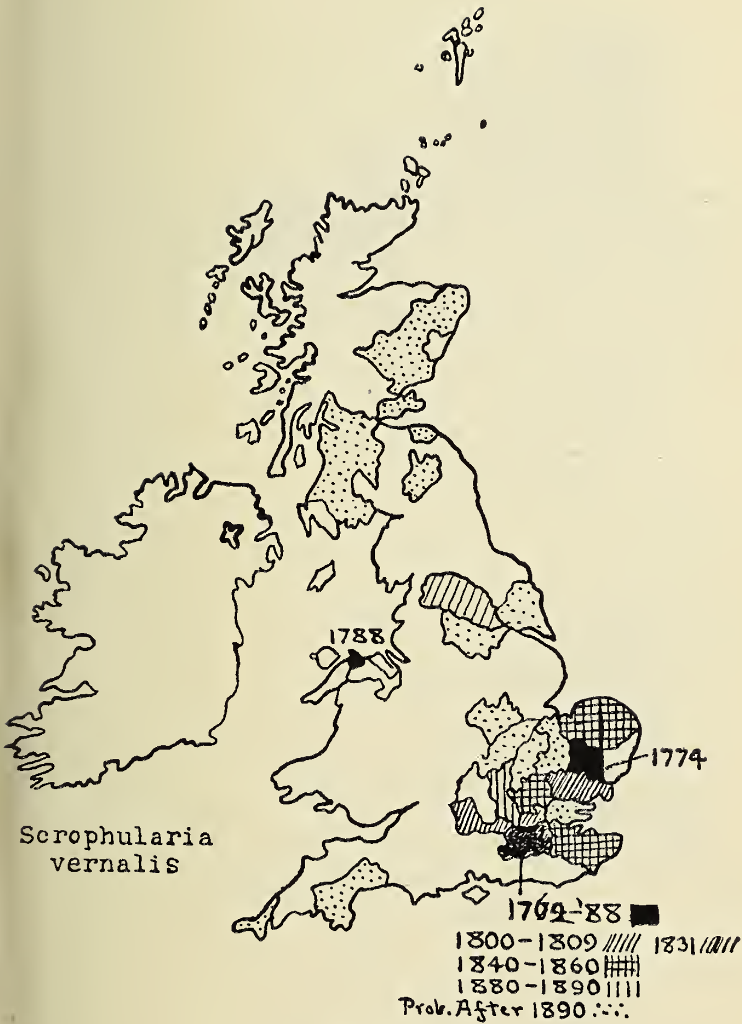
The distribution maps of *Matricaria suaveolens* (Map 106) *Lepidium Draba* (Map 99). *Impatiens* spp. (Maps 100 and 101) *Mimulus guttatus* (Map 103) and *Scrophularia vernalis* (Map 96), which by means of differential shading shew in general the rate and manner of spread of these species in England, illustrate this discontinuity of extension in a striking degree. Moreover, they demonstrate that the types of distribution in Britain, even of species known to be recent immigrants, is no criterion of the direction of their spread, and disposes at once of any suggestion that the types of distribution of "native" species which we have already considered are in any significant degree determined by the length of time which has elapsed since they came into Britain.

Turning to the relation between the range of recent immigrants and the mechanism of dispersal it is noteworthy that the species whose rate of spread has been very rapid are very diverse in this respect. *Matricaria suaveolens* has fruits which are mainly dispersed in mud, upon the feet of cattle, boots, tyres, etc.; and it is very probable that the rapid extension in area of this species subsequent to 1900 was in no small measure due to the coincident increase in motor transport. The patterned tread of the motor tyre is a peculiarly efficient means of dispersal for mud containing seeds, which may be conveyed long distances before the shrinkage on drying results in its dislodgement from the depressions of the pattern.

Impatiens parviflora, another species which has spread rapidly, possesses explosive fruits like its congener, yet these two species have extended their range at very different rates (see Maps 100 and 101). The remarkable extention of *Elodea canadensis* within a few years of its introduction,

Map 95

Map 94


1788
1774
1800-1809
1831
1840-1860
1880-1890
Prob. After 1890
Scrophularia
vernalis

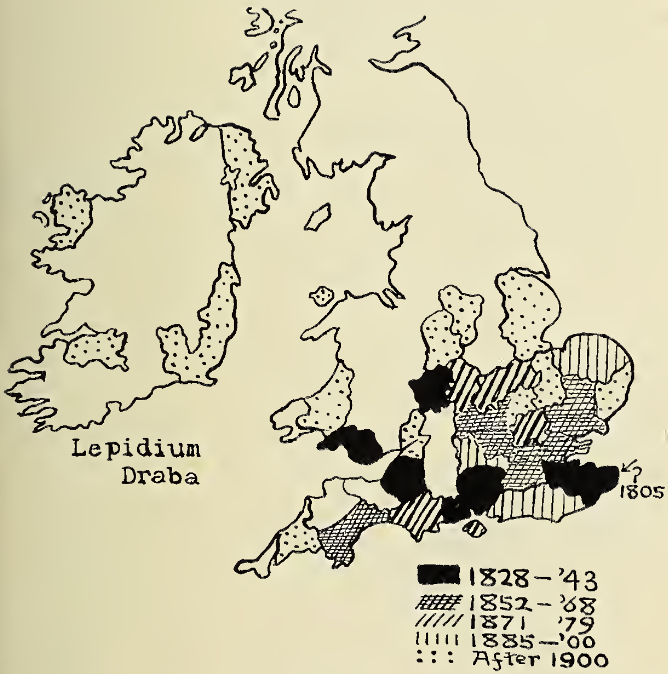
Map 96

Senecio viscosus

Map 98

Senecio squalidus

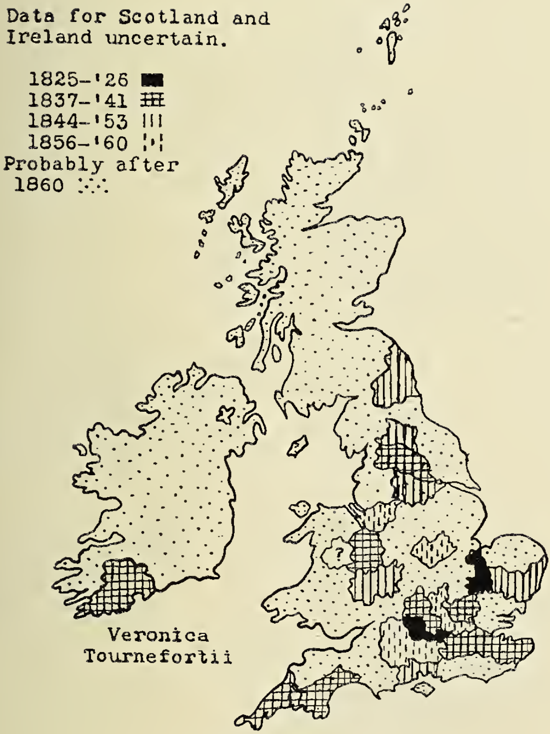
Map 97


Lepidium
Draba
1805
1828 – '43
1852 – '68
1871 '79
1885 – '00
After 1900

Map 99

Map 100

Map 101


Data for Scotland and
Ireland uncertain.
1825-'26
1837-'41
1844-'53
1856-'60
Probably after
1860
?
Veronica
Tournefortii

Map 102


Mimulus
guttatus
1830
1840–'59
1863-'67
1879–'87
1890–1900
Prob After 1900

Map 103

Map 105

Map 104


Matricaria
suaveolens
Before 1900
1900 — '09
1910 — '19
1920 — '24
After 1924
? Absent

Map 106

entirely by vegetative propagation, is too familiar to need more than recalling. On the other hand, the rate of spread of the two species of Groundsel (*Senecio viscosus*, Map 98 and *S. squalidus*, Map 97) and *Erigeron canadensis* (Map 95), which might, from the efficiency of their wind dispersal mechanisms, have been expected to have been rapid, has been in reality comparatively slow. In contrast with these compositæ the Speedwell, *Veronica Tournefortii* (*V. Buxbaumii*) does not appear to possess any special mechanism for dispersal, although ants may assist in the spread of its seeds; yet this species shewed a remarkably rapid spread after its first appearance in this country just over a century ago. The same is true of *Mimulus guttatus*, first recorded in Wiltshire in 1830 (Map 103).

Whilst, therefore, it cannot be said that the study of recent additions to our flora affords evidence that one method of dispersal is significantly more efficient than another, it does appear to warrant the conclusion that the diverse modes of dispersal of species are, in general, so efficient that only in the case of the most recent introductions is one justified in postulating vagaries of dispersal to explain peculiarities of distribution. In time, the opportunities for immigration and extension are probably manifold, though the opportunities for survival in competition may be few. The most recent additions to our flora thus confirm the conclusion that environmental conditions determine the presence or absence of species.

The species known to have immigrated into Britain, or to have been introduced in recent years, are but the last of a long line of immigrants extending back through the centuries to glacial and pre-glacial times, so that whether we call a species "native," "denizen" or "alien" is often a matter of degree, rather than of kind. Such distinctions may not only have little value, but also may even be very misleading. Whether the species occupies natural habitats and communities or can only survive under conditions that are artificially maintained, is of real importance, though native species, as we have seen, may be partial to artificial conditions; whereas recent introductions, such as *Elodea canadensis* and *Mimulus guttatus*, occur as constituents of quite natural communities. Nevertheless, though such a criterion of indigenous origin is invalid, the fact that very few recent additions to our flora can survive in the more advanced phases of plant succession (the introduced continental strain of *Pinus sylvestris* so rapidly colonising the sandy heaths of Devon and Surrey is a notable exception) suggests that such continental species of these later succession phases as do not occur, are absent rather because the conditions of the environment are unsuitable than because the opportunity for their introduction has been lacking. It is true that additions to the comital records of our "native" species are constantly being made, but there is reason to believe that these are, usually at least, due to inadequate knowledge in the past, rather than to recent extensions of range. Most such records indeed concern critical species and segregates, the distinction and distribution of which has only recently been studied. On the other hand, such additional records of Benthamian species as have accrued, apart from their occurence as casuals, have not significantly modified our concepts of their British range.

(i) Species of General Distribution

The species of general distribution in Europe present in the East Anglian Flora are too numerous to cite individually. Most have a similarly wide distribution in Britain and, though of interest from the point of view of their marked plasticity and wide climatic tolerance, they have little significance for our present purpose of comparative study of geographical distribution. Attention should, however, be called to one very noteworthy exception to the above generalisation viz., *Naias marina*, which has its only known British localities in three of the Norfolk Broads, where it was first found in 1883. Whether this represents a recent introduction or was previously overlooked cannot be ascertained, though the former is quite probable in view of the very wide range of this species abroad.

SUMMARY

The East Anglian Flora has, in the foregoing pages, been considered from the comparative geographical standpoint of the constituent species which are here classified into Eight Components, of which four are further subdivided into eleven elements (P. 204). These groups are based on the main area of occupation by the constituent species on the Continent of Europe.

The value of experimental introductions is stressed as the only means of definitely ascertaining whether the absence of species is due to unsuitability of the environment. The need is emphasised for more data as to the type and phase of succession of the communities in which rare species are found. The status of species mainly associated with artificial habitats is discussed and the view advanced that many of these may be truly native to early phases of the plant succession. The importance of the waning phases of the Pleistocene epoch for species of this type is indicated.

The mode of occurence of species at the limit of their range is held to depend mainly on the competition factor, and that in general the later the stage of succession to which a species belongs the more abundant does the species tend to be towards its climatic limit.

The recent geological history in East Anglia is briefly considered and the conclusion drawn that it is highly improbable that any considerable proportion of the Flora survived from Preglacial or Interglacial times. Such few as may have survived were almost certainly hardy northern types. It is suggested that the widerspread character of many of these hardy species may be due to (1) their survival in the unglaciated parts of England, and (2) their priority of immigration into the unoccupied ground exposed with the retreat of the Ice-sheet.

The importance of the Post-glacial climatic fluctuations for facilitating the immigration of the various geographical components is emphasised. The survival of the more specialised types, under a less favourable climatic complex, has been rendered possible by local and peculiar edaphic conditions.

Lists are furnished comprising species of all the more important elements, and the distribution of characteristic members is illustrated by means of maps. The comparative analysis of the various elements clearly demonstrates *the dominance of the climatic factor in determining the distribution of species within Britain*. The importance of edaphic conditions and, less markedly, of topography and the biotic factor in modifying the climatic complex is shewn especially where these accentuate the meteorological tendencies.

The following generalisations appear to be justified from the data furnished :—

(1) That the type of distribution in Britain can usually be correlated with the climatic preference (or tolerence) as indicated by the Continental distribution of the species.

(2) The northern limits of southern species in Britain and the southern limits of northern species can be grouped naturally into three categories according as the limit is diagonally S.W.—N.E.; Diagonally N.W.—S.E. or approximately E.—W. The direction of these limits is shewn to be generally symptomatic of the climatic tolerance, or preference, of the species for Continental or Oceanic climatic conditions.

(3) The evidence is in favour of the present distribution of most species being due to the suitability of the climatic-edaphic complex, and not to any influence of the time factor on dispersal.

(4) The Watsonian groups, from their purely insular basis, are liable to obscure the true geographical distribution affinities.

(5) The absence of a species from, or its presence in, Ireland corresponds in general with the intolerance, or tolerance, of Oceanic conditions; and it therefore would seem that the absence of species from Ireland is not in general to be attributed to accidents of dispersal. This is clearly indicated by the fact that, whereas of the Oceanic and Southern Oceanic elements, together representing over seventy species, over eighty per cent. extend into Ireland, only fifty-eight per cent. of the continental species extend into Ireland; whilst of the markedly continental Steppe element the proportion reaching Ireland is only 12 per cent.

Of the land and fresh-water mollusca, for which the facilities for dispersal are probably less than for seed plants, 80 per cent. occur in Ireland and of these most shew approximately the same extension in England on the east as on the west; only about 11 per cent. of these Irish species shew any appreciably diagonal northern limit in the S.W.-N.E. direction and about an equal number shew a diagonal limit in the S.E.-N.W. direction. On the other hand the former type of limit preponderates in those species which are confined to England. Probably the nearest approach to the type of distribution shewn by plants with their limit in E. Anglia is that of *Theba cartusiana* which extends from East Anglia to Hampshire and is perhaps the nearest approach to a steppe species amongst our British land mollusca.

(6) The distribution of many continental and southern species is shewn to exhibit a marked similarity to the distribu-

tion of the number of hours of sunshine. Evidence is afforded that certain continental species fail to produce any appreciable proportion of fertile seed in a season deficient in sunshine, and it is suggested that this may be an important factor in determining the geographical limits of southern and continental types.

(7) East Anglia is shewn to possess two strikingly contrasted climatic areas, in which the marked difference in precipitation is accentuated by differences of the soil and topography. Hence the striking juxtaposition within East Anglia of both continental and oceanic types, which renders the flora so rich, is no indication of indifference to climatic factors in the species concerned. On the contrary, their distribution within the county of Norfolk alone emphasizes the importance of climatic distinctions and the part played by soil conditions in ameliorating or accentuating them.

For purposes of comparison within the British Isles the concept of "Comital frequency" has been found useful. This is the number of counties and vice-counties in which a given species has been recorded expressed as a percentage of the total number. Owing to the latitudinal equivalence of England and Ireland comparisons of comital frequency between them are especially significant.

(8) It is shewn that, though calcareous soils are chiefly encountered in the South-eastern parts of England, even markedly calcicolous species may have a wide distribution in Britain, if tolerant of oceanic conditions. Amongst the species associated with each of the marked soil types, there are representatives of all the distribution types, so that it is unlikely that the latter are appreciably affected by the former.

(9) The evidence afforded by species of known or presumedly recent immigration into Britain gives no support to the view that the type of distribution is influenced by the length of their occupancy of this country, except in some though not all of the most recent arrivals.

(10) The recent immigrants support the view that the extension of a species to its climatic limits is commonly discontinuous, though local continuous extension occurs from the centers thus originating. It follows that the type of

distribution is no indication either of the time of occupation or of the direction of dispersal.

(11) On the assumption that the earliest record for Britain represents the approximate location of the first introduction of recent immigrants, there appears no ground for regarding dispersal as taking place more readily in one direction than another.

(12) The Northern Component (p. 206), which comprises some two dozen species, would appear in general to be a diminishing one, and evidence is offered that low humidity is an important factor in their restriction. Although probably comprising the most ancient members of our Flora, the arctic element consists of some of the most restricted species.

(13) The Southern Component comprises about one hundred species, of which about fifteen per cent. are Mediterranean, eighteen per cent. southern in the less restricted sense, and sixty-seven per cent. continental southern types. Sixty per cent. of the Continental-Southern Element exhibit a diagonal limit in the S.W.—N.E. direction, indicative of their comparative intolerance for oceanic conditions. Many have a distribution south of the line from the Bristol Channel to the Wash. Comparison between different calcicoles indicates that soil types play little, if any, part in determining this distribution, except in so far as well-drained soils render possible their northward extension.

(14) A parallel is shewn to obtain between the northward extension of range and the western extension. Comparison between pairs of species having comparable modes of dispersal indicates that the causes are environmental rather than temporal.

(15) The Oceanic Component comprises seventy-four species, of which about fifty-eight per cent. are species of Western Europe and forty-two per cent. species of the Southern-Oceanic Element. The majority of these exhibit a diagonal limit passing in a S.E.—N.W. direction thus offering a marked contrast to the Continental-Southern Element. It is suggested that the restriction of certain species to arid habitats in oceanic conditions is determined by the competition factor.

(16) The Continental component comprises twenty-five Steppe species, forty-four central European species and thirty

Northern-Continental species. Only two of the first named occur in Ireland, where they are rare. The view that these Steppe species are in part a survival from the preglacial flora of the ancient Rhine distributary is held to be untenable; their occurrence is associated with a combination of low rainfall and favourable edaphic conditions. The Northern-Continental species include a number of wet habitat types which mostly extend into both Scotland and Ireland.

(17) The West-Central European Element comprises few species; but some of these are local and exhibit marked discontinuity, indicative of peculiar requirements which the compromise between Continental and Oceanic conditions suggests.

(18) The endemic Component comprises six species, and it is suggested that *Oenanthe fluviatilis* may formerly have belonged to this category. These endemics include types of distribution similar to those representative of the diverse elements, so that their distribution is unlikely to be connected with their presumedly recent origin.

(19) The study of the diverse elements confirms the view that the distribution of species in Britain is determined by environmental factors, and thus constitutes a useful clue to specific requirements.

In conclusion the author would like to express his indebtedness to the Society for having made possible the reproduction of distribution maps of so large a proportion of the more interesting species of the British Flora, which it is hoped will prove valuable to students of geographical distribution generally. Also to Dr. S. H. Long for valuable assistance in seeing the manuscript through the press.

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II

WILD BIRD PROTECTION IN NORFOLK IN 1932

Report of the Committee

Once again the Committee has to express its appreciation of the support it continues to receive for its work of Bird Protection in Norfolk, and thanks all subscribers for continuing their subscriptions in a specially difficult year.

The Norfolk Terneries

For many years Terns have nested in varying numbers on different sites on the Norfolk coast line, and since these have been placed under the care of watchers their numbers have very largely increased. At the present time there are three principal terneries :—on Scolt Head Island, Blakeney Point and Salthouse Broad. These three areas offer alternative sites, and there appears to be no obvious reason which will be selected when the birds arrive. All are very exposed, but the eggs of Terns and of other shore nesting birds, such as the Oyster-catcher, would seem to be very resistant to changes of temperature. Success in rearing the chicks is dependent upon an adequate and easily-obtainable food supply which, in the case of the Common tern, is " whitebait " (young herrings, etc). The in-shoring of these small fry usually takes place about the time the young are born—towards the end of June—but this year it did not do so until about a week after the first clutches of eggs were hatched. This necessitated both parents flying far out to sea to get food ; the weather was very cold at the time and in scores of instances they returned to dead chicks—dead from exposure and starvation. On June 19th, for example, Chestney, the Scolt Head watcher, went round the ternery and picked up scores of dead newly-hatched birds. A similar experience is recorded from Blakeney Point. Many of the birds laid second clutches, but a big tide on July 6th washed out a number of these on Scolt Head, and a sand storm covered many eggs.

During the past two years a small island on Salthouse Broad has been the site chosen by the Sandwich terns, and here there were about 600 nests this year, all so close together that it was impossible to walk between them. The eggs hatched out well and there was no undue mortality amongst the chicks. Several hundred of the latter were ringed. A few Black-headed gulls also nested on the island. On Blakeney Point there were twenty-eight Sandwich terns' nests containing thirty-eight eggs and on Scolt Head 204 nests.

The largest colony of Common terns in Norfolk is still at Blakeney Point where, on June 8th, Mr. Marples and the watcher made a careful census and counted 1459 nests containing 3797 eggs. There were five nests with four eggs in each, and 974 with three eggs. The tendency of the birds is to extend their nidification area from the Far Point and the nests are now distributed in the lows, dunes and shingle ridges as far east as the Beachway. On Scolt Head Island the Common Terns nest over a wide area, so that it is impossible to make an accurate census, but from 500 to 600 nests would be a conservative estimate for the past year.

Nests of the Little Tern are found dotted about in many places along the Norfolk coast line, but they are in greatest number on Scolt Head, where 122 nests were counted this year ; and on Blakeney Point, where there were twenty-one nests.

A Roseate tern was identified on the Scolt Head ternery on May 26th and was seen, on and off, until June 30th ; but a second bird never arrived, and there is no evidence of the Roseate having nested in Norfolk in 1932.

Gulls are, perhaps, the most formidable enemies of the terns during the breeding season, and repeated attempts of the Black-headed gull to obtain a nesting footing on the terneries have to be frustrated. A small colony nest on the marsh about two miles to the east of the ternery on Scolt Head, out of range, and are allowed to remain ; but this year all the nests, and second and third layings, were washed out by high tides. On the other hand, a considerable number of the larger gulls—immature Black-backed and Herring gulls—hang about the sands near the ternery all the summer and make periodic raids upon the eggs and chicks. It is difficult to control these robbers.

Cley and Salthouse

The following notes on the rarer birds seen on or near Salthouse Broad between January 1st and September 17th, 1932, are supplied by Mr. R. M. Garnett, of Kelling.

Ruff.—A ruff (or reeve) was feeding among Redshanks during a spell of squally wintry showers and frost on February 11th, an unusually early date; another was seen on May 31st; a little party of three on August 2nd and a pair together on September 7th.

Long-Tailed Duck.—Three, probably young males, on February 15th, and a young male on March 5th. Conditions cold.

Goosander.—An adult drake on February 15th. It had been seen on the previous day by A. L. Hodgkin, who told me of its presence. Wind north for several days previously.

Goldeneye.—Six, one an adult male, on March 13th. Cold, with snow. Five days later the male was seen displaying, with a cold north wind blowing.

Black-Tailed Godwit.—Two, not yet in summer dress, on May 16th, and another on August 13th and 27th.

Spoonbill.—An adult was seen by E. Cohen and myself on May 18th. This bird remained in the vicinity for about a fortnight, being last seen on May 30th. Dr. Ennion reported to me that a second bird joined it on May 26th. On July 7th another arrived, and departed on the 10th.

Black Tern.—One, on a very cold day with N.-E. wind, on May 24th. An immature bird, with a white patch completely surrounding the base of the bill, was seen by Miss M. Barclay, myself and others on June 16th; the wind had been N.-E. for several days. Two others during the first half of September.

Gadwall.—One was seen on August 3rd, an unusual duck on this broad. On August 15th one was shot.

Spotted Redshank.—Two, in autumn plumage, seen in August, and one on September 7th.

Greenshank.—One seen on July 9th; an early arrival.

Bluethroat.—A female, somewhat decomposed, was picked up by Holman, the keeper, on Salthouse beach on May 31st. It was shown to me.

Hoopoe.—On June 5th one was found by Holman resting on "Little Eye," and was seen, later, by Mr. John Armitage and myself. This is the first June record for Norfolk.

QUAIL.—On June 12th I heard a male calling in a strip of oats opposite Salthouse Broad. I have no evidence of nesting.

On the night of August 20-21 a migration of small passerines was held up by a sea fret, and on the 21st there were seen on "Little Eye" Pied flycatcher, Whinchat, Common Redstart, Blue-headed wagtail; and among other passerines were counted twenty-two Wheatears. On August 23rd a dun-coloured swallow was seen at close quarters.

To these records may be added a Great Grey Shrike seen at close quarters on Blakeney Point by Mr. A. Holte Macpherson and Dr. Carmichael Low on September 16th, and two Lapland Buntings seen by the same observers on Salthouse beach on September 18th.

BROADLAND

The following notes from the Horsey-Hickling district have been supplied by Major Anthony Buxton, of Horsey Hall, and to these he has added some notes supplied by Mr. Jim Vincent, of Hickling.

I have had so many dealings with birds this summer, that it is a little difficult to know what to include in these notes and what to omit. As a newcomer to the district, I will start with one or two general impressions.

The following birds, which were once threatened with extinction, seem to have got a good hold as breeders, at any rate in the Hickling-Horsey area: Bittern, Montagu's Harrier, Bearded-Tit, Garganey. The Marsh-Harrier is just reaching, but has not quite reached, the same position. In my opinion we shall not have long to wait before we get back the Black-tailed Godwit, Avocet, Ruff and Black Tern. A fair number of these birds pass through in the spring, on their way to Denmark, Holland, or other parts of the Continent, and rest sometimes for several days on the broads. In any year, by some lucky chance, a pair or two may stop and thus form the nucleus of a nesting colony. One of the puzzles of the broads is the absence of Tufted Duck, Gadwall and Pochard as breeders. Why is it that they prefer West Norfolk to East Norfolk in the summer, whereas Tufted Duck and, still more so, Pochard, swarm in certain places on the broads in winter?

There is naturally a difference of opinion with regard to Harriers and other birds of prey. As long as the present worship of pheasants and partridges (and to a less, but increasing, extent of ducks) continues in England, and the gamekeeper is allowed a free hand, human sportsmen will ensure that most of their winged competitors come to a speedy end. From what I have seen this year there is an equal antagonism between the birds of prey themselves. A cock Montagu's Harrier or a cock Marsh-Harrier has fairly to sharpen his claws and keep himself in good flying trim, if he is to succeed in securing a breeding territory, and a wife wherewith to rear a brood. Apart from rivals of his own kind and his near relations, there are the egg-clutchers, the sentimentalists who are all over the song birds, and in honesty I must admit the photographers.

There were, to my knowledge, four egg-clutchers on my property at different times this summer, and no doubt others that passed unsuspected. One pair was caught just in time, and as the nest was a Marsh-Harrier's, I dared not risk letting them get far enough to provide evidence for prosecution. Another was accosted and apparently frightened out of the district; eyes were on his boat from 5 a.m. till he left at midday. A third, judging by tracks, hunted hard for a Bittern and probably took its first eggs, but it later had a brood. A sentimentalist endangered, but did no harm to a Montagu's Harrier's nest. A photographer—myself—caused the desertion of a Marsh-Harrier; in part I blame the bird, and so I believe does her husband, but I have little doubt that the lady blames me. The whole of that peculiar story, together with the story of the second nest, which we saved from the egg-clutchers and eventually filmed, has been told in "Country Life." A good deal has been written about bird photographers this summer, some of it by people of very limited experience, but it is a fact that photographers need keeping in order. In my opinion they can learn more than anyone else about birds, if they behave themselves, and—more important—can pass on their knowledge to a wide circle of the public, thereby creating an increased interest in the subject.

To go into detail of individual species:—

WARBLERS.—I did not realise until I came to the broads that there were quite so many Sedge-Warblers in the world; they literally swarmed this summer. There were also great numbers of Reed-Warblers in certain places, but they were not distributed over nearly such a wide area as the Sedge-Warblers. Why there are no Great Reed-Warblers in England is a puzzle to me. Grasshopper-Warblers, while common, were not quite as numerous as I expected. Every harrier's nest seems to have at least one pair of these birds in close attendance.

My garden looks ideal for the Blackcap, and the following record seems to me peculiar. A single cock arrived on April 25th, but stayed only a day or so. There was no other Blackcap until June 3rd, when, again, a cock appeared. A second arrived a few days later, seized the other end of the garden and eventually secured a wife, the other cock remaining a bachelor and singing his heart out all the summer, as bachelor warblers always do. Being so late in arriving, I imagine that these birds were individuals driven away by rivals from a good blackcap district, which the broads evidently are not.

At Horsey there were a few pairs of Garden-Warblers, considerably more Lesser Whitethroats, and a large number of Common Whitethroats. A cock Wood-Wren stayed three days in my garden and then passed on. Very few Chiff-chaffs passed and none stayed (one was heard going south on September 18th), but there were, of course, plenty of Willow-Wrens. No Goldcrests in the summer, but nearly always one or two in the winter, the first arriving this autumn on September 11th. Blue-tits lived all round the broads throughout the winter, as well as in the gardens, etc. The stock of Great Tits was much larger in the winter than in the summer. One pair of Marsh-Tits nested at Horsey, and a few Coal-Tits appeared occasionally in the garden in winter. There have been great numbers of Long-tailed Tits this Autumn, but not a single pair nested on the property.

There were about ten pairs of Bearded-Tits breeding at Horsey, and about twenty-four pairs at Hickling. In the spring they seem to feed entirely upon a fly and its grub which live on the lesser Reedmace.

WAGTAILS.—Yellow-Wagtails, arriving April 17th and following days, were local and not so common as the country seems to warrant. Possibly they need more cattle than at present exist to attract insects.

J. Buxton

CHATS.—Stonechats bred wherever there was a suitable spot, but the rarity of Whinchats was noticeable. Numerous Wheatears passed in spring and autumn, but it is doubtful if any bred on the property.

SHRIKES.—There were several pairs of Red-backed Shrikes breeding in what might be described as isolated colonies.

BUNTINGS.—Corn-Buntings were common, too common for my tastes, in certain places. I understand that the Hen-Harriers prey on them ; if so, I wish them the best of sport, for no uglier bird and no uglier note is known to me. Two pairs nested close to a Montagu's Harrier's nest. Reed-Buntings were very nearly, but not quite, so numerous as Sedge-Warblers. The young appear to be much enjoyed by Marsh-Harriers, and are no doubt very easy to catch. A Snow-Bunting was seen on September 13th.

WATER-RAILS.—Water-Rails are very common, but there are said to be less than formerly. I have never been in a country where there were more.

PIPITS.—Mr. J. Vincent saw a Water-Pipit on April 8th.

BITTERN.—On one occasion seven male Bitterns were heard booming simultaneously from Horsey Staithe, and seven between Catfield and Blackfleet broads. Bitterns were heard booming as late as August 2nd. There were certainly four broods on the Horsey property. One of the nests contained six eggs ; five were hatched naturally, and I personally hatched the sixth, but neither its mother nor any of the rest of the family took any interest in the infant either before or after it was hatched ; it squealed loudly both before and after hatching. Four young were reared from these six eggs. I believe that all the first nests of bitterns at Horsey were destroyed by high water.

Bitterns appear to be the worst of mothers, casual and neglectful to a degree, relying on the first-hatched chicks to keep the later ones warm, which they are quite incapable of doing. Some of the cocks boom fairly near the nests, but in one case no cock was heard to boom within 400 yards of the nest. Booming, therefore, seems to be an unreliable guide as to the situation of the nest. Booming deteriorates into a few feeble grunts after the young are hatched.

A good deal has recently been published about the " powderpuffing of the Bittern," and it is indeed strange that no one in Norfolk had apparently seen it before this year.

Despite their intense stupidity Bitterns are quite amusing to look at, particularly while feeding their babies ; first with clear soup sucked from the base of their bills, and then with eel or other fish out of their crops. One bird, with five young, disgorged eight eels simultaneously, handed round one to each baby and then re-swallowed the remaining three for a future occasion. I saw and filmed one baby being taught to fish for a dead roach out of the water round the nest. The best part of the performance, however, is the departure of the parent bird from the nest by means of a slow climb up to the top of the reeds, whence it takes its flight. Nobody looking at a bittern would expect it to be a mountaineer, and nobody looking at the reeds would expect them to bear the weight of a bittern. To what extent a cock bittern assists in the rearing of a family is doubtful, but in one case at least he visited the nest in my presence, and in another he came very close. He was not seen to provide any food nor anything else of value.

Grebes.—There were four pairs of Great Crested Grebes nesting on Horsey mere this year. The nest that was kept under observation had three eggs, all of which hatched ; but after getting two young safely off, the parents were not in favour of having any more and left the third egg to hatch in the sun, never taking any further interest in it. Judging by the normal size of grebe families, this would seem to be a common practice. When hatched the young were taken for a turn on the mere on their father's back, and occasionally on their mother's. To the best of our belief the only food given to them during the first day of their existence consisted of feathers from the back of their father's neck, carefully selected and pulled out by that bird and handed to the babies, which nibbled them slowly up. The cock grebe seemed to be rightly regarded by the hen as being inefficient at everything, particularly nest-building, except the business of taking the babies for a row on the mere. This was clearly his job, and he did it very well, seeing that the babies kept themselves well tucked up in his feathers when the weather was cold by poking their foreheads down with his bill. These incidents are all recorded on the film. Grebes have apparently very good ears, and this pair could quite obviously recognise the sound of my motor-boat from that of any other motor-boat on the mere.

Ducks.—It was a bad spring for Garganey, but a good one for Teal and Shoveller. At Horsey there were from ten to fifteen pairs of Shovellers breeding, but only three pairs of Garganey. Large numbers of Shoveller appeared at Ranworth at the end of January, but they did not spread about the broads until considerably later. The first Garganey appeared at Ranworth on April 1st, and a pair of Gadwall were seen the same day. During the winter there were always a few Goldeneye and a certain number of Scaup with the large flocks of Pochards and Tufted Ducks on Horsey Mere. Two Common Scoters appeared on the mere in April and stayed a day or two; others were seen at the end of October. A small flock of Tufted ducks were seen up to the end of April, but none of them bred at Horsey, although a lone hen, probably a pricked bird, remained through the summer.

Geese.—White-fronted geese were seen in the middle of September.

Waders.—Redshanks and Green Plover nested on the marshes, also a good number of Snipe. I heard the first Greenshank on April 23rd, and others passing south on September 11th. Grey Plover were heard migrating at the end of April, and again in the middle of September. A Ruff was seen on March 22nd, and two Reeves, at both Hickling and Horsey, between August 2nd and September 12th. They were absolutely silent whenever I saw them. Amongst other waders seen were the Wood-Sandpiper, Little Stint, Turnstone, Spotted Redshank and Red-necked Phalarope.

A Spoonbill was seen on May 17th at Hickling.

Gulls and Terns.—Black Terns were passing through from April 28th for about a week; they were hawking gracefully about over the mere, catching insects and were very tame. A small colony of Little Terns shared Horsey beach with the Ringed Plovers and did a lot of fishing on the mere, as well as in the sea.

Vast quantities of Greater Black-backed Gulls come to rest, wash, and brush up, on the mere every day during the herring fishing season, arriving soon after sunrise.

Birds of Prey.—Birds of prey have always appealed to me and there has been quite a good show. A pair of Hen-Harriers and a pair of Rough-legged Buzzards spent the winter and did not leave until the end of March. Common Buzzards were seen at intervals throughout the winter and early spring.

Peregrines seemed to appear and disappear with Mallard and Teal. Short-eared Owls were in considerable numbers in November, but only one pair is believed to have bred in the neighbourhood, and as they were not on my property I do not know how they fared.

There were at one moment five pairs of Marsh-Harriers on the Hickling-Horsey area, but one pair, after twice thinking of nesting just where sailing boats tie up for the night, apparently left the neighbourhood. They probably did not go very far, for the cock, who had very white patches on head and shoulder, was seen in September. This bird would have undoubtedly been killed by a cock Montagu, but for the timely arrival of his wife. He had ducked into the rushes to avoid the Montagu, which tilted up to about forty feet, shut his wings, and swooped on him like a Peregrine. The hen Marsh bustled up and got the Montagu off. We looked for the cock Marsh, but he must have been squatting, for he never got up. In any event he escaped, for I saw him next day.

The cock of the pair, whose nest was deserted, owing to the approach of my guide was a very pugnacious bird. We found the corpse of the first cock to arrive in the spring floating in a dyke under his preening post, no doubt slain by his rival, who apparently lost a wing feather in the process. I saw him on September 12th with the wing feather still missing. This pair must have nested again, for the cock was seen up to about July 20th carrying kills regularly into his particular marsh, but they subsequently disappeared and nothing is known as to what occurred, for we were then too busy on another pair. This other pair consisted of a cock about the colour of a Red Kite and a very dark hen with a yellow head. She was a fiend in temper, he was a very good sort.

After being saved from egg clutchers by us, the hen proved entirely lacking in gratitude and a most difficult creature to deal with. After six weeks' work and twice retiring the hide we got our first bit of filming when the young were about a fortnight old. Ten days later the hen, after every display of temper and sulks, struck work for good and literally

Photo] [*A. Buxton*

Cock Montagu's Harrier throwing prey to young in nest

(The prey is the black-and-white striped object which has hit the young bird on the left of the picture)

passed us the babies, which the cock and we successfully reared between us. The story is recorded in "Country Life," and these notes must be confined to the cock's gamebook, which we have practically complete for ten days, thanks to his habit of making a larder thirty yards from the nest.

The main prey was young water-hens, but there were also a few young partridges, one or two pheasants, hares, rabbits, blackbirds, starlings, young reed-buntings, young sedge-warblers, water-rails, water-rats, short-tailed field-mice and one frog. All the family, except the old hen, were about up to September 20th and were killing land rats. We never saw her again after July 19th, and never wish to. These feelings are doubtless reciprocated. There were two nests of Marsh-Harriers at Hickling; one with three eggs, which were forsaken; the cock of the other nest disappeared about July 4th, and may have been shot.

I watched two nests of Montagu's Harriers in the neighbourhood, within fifty yards of each other.

During long observation of the best looking pair of Montagu's Harriers I ever saw, we came to the conclusion that the cock only visited the nest when his wife's hands were full, or when she was absent. In short, if he could find no one to pass to, he came on, not otherwise. The main prey was skylarks and meadow-pipits, but the cock had one good morning with my partridges and got two brace in quick succession, apparently just as they left their shells. Better than anything else, however, the Montagu's—both the young and their mother—liked sandwiches, ham, egg, cheese or sardine. The hen would be down to a sandwich on the nest directly she saw it. This nest contained five young, all of which got away safely. The hen who appeared to be a very old bird, carried a ring on her right foot, but we could not read it and did not like to catch her, as it might have spoiled the very friendly relations we had established. On several occasions she appeared either smoking a cigar or using a tooth-pick—either description would do. She held a bit of dead rush in her mouth, at the angle of an American's cigar, and kept rolling it round with her tongue. She was one of the nicest individual birds I have ever met, and a first-class mother.

We were once treated to a flying display by this pair of

Montagu's. The performance centred on the manœuvre of the "pass." Nothing was in their claws, but they swirled and swooped, often sideways and on their backs, at each other, screaming with excitement. This cock was the bird that nearly slew the cock Marsh-Harrier, and it was probably he who slew the rival cock found on June 9th and carrying a ring put on him at Hickling in June, 1930. The second nest of Montagu's Harriers belonged to what appeared to be a much younger pair of birds. They nested about a fortnight later than their neighbours and hatched all four eggs, but two of the young died in infancy. The other two were successfully reared. I am told that both Montagu's Harriers and Short-eared Owls feed mainly on short-tailed field-mice, and that when this rodent is plentiful in the spring, there is a good breeding stock of both of these birds. This year there would seem to have been a short supply of mice, Short-eared Owls and of Montagu's Harriers.

Breckland

The extensive afforestation that has already taken place, and is still being pursued, by the Forestry Commissioners in Breckland has for some years been a matter of concern to the Committee, from the point of view of the preservation of the Stone-Curlew, so that it is highly satisfactory to be able to report that during the year The Norfolk Naturalists Trust has negotiated an arrangement under which some 2,000 acres shall remain free from planting. The area referred to is Lakenheath Warren, one of the most typical bits of Breckland. In this report we reproduce photographs of two of the most characteristic birds of the district—the Stone Curlew and Wood-Lark—taken by Mr. Hugh G. Wagstaff during the past nesting season.

A Woodland Bird Sanctuary

At South Wootton, near King's Lynn, Mr. N. Tracy owns, and lives in, a small wood of about seven acres which he purchased eleven years ago with the object of making a sanctuary for birds. That he has succeeded is evident to all who have had the pleasure of visiting his wood in the nesting season. We extract the following from his notes of the past year :—

Photo] [*H. G. Wagstaff*

Wood-Lark running from nest, which is in the dark patch behind the bird

He found the nests of the following thirty species of birds in his wood in 1932, as compared with twenty-one species in 1923.

Blackbird—many
Song-Thrush—many
Mistle-Thrush—several
Robin—three
Wren—several
Hedge-Sparrow—one
Starling—one
Great Spotted Woodpecker—one
Chaffinch—many
Redpoll—several
Willow-Wren—three
Redstart—three
Tree Creeper—four
Goldcrest—two
Long-tailed Tit—one
Great Tit—twelve
Blue Tit—six
Coal Tit—two
Marsh Tit—two
Wood-Pigeon—many
Stock-Dove—several
Turtle-Dove—one
Moor-Hen—one
Tawny Owl—one
Pheasant—several
Spotted Flycatcher—three
Greenfinch—one
House-Sparrow—one
Goldfinch—one
Cuckoo

The Long-tailed Tits started nesting on January 24th, and the female was seen carrying nesting material when there was an inch of snow on the ground. The young left the nest on May 9th.

Towards the end of April several pairs of Redstarts arrived in his wood, but only three pairs remained to nest. Some unknown robber took the eggs, and sometimes the nest lining, from all the boxes in which they were placed, even though the birds nested a second and a third time. Mr. Tracy came to the conclusion that the culprit was a female cuckoo, for cuckoos were numerous in the wood throughout June, and on June 27th he found a cuckoo's egg in one of the robbed nests. Mr. Tracy adds, " In the ten years that I have had the wood I have had between thirty and forty redstarts' nests and only two have come to grief through accident."

A pair of Great-Spotted Woodpeckers were turned out of their first nesting hole by starlings, even though Mr. Tracy shot ten of these intruders and hung them round the tree hole as a warning to others! He came to the conclusion that the male woodpecker alone did all the boring. This pair of woodpeckers eventually reared a brood in another hole, and it is interesting to note that Mr. Tracy found that the young were fed with flies which the parents extracted from oak apples. These were wedged in the clefts of branches so that they could be pulled to pieces. The parent birds also split open the oak root galls for the grubs contained in them, and to get at these they went down to the ground and attacked them *in situ*.

Mr. Tracy had three pairs of Wood-wrens just over his boundary, and a pair of Wood-Larks outside his wood. He located only one Crossbill's nest, which was in building by the hen bird on January 17th. The young hatched off safely. He found the usual number of Siskins in his district, and on February 14th saw a large flock feeding on larch cones.

Miscellaneous Notes

The Chaffinch was first heard singing, in Norwich, on February 9th.

On March 4th eleven Waxwings were seen by Mr. G. J. Cooke in the grounds of the Norfolk and Norwich Hospital. This little colony remained in the gardens of Norwich for several weeks, and regularly paid visits to some hawthorn bushes in the grounds of the castle until they had stripped these of all berries. They were very tame. The last was seen by the writer on April 11th. There has been a further immigration of these birds this year. Mr. Victor Ames reports "many" in the lanes around Thornham on November 11th, and on the 30th Major S. W. Trafford showed one to the writer which had that day been picked up dead at Wroxham.

The Hawfinch is not a common bird in Norfolk, so that it is interesting to record that Mrs. Smith, of Ellingham Hall, found six young ones with three old birds on the lawn of the house on April 6th.

On April 15th, Mr. D. J. Thomas, of the London Nat. Hist. Soc. had a good view of a Golden Oriole on the roadside hedge between Morston and Stiffkey.

Black Terns, though regular passing migrants in spring and autumn, are not often seen to the number of eighteen over one small piece of water, as was witnessed by the writer at one of the West Norfolk meres on April 28th. On July 2nd a Black Tern visited Scolt Head Island and remained at the ternery all the day.

The Common Scoter (Black duck), except in the nesting season, is essentially a sea duck, and is infrequently seen on inland waters, so that it is of interest to record that, on August 2nd, the writer found a male on one of the inland waters of Norfolk, in about the centre of the county.

On August 11th a flock of between twenty and thirty small birds flew in from the sea to Blakeney Point and settled on and around the watcher's house. One entered and was caught, but was released. They were described as being from three to four inches in length, with blood-red bills and blood-red spectacles. After resting, they all passed inland. So far, they have remained unidentified, but they were certainly foreign birds and had probably escaped from some ship taking them, perhaps to Hamburg, or other ports in Europe.

A small colony of Black-headed gulls—about fifty pairs—nested again on Alderfen Broad this year. When visiting the broad on May 26th the writer found that about half the nests had been robbed of their eggs—there were no broken egg-shells—and there were several half-eaten gulls lying about on the floating hovers on which the nests were built. It was concluded that this was the work of an otter. (Query, do otters eat eggs ?).

During the winter of 1931-32 there were several Common Buzzards in Holkham Park, and on March 6th he writes saw three of these birds soaring over a wood that they frequented. They appeared to live on rabbits and by the instructions of Lord Leicester were in no way molested. It was hoped that one or more pairs would remain to nest, but there is no evidence of their having done so. In another part of the county fifteen Buzzards are said to have been shot during that winter.

The past year has not been what is sometimes called an osprey year, so that it is worth recording that early in September, when duck shooting on Buckenham Broad, Mr. E. C. Keith saw one of these birds, and a bittern. He says, " it flew round the broad twice and was very little disturbed by the shooting." It had been there about ten days, and left a few days after the shoot.

An unusual number of Common Buzzards visited Norfolk last winter, and on March 6th the writer saw three of these birds in Holkham park, soaring over a wood which MacEwan, the keeper, said they frequented. On one day MacEwan had seen ten of these birds. By instructions from Lord Leicester they were in no way molested, and it was hoped they would remain to nest, but the last two departed at the end of April. On one estate in the county it is reported that fifteen buzzards were killed last winter, but we have not heard whether these were " Common " or " Rough-legged."

Prosecution for Taking Sandwich Terns' Eggs at Salthouse

At the Holt Petty Sessions on August 5th, Henry James Knightley Burne, described as a solicitor's articled clerk, of The Nunnery, Diss, was summoned for taking eggs of the Sandwich Tern from a colony of nesting terns on Salthouse Broad. The defendant was represented by Mr. W. C. F. Brundell and pleaded guilty.

Robert Bishop, of Cley, the watcher of the Norfolk Naturalists Trust, gave evidence that he, with two others, saw the defendant walking over the marshes. He blew his whistle and waved to the defendant to turn back, but he did not do so and, instead, took off his boots and crossed a dyke to the island. He saw him stoop and put something into his pocket. On his return Bishop waited for him and said, " Have you got leave to go on there ? " Burne replied, " No." Bishop then asked, " Why did you not come back when I called to you and waved to you to come back ? " Burne answered, " I did not hear you." Bishop remarked, " You must have heard me." When asked for the eggs Burne said, " I have not got any." Bishop stated that he could see there were eggs in Burne's pocket and told him so, and defendant then pulled out six eggs of the Sandwich Tern. Mr. Hugh Thompson, of Thursley, Godalming, gave evidence corroborating Bishop's statements.

The Chairman (Lieut.-Col. F. Watson Kennedy) said that the magistrates looked upon this as a bad case for a man of defendant's position, especially as he had denied that he had taken the eggs. " We are determined to stop the taking of eggs," continued the Chairman, " Defendant will be fined £1 for each egg, £6 in all."

The Committee cannot conclude this report without expressing their thanks to the loyal watchers who so ably assist them in carrying out their work. For the information of those to whom they are not known, they are :—

For Scolt Head Island.—Mr. Charles Chestney, Dial House, Brancaster Staithe, King's Lynn.

For Blakeney Point.—Mr. William Eales, Blakeney Point, Morston, Blakeney, Norfolk.

For the Cley Marshes.—Mr. Robert Bishop, Hill Top, Cley, Norfolk.

For Breydon Water.—Mr. W. Bulldeath, 35, North River Road, Great Yarmouth.

The first three are employed as whole-time watchers ; the last during the five summer months—April to August.

Signed (on behalf of the Norfolk W.B.P. Committee),

SYDNEY H. LONG, *Hon. Sec.*

LIST OF SUBSCRIPTIONS AND DONATIONS TO THE NORFOLK WILD BIRDS PROTECTION FUND FOR 1932

	£	s.	d.
H.M. THE KING	3	3	0
H.R.H. THE PRINCE OF WALES, K.G. ...	2	2	0
Adam Miss M. E. ...	1	1	0
Ainslie Mrs.		5	0
Allars R. W. E. ...	3	3	0
Allen J. W. ...	2	2	0
Allen T. H.	1	0	0
Anderson Edward ...		10	0
Attenborough, Col. J. C.M.G.	1	1	0
Back H. W.	1	0	0
Barclay F. H. ...	1	0	0
Barclay H. G. ...	2	2	0
Barclay Miss M. ...	1	0	0
Barlow J. Allen, C.B.	1	1	0
Barnard Mrs. ...	1	1	0
Barrow Miss		5	0
Barry W. J.	1	1	0
Barton S. J., M.D. ...	1	1	0
Beevor Sir Hugh, Bart.	1	0	0
Beevor Thomas ...		15	0
Benn Sir Ion Hamilton Bart., C.B., D.S.O.	1	1	0
Bewly Miss N. ...		5	0
Blackburn C. J. ...	2	0	0
Blake H.	2	2	0
Bland Miss R. ...		10	0
Blatch Edward ...	1	0	0
Boardman E. T. ...	1	0	0
Carried forward ..	£33	11	0

	£	s.	d.
Brought forward ...	33	11	
Boileau Sir Maurice, Bart.	1	1	0
Bourne T. W. ...	0	5	0
Brash T.	2	2	0
Briscoe Capt. F. M. Eliot-Drake .		10	0
Brooks J. R.... ...	1	1	0
Brown E.	1	1	0
Brown H.	1	1	0
Bruce Mrs.		10	0
Buckle Lt.-Col. D. W.	1	1	0
Bullard Ernest ...	1	1	0
Bulwer Col. E. A. ...		10	6
Burrowes R. B. ...		10	0
Burrows Mrs. ...	2	0	0
Burton G. Murray ...	1	1	0
Butcher R. W. ...	1	1	0
Butler R. Fawsett ...		10	0
Butler Richard W. ...	1	1	0
Buxton W. L. ...	2	0	0
Buxton Major Anthony Proceeds of Lecture	6	16	8
Byers J.		10	0
Caffyn D. E. ...		10	0
Calder Sir James C., C.B.E.	1	1	0
Capron J. T.		10	0
Capron Miss J. ...		2	6
Carr Mrs. Laurence ...		10	0
Carried forward ...	£61	17	8

	£	s.	d.
Brought forward ...	61	17	8
Carruthers D. ...	1	1	0
Cassie R. L.		10	0
Cator John		11	0
Chadwick Dr. Morley	2	2	0
Chapman E. H., His Honour Judge ...	3	3	0
Churchill Mrs. Arnold		5	0
Clarke Mrs. Frank ...	2	2	0
Cleminson H. M. ...	1	0	0
"Cley"		2	6
Clogstoun H. P. S., M.B.E.	1	1	0
Clutton Brian ...	3	3	0
Coe Mrs. A. E. ...		10	0
Collar Arthur ...		5	0
Collier Dr. and Mrs. W. T.	1	0	0
Colman Miss E. M. ...	1	1	0
Colman Miss H. C. ...	1	1	0
Colman R. J. ...	1	1	0
Colomb Admiral P. H., C.B.	1	0	0
Cook Miss Margaret ...	1	1	0
Cooke G. J.		10	0
Cox Major General Sir Percy, G.C.M.G.		10	0
Cozens-Hardy A. ...	1	1	0
Cresswell Mrs. George	1	1	0
Dalgety Christopher T.	1	1	0
Dallas C. C.	1	0	0
Davis H. L. N. and P.	1	2	0
Deacon Dr. G. E. ...		10	0
De La Warr, Lady ...	1	1	0
Drury G. L.		10	6
Duncanson T. J. G. ...	3	3	0
Eccles James R. ...	1	1	0
Eddison C. R. ...	1	1	0
Edwards Francis ...		10	0
Edwards G. C. ...		5	0
Edwards Michael ...		5	0
Elphick Dr. G. ...	2	2	0
Ennion E. F. R. ...		10	6
Ennion Mrs.		10	6
Enock A. G.	1	1	0
Everitt W. G. ...	1	1	0
Ewing Miss J. Orr ...		5	0
Ferrier Miss Judith ...		10	0
Finch F. R.	1	1	0
Fisher H. H., F.R.C.S.		10	0
Fletcher Miss R. ...	1	1	0
Flowers John, K.C. ...	1	1	0
Forbes H.	1	1	0
Foster, Capt. T. H., R.N.		10	0
Fox F. Douglas ...	1	1	0
French Miss E. M. ...		12	6
Carried forward ...	£111	6	2

	£	s.	d.
Brought forward ...	111	6	2
Friedlein W. ...	1	1	0
"Friend"		5	0
Garnett R. M. ...		10	0
Garrod F. W.... ...		10	6
Gay Miss C. E. ...	1	1	0
Gay Miss Ellen ...		10	0
Gayner Dr. J. S. ...	1	1	0
Giles C. C. T. ...		10	0
Giles Rev. A. Linzee		10	6
Gilman Randon ...		10	6
Glegg W. E. ...	1	0	0
Goddard W. N. ...		10	0
Gowen H. P.... ...	1	1	0
Graves Mrs.	1	1	0
Green Major E. A. Lycett	1	0	0
Gresham School Nat. Hist. Soc.	1	1	0
Gurney G. H. ...	2	2	0
Gurney Q. E. ...	1	1	0
Gurney R., D.Sc. ...	2	2	0
Haig Mrs. Donald M.		5	0
Hamilton Miss M. E.		2	[illegible]
Hannaford G. ...	2	2	0
Harding J. Rudge (the late)		10	[illegible]
Hardy Mrs. H. F. H.		5	0
Harker W.	1	1	0
Harrison Mrs. M. ...		10	0
Hastings Thomas ...	1	1	0
Haydon W.		5	0
Heywood R.	1	1	0
Hill Nettleship ...		10	[illegible]
Hill T. A. M. ...	1	1	0
Holland C. B. ...	1	1	0
Homere Miss (In Memoriam, J. W. C.)	3	3	0
Hopwood Miss M. ...		5	0
Horsley Miss S. ...		10	0
Hudson Rev. J. Clare		5	0
Hulse Mrs. M. W. ...		10	0
Hulse Miss E. M. ...		10	0
Hyslop Brig.-Gen. H. G., D.S.O. ...	1	1	0
Hyslop Miss T. S. ...		10	0
Jago Cyril		10	0
Jenkins Rev. T. L. ...	1	0	0
Jones Commander B. E., R.N.		10	0
Jones Sir L., Bart. ...	1	1	0
Jones Lawrence E. ...	2	2	0
Ketton-Cremer W. C.	1	1	0
Keith E. C.	1	10	0
Kerr Mrs. H. M. Rait	1	1	0
Knight E.	1	0	0
Kolle H. W.	2	2	0
Carried forward ...	£157	0	2

	£	s.	d.
Brought forward ...	157	0	2
Lance Capt. H. W. ...	2	0	0
Lang Gordon L. ...	1	1	0
Lawson Harry ...	1	1	0
Lee-Elliott Rev. D. L.	1	1	0
Lees M. Mackenzie ...	1	1	0
Littlewood Miss ...		10	0
Lister S. R., M.D. ...		11	0
Lewis J. Spedan ...	2	2	0
Linkhorn James ...		5	0
Lloyd Capt. L. ...	1	0	0
Long Miss		2	6
Long S. H., M.D. ...	2	2	0
Low Dr. G. Carmichael	2	2	0
McHardy Maj.-Gen. A. A., D.S.O. ...	1	0	0
Macdonald Malcolm, M.P.		10	0
Mackay Dr. Helen M.		10	0
Macpherson A. Holte	1	1	0
Madoc Col. H. W. ...	1	0	0
Maidment Dr. F. W. H.	1	1	0
Marples George ...	1	1	0
Marshall E. H. ...	1	0	0
Marshall W. K. ...	3	3	0
McIlquham Miss M. ...		5	0
McKenzie Miss G. ...		10	0
McKittrick T. H., Jun.	1	1	0
McLaren Mrs. ...		10	0
McLaren Miss Sheila		2	6
McLean C.	1	1	0
Marshall J. M., J.P....	1	1	0
Matthews T. G. ...	1	1	0
Meade-Waldo E. G. B.	1	1	0
Meadows Mrs. A. H....		10	0
Medlicott Miss ...		5	0
Mennell E.		10	0
Micholl Mrs.	1	1	0
Milne Mrs. Findlay ...	1	1	0
Mitchell Arthur ...	1	1	0
Molteno D. J. ...	1	1	0
Mortimer Gilbert ...		5	0
Murton Mrs. ...	1	0	0
Nash W. (the late) ...	1	0	0
National Trust, The...	10	0	0
Naylor W. S. ...	1	1	0
Newman Miss F. B. ...		10	0
Noble E.		5	0
Noel-Buxton Lord ...	2	0	0
Norwich High School for Girls	1	9	0
Oliver Prof. F. W., F.R.S.	1	1	0
Palmer A. J.		5	0
Pearson S. V., M.D. ...		10	0
Carried forward ...	£213	12	2

	£	s.	d.
Brought forward ...	213	12	2
Penrose F., M.D. (the late)	1	1	0
Perry Miss M. ...	1	1	0
Phelps Mrs. B. ...		10	0
Pilkington Mrs. Hubert	1	1	0
Plowright Dr. C. T. ...	2	2	0
Poole Miss D. Lane ...		5	0
Powell A. M.... ...		5	0
Pratt Alfred	1	1	0
Preston Sir E., Bart., D.S.O.		10	6
Previté A. W. ...		5	0
Prior A. V.		10	0
Purdy T. W.... ...	1	1	0
Ransome Mrs. ...	1	1	0
Raikes Miss D. T. ...		10	6
Reid Dr. E. S. ...		10	0
Richmond H. W., F.R.S.	2	0	0
Riley W. (the late) ...	1	1	0
Ringrose B. J. ...	1	1	0
Rippingall Neal F. ...	1	1	0
Riviere B. B., F.R.C.S.	1	1	0
Rogers Rev. H. ...	1	0	0
Royal Society for the Protection of Birds	2	2	0
Rushton Miss... ...		10	6
St. Quintin W. H. ...	1	1	0
Savill Harry	2	2	0
Savin A. C.		5	0
Savory Mrs.		10	0
Sawyer H. C. ...		10	6
Sewell P. E.	2	2	0
Sheldon W. G. ...		10	6
Soman A. E. & Co., Ltd.	1	1	0
Spalding G.		10	0
Sparrow Col. R. ...		10	6
Southwell E. B. ...	1	1	0
Stimpson E. ...		10	0
Sumpter Dr. B. G. ...	1	1	0
Tate Mrs.	1	0	0
Tawse Mrs.		10	0
Taylor Dr. Mark ...		11	0
Tennant Bernard V. A.	1	1	0
Thouless H. J. ...		10	0
Times W. O.	1	1	0
Tomlinson J. R. ...	2	2	0
Tracy N.		10	0
Trafford Maj. E. B. ...	2	2	0
Tuke Anthony W. ...	1	1	0
Upcher H. E. S. ...	1	0	0
Upcher Miss L. ...	2	2	0
Vincent Miss. G. H. M. M.	2	2	0
Carried forward ...	£262	9	2

	£	s.	d.
Brought forward ...	262	9	2
Walter C. H. ...	1	1	0
Walters Lewis ...	1	2	2
Watson-Kennedy Mrs.	1	1	0
Wemyss Major G. ...	1	0	0
West, Leonard H., LL.D.		10	6
Whittaker W. I. ...	1	1	0
Winch Major S. B. ...	2	2	0
Carried forward ...	270	6	10

	£	s.	d
Brought forward ...	270	6	1
Wing J. Slade ...	1	1	
Winter Gordon ...		10	
Wolley-Dod Mrs. ...		10	
Wright T. J.		10	
Wyllys H. J. M. ...		10	
Wyllys W.		10	
Young Rev. Belton ...		5	
Total ...	£274	3	

NORFOLK WILD BIRDS PROTECTION FUND

Year ended 31st October, 1932

Receipts

	£	s.	d.
Balance brought forward from 1931	53	15	1
Subscriptions and Donations, 1932	274	3	4
Blakeney Point Collecting Box		14	0
Scolt Head Collecting Box ...	3	7	6
Sales of Report	3	7	10
	£335	7	9

Payments

	£	s.
Breydon Watcher's Wages and Insurance	40	7
Oil, Coal, etc., for Breydon House Boat	1	6
Scolt Head Watcher's Wages and Insurance	110	17
Blakeney Point—Contribution to Watcher's Wages	30	0
Oilskin for Watcher	2	4
Workmen's Compensation Insurance Premium	1	0
Yarmouth Port and Haven Commissioners—Registration fees for boats		15
Printing of Annual Report ...	11	15
Hon. Secretary—Stationery and Postages	4	17
Cheque Books		10
Transferred to Deposit Account	100	0
Balance	31	14
	£335	7

Deposit

	£	s.	d.
Balance, 20th November, 1931 ...	141	13	4
Interest to 30th June, 1932 ...	3	9	1
Transferred from Receipts and Payments Account (as above)	100	0	0
	£245	2	5

Examined and found correct,

FRANK INCH

Norfolk & Norwich Hospital
Norwich, 1st Nov., 1932

III

THE ZONE OF GRANULATED *ACTINOCAMAX* IN EAST ANGLIA

By R. M. Brydone, F.G.S.

The zone of granulated *Actinocamax* for East Anglia covers the chalk between the top of the zone of *Marsupites* and the base of the zone of *Belemnitella mucronata ;* and I so defined it when proposing it in the last issue of the Society's Transactions (Vol. XIII p. 118). Of course it is essentially a negative conception, depending in truth upon the absence of *Marsupites* at one end and *B. mucronata* at the other end, rather than on any positive character (in that way much resembling " space," which is primarily the negative idea of absence of matter, and is therefore incapable of the positive and physical attributes, such as expansion and curvature, freely attributed to it by speculative physicists, who must surely be using the term in some sense other than the primary one, without warning that they are doing so). Even so the zone is not closely defined. The top of the zone of *Marsupites* has been fixed in many ways. Barrois placed it on the Sussex coast at least 200 feet above the last *Marsupites,* as he brought into the zone of *Marsupites* all the accessible chalk. Elsewhere he seems to have regarded his zone of *Marsupites* as ended only by the deposits of the " mer à *Belemnitelles* " (by which he meant apparently the chalk of the zone of *B. mucronata*). He does not seem ever to have linked either its top or its base with the range of *Marsupites.* Rowe, not recognising any question as arising on the Kent coast, first grappled with the problem in Sussex where he placed the top of the zone about 20 feet above the last *Marsupites* because of the local peculiarity of a line of *Offaster pilula* about 5 feet higher which neither marks the first appearance of that fossil nor its permanent establishment in force. In other coast sections extending upwards beyond his zone of *Marsupites,* he seems to adopt the highest *Marsupites* as determining the boundary of the zone : but neither standard will account for his including in it the highest chalk in Thanet where there is chalk at the top of the cliff in which *Marsupites* almost certainly does not occur. It would be very interesting to know by what criterion Boswell recognised that upper boundary of the zone of *Marsupites* which he represented in the map in Vol. XI. of the Society's Transactions, at p. 24, to the west of Botesdale and therefore somewhere in the middle of a five-mile tract of chalk with *Uintacrinus*.

The base of the zone of *Marsupites* was fixed in Kent by Barrois, and Rowe, at a local sponge bed, which is almost more a lithological than a palæontogical base, Rowe expressly saying that it was below the downward range of *Uintacrinus*, and by Barrois in Sussex at a flint bed a long way below the range of *Uintacrinus ;* but it has generally been fixed by the downward range of *Uintacrinus*. The net result is that the term " zone of Marsupites " standing alone is devoid of any precision either as to its top or bottom. I have always maintained that the last *Marsupites* is the only possible criterion of universal service for fixing the top of the zone of *Marsupites* and by it I define the level immediately above which the zone of granulated *Actinocamax* begins.

Unfortunately the end of the zone of granulated *Actinocamax*, which can only be fixed by the beginning of the zone of *Belemnitella mucronata*, cannot be closely defined in terms of the latter zone owing to the uncertainty as to what distinguishes *B. mucronata* Schlot. from *B. lanceolata* Schlot., and whether they overlap. The best that can be got out of current opinion is that " Sharpe was all wrong about *B. lanceolata*," which has little constructive value. I did once wring from the late Dr. Blackmore, who had rejected my identification of some very black and smooth Trimingham belemnites with *B. lanceolata*, the statement that *B. lanceolata* widens steadily from the point and that its vascular markings tend to be longitudinal while those of *B. mucronata* are transverse : but I have not found these points always satisfactory in practice, and I have no idea whether they are the standard on which other people who claim to be able to identify *B. lanceolata* rely. But I think that to Dr. Blackmore *B. lanceolata* was predominantly and perhaps wholly a fossil of the zone of *Actinocamax quadratus*, displaced, like *A. quadratus*, by *B. mucronata*.

The zone of granulated *Actinocamax* is practically co-extensive with the zone of *Actinocamax quadratus* as that term was employed for many years in the South. But two zones are now recognised as distinguishable in that body of chalk in the South, those of *Offaster pilula* and (restricted) *Actinocamax quadratus*, and it is an important question whether any corresponding division can be traced in East Anglia. As Belemnites appear to be far more abundant in East Anglia than in the South at all horizons above the zone of *Micraster cor-anguinum*, and better preserved, it is very unfortunate that there is a serious lack of correspondence between the Belemnites at this level in the two districts. The scanty evidence in the South (which is amazingly scanty considering the enormous areas exposed under very favourable conditions) seems all to point to *Actinocamax granulatus* surviving from the *Marsupites* chalk (or zone) some way into the zone of *O. pilula* in slightly increasing numbers and being then replaced for some 20 or 30 feet by intermediate forms whose alveolar cavities are round like those of *A. granulatus* and deep like those of *A. quadratus*, which are replaced in the subzone of abundant *O. pilula* by *A. quadratus* which from that point is the only granulated Belemnite occurring up to the top of the (restricted) zone of *A. quadratus*, *A. granulatus* being therefore a sure indication of the lower part of the zone of *O. pilula*. In the East Anglian area it has been positively stated by the Geological Survey that at Bramford *A. granulatus* persists right up to the base of the zone of *B. mucronata*. It is unfortunately not clear whether they mean *Actinocamax* with round shallow cavities (which is the current standard of *A. granulatus*), or with round deep cavities (the intermediate form of the South), or both, but it may well be both. As I have seen strong indications of " quadrature " low down in the zone of granulated *Actinocamax*, and " quadrature " is definitely present even in the *Marsupites* chalk (or zone)—the relations between *A. granulatus* and *A. quadratus*, so apparently simple in the South, are very complicated in East Anglia. Indeed there is hardly any more crying need than that for a thorough study of the belemnites of the Upper Chalk. There may easily be ten or a dozen species, not one of which has been described in England in relation to others of its group and only about four of which have even been reliably described in isolation. I do not, for example, know of even an isolated description of such a widely quoted form as *Actinocamax Westfalicus*, or of any study of the even more popular *Act. granulatus* in relation to its neighbours in the granulated group: and there must be a great abundance of material available from East Anglia.

On the question whether there is any trace of a dividing line within the zone of granulated *Actinocamax* which might correspond to that between the zone of *Offaster pilula* and the (restricted) zone of *Actinocamax quadratus* it is difficult to give anything more than a very vague answer. Out of the various strings of sections across parts of the zone, only two, that along the upper Wensum valley and that along the north coast, cut across the lower half of the zone; and of these the Wensum Valley series has an interval of about two and a half miles between Swanton Morley and Sparham, just at the crucial horizon, without a single section. Only along the north coast have I found any testing sections. Here, at Wells, in the pit in Bases Lane mentioned in the 1904 Survey Memoir, which cannot be far above the *Marsupites* chalk (or zone), we have obviously the chalk with abundance of *Ostrea incurva* Nilss., and generally abundance of *Actinocamax*, which can be followed through Walsingham in the roadside pit at Towns End, Great Walsingham and the railway cutting by Large Half Moon Plantation, Little Walsingham (there only a little way above the *Marsupites* chalk of Houghton and Barsham) by Guist and Bintree Mill (there only a little way above the *Marsupites* chalk of North Elmham) to Quidenham Home Farm and Banham old Lime Kiln (at the first place very little above *Marsupites* chalk at Quidenham old Lime Kiln). [Boswell's zonal map (supra Vol. XI. p. 24) *seems* to show the *Marsupites* chalk extending a considerable way west of East Harling. If so, a number of good sections in the zone of *M. cor-anguinum* and the *Uintacrinus* and *Marsupites* chalk in the neighbourhood of East Harling must have been taken for something quite different from what they are]. This chalk offers a remarkably close correspondence with the chalk immediately succeeding the *Marsupites* chalk in the South and which is probably the most prolific horizon there for *A. granulatus*. (At the top of the Bases Lane pit can be clearly seen the base of the magnificent raised beach of Wells.)

None of the succeeding sections about Wells have any parallel elsewhere in East Anglia.

In the railway cutting above the Bases Lane pit and about 40 feet higher the chalk, which is finely exposed, is about as barren as any that it has been my misfortune to meet. I could not find any significant fossil: and it afforded considerable evidence that the special fauna of the subzone of *Echinocorys scutatus* var. *depressus* never penetrated as far as this. Assuming this cutting to straddle part of the chalk corresponding in time to the above subzone, the cutting south of Wells Rectory may be fairly expected to be in chalk at the level of some part of the subzone of abundant *Offaster pilula*. The surface is very dirty but I found it possible to get a fairly extensive sample of the fauna, which did not contain a single instance of any of the striking fossils characteristic of the subzone of abundant *O. pilula*, except for a single fragment which might be a fragment of *Offaster pilula*. The next section to the east across the assumed strike is that at the old lime-kiln on the opposite side of the railway line to the Leicester Lime Works. There is not much chalk now exposed there, not enough to offer an expectation of fossils, though I found a *Bourgueticrinus* joint of exceptional size; but it is sufficient to show the presence of a thick marl bed. Marl beds are extremely rare in the upper chalk all over East Anglia, so much so that I know of no other below the zone of *B. mucronata*. On the opposite side of the railway line the Leicester Lime Works show a splendid section some 30 feet high, which must start a very few feet above the marl bed, in rather gritty and locally hardened chalk in which *Echinocorys* is, for the first time above the *Marsupites* chalk, a regular feature of the fauna, *Pteria tenuicosta* Roem. occurs freely (for it) and *Offaster pilula*, Lam., rather small, occurs most erratically (I found five at one visit and none at two other visits). From this point eastwards granulated *Actinocamax* occurs at Wells Harbour (with *Pteria tenuicosta*) Cocklestrand Drove, Stiffkey, Cockthorpe Common and Fox Covert, near Morston, being found in each case in a single visit, and the top of the zone can be located pretty closely in the village of Morston, as *B. mucronata* has been found at Morston Downs. This chalk from Stiffkey eastwards, cannot but correspond with the (restricted) zone of *A. quadratus* in the South. It seems rather barren in comparison, even allowing for the superficial character and dirty condition of most of the exposures ; but I have been able at Stiffkey to establish that it contains several of the usual free Polyzoa, *Retispinopora arbusculum* Bryd* and irregular *spinoporæ.* The only ambitious section is that at Stiffkey Hall Farm, already sadly overhung by trees and dirty and doomed apparently to further steady deterioration : this was the scene of a triumph and a catastrophe. The triumph was the finding of three specimens of *Belemnitella* which seemed clearly *B. lanceolata* by the standard given above, and which were relieved from any suspicion of being *B. mucronata* by an accompaniment of three fine specimens of granulated *Actinocamax.* This find strongly confirms the assumption I had already made that the Belemnite or Belemnites from Wells which Jukes-Browne (the Cretaceous Rocks of Britain, Vol. III, p. 259) records as having been identified as *B. mucronata,* without in any way committing himself to that identification, was (or were) *B. lanceolata.* The catastrophe was a finding of a specimen of *Membranipora Taverensis* Bryd., a species which I had hoped would prove to be rigidly confined to the basal section of the zone of *B. mucronata,* of which it is so characteristic. The extreme scarcity in this chalk (above the Leicester Lime Works) of even fragments of *Echinocorys* is strictly in accordance with experience in the Gipping valley near Ipswich (as soon as the immediate proximity of the zone of *B. mucronata* is left) and of course robs us of a valuable source of information as to adherent forms ; but even this fact leaves the total absence (closely paralleled in the Gipping valley) of such Polyzoa as *Membranipora pellicula* Bryd., *Semieschara Pergensi* Bryd., *Semieschara Woodsi* Bryd., *Onychocella* (*Cellepora*) *Parisiensis* d'Orb, and *Cribrilina Gregoryi* Bryd., which are almost literally massed at this horizon in the South, indicating a radical separation of the two areas or a radical difference in their conditions.

It seems to be the inevitable conclusion that no clear parallel

*It seems that Lonsdale's " new genus " *Spinopora* really covered a mixture of forms of *Neuropora* Bronn and *Spinopora* Bronn (which latter he must have overlooked), and that it is doubtful whether there is any room for my genus *Retispinopora.* But I think that it can be usefully retained for isolated regular forms such as these for which it was employed at its foundation: and I am now convinced that the form with an upright lower part and conical upper part (Brydone, The Stratigraphy of the Chalk of Hants., Pl. III, figs. 30f and g) should be a separate species to which I give the trivial name of *columnaris.*

exists in East Anglia to the division (of the importance of a break between stages according to Jukes-Browne, with only part of the evidence before him) between the zones of *Offaster pilula* and (restricted) *Actinocamax quadratus* in the South. It is, however, distinctly tempting to speculate that whatever causes were responsible for the disappearance of marl and *Offaster pilula* at the end of the zone of *O. pilula* in the South effected a temporary (in the case of marl, momentary), transfer of them into the East Anglian area and that the marl bed of Wells marks the level corresponding to that at which the change took place in the South. This will fit very well with the distribution of *Pteria tenuicosta* in the Gipping valley as a notable fossil of the upper part of the zone, and with the occurrence of *Pycinaster magnificus* Spen. of a zone-of-*Offaster-pilula* typed, in the Rectory cutting and *Stauranderaster senonensis* Spen., which is believed to appear first above the zone of *O. pilula*, in the Leicester Lime Works pit.

I have referred above to the magnificent raised beach at the west end of Wells, which rises to some 75 feet at least above O.D. It is almost inevitable that to the same submergence should be attributed the thick bed of sand (coming on at about 60 feet above O.D. but apparently lying in a local hollow in the chalk) through cuttings in which the Fakenham line approaches Wells. This bed can still be seen to consist almost entirely of sand with a few flints scattered through it at considerable intervals and it can hardly be anything but a seaside sand dune. In the siding for the Leicester Lime Works its base, resting on undisturbed chalk, consists largely of little rounded pellets of chalk corresponding very closely with the normal base of banks of blown sand beside a chalk foreshore. A comparatively recent sea level at Wells 50 feet or more above the present level would account almost perfectly for the absence of any crushed zone crowning the chalk round Wells, as such a sea would have quickly swept away any crushed chalk and any glacial deposits overlying it. That such a crushed zone once existed over the Wells area may be inferred with practical certainty from the fact that at Great Walsingham where the chalk rises to about 100 feet above O.D. it is crushed to at least the full depth of the roadside pit, at the bottom of which a tabular flint vein is seriously dislocated, i.e., nearly down to

80 feet above O.D. which still is above the probable high level of the chalk at Wells.

A sea which probably reached up to 70 feet or more above O.D. at Wells would almost certainly have covered a lot of land now dry about Holkham and this might explain the presence of at least 10 feet of laminated marl in Holkham Park (close to Great Barn) within a quarter of a mile of undisturbed chalk at the same level, and the water must have been deepish over the 105 feet or so above O.D. to which the marl reaches.

In the same way it becomes probable that all the low ridges of chalk fringing the marshes eastwards of Wells were at one time submerged by this sea, in which case the various outliers of gravel and sand left here and there along them, including the " town " pit at Stiffkey, are likely to be relics of raised beach.

Such a submergence at Wells would, if the land had then its present contours, also carry the sea some considerable way inland and in this connection it is worth noting that the pit at the north end of " Old Wells Road " near Great Walsingham at about 100 feet above O.D. and marked in the ordnance map as a chalk pit appears to be in sand very closely resembling that by the Leicester Lime Works (which we have seen is probably blown sea sand).

There seems to be a good case for the examination of all patchy post-chalk deposits in this neighbourhood less than about 100 feet above O.D. with an eye to the possibility of their being of beach or marine origin.

A possible chronological link with these earth movements is afforded by the presumably neolithic chalk caves of Stiffkey. Little has been recorded yet about them but I do know that one of them at any rate was situate nearly at the top of the chalk in the side of the valley, which here rises to about 70 feet above O.D., not at the bottom of the chalk valley. It may fairly be presumed that the glacial age left all chalk in this neighbourhood buried beneath a substantial covering of glacial debris and it seems to follow that this chalk could never have been accessible to neolithic man until it had been cleared of the glacial deposits by the submerging sea and then left dry at the edge of the same sea at some early stage of its recession. We may reasonably attribute to this period the excavation of

Marsh fauna of the island. Probably the ideal way would be to issue these papers separately, but for general convenience it has been thought best to collect them in one volume, later editions of which can be made more comprehensive. The handbook will be fully illustrated, and will also contain some detailed maps. A new map of the island, on a scale of six inches to the mile, is in preparation, and this map also includes a good deal of the adjoining areas, so that anyone using it can more easily relate the island to its environment than can be done at present.

It has also been agreed that papers on the island should appear—as they do for the first time in this issue—as a Report. Mr. V. J. Chapman, B.A., of Pembroke College, Cambridge, has been working on the island this summer, and is carrying on field research throughout the year. He has contributed a preliminary paper, in which several new plant species are catalogued. Mr. D. L. Serventy, of Gonville and Caius College, carried out some interesting work on the salt marsh fauna in the Long Vacation, and hopes to continue the work next year. He will be able to contribute an account of this work later on.

The Ternery has been re-mapped by Mr. R. F. Peel of St. Catharine's College. The chief point of interest is the big gap cut through the dunes. This gap first began to form last September (1931), and a reference was made to it in the previous number of these *Transactions*. The gap has increased in size, and on October 2nd, 1932, it was more than 200 paces (approximately 200 + yards) wide. The big tides of that week-end did not do a great deal of damage to the island, but if a north-west wind corresponds with a big tide during the coming months, interesting changes will take place. The small dune left beyond the gap is, at the best, a very temporary structure.* Apart from the gap itself, the dunes just east of it are suffering a good deal of erosion.

Although not actually on the island, a word must be said about the erosion now taking place to a considerable extent on the Brancaster Golf Course. Just around the Club House, and for a few hundred yards west thereof, the sea has seriously cut into the dunes, and is undoubtedly a menace. Several bathing huts have had to be moved back. Prolonged attack here would

* This dune practically disappeared on October 31st, 1932

THE TERNERY AND FAR POINT, SCOLT HEAD ISLAND, June, 1932

(From a Plane-table Map by R. F. E. W. Peel)

Photo] [*E. Winsl*

The Erosion near the Club House, Brancaster Golf Links

The distance between the figure and the dunes represents the approximat amount of erosion between 1930 and 1932 ead to a complete break in the dunes, and would render the Golf Course an island at high water. This, however, is not ikely to come yet, if at all. Unfortunately there is apparently no local beach material coming to this part of the coast which can be held up by groynes to provide an efficient means of protection. It is notoriously unsafe to predict what is going to happen on such a coast; but it seems fairly certain that extensive, and expensive, defence works will be necessary if this end of the course is to be adequately defended.

The attack of the sea is very local. Only about a quarter of a mile west of the Club House accretion is taking place, probably at the expense of that which is lost at the vulnerable spot. New shingle ridges and dunes are growing quite quickly near the entrance to the north-south reach of Brancaster Harbour. It is interesting to speculate on the connection between these changes and the recent growth of Scolt Head Island. As can be seen from recent maps published in these *Transactions* since 1925-26, the island has grown rapidly westwards; and the growth is perhaps greater than is apparent, because the shingle and sand ridges at the far end extend very considerably farther than the dunes. The result has been to deflect Brancaster Channel west and south. Part of the cause of the erosion of the links may possibly be sought in this way, even though the distal point of the island is opposite the unattacked part of the Golf Course. If, as is by no means impossible, the gap in the Ternery increases to such an extent as to cut off the end of the island, and possibly to divert the Harbour mouth eastwards again, the shingle which would be left west of such a new harbour would be "dead." Such shingle might possibly be driven on the beach along the Golf Links and, if so, may be of use as a natural protection to that shore. Whether it would do so depends on several important factors, many of them unknown. However, interesting changes are likely to take place here in the near future. The maps to be published in the proposed Handbook will indicate these changes in more detail.†

† Since this note was written, the sea has cut farther into the Links, especially during the high tides of 30th and 31st October, 1932.

V

RECENT ADDITIONS TO SCOLT HEAD FLORA

By V. J. Chapman, B.A., Pembroke College, Cambridge

The chief interest attaching to these additions is concerned mainly with a knowledge of what plants have been able to obtain a footing on the island. Now that the island is largely covered with vegetation, it is very difficult for new species to grow successfully. These new species of flowering plants are additions to the flora prepared by Deighton and Clapham (1). They were found during a short survey of the flora made during visits to Scolt Head Island in June, July and August, 1932.

Dr. S. H. Long brought me *Thymus chamædrys*, Fries., which he had found on the dunes near the watcher's hut. *Carduus pycnocephalus*, Jacq. was found on the western slope of House Hills. *Centaurea cyanus*, Linn. was found by Mr. J. A. Steers on the small portion of the ternery which was cut off by the break through in 1931, and it was growing on the young dune remaining there. At the entrance of the channel to the spiral marsh *Zostera marina*, Linn. was found growing ; there is quite a large patch, which may have been overlooked by Deighton and Clapham. In July *Cnicus palustris*, Hoffm. was found in abundance in the marsh in Norton Hills. In the same place, in August, *Epilobium parviflorum*, Schreb. was found, there being only about four plants. *Epilobium angustifolium*, Linn. was found by the watcher, C. Chestney, on House Hills, where there is a small patch, which has probably been there for a few years, and is slowly spreading. On the Hut Massif two new species were recorded. There are several plants of *Capsella bursa-pastoris*, Mœnch. growing in the shingle just in front of the hut ; and in the middle of the Massif a patch of *Thalictrum minus var. dunense*, Dumort. was found flourishing in the dense Psamma. In August plants of *Atriplex hastata*, Linn., and *Atriplex patula*, Linn., were found at the edge of the dunes bordering the small marsh behind the hut.

In the copy of Deighton and Clapham's paper in *Vol. XII* of the *Transactions* of the Norfolk and Norwich Naturalists'

Society which is kept in the hut, the following additions have been marked in in pencil by previous visitors :—

Trifolium pratense, Linn. Ternery, August 1931.
Geum urbanum, Linn.
Filago germanica, Linn. Ternery, August 1931.

These were looked for, but were not found. It will be noted that a number of these new additions come from the Ternery, which is the area where most of the birds are to be found. In several cases they are not found again, and it is doubtful whether *Centaurea cyanus* will be found next year, the two plants that were found being small and weakly. It is probable that a number are stray visitors brought as seeds by the birds, and they only manage to survive one year in the dry conditions. It would therefore seem advisable, in a case like this, not to place plants as a permanent component of a flora until they have been recorded for two or more successive years. Those that occur only periodically should be put down as sporadics. It seems probable that the bulk of these will be brought by the birds or wind, and this particularly applies to the Ternery, where the chances are very great of seed being brought by birds, especially in mud on their feet.

In connection with the flowering plants, it was noted this year that *Senecio jacobæa*, Linn. was very badly attacked by caterpillars of the cinnabar moth, *Euchelia jacobææ*, and to a much less extent by caterpillars of two other species. The attack on the plants of House Hills was by far the worst, and, as the photograph shows, the plants were completely denuded, no fruits being produced. In view of the vast quantity of ragwort on the dunes and elswehere in the country, the exploitation of the cinnabar moth suggests itself as a method of biological control of the ragwort. Its success would depend on all the plants in the neighbourhood being attacked, so that no seed was set, and then the rootstocks of the dead plants should be pulled up.

For future workers it seems advisable to record here that all the trees (except Elder, and the Privet on Privet Hill) on the island have been planted, including all those round the pool in House Hills (2). The reason for recording this is that in time these trees will look as if they had occurred naturally (as some of them already do) and future workers may be in doubt as to their origin.

One new fern was added to the flora. This is *Dryopteris dilatatum*, Desv., which was found on House Hills. I am grateful to Mr. Gilbert-Carter for this identification.

A preliminary survey was made of the algal flora, which is a large one. This is surprising, seeing it is a mud and sand region. The bulk of the algæ are in the mussel beds in Norton Creek, but there are also three patches on the foreshore, where algæ have become attached to stones embedded in the sand, and these patches also have a rich flora. On the marshes the following Phæophyceæ are found :—*Fucus volubilis*, Baker, which is most abundant on the Aster marshes: *Pelvetia canaliculata forma libera*, Baker, occurring on most of the marshes, being absent only from the very lowest and very highest. Lastly, there is *Fucus coralloides*, Baker, recorded as being found once by Deighton (1) to the south-east of House Hills. The above three algæ have been described by Miss Baker (3) for Blakeney, and it is probable that they are characteristic of the East Anglian salt marshes. The Pelvetia is also recorded by Dr. Carter (4) for Canvey Island. Also on the marshes the Rhodophyceæ are represented by *Bostrychia scorpioides*, Kütz., which occurs in much the same places as the Pelvetia.

The green algæ along the creeks are mainly Enteromorpha and Vaucheria. *Enteromorpha intestinalis*, Link, may be found growing on stones in the main creeks, especially those of the Great Aster Marsh. The list of algæ recorded so far is given at the end of this account. No attempt has been made to group them according to habitat, but this may be possible later on.

Galls

Three galls have been seen on the island, and they all come from House Hills. *Taphrina aurea*, Fries., a fungus, has attacked the leaves of *Populus nigra*, planted by the pool, giving the golden blisters on the under surface of the leaves. *Rhodites rosæ*, Linn. is found on *Rosa rubiginosa*, which occurs wild, and also on the leaves of this rose is *Rhodites eglanteriæ*, Iartig. which forms round, red growths, chiefly on the under urface of the leaves.

Lastly, some little while ago, Professor Salisbury suggested hat when an ecological study was being made of an area, one art of the work should be the collection of an ecological erbarium, which should be kept in a place for reference for uture workers. Such an herbarium has been started for colt Head Island, and it will be kept at Dial House, Brancaster taithe.

My thanks are due to Miss Dickinson of Kew, who identified our of the algæ, and to Mr. Steers for the photograph; also to Ir. T. Tutin, who identified the two species of Atriplex.

IST OF PLANTS RECORDED SINCE 1925

LGÆ. (5)

Chlorophyceæ.	Ulva lactuca, var latissima, D.C. (U. latissima, J. Agardh).
	Ulva linza, J. Agardh.
	Enteromorpha intestinalis, Link.
	Enteromorpha compressa, Grev.
	Enteromorpha clathrata, J. Agardh.
	Cladophora utriculosa, Kütz.
	Percursaria percursa, Rosenv.
	Vaucheria sphærospora, Nordst.
	Rhizoclonium implexum, Batt.
Phæophyceæ.	Fucus spiralis, Linn.
	Fucus vesiculosus, Linn.
	Fucus ceranoides, Linn.
	Fucus spiralis var platycarpus, Thur.
	Fucus fasiculosus megecad limicola ecad volubilis, Baker.
	Pelvetia canaliculata megecad limicola ecad libera, Baker.
	Ectocarpus siliculosus, Harv.
	Ectocarpus fasiculatus, Harv.
Rhodophyceæ.	Bostrychia scorpioides, Kütz.
	Hypoglossum Woodwardii, Kylin. (Delessaria hypoglossum, Lamour).
	Ceramium rubrum var pedicellatum, J. Agardh.

	Ceramium rubrum var corymbiferum, J. Agardh.
	Lomentaria clavellosa, Gaill.
	Griffithsia setacea, C. A. Agardh. (G. flosculosa, Batt).
	Callithamnion byssoides, Arn.
	Polysiphonia urceolata, Grev.
	Polysiphonia nigrescens, Grev.
	Porphyra umbilicalis, J. Agardh.
FILICINÆ	
Polypodiæ.	Dryopteris (Nephrodium) dilatatum, Desv.
PHANEROGAMS.	
Ranunculaceæ.	Thalictrum minus, var dunense, Dumort.
Cruciferæ.	Capsella bursa-pastoris, Mœnch.
Leguminosæ.	Trifolium pratense, Linn.
Rosaceæ.	Geum urbanum, Linn.
Onagraceæ.	Epilobium parviflorum, Schreb.
	Epilobium angustifolium, Linn.
Compositæ.	Filago germanica, Linn.
	Centaurea cyanus, Linn.
	Carduus pycnocephalus, Jacq.
	Cnicus palustris, Hoffm.
Labiatæ.	Thymus chamædrys, Fries.
Chenopodiaceæ.	Atriplex hastata, Linn.
	Atriplex patula, Linn.
Naiadaceæ	Zostera marina, Linn.

FUNGI

A few fungi had been noted on the island, but recently som observations made by Deighton in 1925 came into my hands and the opportunity is now taken of publishing his list, and am very grateful to him for permission to do so.

ERYSIPHACEÆ

Erysiphe horridula, Lev. This attacks *Cynoglossum officinal* occurring on both sides of the leaves. Perithecia occur on th under surface. This year it was most abundant on plants o the dunes of Butcher's Beach.

Erysiphe polygoni, D.C. on *Trifolium dubium.*

Erysiphe communis, E.F. This occurs on *Statice limonium* In 1925 it was very abundant on plants in the Spiral Marsh

The leaves shrivelled, and the plants rarely flowered. There were abundant perithecia on both sides of the leaves.

Erysiphe umbelliferum, de Bary. Found on *Pastinaca sativa* on the Hut Massif east of the hut. It was sparingly present on the upper sides of the leaves.

Sphærotheca mors-uvæ, Berk. Found on the plant of *Ribes uva-crispa var grossularia* behind the Hut. It caused a die-back of the twigs, and there was a sterile mycelium on the fruit.

Sphærotheca humile, Burr. This was found on a variety of *Taraxacum officinale.* Perithecia were on both sides of the leaves.

Microsphæra grossulariæ, Lev. on the leaves of the gooseberry plant behind the Hut. Perithecia were present.

UREDINEÆ

Puccinia schæleriana, Plow. The aecidia are found on *Senecio jacobæa.* In 1925 it was abundant all over the dunes, but this year it was found only on the dunes of Butcher's Beach.

Puccinia pulverulenta, Grev. Aecidia and teleutospores on *Epilobium tetragonum*, which grows in the marsh in Norton Hills. There were six plants, and three were infected.

Puccinia hypochæridis, Oud. Uredospores on *Hypochæris radicata.* It occurred as small pustules towards the tips of the leaves, being found on young plants near the Burnham Harbour end of the island.

Puccinia taraxaci, Plow. on *Taraxacum officinale* in the dune hollow east of the Hut.

Puccinia violæ, Schum. Teleutospores and Uredospores on *Viola riviniana* on House Hills.

Puccinia sonchi, Rob. Uredospores on the leaves of *Sonchus asper* on the Hut Massif.

Puccinia dispersa, E. et H. Uredospores on *Holcus lenata* on the Hut Massif. There was only a little of this rust.

Phragmidium violaceum, Schultz. Uredospores on *Rubus fruticosus* on the Hut Massif, but not found on the plants on House Hills. There was a little on a bush at the Burnham Harbour end of the island.

Coleosporium sonchi, Pers. Uredospores and Teleutospores on the leaves of *Sonchus asper* on the Hut Massif.

Coleosporium senecionis, Pers. Uredospores on *Senecio* *sylvaticus* and *Senecio vulgaris*. It was also very abundant this year.

Uredo ammophilina, Kleb. Uredospores on *Ammophila arenaria*.

Uredo agropyrii, Preuss. Urẹdospores on *Agropyrum junceum* growing on the embryo dunes at the Ternery.

Uromyces limonii, Lev. Aecidia and Teleutospores on the leaves of *Statice limonium*. The Aecidia occur only the mid-rib, and this year they occurred on some leaves in such quantity as to distort them. It does not attack the variety *pyramidale* to anything like the same extent.

Uromyces betæ, Pers. Small pustules on the leaves of *Beta matriima*, of which there was one plant on Long Hills in 1925.

Uromyces behenis, D.C. Aecidia on the leaves of *Silene maritima*. It occurred on only a few plants and was not common.

USTILAGINEÆ

Ustilago hypodytes, Fr. On the stems and leaf sheaths of the flowering shoots of *Elymus arenarius*. There was only one patch, near the watcher's hut.

Ustilago macrospora, Desm. On the grain and glumes of *Agropyrum junceum*, causing the spikes and glumes to be elongated and twisted. Found on plants at the south end of Long Hills.

PYRENOMYCETES

Pleospora herbarum, Rabh. Perithecia on the leaves and stems of dead *Arenaria peploides*.

HYPHOMYCETES

Fusarium roseum var calystegiæ, Sacc. In a soft rot of the old corolla and fruit of *Calystegia soldanella*.

Fusarium lolii, W. G. Smith, on old leaves of *Holcus lanatus*.

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VI

THE GREAT YARMOUTH HERRING FISHERY 1931

By Sydney H. Long, M.D.

For much of the information contained in this report of the Great Yarmouth Herring Fishery for 1931, I am indebted to the columns of the "Eastern Daily Press."

Europe's economic distress has had a repercussion on Yarmouth herring industry, which mainly depends upon the foreign demand, and the season of 1931 was one of the worst in living memory. The bulk of the catch is made by the Scottish fleet, which began operating later than usual, and closed its season earlier. Curers last year lost heavily, and this season they cast about for ways and means to avoid a repetition of this experience. They shortened the season at both ends, reduced their staffs in order to produce a smaller output, and they would only buy fresh herrings at lower rates.

The catch decreased from 540,644 crans last year to 389,740 crans this season, while the prices paid for herrings were on the average only one-half what they were in 1930. The first-hand value of herrings landed at Yarmouth is estimated by the Ministry of Fisheries to have been £585,310 less than last year.

October provided the biggest landings, the heaviest day being 33,075 crans on October 27th, 24,555 crans the following day, and 21,535 crans on October 24th. The fleet comprised 612 Scotch boats, 22 less than in the previous year, 122 Yarmouth boats, 165 Lowestoft boats against 40 in 1930, and one Milford Haven drifter, making a total of 900 boats as against 803 last year. The Yarmouth boats earned from £1900 down to £600. As in 1930, the Scotch fishing was practically a failure. Three-fourths of the herrings landed are taken by the Scotch fleet, and the great bulk is purchased by Scotch curers who follow the herrings.

The weekly landings for the past three seasons were as follows :—

	1931	1930	1929
	Crans	Crans	Crans
Oct. 3	13,144	17,620	9,237
„ 10	14,379	53,783	24,446
„ 17	68,611	79,344	81,307
„ 24	69,617	98,730	63,172
„ 31	92,064	60,011	92,196
Nov. 7	44,609	106,882	101,554
„ 14	25,651	60,240	55,732
„ 21	10,946	18,763	43,910
„ 28	18,160	7,680	19,075
Dec. 5	5,420	7,443	11,958
„ 12	4,583	4,418	179

The first herrings taken on the Shields grounds reached Yarmouth on June 27th. Herrings came to the market from this area until August 20th, when supplies were brought from Whitby, the Castle grounds off Scarborough, Flamboro' Head, and the Silver Pits. By the middle of September, the shoals had reached Cromer Knoll and Haisbro'. No herrings from the Dowsing grounds were permitted to be landed, as they were "spawny" and therefore poor quality. Some boats which brought herrings from this ground had to take them back to sea and dump them or let them go at manure price. The icing of herrings on board as soon as caught was not done so much as in previous years.

The first shot from local grounds came to hand on September 25th. At the beginning of October the herrings had arrived at Smith's Knoll.

The highest price per cran for fresh herrings was 118s. on November 4th, and the lowest figure 5s. on October 3rd and October 17th. Values for iced herrings ranged between 51s. on December 15th and 6s. on October 6th. "Overdays" reached 48s. 6d. on December 15th and touched bottom on October 17th, when the price was 2s. Sea-salted herrings realised 34s. 6d. on September 8th, the top price of the season, and the lowest figure was 3s. on September 24th. Curers paid on the average 18s. 6d. per cran, compared with 37s. 6d. in 1930, 33s. to 34s. in 1929, and 29s. 1d. in 1928.

Of Scotch girls, 2,566 were employed at Yarmouth, the first train arriving on October 8th, and they started to return in the middle of November. This figure compares with 3,540 in 1930 and 3,339 in 1928. Of Scotch coopers, 602 were employed, against 899 in 1930 and 819 in 1929. The number of curers operating at Yarmouth was 75 and at Gorleston 7. In 1930 the figures were 81 and 15 respectively and 76 and 17 in 1928. Of fishery salt, 19,180 tons arrived from Spain, Scotland, and Cheshire, and the average price was 32s. per ton. Coal for bunkers cost 32s. per ton ; paraffin for the motor boats was 6d. per gallon.

Curing and Freshing

Curing commenced on October 12th and ended on November 10th, so far as the Scotch operators were concerned. The total cure at Yarmouth was 288,470 barrels against 524,994 last year. Up to December 15th the quantity shipped was 184,264 barrels. The total quantity exported fresh to Germany was 20,245 crans.

VII

METEOROLOGICAL NOTES, 1931

(From observations taken at Norwich)

By Richard J. Preston

JANUARY

The mean temperature was about normal, and while there were few mild days, there was an absence of severe frost. Rainfall was about half an inch above the average, and snow fell on only two days. Fogs occurred on the 3rd, 10th, 21st, and 30th. There was a heavy gale on the night of the 16th. Sunshine was in excess of the average.

FEBRUARY

There was again an absence of any severe wintry weather, and although frost occurred on the ground on 20 nights, the lowest reading was 20.4 deg. on the grass and 25 deg. in the screen. Snow fell to the depth of about half an inch on the 5th and 7th, and there were showers of sleet and snow at the end of the month. Mean temperature was almost exactly in accordance with the normal, rainfall was three-quarters of an inch in excess, and sunshine 29 hours deficient. Thunder occurred on the 11th and 21st.

MARCH

This was in many respects a remarkable month. The mean temperature of the first fortnight was below 34 deg., and very cold winds prevailed during this period. On the night of the 9th the screen thermometer fell to 13.1 degrees, and that on the grass to 9.5 degrees. The latter reading would have been much lower, but for a slight covering of snow over the thermometer. Mr. Willis recorded a reading of 1.2 deg. at Ipswich Road. This was the severest March frost for nearly 30 years. Snow fell on 7 days out of the first 11, and was 4 ins. deep on the 10th. On the 18th there was a change to summer-like conditions, and the thermometer reached 64.4 degrees on the 19th, although patches of snow were still to be seen in shady spots. On the 27th the thermometer rose from 25 deg. in the early morning to 64.2 deg., giving the extraordinary range of 39 deg. The mean temperature of the month was 1.8 deg. below normal. The total rainfall was only .58 in. (of which only .03 was rain, the remainder being melted snow) and was 1.33 in. deficient. With the exception of March 1926 (.37 in.) it was the driest March since these observations were commenced in 1883. Only .03 in. fell from the 12th to the end of the month.

Sunshine was 67.8 hours in excess of the average, and it was the sunniest March ever recorded locally.

APRIL

This month kept up its reputation for showery weather, and the rainfall was an inch and three-quarters above the average. Some snow fell on the 17th. Summer time was ushered in on the 19th by a wintry day of continuous rain, when the maximum temperature failed to exceed 41.6 deg. Thunder occurred on the 22nd, 26th, 27th and 28th. Sunshine was 29 hours deficient.

MAY

Although there was no really hot weather, there were many warm and summerlike days. The mean temperature was nearly 2 deg. above normal. The rainfall was about double the average, largely accounted for by 1.57 in., which fell on the 16th and 17th. Sunshine was 27 hours deficient. Thunder occurred on the 23rd and 28th.

JUNE

The most important occurrence during this month (though perhaps not strictly of a meteorological nature) was the earthquake in the early morning of the 7th. A severe shock was accompanied by an ominous rumbling noise, causing great alarm, and some slight damage was caused to buildings. There was again an absence of anything in the nature of a "heat wave," although the thermometer reached 70 deg. on several days. The mean temperature was 1.6 deg. above normal. Rainfall was .26-in. above the average, and sunshine 17 hours deficient. Thunder storms occurred on the 1st, 6th and 8th, and there was distant thunder and lightning on the 19th.

JULY

Apart from a few showers, the first fortnight was fine and dry, but the weather broke down on the 14th, when there was a heavy downpour registering nearly an inch. On the 19th there were heavy thunderstorms yielding .70 inches. The 22nd to 24th were fine and hot, the thermometer reaching 78 deg. on the 23rd.

Rainfall was again above normal by about three-quarters of an inch. Sunshine was 46 hours deficient.

AUGUST

During the first week the weather was fine and warm, the maximum on the 5th reaching 79.5 deg., the hottest day of the year. The rest of the month was unusually cold, and the thermometer failed to reach 60 deg. on four days, and on the th the maximum was as low as 57.6 deg.

On the night of the 22nd the screen thermometer fell to 36 deg., the lowest August reading since these records were started, and in exposed situations there were ground frosts on several nights. Further inland as many as six degrees of frost were recorded. The mean temperature was 58.9 deg., over 2 deg. below the average.

Rainfall was again above the normal, and on the 8th heavy rain was followed by thunderstorms, and 1.64 in. was measured Sunshine was below the average.

In addition to the storms on the 8th, thunder occurred on th 4th, 5th, 15th and 16th.

SEPTEMBER

This was another cold month, the mean being 2.8 degree below normal. 70 deg. was reached on only three days Rainfall was again above the average, the total having beei 2.36 in. more than two-thirds of which fell during the firs six days. In the latter part of the month there were man dull gloomy days, with slight rain and drizzle, which were ver depressing. Sunshine was 40 hours deficient, the total o 109.4 hours having been the lowest for September ever recorde by Mr. Willis. There were thunderstorms on the 3rd and 4t and early morning fogs on the 15th and 16th.

OCTOBER

The most remarkable feature of this month was the extra ordinarily severe frost during the last week. On the nights c the 27th-28th, and 28th-29th the screen thermometer fell t 22.9 deg. and 24.4 deg. and the grass thermometer to 18.6 deg and 16.9 deg. respectively, these being the coldest Octobe nights in these records. During the month there were frosts o 7 nights in the screen, and on 10 nights on the grass. Th earlier part of the month was mainly mild, and the mea temperature was only slightly below normal. Rainfall w 2.09 in. below the average, and sunshine 25 hours in excess.

NOVEMBER

This was the warmest November since 1899, the mea temperature working out at 3.3 deg. above normal. Tempera ture reached 50 deg. every day during the first fortnight, an on 22 days during the month, as compared with 23 days i the previous mild Novembers of 1928 and 1899. The maxim on the 3rd and 4th were 61.5 deg. and 60 degrees respectivel There were few frosts, and no snow fell. Rainfall was nearl three-quarters of an inch below normal. There was som thunder and lightning on the 11th, and the wind reached gal force on the nights of the 3rd and 26th. There was an almos entire absence of the fog and gloom usually associated with thi month.

DECEMBER

The mild weather of the previous month continued for the st fortnight, after which there were a few rather colder days. ›ringlike weather again prevailed during the Christmas ›lidays, but on the 29th there was a sudden change to wintry nditions, which lasted till the end of the month. The ean temperature was 2.3 deg. above normal. The maximum ı the 4th was 58.5 deg., and this appears to have been the armest December day locally since 1856. No severe frosts ere recorded but the minimum for the 24 hours ended 9 a.m. ı January 1st, was 19.4 deg., and on the grass the thermometer ıring that night fell to 4.9 deg. Rainfall was again deficient. ıow fell on the 29th and 30th and at the end of the month as 3 in. deep. Sunshine was approximately in agreement ith the average. The mean barometrical pressure (30.21 in.) as unusually high.

The glass stood at 30.70 in. on the 22nd and 23rd. The ıly gale was on the night of the 24th. There were very few gs.

THE YEAR

The mean temperature of the year (49.2 deg.) was slightly ›ove the average. The warmest day was August 5th (79.5 ›g.) and the coldest night March 10th (13.1 deg. in screen and 5 deg. on the grass).

The warmest month was July (61.9 deg.) and the coldest ınuary (38.1 deg).

It is very rarely that the thermometer fails to reach 80 deg. ıring the summer months, and the only previous years in which ıis has occurred since these observations were started were ›27 and 1920.

Rainfall was 1.70 in. above normal, the wettest months being pril (3.49 in.) and May (3.57 ins).

The sunshine readings again very kindly supplied by Mr. H.Willis, show that the year's deficiency was 154 hours.

A winter of normal temperature with little really cold weather as followed by a very dry and bitterly cold early Spring. April nd May were warmer, but very wet. A most disappointing ummer was to some extent compensated for by a fine October nd an unusually mild and open November.

MR. PRESTON'S METEOROLOGICAL RECORDS FOR 1931

1931	BAROMETER					THERMOMETER					HYGROMETER	SUNSHINE	RAINFALL		WIND							
															Direction and Days							
Month	Highest	Date	Lowest	Date	Mean	Highest	Date	Lowest	Date	Mean	Mean Relative Humidity 9 a.m	Hours	Inches	No. of Days	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
	in.		in.		in.	°		°		°	%											
Jan.	30.45	8	29.14	24	29.81	52.7	16	25.7	8	38.1	90	62.3	2.42	25	3	2	0	1	3	1	13	8
Feb.	30.26	5	29.25	16	29.81	57.0	25	25.0	6	38.8	88.3	50.0	2.36	21	1	3	1	1	3	5	11	3
March	30.47	26	29.51	1	29.96	64.4	19	13.1	10	39.7	84.7	191.9	.58	7	2	3	8	5	5	0	7	1
April	30.24	10	29.30	26	29.82	65.5	11	31.8	1	47.1	79.0	131.3	3.49	19	8	2	1	2	4	4	6	3
May	30.17	9	29.38	4	29.83	73.0	26	36.7	21	54.1	76.7	179.3	3.57	12	6	1	4	4	4	5	6	1
June	30.26	26	29.66	8	29.94	78.0	27	38.6	26	59.7	74.0	189.4	2.19	13	3	0	4	1	0	8	11	3
July	30.06	1	29.35	15	29.75	78.0	23	44.5	21	61.9	80.0	164.6	3.28	16	0	1	0	0	3	9	16	2
Aug.	30.39	27	29.41	20	29.87	79.5	5	36.0	24	58.9	84.4	171.7	3.24	14	7	3	6	4	0	2	8	1
Sept.	30.48	20	29.36	4	30.10	71.9	16	37.0	8	58.3	88.0	109.4	2.36	17	8	2	0	1	2	3	9	5
Oct.	30.60	15	29.35	24	30.09	71.0	6	22.9	27	49.6	86.0	132.5	1.03	13	8	2	1	1	3	3	9	4
Nov.	30.34	16	28.86	11	29.78	61.5	3	30.0	17	46.7	90.4	59.0	1.87	17	0	2	2	5	10	5	5	1
Dec.	30.69	22, 23	29.25	29	30.21	58.5	4	26.0	31	41.2	90.0	41.7	1.79	17	5	0	1	1	1	3	16	4
Means					29.91					49.2	84											
Extremes & Totals	30.69	Dec. 22, 23	28.86	Nov.		79.5	Aug.	13.1	Mar.			[illegible]	[illegible]	[illegible]	[illegible]							

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