Topography and Vegetation of Blakeney Point, Norfolk.

·1913·

BY
F. W. Oliver
AND
E. J. Salisbury.

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BLAKENEY POINT, NORFOLK

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CONTENTS.

ILLUSTRATIONS.

Figs. 10—17 on plate at end.

II.

THE TOPOGRAPHY AND VEGETATION OF THE NATIONAL TRUST RESERVE KNOWN AS BLAKENEY POINT, NORFOLK.

By Prof. F. W. Oliver, F.R.S., and E. J. Salisbury, D.Sc., F.L.S.

The object of the present paper is to present an epitome of the salient facts of the constitution and distribution of the plant populations of the well-defined area of maritime waste lands known as Blakeney Point, an area which has recently been brought under the National Trust as a Nature Reserve, with the express intention that the natural conditions which have prevailed in the past shall continue in operation without interference, at any rate from human agency.

Since the year 1910, Blakeney Point, long famous for its bird life and known to botanists as a locality for rare and interesting shore plants,[1] has been the theatre of systematic vegetation studies at the hands of organised parties. The work of collecting and correlating the data of plant distribution was

1. The late Prof. Babington, the well-known British botanist, records visiting Blakeney Point and collecting plants there, May 23rd, 1834.—"Memorials, Journals, etc."

entrusted to a special "floristic section," under the leadership of Dr. E. J. Salisbury, and it is largely the preliminary statement of the results obtained by this section which forms the subject matter of the present communication. This statement is for convenience preceded by a general introductory account of what is topographically important in the area as a whole, with especial reference to the distinctive characters of the various types of habitat into which the ground naturally falls.

F. W. O.

Part I.—TOPOGRAPHY.

By Professor F. W. Oliver.

General Features.

Blakeney Point is technically a *shingle spit*, a type of construction of which numerous examples occur on the English coasts. It leaves the shore at a point on the North coast of Norfolk, near Weybourne, and runs for a distance of about eight miles in a direction slightly North of West. The extremity ends freely in the sea, just short of Stiffkey, at a distance of about one and a-half miles from the shore. On its landward side is a long, narrow, tidal inlet, known as Blakeney Harbour, which receives at Cley the waters of the River Glaven. This estuary has become much silted up, and bears a covering of salt marsh intersected by creeks and channels, now navigable only at high tide by fishing boats and other vessels of small tonnage. The salt marshes of the upper part of the estuary have been reclaimed for pasture by the construction of banks reaching above tidal limits.

The total area within the spit, including the marshes, is about five square miles, of which rather more than one and a-half square miles consist of reclaimed, and two square miles of unreclaimed, salt marshes ("saltings"); the remainder consists of bare mud.

The dominating topographical feature is the shingle spit, which follows the edge of the shallow coastal shelf and delimits the seaward side of Blakeney Harbour. Along its course, to

leeward, numerous salt marshes have accreted, whilst towards its extremity—where the sea shallows off the headland from the accumulation of vast quantities of sand—much of the latter has been blown from the strand to form systems of sand dunes, which rest upon and mask the shingle.

Blakeney Point is thus an aggregate of shingle beaches, sand dunes, and salt marshes, all the materials of which have been derived from and sorted out by the sea. It is no doubt the re-incorporated residuum of an old land area, but whether this was formerly a seaward extension of the existing coast, or whether under very different conditions the materials were eroded from inland by the River Glaven of those days, are questions outside the province of the present article. In many similar formations of this kind, existing sources of supply from the present waste of cliffs seem inadequate to account for such vast accumulations of shingle—as, for instance, in the case of the Chesil Bank, in Dorset—and it is quite possible the same may be true of Blakeney Point.

Of this structure the terminal three and a-half miles form the National Trust Reserve, *i.e.*, the whole of that represented in Fig. 1, together with an additional half-mile to the East; the Trust also possess the strip of saltings abutting on the reclaimed marshes between Blakeney and Cley. All in all, the Reserve is a self-contained area of outstanding interest —physically, botanically, and as a haunt of birds.

The great peculiarity of the Blakeney spit is the high degree of complexity it has attained from repeated branching, a feature wherein it occupies a class by itself among similar formations in the British Isles.

If the spit be followed from its point of departure at Weybourne to its extremity beyond Blakeney, it will be found to consist of a straight, unbranched shingle beach for the first five miles (*i.e.*, up to the right-hand edge of the map, Fig. 1)— a toilsome causeway, about 400 feet in width, sloping from the crest at a very gentle angle to the marshes on its lee flank, more steeply on the sea face. The crest, though it stands fully six feet above the level of spring tide high-water mark, is

liable to be over-run by the waves, particularly when an exceptionally high tide happens to coincide with an onshore gale.

From the fifth mile onwards to the extremity, the main beach carries on its lee side some five-and-twenty lateral shingle banks or hooks, varying in length from a few hundred feet to half-a-mile, or even more (Fig. 1). These hooks are aggregated together in three groups, each of which has its own special characteristics. The first of these, which is known as the *Marams*, includes twelve hooks with intervening salt marshes; the second, which includes five hooks, is largely covered by a small sand-hill, a prominent feature in the landscape known as the *Hood;* whilst the final series of at least ten more banks includes two topographic features, the *Long Hills* and the *Headland*, separated from one another by a large triangular salt marsh (the Pelvetia Marsh, P.M., Fig. 1). Each bears a system of sand dunes, viz.: the Long Hills to the East, whilst on the Headland to the West of the marsh, are the series of ranges collectively termed the Beacon Hills; the latter provide the principal breeding ground for the terns,

The relations of all these regions are indicated in the map (Fig. 1).

THE MARAMS.

Here within a length of a mile or less, are twelve hook-shaped lateral shingle banks,[2] the extremities of which are almost without exception turned at a right angle so as to point East. These laterals consist of stabilised shingle; they are well covered with vegetation, and their crests stand above tidal limits. Under the protection of these banks the surface level of the bays between has been raised by the accretion of mud, and a very homogeneous series of salt marshes has developed, having an average level slightly above that of high water of neap tides. The process of accretion has probably been promoted by the narrowing of the mouths of these bays and the consequent protection from scour which results from the L-shaped terminals of the separating banks.

2. Whilst there are twelve banks involved (Cf. Fig. 2), in two cases three banks are so closely juxtaposed as to be represented each by one effective bank only; hence for practical purposes, it may be said that there are eight banks and eight salt marshes occupying their eastern flanks.

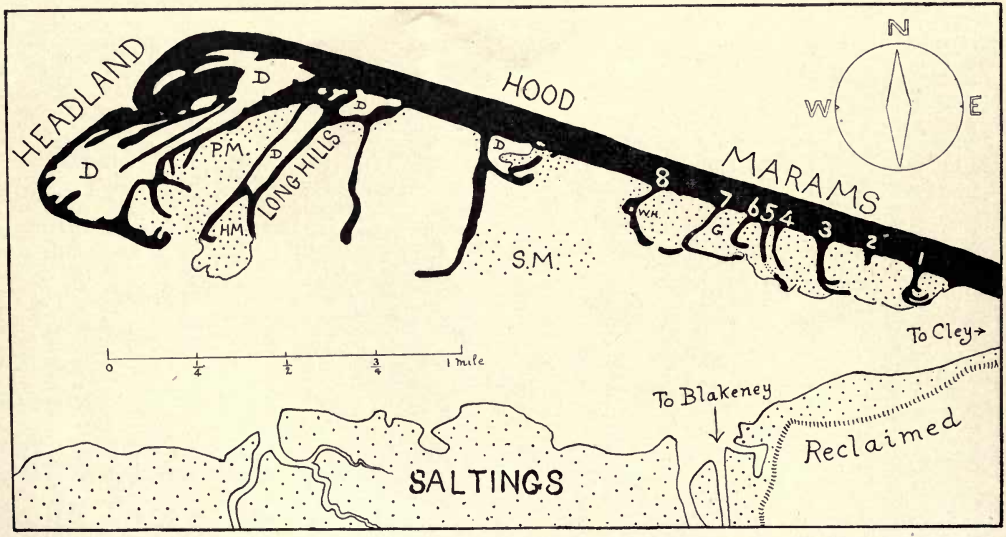

FIG. 1.—Map of the National Trust Reserve, being the extremity of Blakeney Point. Shingle is drawn black; Salt marshes are dotted; Dunes are marked D, but otherwise left plain. H.M. *Statice humilis* marsh; P.M., *Pelvetia* marsh; S.M., the Samphire marsh; G is a salt marsh on the Marams covered with very pure *Obione portulacoides*; W.H., Watch house. The numbers attached to the Marams lateral banks are those employed for the localities in Part 2 of this paper.

Before leaving the subject, a remark may be added as to the name Marams (*sic*); this, under present conditions, would appear to be a misnomer, as Marram Grass (*Psamma*) plays no conspicuous part in the vegetation. Blown sand is not transported to this part of the system, and nothing of the nature of dune formation now exists. The question whether dunes may not have existed here in bygone times, so that the name really possesses historic justification, is referred to on a later page.

The Hood.

A third of a mile west of the Marams is a small cluster of lateral banks, largely masked by a double-headed sand dune of horse-shoe form. In the concavity of this hill a little salt marsh is concealed—notable as the only locality on Blakeney Point for *Juncus maritimus*.

The most westerly of this group of laterals, after fringing the sand hill, continues right out into the estuary for a distance of nearly half-a-mile, where it ends in a terminal pointing West instead of East—a most exceptional phenomenon. The probable explanation is that the great length reached by this bank has made it subject to the scour of the tide as it runs off the flats. In any case this bank is much wasted, and its crest only slightly raised above the general level of the mud. On its Eastern side, near its extremity, is an extensive salt marsh of some interest, named the "Samphire Marsh," owing to its being resorted to by local samphire gatherers (Fig. 1, S.M.).

The Long Hills and the Headland.

Beyond the Hood the main beach continues its direction for a third of a mile, where it gives off another lateral; its general direction then undergoes a landward inflection of about 30 degrees, and at the same time widens out into an intricate complex of laterals which collectively form the Long Hills and the Headland.

As already stated, two approximated banks on the East bear the Long Hills system of sand dunes, whilst the Beacon

system (the most extensive of all) rests on the Headland—a number of crowded stabilised banks to the West.

Between these two systems is a deep bay occupied by the Pelvetia Marsh (P.M., Fig. 1). This marsh is divided into a number of arms or compartments by low lateral shingle banks on the North-west side (Fig. 4). These in general are of the same character as the banks on the Marams, except that they are lower and bear a less complex vegetation covering; one of them (No. 22 in Fig. 2) is shown end on in Fig. 5.

Between the two Long Hills banks,[3] at their distal extremity, is a smaller salt marsh (H.M., Fig. 1) of interest as being the only locality on the Point for *Statice humilis*.

From this purely topographical summary of the main features of Blakeney Point we may pass on to consider the mode of development.

THE MOBILE AND STABILISED SHINGLE BEACHES.

In a general way (though subject to some reservation in special cases) shingle washed by the open sea remains in a state of mobility; that is to say, storms throw shingle over the crest and scatter it down the lee slope. By the repetition of this operation the whole of the length of the main beach is

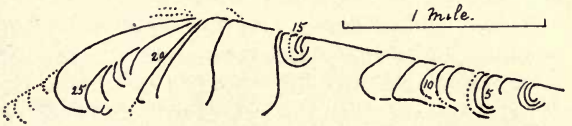

FIG. 2.—Diagram of area given in fig. 1 to show the relation of successive bank segments. Every fifth segment is numbered (from right to left). Dotted lines indicate banks or portions of banks that have disappeared or become masked.

being slowly driven shoreward, whilst the materials of which it is composed are not permitted to remain at rest long enough for a permanent, continuous carpet of vegetation to become established. What applies to the main beach also applies to its extremity—deflected as a landward hook by the scour of the tide. When, however, the main beach resumes its old line of advance the new apical deflection which it in due course

3. The more westerly of the two may be distinguished as the "Yaukee" bank, in reference to a house-boat of that name moored alongside.

develops will shelter the preceding hook from wave buffeting and tidal scour.

When the whole construction of the Spit is considered in relation to contemporary events, it becomes evident that growth has taken place from East to West by the superposition of a series of segments each of which has acquired, sooner or later, a landward hook. Though information is still required for the formulation of the precise conditions determining direct advance and deflection of the apex, respectively, there is no reason to doubt the periodic recurrence of these phases.

The relations in space of these successive segments are given diagrammatically in Fig. 2, where every fifth segment is labelled with a number—the most easterly of the Marams series being No. 1. Each segment possesses a proximal and a distal portion; the former, in alignment with the proximal parts of other segments, remains mobile; the latter, as a hook, becomes stabilised. In some instances there is evidence that complete segments or portions of segments have either become masked by overlying sand or have been actually eroded away; in these cases they are represented in the diagram by dotted lines.

To recapitulate the history of the Blakeney spit: There was an earlier phase during which it grew unbranched, and a later phase during which repeated hooks or lateral banks were formed. These two phases are represented by the straight run from Weybourne to the beginning of the Marams (five miles), and by the highly complex distal part stretching from the beginning of the Marams to the tip of the Headland, respectively. That the production of laterals should be characteristic of the later phase of growth is just what might be expected and needs no discussion here[4]; that these laterals should occur in clusters separated by non-lateral-bearing intervals depends probably on an aggregate of factors which includes the supply of materials, the incidence of storms, and perhaps the rate at which the estuary behind silted up. Of one phenomenon we have direct

4 Cf. F. W. Oliver, "The Shingle Beach as a Plant Habitat," New Phytol., 1912, p. 81.

evidence as to the cause. Prior to the winter of 1910-11 the Long Hills bank (No. 20, Fig. 2) was still straight, or at any rate only slightly curved. In the early part of 1911 a series of gales from the South-West broke off its exposed apex—cutting it off square and transporting the eroded materials so as to make a new bank inserted at right angles to the stump of the old one (Fig. 8). This observation gives the probable solution of how the L-shaped terminals on the Marams banks and elsewhere came into existence—of course at a very remote period.

Relation of Marshes to Main Beach and Laterals.

From the preceding general account of the main shingle beach and the relation to it of the lateral banks, it follows that the state of the materials in these two classes of structure must be markedly dissimilar. In the one the pebbles ranged parallel to the shore will remain mobile, so that the beach must slowly encroach on the marshes behind; whilst the laterals, on the other hand, being set at right angles to the shore and in large measure sheltered from wave impact, will enter on a state of dormancy.

One consequence of this will be the fundamentally different relations obtaining along the lines of contact of the salt marshes with the main bank and laterals, respectively. The marshes, as their level rises, will gradually overlay the flanks of the *laterals* with mud; we get here mud resting on shingle. At the junction of the marshes and *main* bank, however, the relations are precisely reversed, for here it is the shingle (being mobile) that is being drifted over the mud. It is needless to point out that these physical peculiarities are reflected in the character of the vegetation along these different types of junction.

Stabilising Effect of Vegetation.

Whilst the main bank tends to overwhelm the marshes behind it, its travel will be liable to retardation by a variety of circumstances. Thus the presence of bushes of *Suæda fruticosa*, very general on parts of the Blakeney Bank, tends to arrest the marshward flow of the shingle. The pebbles become piled up on the weather face of the bushes, whilst on

their lee sides the surface of the shingle, being protected, strip-like "islands" of partially stabilised shingle occur where many plants gain a footing and flourish. The positions of the characteristic fans—the form in which the shingle advances over the marshes (Fig. 6 and centre of Fig. 12,)—are closely related to the occurrence of gaps in the ranks of the Suæda bushes. The presence of other plants, especially those like *Silene maritima* and *Arenaria peploides*, which form extensive mats with deep-seated plexus of rhizomes, will also operate as stabilising factors, though much less effectively than Suæda, which is matchless in this connection. In view of this importance of vegetation, any special circumstance which promotes its establishment must be reckoned as a factor co-operating in stabilisation. Important among these is the proper supply of tidal drift to the bank (Fig. 12,), for this not only contributes in a conspicuous way to the formation of a soil, but also is in itself a condition favourable to the germination of seeds, as well as being the means of introducing many seeds to the bank.

The high degree of mobility often shewn by sections of shingle beaches fronting on reclaimed marshes is probably largely due to the starving of the beach of its proper drift (which mainly comes from the lee side) consequent on embanking—well illustrated by the Blakeney spit, where it borders the reclaimed marshes opposite Salthouse.

The presence of dunes on the beach is another factor operating as a very efficient mechanical barrier to the advance of the sea.

Mobility Effects along the Main Beach.

In view of the conspicuous way in which evidence of landward drift of shingle forces itself on the attention of the observer, it will be convenient here to epitomise the whole matter. It will be understood that throughout the length of the main bank shingle is liable to be shot over the crest by the onshore gales, especially when they accompany very high

tides. And not only is the material shot over, but it is also driven down the lee slope by the breakers, commonly emerging on the fringe as a projecting talus fan. This is the typical procedure all along the Marams—the fans or fingers (Fig. 6) projecting over the saltings and there remaining *in situ* on account of the protection from scour afforded by the hook-shaped lateral banks. Successive storms (it may be after the lapse of years) reinforce identical fans with additional shingle. This constancy in the dynamic lines of travel is of course referable to the permanance of the gaps between the *Suæda* bushes (well established on the Marams), which act as lines of least resistance.

Now, that part of the main bank to the East of the Marams is without Suæda bushes; moreover, from Kelling to the Cley Channel it is backed by a sea wall to protect the reclaimed marshes. Throughout this section of the bank the travelling shingle becomes heaped up against the bank, and, in the case of the Salthouse marshes, at very many points has burst through the wall and spread in great fans, about two feet deep, over the actual surface of the marshes.

As no effective means have been taken in recent years to repair the Salthouse bank, the condition described is going from bad to worse.[5] In contrast to this may be mentioned the section of marshes between Salthouse and Cley. Here the wall, evidently under difficult conditions and at considerable expense, has been kept in repair, with the result that it has been possible to exclude the drift of shingle up to the present time.

From these marshes to the Marams (half-a-mile) the shingle bank has rapidly encroached on the unprotected Cley channel. The shingle stands as a cliff on the seaward flank of the channel some six to eight feet in height, but the projecting fans or fingers of shingle are washed away, as soon as formed, by the current which here undercuts the bank. As a consequence, the channel has latterly become much blocked by shingle and

5. However deplorable this section of the bank may be from a purely economic point of view, it is replete with instructive illustrations of the dynamics of shingle flow.

navigation rendered difficult. Furthermore, as a result of this encroachment the waters of the Glaven tend to cut back the saltings on the South bank of the channel—an operation that seems likely to persist.

Passing on now to the state of affairs between the Marams and the Hood. Much shingle is driven across this section, but the fans are non-permanent, as the bay is an open one liable to be swept by the wind and tide from the landward side. As a consequence, a large part of the talus is driven into the corner by the Watch-House bank of the Marams under the influence of S.-W. winds—a residuum going in the opposite direction towards the Hood, drifted by winds from the S.-E. quarter. What holds for this section applies in large degree to that between the Hood and the Long Hills—the bay here being also open and unprotected.

The general result is, of course, that these sections of the bank are being steadily deprived of shingle and undergoing attrition, so that they are in effect becoming danger spots in the system—places at which something of a drastic nature may be expected to occur.

A serious aspect of the matter is that no *Suæda* bushes are able to establish themselves upon these sections. As we see from the Marams (Fig. 12), the fans of talus during intervals of quiescence are the great places for the establishment of seedlings. In consequence of the scour in the open embayments these fans are not permitted to remain, and thus the fringe of the bank is kept continually on the move, with the result just stated, that there is no spreading of Suæda. As the Suæda is the most important factor in arresting the travel of shingle, the employment of the word serious in this connection is not without justification.

The Plant Habitats.

It will be evident from the foregoing that Blakeney Point affords a great variety of different kinds of habitat for the establishment of vegetation. There is the *main beach*, which,

being mostly in a state of greater or lesser mobility, rarely acquires the close continuous turf of plants characteristic of ordinary ground. Of this, portions are outside direct influence of the tide, whilst the lower slopes on the Marams area have not a little in common with the salt marshes, in view of the opportunity of continuous colonisation of the advancing fringe of shingle from that source.

Then, contrasting with the main bank, are the *laterals* whose stabilised shingle bears a characteristic vegetation. Between the laterals is the long series of little bays occupied by salt marshes in various phases of development. Many of these, both on the Headland and Marams alike, are of the narrow mouth type, and all bear a continuous carpet of halophytes. At places, as to the East and West of the Hood (Fig. 1, p. 489), the bays are open and exposed to scour, so that the establishment of halophytes is much retarded in comparison with those protected by L-shaped terminals.

A very distinct series of habitats forming the principal, if not the sole, localities of several of the most interesting plants on the same area is what may be termed generically the *shingle low*. These are depressions left between closely juxtaposed banks, and occur especially at the convergence of laterals near their junction with the main bank. Being accessible to the highest tides, a covering of mud is deposited on the shingle. In the neighbourhood of sand dunes these lows are liable to be cut off from the tide, and to be drifted over with blown sand; this change of substratum modifies the vegetation in the sense that several of the original colonists tend to die out, whilst new ones make their appearance.

Finally there are the *dunes* already referred to, which are represented in the nascent state on the sea front of the Headland, and in established series of varying ages by the extensive Beacon Hills of the Headland, the Long Hills, and the Hood.

Here, as with the marshes, hooks, and shingle lows, a great stimulus to detailed study arises from the fact that all these different sorts of habitats are present in rich series, the

individual members of which are arranged in sequence of age. It thus becomes possible to follow each type in proper historical order through all the stages of its physical establishment, colonisation by plants, and the "successions" which these undergo. Indeed, it is hardly possible to imagine any area that could be better adapted to such a purpose.

These introductory remarks may be closed by some reference to the nature of the changes now in progress on the Headland.

Recent Changes on the Headland and Long Hills.

The earliest available map with topographical detail adequately represented is the six-inch map of the Ordnance Survey, published in 1886. A somewhat schematised reduction of this is reproduced, with two maps of later date, in Fig. 3. Shingle and shingle overlaid by bare sand are given in black, whilst the dune systems are dotted. The salt marshes (M.) which occupy the two principal bays have not been distinctively marked on the maps here given. It will be noted that the *shingle* continues more than a quarter of a mile beyond the sand hills, and that it bears several hooks. At the top of the map two spurs of shingle are represented, and on the extreme right yet another.

The 1897 map shows considerable change. The bare apical system of shingle is now represented by a single attenuated hook that has swung round nearly forty-five degrees to the South; the hook guarding the West side of the mouth of the Pelvetia marsh, that had in 1886 a single L-shaped terminus, has now budded out a second terminal: the two spurs at the top have coalesced with the main system, whilst the excrescence to the right has disappeared. Elsewhere there is little change to merit comment, except, perhaps, the wasting of the expansion at the end of the more westerly of the two Long Hills banks.

Turning to the 1911 map (based on our own surveys), the disappearance of the apical hook will be noted. As recently as 1907 this hook still existed as a topographical feature, though bent round so as to lie nearly parallel to the edge of the main

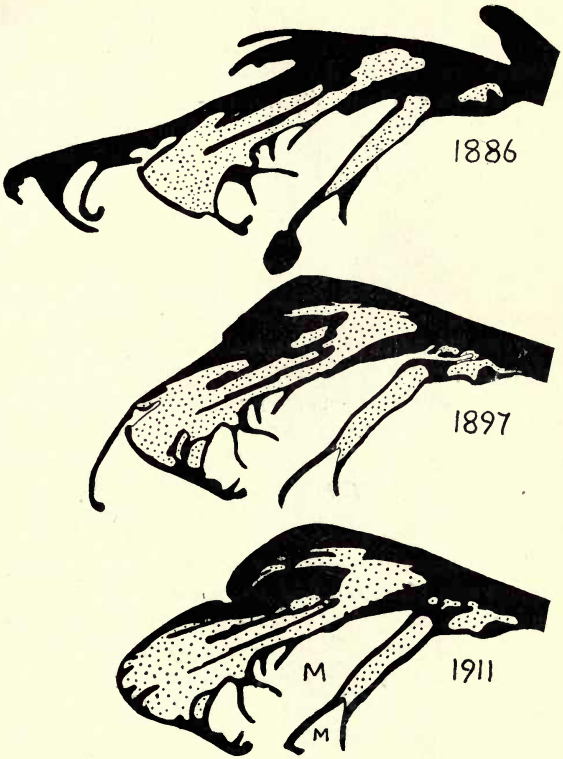

FIG. 3.—Blakeney Point—the Headland and Long Hils, showing distribution of shingle (black) and sand dunes (dotted) in the years 1886, 1897, and 1911 (the first two from the six inch ordnance survey maps). The *Pelvetia* marsh in the centre is left white. Note the wasting at the tip and the consolidationof the shingle on the sea front, the gradual extension of dune ranges, and the permanence of the linear 'lows.' M, salt marsh.

area. Most of the shingle of this wasted system of hooks would appear to have drifted alongside the forward edge of the main area, which has, in consequence, been much reinforced in recent years. A further change is the production of an L-shaped terminus to the left-hand Long Hills bank—a re-arrangement that took place early in 1911 (Fig. 8). On the sea face there has been some slight widening of the shingle plateau and the production of a channel leading into the large black central area, which consists of sand overlying shingle. This inlet, which is named the Great Sandy Low (Fig. 14), is filled by the higher tides, but the water does not extend into the other lows which are associated with it.

Having regard to this history of shingle movement of the last twenty-seven years, it is evident that growth in length is, at any rate for the moment, suspended, and that the present tendency is for such shingle as drifts on to the North-West face of the Headland to remain there in the form of apposition banks, with consequent widening of the Headland.

Turning now to the *dunes* (dotted), with the North-West extension of the shingle plateau these have undergone an extension in the same sense, throwing out from each end of the Great Sandy Low successive tentacles or parallel series of embryo *Psamma* dunes, which grow in height and extent as they arrest the sand which blows up from the strand beyond. In connection with this spread of the dunes, very striking is the persistence of the *lows* left between the successive dune ranges. The Long Low of the 1886 map[6] has persisted without material change to the present time; while a second one, parallel to this and known as the *Glaux* Low, has been isolated during the period represented by the series of maps. Further to seaward a third row has come into existence. The entrance of the tide into these lows—other than the Great Sandy Low—is prevented by embankments of blown sand near their former junctions with the Great Sandy Low.

As to the Great Sandy Low itself (Pl. Fig. 14), at present forming a great plain in the heart of the Beacon Hills, the

6 The long straight line of black just above the Pelvetia Marsh.

FIG. 4.—The Pelvetia marsh on the Headland. On the left are the dunes of the Beacon Hills; from the edge of these low shingle laterals run out into the marsh bearing bushes of *Sueda fruticosa*. On the right are the Long Hills, and beyond, the waters of the estuary. (From *Types of British Vegetation*).

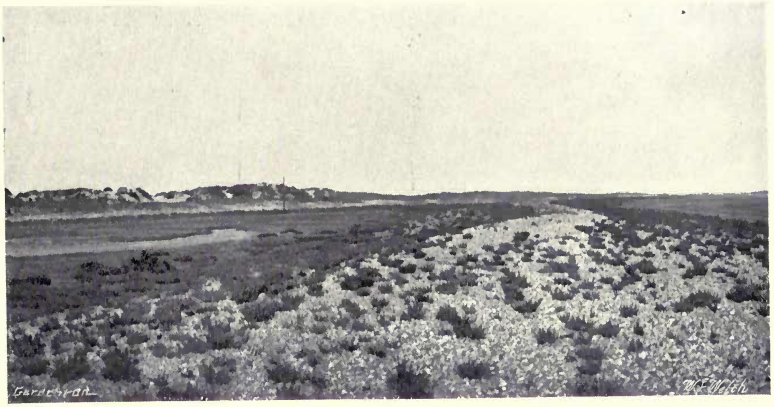

FIG 5.—A lateral bank from the Pelvetia marsh end on, bearing *Sueda fruticosa* bushes (No. 21 of fig. 2). The dunes on the left are the Beacon Hills of the Headland. (From *The Gardeners' Chronicle*).

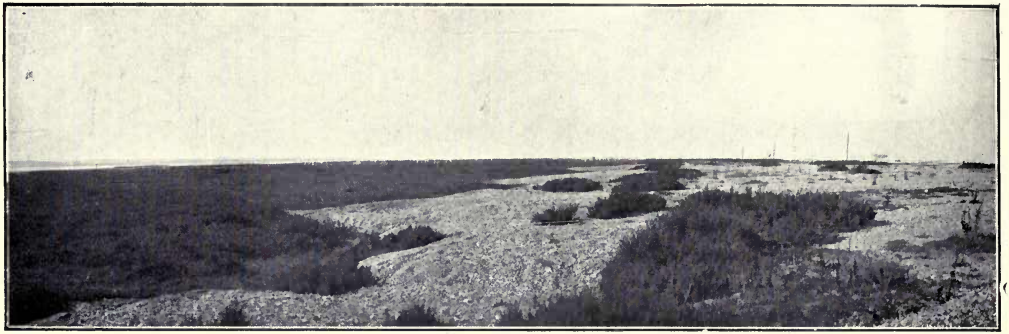

FIG. 6.—Edge of main beach opposite the Marams. Fans of shingle are encroaching on the saltings. The bushes on the beach are *Suæda fruticosa*.

FIG. 7.—Sea front of the Beacon Hills on the Headland. Psamma-dunes of various ages. The picture shows the principal breeding ground of the terns.

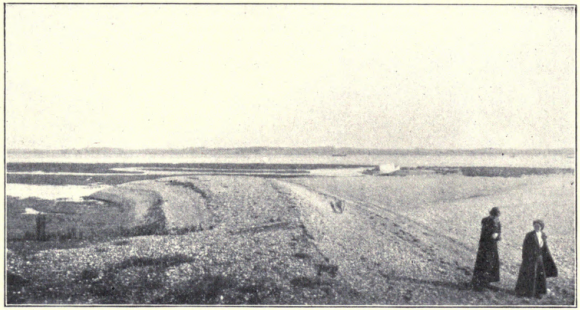

FIG. 8.—The L-shaped terminal formed in 1911 on the Long Hills bank—seen from its insertion on the latter. The figures are standing where formerly was the straight continuation of this bank. On the left of the picture, level with the head of the shorter figure, is the *Suæda fruticosa* zone ; to the right of the crest of the terminal a bush of Suæda belonging to this zone has grown up through the newly-arranged shingle. In the distance are seen the mud-flats and waters of the estuary (cf. also Fig. 3, 1911).

future development is uncertain. Should its mouth be effectually cut off from the sea by the throwing up of an apposition bank, it would either remain a low indefinitely, or, if the outer embryo dunes did not develop too rapidly and so cut off supplies of sand, it might become dotted over with *Psamma* dunes. On the other hand, should it remain tidal there is the possibility that it may develop a salt marsh—not, in all probability, a muddy marsh like the Pelvetia Marsh to its south, but on present conditions a salt marsh of the sandy order.

Part II.—VEGETATION.

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

(*Lecturer in Botany, East London College, University of London.*)

The following preliminary account of the Flora of Blakeney Point and Shingle Bank is the result of work carried out during the past three years as a member of Professor Oliver's ecological party. The author is deeply indebted to Professor Oliver, not only for valuable advice and criticism on many points, but also indirectly to his stimulating influence through the whole co-operative effort of which the present paper is but a single outcome.

For the investigation of the area in question the work was divided up into separate parts, each being allotted to a different section, and it is to the other members of the "Floristic Section" that the writer's thanks are due for their assistance in the field.

For an account of the topography of the district dealt with in the following communication the reader is referred to the preceding section of this paper.

I. The Main Shingle Bank.

The main shingle bank at Blakeney, which extends for some 7½ miles in length beyond the point at which it becomes free from the mainland, has the usual contour associated with this type of formation (see Oliver, The Shingle Beach as a Plant Habitat, New Phyt., Vol. XI., 1912, p. 76), and it is to the landward face that the flora is almost entirely confined. The limits of the shingle bank proper are not always easily defined, as for a considerable portion of its length there are sand-dunes and salt-marshes abutting upon it. We consequently find at these points that the members of one association become mingled with those adjacent, and thus render it not altogether easy to determine what plants should be included in the one or the other. In the following account and in compiling the lists it has been thought best to omit those species which were plainly the fringe of another formation. On the other hand, it is important to emphasise the fact that salt-marsh and dune plants do occur on the main bank well away from these doubtful zones of transition: these are, of course, included, as they have an important bearing either as relicts or as colonists.

The Principal Species.

The commonest and certainly the most characteristic plant of the formation is undoubtedly *Suæda fruticosa*, and as its distribution appears to be a marked factor in determining that of other species it will be well to consider it first. The proper position of *Suæda fruticosa* is best seen towards the distal extremity and on the relatively stable laterals (these latter will be dealt with subsequently in detail); in both these positions it occupies the extreme edge of the banks, and in general is most abundant between tidal limits.

This plant also occurs, however, in considerable quantity on the crest of the main bank, where the bushes form lines parallel to its axis. (Fig. 6.) The individuals increase gradually in number as we pass from the older proximal to the younger distal or free end of the bank, where they again decrease. We thus find a maximum number of bushes on the crest towards the centre or region of medium age, and minima corresponding

to the two ends. But, whereas the first or proximal minimum is not associated with the presence of bushes lower down on the flanks, these are abundant in the region of the second minimum, i.e., the youngest part. Prof. Oliver (loc. cit. p. 92) has pointed out that the bank moves inwards as a whole, slowly travelling towards the land, and this, taken in conjunction with the above distribution, clearly indicates that the parallel rows upon the crest are in the nature of relicts which represent former edges of the advancing shingle, which by its continued passage landward has given them their present position. (Fig. 6.) On the older parts of the bank the relicts have died out or are diminished in number, whilst in the younger positions the bulk of the bushes have not yet reached the crest, the shingle here having not yet overwhelmed them. The presence of more than a single line of bushes on older parts of the crest may have come about in more than one way. The more obvious explanation is that the advance of the shingle has not been constant, but intermittent in action: since the force which drives the shingle forward is applied from the seaward face, whilst the Suædas occupy the landward, it is quite possible that owing to the width of the bank a considerable period of such driving activity (probably almost entirely due to storms) has to elapse before the angle of the shingle sufficiently approaches the critical, on the landward face, to advance appreciably.

Such periods of preparation may be represented by a number of years, and would be followed by a period of readjustment, probably much less extended, involving, however, considerable advance. The distribution of seedlings of *Suæda fruticosa* is of importance here; they are mostly to be found on the landward edge, often upon the fan-like expansions which constitute the advancing face of the bank. All stages of development can be found, and a persistence of these would result in the formation of a somewhat irregular line of bushes parallel with the axis of the bank (Fig. 12).

Another origin suggests itself from the study of the laterals, which, though much less probable, may in part explain the irregularities both in number and arrangement of the parallel

lines. We find these laterals often shew the Suædas as a broad belt with extensive elongated islands of *Festuca rubra*, together forming an interrupted zone in which the Suædas are either absent or small and very occasional.

The occurrence of *F. rubra* between the lines of Suædas on the main bank, though in small amount only, may indicate a similar origin here as relicts from such a zone. Besides *Suæda fruticosa*, the other species which are abundant throughout the less barren portions of the bank are *Arenaria peploides*, *Silene maritima*, *Glaucium luteum*, and *Rumex trigranulatus* (Fig. 16); of these, the first two are met with throughout the length of the bank, not only in the regions of relatively greater stability, but also in the older and more mobile parts.

Arenaria peploides probably only tolerates positions in which a considerable amount of sand is present, a condition which obtains along the greater part of the Blakeney bank; generally speaking, Arenaria approaches nearer the sea than any of the other plants of this formation, not infrequently being found some way down the seaward slope. *Silene maritima*, like *Arenaria peploides*, is not by any means uncommon on the neighbouring dunes, and the presence of these two species here shews that they can endure considerable mobility, which is in harmony with their moderate abundance on the older parts where other species are either very rare or entirely absent. These two plants, with their extensive aerial systems and deep roots, can be regarded as the "Psammas of the shingle," and this is especially true of *Silene maritima*.

The densest vegetation, as perhaps we should expect, is to be found where the Suæda bushes are most numerous on the crest. In general, as has been pointed out by Prof. Oliver (loc. cit.), the barren or almost barren stretches are those where, owing to the absence of fringing marshes, the bank is unfed by accumulations of drift. But the amount of vegetation where there are bordering marshes is far from being constant throughout, and in fact corresponds broadly to the extent of surface stability brought about by the groyne action of the Suæda

bushes, which, at the surface, stem the tide of the advancing shingle.[7]

The presence of the Suæda bushes converts the surface into a partially stable crust, but apart from the movement forward of the upper layers of the shingle, there is perhaps also a bodily movement derived from the wave impact through which the underlying portions of the shingle are driven forward beneath the partially stable crust as if of semi-fluid consistency. So that the bank as a whole advances even though the surface in parts remain stable, and its vegetation undisturbed. The importance of this groyne action as a factor bearing upon the vegetation is well seen on that part of the main bank which lies between the dunes of the Headland itself and those which constitute the Hood. Along this stretch of shingle large quantities of drift accumulate, but the Suæda bushes are situated low down on the flanks and are no longer to be found on the crest. The shingle is thus relatively mobile, but though at the same time well fed with drift, we nevertheless find associated with these conditions a sparse vegetation in which the dominant species are those like *Glaucium*, *Sedum* and *Rumex trigranulatus*, which readily arise from seed. Of these plants, *Sedum* and *Glaucium*, though potentially perennial, frequently behave as biennials. This is most strikingly the case with *Sedum* which, though present in abundance one year, may completely die away to be replaced by seedlings, so that in the year following the maximal region has shifted elsewhere. On the landward slopes and in other protected situations, *Glaucium* is usually perennial, but on and near the crest the bulk of the individuals do not survive the flowering period. On the old sterile portions, *Glaucium*, *Rumex* and *Sedum* are wanting or very rare, and it would seem from this that drift is to them a prime necessity.

The results of cultures of *Rumex trigranulatus* bear out this hypothesis. Pots were for this purpose filled with shingle

7. Prof. Oliver informs me that in December, 1912, a high tide had been over the main bank, which by its effects shewed clearly this groyne action of the Suædas; where the waves had had an uninterrupted run the shingle was smoothed out as by a steam-roller, and the level often raised (as indicated by the burying of the Rumex) quite six inches.

mixed with drift and the controls with shingle only. All were then sown with approximately equal quantities of seed of *Rumex trigranulatus*. Unfortunately, of the control cultures the seeds germinated in one case only, suggesting that the drift may be necessary to prevent the seeds in the first instance from being washed too far down into the shingle. Those plants which were grown in shingle and drift were both large and vigorous, whereas those in the single control were comparatively small.

Other moderately common species are *Festuca rubra*, *Sonchus oleraceus* and *littoralis*, and *Senecio vulgaris ;* the last, as one might surmise from its ephemeral character, is fairly common throughout the whole length of the bank ; *Sonchus littoralis* is almost invariably found either on the lee side of the bushes of *Suæda*, or else growing out of the turf-like patches of other plants, such as *Arenaria*, *Silene* or *Festuca*. As has been already mentioned, the last-named species is usually on the sheltered side of the *Suæda* bushes between their ranks ; it and also *Triticum junceum* are especially characteristic of the most stable portions.

Plants of the Depressions.

A few plants are found chiefly in the troughs and shallow depressions, towards the landward edge. Of these, the most characteristic and abundant is *Poa annua*, whilst *Sedum acre* is also fairly common and possibly in part owes its situation to the frequency with which plants that have passed the flowering stage become uprooted and get blown along by the wind, finally coming to rest in one of these hollows where the seed is probably shed. *Aira præccx* also occurs.

Two other grasses of the depressions are *Desmazeria loliacea*, which is local, and the second, *Lepturus filiformis*, rather rare and much commoner on the lateral hooks. These depressions, however temporary, are obviously for the time being regions of greater surface stability, and besides giving shelter, the shingle is usually finer here than on the bank around, and is consequently more retentive of water. As the characteristic species above mentioned are all shallow-rooting

plants, probably these two later factors afford the best explanation of their presence.

The Halophytic Element.

We now come to a consideration of the plants which are properly members of other formations.

By far the most interesting of these are the salt-marsh plants, which comprise *Artemisia maritima*, *Aster Tripolium*, *Glyceria maritima*, *Obione portulacoides*, *Plantago maritima* and *Statice Limonium*. Broadly, these halophytes are found on the main bank in two types of locality, viz.: (1) Opposite to where the bank is at present fringed by salt marshes; (2) In regions where no such marshes are present, but where drift accumulates above normal tide limits carried up by the action of storms.

In the latter habitat we find *Glyceria maritima* and some of the specimens of *Obione portulacoides*. There seems no reason to doubt that they have originated from the seeds or fragments carried up with the drift which they accompany.

The remaining four species and other plants of *Obione* are found in the shingle opposite to fringing marshes. Of *Plantago maritima*, *Statice Limonium* and *Aster Tripolium*, one plant of each was observed growing well up on the shingle bank, though others are found at the extreme edge which have only recently been overwhelmed by the shingle.

The number of *Obione* plants found high up was six, of which one was situated about half-way to the crest and the remainder nearer the landward edge; besides these there are numerous plants which form an interrupted zone marking the upper limit of the drift, and especially well developed on some of the advancing fans.

Artemisia maritima is at once the most interesting and frequent amongst the salt-marsh plants which occurs on the shingle; it is met with in over a dozen separate stations, of which some bear large patches.

Three of the localities were in more or less isolated positions and are of no interest beyond their actual occurrence. Two others were found on the seaward side of isolated small plants of *Suæda fruticosa*, whilst the remainder, comprising not only

the majority of localities but also the bulk of individuals, were all on the landward edge of the nearest line of *Suæda* bushes, and in most cases quite close to them.

To anticipate slightly with respect to the lateral hooks (cf. p. 30); the distribution of the *Artemisia* there is in general very clearly and sharply defined, forming a zone between the outer edge of the *Suæda* bushes and the salt marsh itself, with a few plants occasionally intermingled. The close association, usually in the same definite relative position obtaining between these two species on the main bank as on the laterals, impresses us forcibly with the fact that we have here no mere coincidence but a clear indication that these plants formerly occupied such places at the edge of the salt marsh now overwhelmed by the landward advance of the shingle.

We can, therefore, conclude that the halophytic flora of the main bank is to be regarded as comprised of relicts, and the data for this can be summarised as under :—

(*a*) The relative positions of the *Suæda*, *Artemisia* (and perhaps *Obione* and *Festuca*) which obtain in undisturbed marshes are retained by the relicts on the mobile shingle.

(*b*) Instances of recent overwhelming are not infrequent at the edge.

(*c*) The relicts occur chiefly where marshes now fringe the bank, and are mostly distributed towards the landward edge.

(*d*) The absence of *Suæda* opposite hooks due to "hook sliding." (Oliver, loc. cit., p. 92).

(*e*) Plants of *Artemisia*, *Statice* and *Plantago* close to the edge still have their roots in the marsh soil below.

The Arenicolous Element.

Dune plants are likewise represented in the shingle flora, and some of these, at all events, are to be regarded as colonists. At its distal extremity (the Headland) the shingle bank is almost completely covered by dunes, and transitions between these and the shingle formation are to be found, and will be considered in connection with the dune formation. The following

Sand-dune plants, viz., *Carex arenaria*, *Convolvulus Soldanella*, *Elymus arenarius*, *Eryngium maritimum*, *Senecio Jacobæa*, *Stellaria Borœana*, and *Psamma arenaria* are all met with either as rareties or, in the case of the last, as a not infrequent component of the shingle formation.[8] Curiously enough *Eryngium maritimum*, although typically a psammophyte, is only to be found on the shingle and is totally absent from the dunes[9] themseves. With the exception of a single meagre plant, upon the dunes, the same may also be said of *Elymus arenarius*.

Typical gravel heath plants are rare (with the exception of *Festuca rubra* referred to above) and few in number; they comprise *Lotus corniculatus*, *Festuca ovina*, *Holcus lanatus*, *Poa pratensis*, *Hieracium Pilosella*, and perhaps *Arrhenatherum avenaceum*.

CASUALS.

Besides the normal constituents of the flora, there are here, as always, casuals which, regarded from the point of view of a shingle beach, are certainly weeds. Of such plants *Lychnis vespertina* and *Papaver Rhœas* represent the cornfield element with a single plant each. (A second specimen of the former has been found for the past two years on the shingle near the Hood.) *Carduus arvensis*, *Dactylis glomerata*, and *Tussilago Farfara*, which are usually to be found in stiff soils, may also be placed in the same category.

Enumeration of species growing on the main shingle bank.

In all, sixtyplants have, up to the present, been recorded for the Blakeney main bank, a complete list of which is appended below—

Agrostis maritima (r.)
Aira præcox (occ.)

8 In view of the name Marams applied to the complex of laterals and marshes abutting on the central part of the main bank, and the presence of sand-dunes on both the other aggregations of laterals, viz.: "The Hood" and the Headland, it is possible that these Psamma plants may indicate the presence of dunes in former times on the more proximal part of the Point. On this conjecture the forward movement of the shingle has been accompanied by a similar advance of the sand supplies preventing the regeneration of these dunes as they became eroded by the wind.

9 *Eryngium* is reported as having been quite abundant on the bank in byegone times, and is now again increasing.

Anagallis arvensis (r.)
* Arenaria peploides (v.c.)
Armeria maritima (loc.)
Arrhenatherum avenaceum (v.r.)
Artemisia maritima (occ.)
Aster Tripolium (v.r.)
Atriplex hastata (r.)
Atriplex littoralis (r.)
Carduus arvensis (v.r.)
Carex arenaria (r.)
Chenopodium album (occ.) (glomerulosum ?
Convolvulus Soldanella (r.)
Dactylis glomerata (v.r.)
Desmazeria loliacea (loc.)
Elymus arenarius (v.r.)
Epilobium hirsutum (v.r.)
Erophila vulgaris (v.r.)
Eryngium maritimum (v.r.)
Festuca ovina (v.r.)
* Festuca rubra (f.)
* Glaucium luteum (v.c.)
Glyceria maritima (r.)
Hieracium Pilosella (v.r.)
Holcus lanatus (r.)
Lepturus filiformis (r.r.)
Lolium perenne v. tenue (v.r.)
Lotus corniculatus (v.r.)
Lychnis vespertina (v.r.)
Matricaria inodora (r.)
Mertensia maritima (v.r.)
Myosotis collina (occ.)
Myosotis versicolor (r.)
Obione portulacoides (r.)
Papaver Rhoeas (v.r.)
Plantago maritima (v.r.)
Poa annua (f.)
Poa pratensis (r.)

Psamma arenaria (occ.)
Ranunculus repens (v.r.)
* Rumex trigranulatus (v.c.)
Rumex acetosa (v.r.)
Sagina apetala (r.)
Sagina maritima (occ.)
Sagina procumbens (loc.)
Salicornia disarticulata (v.r.)
* Sedum acre (c.)
Senecio Jacobæa (r.)
* Senecio vulgaris (forma) (c.)
* Silene maritima (v.c.) (including several forms).
* Sonchus arvensis v. littoralis (c.)
* Sonchus oleraceus (f.)
Statice binervosa (f. on slopes of distal end)
Statice Limonium (v.r.)
Stellaria Boræana (occ.) (Suæda Islands).
* Suæda fruticosa (v.c.)
* Triticum junceum (f).
* Triticum pungens (r.)
Tussilago Farfara (r.)

V.C. = very common; c. = common; f. = frequent; occ. = occasional; loc. = local; r.r. = rather rare; r. = rare; v.r. = very rare. The more important species marked *

The most striking feature which these shingle plants have in common is their low growth (Fig. 13), a habit that, apart from the shrubby *Suæda*, which except in sheltered situations sheds its leaves in winter, is universal. The majority grow close to the shingle throughout their life history, and some, like *Arenaria*, *Silene*, etc., attain added protection by the aggregation of their shoots to form a mat-like surface.

Of those which attain any height the greater period of the year is passed in the rosette condition *(Sonchus, Glaucium)*, or with the young leaves protected by those which are dead and withered *(Rumex)*; it is only during the milder months that these species send out a vertically elongated axis for the

purposes of reproduction, and even so occasionally suffer considerably in consequence.[10]

It is worthy of note that only those species attain any degree of frequency which in one way or another are adapted to the strenuous conditions which characterise this class of habitat.

It is not in the scope of the present paper to treat in detail of the cryptogamic flora, but before leaving the main bank it may be said that where extreme stability obtains, as in the shelter of the dunes or on the barer shingle of the lateral hooks, lichens are of frequent occurrence. Of these the more important pioneer species are *Buellia colludens* and *Rhizocarpon confervoides* which are most frequently followed by *Lecanora atra* and *Physcia parietina*.

II. The Lateral Hooks.

As the flora of the lateral banks will be treated with greater detail in another connection, we shall only give here a general account summarising the observations on all the banks.

Whilst the main bank is essentially a shifting formation, the laterals, though belonging to the same class, are relatively stable, and associated with this greater fixity we find not only that colonisation has proceeded much further, but also the somewhat indefinite character of the distribution on the main bank gives place to a much more clearly marked arrangement. No fact could emphasise this more than the repetition on each of the successive banks of the same sequence of zonations; so that, in general, an examination of any single hook gives broadly the essential features of all.

Viewed from the aspect of their conformation we can distinguish three main parts consisting, respectively, of the sloping sides (these are steeper on the face directed towards the free end of the main bank and usually very gentle on the opposite face); the crest, forming a flattened or slightly convex top to

10. The following is an extract from Professor F. W. Oliver's field note book for July 13, 1909. "Rumex—after storm (N.W.) of July 7, most spikes of Rumex hanging brown or dead (wind, or wind with salt?). Those under the protection of *Suæda fruticosa*, etc., uninjured. The Rumex was all right on the 6th, so this fixes cause of damage."

the bank; and the "high elbow" which occupies the top of the sharp bend or L-shaped termination of each lateral.

There are seven such banks on the Marams area (Fig. 1) which are of importance (one other which exists (No. 2) has no bearing in this connection),[11] separated from one another by salt marshes of varying width; they will be referred to in the following account by numbers, the eighth or youngest (on which the Watch House stands, Fig. 1, W.H.) being that nearest The Headland, and forming a boundary to that end of the series of salt marshes. The first or oldest has marshes on both sides, but between it and the junction of the pebble beach with the mainland, no other laterals occur. Still younger hooks are found nearer the Headland, and one of these will be dealt with in the sequel.

Of these seven banks two call for special comment before we embark on a generalised description of the flora. The eighth bank bears towards its distal extremity a Coast-guard Watch House, and is consequently subject to considerable human influence, and perhaps the much more extensive flora which it possesses as compared with the others is largely accounted for by this factor. The other bank which exhibits special features is the fifth in order; it arises as a branch from the base of number six, and is peculiar in that it is so broad and flattened that it may be regarded floristically as being devoid of any crest or high elbow such as we find in the remaining five.

The Vegetation Zones of the Hooks.

Passing from the lower edge of one of these banks on to the high elbow, five principal zones can be recognised, which, taken in order of their ascent, are: 1. The *Suaeda fruticosa* zone. 2. The *Festuca rubra* zone. 3. The *Statice binervosa* zone. 4. The Crest or *Agrostis maritima* zone, and lastly, 5. The High Elbow. (Fig. 10.)

(1.) *The Suæda Zone.*

The *Suaeda* zone proper is a dense belt of bushes some two feet in height and of varying width, which occupies the lower

11. Strictly speaking several of these banks are compound in origin, but for convenience each complex is treated as a unit.

part of the sloping sides of the bank. Its outer margin abuts closely upon the zone of *Artemisia maritima*, which is here taken as the upper limit of the salt-marsh vegetation. (Fig. 10 on left.)

The shade of the *Suædas*, which here stand in somewhat close formation, commonly restricts in marked degree the growth of other plants. *Obione portulacoides* is, however, common in this zone, more especially upon the older banks that separate marshes in which it is the dominant species. *Aster Tripolium* and *Glyceria maritima* are likewise present, the former usually as scattered individuals, but the latter sometimes in considerable frequency.

A very characteristic plant of this association and entirely restricted to it, is *Cochlearia anglica*, which, however, is rather rare and confined to the older laterals.

Beyond the *Suæda* zone scattered bushes are still found in the succeeding associations up to the crest, but in continually decreasing amount.

(2.) *The Festuca rubra Zone.*

The second zone consists typically of an almost pure sward of *Festuca rubra* and is much less clearly defined than the first, being of very variable width, occasionally broken, and merging below into the zone of *Suæda*. Between this and the third zone, a more or less subsidiary zone can often be distinguished, consisting of *Triticum pungens* (with occasionally *T. pungens* v. *aristatum)*, frequently associated with which is *Cochlearia danica* and more rarely *Atriplex littoralis*. This last forms the upper limit of the drift, and beyond this line the *Suæda* bushes, though they persist up to the crest, are very scattered and low in growth.

(3.) *The Statice binervosa Zone* (Figs. 10 and 15).

The third zone is characterised by the presence of *Statice binervosa* in considerable amount, and much less abundantly *Frankenia lævis*. These two species appear to be normally associated with bare shingle in which the interspaces are completely filled with sandy mud. A few dwarfed and scattered *Suæda* bushes are usually present in this zone, and also

numerous scattered plants of *Obione portulacoides*, which, however, is prostrate in habit, seldom attaining more than two or three inches in height or a foot in diameter. To these species must be added *Armeria maritima* and stunted plants of *Glyceria maritima* and *Plantago Coronopus*, the latter usually with almost glabrous and but slightly toothed leaves.[12]

(4.) *The Crest.* (Fig. 13).

The fourth zone forms the larger part of the bank, and is a grassy sward of numerous species in which the dominant plants are *Armeria maritima*, *Silene maritima* and *Agrostis maritima*.

Common in this zone also are *Sedum acre*, *Arenaria serpyllifolia* and *Plantago Coronopus*; the first two are usually associated together, and the last frequently with *Cladonia rangiferina*, especially towards the base of the banks. *Trifolium arvense*, *Trifolium striatum*, *Cerastium tetrandrum*, *Sagina maritima*, and *Lepturus filiformis*, have a distribution which coincides roughly with the tracks, formed by the coastguards and others, which usually pass along the main axes of the banks. This habitat is probably to be interpreted as due to the low growth and barer character of these places, rather than to direct human agency in their distribution. Such a view seems to be borne out by the fact that some of these species are most abundant on banks where the amount of traffic is not greatest. In the case of *Lepturus filiformis*, there is a decrease in amount as we pass from the older to the younger laterals, till on bank No. 8, which is probably visited more than any other on account of the Watch-house, the species is entirely absent. The mode of occurrence of several of these plants in other localities and formations is also in accordance with the view here expressed.

Owing to the exceptional character of bank No. 5, mentioned above, the whole of its flat top is occupied by the *Binervosa* association, and the crest plants themselves are altogether

12 On Bank No. 8, and there only, we find in this association in one place plants of *Spergularia salina*.

wanting. A similar phenomenon is presented by a small area on the crest of the eighth bank, which lies a little below the general level, and has not yet become a closed turf; here we find *Statice binervosa*, *Frankenia lævis* and the usual associates, together with *Spergularia salina*. It would appear that the amount of soil accumulated on the shingle was as potent a factor as the actual level, and such accumulation will, naturally, be greatest on the flat expanse which forms what we have termed the crest, where the soil reaches a depth of about two inches.

In the following list of plants observed in the Crest association, the numbers indicate the banks on which the species occur; where no number follows, presence on all the banks (with the exception of No. 5) is implied.

Agrostis maritima (v.c.)
Arenaria peploides (7 and 8) (r.)
Arenaria serpyllifolia (c.)
Armeria maritima (v.c.)
Artemisia maritima (1) (v.r.)
Cerastium tetrandrum (8, 7, 6, 3 and 1) (f.)
Desmazeria loliacea (3,4, 7) (loc.)
Leontodon autumnale (8) (v.r.)
Lepturus filiformis (3, 4, 6 and 7) (r.r.)
Plantago Coronopus (c.)
Sagina maritima (4, 6, 7, 8) (r.r.)
Sedum acre (c.)
Silene maritima (v.c.) (less so on older banks).
Statice binervosa (as relict) (f.)
Trifolium arvense (f.)
Trifolium procumbens (7 and 8) (occ.)
Trifolium striatum (7 and 8) (loc.)

(5.) *The High Elbow.*

The association of the high elbows, whilst including several of the species found on the major part of the crest, comprises many which do not grow elsewhere, and we shall include in this category the high ridge-like portion of bank one, which,

although topographically not part of the "elbow," must from the character of its flora be included here.

The common species are: *Lotus corniculatus*, *Rumex acetosella*, *Plantago lanceolata*, *Armeria maritima* and *Poa pratensis*.

All of the above, with the exception of *Armeria*, are characteristic members of inland gravel heaths; and to these we can add *Galium verum*, *Aira præcox*, *Festuca ovina*, *Koeleria cristata* and *Senecio sylvaticus*, which are also found on the highest parts of one or more of the banks. Such plants as *Bellis*, *Carduus*, and *Hordeum*, which are only to be met with in the near neighbourhood of the Watch-house, doubtless owe their presence to human agency.

The following is a complete list of the species observed on the elbow, the numbers of the banks, as above, only being given when the distribution is not general:—

Aira præcox (6, 7 and 8) (f.)
Arenaria serpyllifolia (occ.)
Armeria maritima (c.)
Bellis perennis (8) (v.r.)
Bromus mollis (8, 7, 3 and 1) (f.)
Carduus lanceolatus (8) (v.r.)
Erodium cicutarium (8) (r.)
Festuca ovina (8) (r.r.)
Festuca maritima (8) (v.r.)
Galium verum (8 and 7) (f.)
Geranium molle (8) (r.)
Hordeum murinum (8) (r.)
Koeleria cristata (8) (v.r.)
Lotus corniculatus (c.)
Plantago lanceolata (8, 7, 6 and 4) (c.)
Poa pratensis (c.)
Rumex acetosella (8, 7 and 4) (c.)
Rumex trigranulatus (8, 7, 6 and 3) (r.)
Sedum anglicum (7 and 8) (r.)
Senecio Jacobæa (7 and 8) (r.)

Senecio sylvaticus (8) (v·r.)
Silene maritima (f.)
Vicia angustifolia (7, 8 and 1) (occ.)

The Younger Hooks.

Of the lateral hooks which intervene between the west end of the Marams and the distal extremity of the main bank, most are of little value in the present consideration, as they are, either in whole or in part, covered by portions of the dune system. The distal extremity of one of these, however, situate at the end of the "Long Hills," and which may be termed the Yankee bank,[18] is sufficiently unaffected to be of value in this connection and is chiefly of interest as furnishing us with a younger stage in which the crest has not yet passed beyond the condition of an open formation.

Along either side of this bank is the usual zone of *Suæda*, and just above it towards the base is a clearly-defined zone of *Statice binervosa*, which gets rarer as we pass towards the distal end where the shingle is more mobile; elsewhere it is worthy of note that the *binervosa* zone is intermittent, and that the breaks correspond with those positions where the *Suæda* bushes present gaps, so that the shingle of this zone is there unprotected and consequently unstable. *Frankenia*, which usually accompanies this *Statice*, is absent from the bank proper, but where this joins on to another bank at its base a depression of stable shingle covered with mud furnishes a habitat for *Frankenia lævis*, *Statice binervosa* and *S. reticulata*. These depressions are of frequent occurrence, and always correspond to the V-shaped "low" where two banks join—in some cases cut off by a bridge, in others exposed to normal tidal invasion. The floor is covered with low-growing *Suædas* about 6 inches high, forming "hummocks," between which grow the *Frankenia* and *Statice reticulata* (with occasional *S. maritima* and *Salicornia*), and at the edges of the depression *S. binervosa*. Where entirely removed from tidal action, as in the bare shingle lows of the dune area and near the Hood, *Plantago Coronopus* var. *pygmæa* (some-

13. In reference to Mr. Hart's house boat "Yankee," which is moored off the N.W. face of this bank.

times in association with *C. semidecandrum*) is characteristic of the older, and *Glaux maritima* of the more recently formed.

To revert to our intermediate "Yankee" shingle bank. The commonest species of the crest are *Arenaria peploides*, *Armeria maritima*, and *Silene maritima*. *Glaucium luteum* is entirely absent, whilst *Rumex trigranulatus* is only occasional. The increase of stability here, as compared with the main bank, is marked by the presence of such species as *Rumex acetosella*, *Plantago Coronopus*, *Lotus corniculatus*, and *Filago minima*.

The near neighbourhood of the dunes explains the presence in the list which follows of several psammophytes, such as *Phleum arenarium* and *Stellaria Boræana*.

Enumeration of Species on "Yankee" Bank.

Aira præcox (f.)
Anagallis arvensis (f., towards sides)
Arenaria peploides (v.c.)
,, serpyllifolia (c.)
Armeria maritima (v.c.)
Atriplex hastata (f.)
Carduus lanceolatus (r., near end)
Cerastium tetrandrum (f.)
Cochlearia officinalis (occ.)
Erodium cicutarium (f.)
Filago minima (v.r., except at base, f.)
Lotus corniculatus (r.)
Myosotis collina (v.r.)
Phleum arenarium (v.r.)
Plantago Coronopus v. pygmæa (c., near base, gets rare towards apex)
Rumex acetosella (f.)
,, trigranulatus (occ.)
Sagina maritima (occ.)
Sedum acre (c.)
Senecio Jacobæa (occ.)
Silene maritima (v.c.)
Statice binervosa (f.)
Stellaria Boræana (v.r.)

Colonisation and Succession.

From an examination of the various phases of shingle bank succession there seems little doubt that the primary colonisers are usually forms with extensive root systems, such as *Arenaria peploides* and *Silene maritima*, followed on closely by *Rumex trigranulatus*. The main bank must doubtless be viewed as exhibiting an early condition in pebble beach colonisation, which condition is rendered permanent by its mobility. On the intermediate "Yankee" bank (p. 34) we still find most of the plants of the main bank, but with the addition of species of more stable situations.

On the older laterals of the Marams the open association has given place to an almost continuous turf, in which the early colonisers are less and less abundant; thus in the Marams series we find *Silene maritima* with less and less frequency, *Arenaria peploides* is only on banks Nos. 6 and 8, and *Rumex trigranulatus*, although present on all but three, is rare in every case, but most frequent on the first and second. Some of the annual species, such as *Senecio vulgaris*, *Sonchus oleraceus*, and *Myosotis collina*, which were frequent on the main bank, have been entirely driven out.

In marked contrast is the increase of those plants which prefer a stable habitat, such as *Sedum*, *Armeria*, *Agrostis*, *Lepturus*, and *Triticum junceum*. Besides which there is a steady influx of gravel heath plants. On the "Yankee" bank these last are represented by a few species only, and these in no great abundance; they comprise *Aira præcox*, *Filago minima*, *Lotus corniculatus*, *Plantago Coronopus*, and *Rumex acetosella*, the last being the most common. Such become much more numerous both in species and in individuals on the high elbows of the older laterals.

Factors Determining Distribution: Case of Statice binervosa.

There seem then to be two factors of prime importance which together determine plant distribution on the shingle; these are stability and the amount of accumulated soil, the latter in part depending on the former. The importance of stability

has already been emphasised more than once, and a brief consideration of *Statice binervosa* will serve to illustrate the second.

As described above, this plant is in general confined to a zone corresponding with the flanks of the laterals. On the main bank it is only found sparsely near the crest where the bank is very broad and consequently less mobile. It is also present on the slopes of the main bank, where a condition of stability comparable to that of the laterals is brought about by the presence of dunes situate on the seaward face. With increase of fixity comes an acceleration in the rate of soil accretion, and this favours the growth of the *Statice* until the colonisation and spread of other plants brings in the factor of competition. These, although unable to establish themselves on the bare shingle, can successfully compete with the *Statice* immediately a shallow soil has been formed. It would seem that the condition of the fifth bank of the Marams series, where the "*Binervosa*" zone extends completely over the crest, is a condition in which the normal accretion of soil has been delayed. The arrival of the crest flora marks the beginning of a struggle in which, by the centrifugal extension of the turf, the "*Binervosa*" zone is driven further and further towards the sides (the places of slowest accretion), till finally it is narrowed to the merest line, or even disappears entirely. Evidence for such a sequence of events is furnished by relict plants of *Statice*, which are distributed with some frequency towards the edges of the crest association; also on one of the laterals (Marams bank No. 8), where a portion of the crest has been artificially denuded of the overlying soil, we find *Statice binervosa* in some considerable amount. The very narrow zone of *Statice* on the intermediate lateral ("Yankee" bank) described above is no doubt related to instability, but whether this zone in the normal sequence of events spreads to the top of the bank before conditions for establishment have become adverse by the thickening up of the crest flora is open to considerable doubt.

A striking feature of the relict *Statices* on the crest is that their average height and general vigour is considerably in excess

of that which obtains in the zone of greatest abundance, viz., the flanks. Also where the relict *Statices* near the base of a lateral have become buried by the advancing shingle of the main bank there is even slightly greater luxuriance exhibited.

In the appended table the heights, in inches, of twenty plants, taken at random from the crest and flanks, are given, from which it is seen that the average of the former shews an excess of about 4¼ inches over that of the latter.

Statice binervosa: Heights of Plants:—

Crest	9·5	9	11	6	7	10	10·5	9	7	10	Average
	6	9·5	9·5	7	9	10·5	6·5	8	9·5	6·5	8·5 ins.
Sides	3·5	3	4·5	4·25	5·5	3·25	3	4·5	3	4·5	
	3	3·5	6	3·5	4	6	3	4	3·75	5	4·18 „

An examination of *Plantago Coronopus* from the three regions shewed the same general relations both as to the size of the plants and the relative lengths of their individual leaves. The leaves of the plants from the "*Binervosa*" zone were small, fleshy, sub-cylindrical, and nearly glabrous, with often little or no sign of teeth. On the crest the plants bore leaves which were much flatter, with well-developed teeth, and very hairy. Where covered by shingle, the leaves were again fleshy and glabrous, or nearly so, but the dentation was well developed (though not as in crest plants), and the leaves were flat though thick.

P. Coronopus: Length of Leaves.

Binervosa Zone—											Average
1	·7	·8	·8	1·2	·8	·9	1	1·2	·9	·93 ins.	
Crest—											
2·5	3	2·5	1·5	2	1·5	1	1·5	1·5	1	1·8 „	
Shingle—											
3	3·5	2·5	2·5	3·5	2	1·5	1·5	1·75	2	2·3 „	

In the above table typical plants were selected from each habitat and ten leaves of each measured.

The only reasonable explanation of these data appears to be that under the rigorous conditions of the sloping flanks, the *Statice* abounds through the absence of its less hardy competitors, but with the accretion of soil the limiting factor for

these latter is removed and only the more robust of the *Statices* survive the ensuing struggle; these from their perennial character may remain for a considerable period of years, and by virtue of the two inches of soil in which they grow, will be better nourished and therefore larger than those of the flanks which are rooted in bare or nearly bare shingle. The increase in size of those overwhelmed by the main bank may be due to one of two causes, or even more probably to a combination of both.

The shingle, when it submerges the crest in this way, kills most of the plants that it covers, so that such survivors as remain are freed from the competition of others, whilst, being still rooted in the soil below, they retain all the advantages of nourishment.

The shingle may further act as a mulch to the bnried soil and so increase its water-retaining powers.

Those plants which were dug up shewed few or no lateral roots except in the soil beneath and in the top layers of shingle, where soil or humus had collected, and this would appear to negative the idea that the shingle is of value *per se*.[14]

III. The Dune System.

The dunes at Blakeney form three separate groups, situated in each case upon a foundation of shingle derived from a complex of crowded and anastomosing laterals arising from the main shingle bank. By far the largest of these groups, some 100 acres in extent, occupies the region which we call the Headland, and comprises a series of successive ranges of dunes roughly parallel to the main axis of the bank. From near the eastern extremity of this main system, but not in actual connection with it, a narrow series of dunes extend in a south-westerly direction for about one-third of a mile. They are low in height, and more densely clothed than those of the Headland, from which they are distinguished by the name of the "Long Hills" (see map, fig. 1). The third dune group is

14 One minor point may be mentioned here with regard to the duration of *Plantago Coronopus*; this is given in most of the Floras as either doubtfully annual (Babington, 9th ed., H. and J. Groves, p. 347) or as either annual or biennial (Hooker, p. 289). There is no doubt that the plants at Blakeney are in some cases several years old, as the remains of successive leaf rosettes testify, besides actual cultural experiments.

of very small extent, and forms an excrescence on the side of the main bank some one-and-a-third miles from its distal termination at the Lifeboat House; this, like the "Long Hills," is also a late phase, and is designated by the name of "The Hood."

The Blakeney dunes, although they do not furnish us with any of the final stages in sand fixation, are of great interest as affording a striking series from the first small heap of sand collecting around a single plant of Marram grass to the semi-fixed condition on which numerous species compete with one another.

(*a*) *The Headland.*

The main system comprises several parallel series, which increase in height as we pass away from the sea front, and finally reach a maximum as a more or less continuous ridge (the Beacon Hills), whence the general slope is at first somewhat steep, followed by a gradual fall to the margin of the Pelvetia Marsh, thus forming a more flattened and relatively sheltered expanse on the leeward face (Fig. 7). A search on the flat beach, where the youngest stages are in progress of development (Cf., Fig. 14), reveals *Psamma* seedlings about which the sand has only just begun to collect in miniature kite-shaped heaps, the long tapering tails of which swing to and fro with each change in the direction of the stronger winds. Even the most advanced in this first series are not more than one or two feet in height, and support a flora which consists exclusively of *Psamma*. The outward edge marks the limit of normal tide action, and in consequence a region of drift accumulation.[15] It is here that we find in the greatest abundance plants characteristic of dune faces, such as *Cakile maritima* and *Salsola Kali;* here, too, where sand meets shingle, *Arenaria peploides* and *Atriplex hastata* are frequent, the former sometimes acting as a sand collector and producing sand hummocks, but which unless colonised by the Marram grass do not reach any further stage.

15. The central figure in Fig. 14, is standing on the drift line beside an inlet of the sea between the ranges of young dunes.

As we pass inwards to the slightly older and larger dunes, the process of their formation by the floating action of the *Psamma* can be seen in all the phases and vicissitudes of accumulation and erosion. By this term "floating" is implied the well-known character of *Psamma* which it bears in common with many other dune plants, viz., that the burying of its aerial parts beneath a fresh accumulation of sand serves as a stimulus to renewed growth, so that a new crop of leaves is produced at the surface. The *Psamma* thus keeps pace with the growth of the dune, and so binds each fresh layer to those beneath. It not infrequently happens that strong winds obtain for some days in a direction different from those which normally prevail. The sand which before accumulated is thus in large part removed and there become exposed the long stems of *Psamma*, bearing at intervals the tufts of leaf bases that coincided with the surfaces of successive increments in the building up of the dune unit. By the time that considerable fusion and increase in size of the primary units has taken place, the pure association of Marram grass becomes invaded by other species.

Of these by far the commonest and probably the first of the perennials to appear is *Festuca rubra var. arenaria*, whilst *Senecio Jacobæa* is of almost equal prevalence and likewise a pioneer. These, together with *Triticum junceum* and two thistles which are found as occasional weeds (viz., *C. arvensis* and *C. lanceolatus*), constitute the bulk of the perennial flora of the seaward face, the majority of the species found on the primary dunes being confined to the more sheltered slope of the landward face. An exceedingly common plant on this slope is *Tortula ruraliformis*, which, though frequent amongst the larger plants, attains its maximum luxuriance on the stretches of sheltered sand which are otherwise bare. The carpet that it forms often provides foothold for the small ephemerals, of which *Cerastium semidecandrum* is its commonest associate.

The Ephemerals.

The extreme porosity of a sandy soil renders the water problem of prime importance to the dune flora, and this is

reflected in the abundance of ephemeral plants on the older phases in the early part of the year, which pass through their life history in those few months in which the rainfall is greatest. In the late autumn and spring these plants form an almost continuous carpet, but by July they have nearly all shed their seeds and become so dried up as to leave little evidence of their former dominance. Chief amongst the ephemerals are *Cerastium tetrandrum*, *Erophila vulgaris*, *Cerastium semi-decandrum*, and *Stellaria Boræana;* whilst scarcely less abundant are *Phleum arenarium* and *Myosotis collina*, all of which probably play an important part in surface protection during a critical period of the year. Where there are depressions, such as local subsidences due to rabbit holes, in which the soil remains damp even in summer, ephemerals may still be found in the later months, particularly *Stellaria Boræana*, but such exceptions merely emphasise the dependence of these shallow-rooted plants on surface moisture.

The Sand-Binders.

The sand-binder *par excellence* is of course the Marram grass, which furnishes the skeletal structure of the system but does little to fix the actual surface itself. The latter function is to a large extent performed by *Festuca arenaria*, which comes in at an early stage, and locally we also find the sand sedge *(Carex arenaria)*, but always in situations of comparative shelter, as though climatic conditions were an important factor in its distribution.

The sea convolvulus, which elsewhere plays a conspicuous part in the fixation of sand, is on our area confined to a single flat-topped dune on the lee side of the main ridge. In this one spot it is the most abundant plant, and associated with it are *Senecio Jacobœa* (c), *Anagallis arvensis* (c), *Cerastium semi-decandrum* (c), *Erodium cicutarium* (f.c.), *Psamma arenaria* (f.c.), and *Silene maritima* (r.r.)

The following list is compiled from the dunes of the Head-land, and fairly represents the flora in this phase. The only species which calls for special remark is *Elymus*, represented

by a single specimen only, and in a far less flourishing condition than on the main shingle bank :—

Enumeration of Species and Frequencies.

Anagallis arvensis (f.c.)
Carduus lanceolatus (f.)
„ arvensis (c.)
Carex arenaria (loc.)
Cerastium semidecandrum (v.c.)
„ tetrandrum (v.c.)
Convolvulus Soldanella (loc., a.)
Corynephorus canescens (v.r.)
Elymus arenarius (v.r.)
Erodium cicutarium (f.), glandulosum (c.)
Erophila vulgaris (v.c.)
Festuca arenaria (a.)
Galium verum (f.), maritima (occ.)
Hieracium Pilosella (v.r.)
Myosotis collina (v.c.)
Phleum arenarium (v.c.)
Psamma arenaria (a.)
Sedum acre (c.)
Senecio Jacobæa (v.c.)
Silene maritima (r.)
Solanum Dulcamara (v.r.)
Stellaria Boræana (c.)
Triticum junceum (r.)
Tortula ruraliformis (v.c.)

Drift Line—

Cakile maritima (f.)
Salsola Kali (c.)

Mention should also be made here of a solitary specimen of *Iris Pseudacorus* on one of the small sand dunes towards the proximal extremity of the main system.

The more easterly part of this system approaches very closely to the later phase represented by the "Long Hills," the vegetation of which is described later. Its flora differs chiefly from that enumerated above in the presence of lichens,

of which *Cladonia rangiferina* and *Peltigera canina* are the most conspicuous.

Transition Flora.

The transitions between dune and shingle already referred to are most frequent near the Headland. The dune species are represented by abundant *Psamma*, together with *Senecio Jacobæa* and *Cerastium semidecandrum*, all of which are common. Occasionally *Erodium* is present, and, more rarely, *Carex arenaria*. *Arenaria peploides* is also common, but is perhaps to be regarded as belonging equally to the one type of habitat as to the other.

The shingle species proper are represented by one plant in abundance, viz., *Silene maritima*, and the occasional species are *Anagallis arvensis*, *Atriplex patula*, and *Rumex trigranulatus*.

Situated near the Lifeboat House is an interesting depression bounded by lateral banks on either side and cut off from the sea by a third; this is in process of passing into dune through the collection of sand around the low hummocks of *Suæda fruticosa* with which it is studded. At one point near the edge is a small association of *Glaux maritima* and *Plantago Coronopus f. pygmæa;* these also occupy in part the channels between the hummocks, suggesting that the association had formerly a much greater extent. but is being driven out by the sand that accumulates above the shallow black mud which forms the soil of these depressions (shingle lows).

Many of the hummocks are occupied by *Silene maritima*, whilst their slopes to the channels between afford support for *Statice binervosa*, from which situation the blown sand is rapidly driving it out. Between the hummocks, besides the plants already mentioned, *Poa annua* is present in considerable amount, and *Frankœnia lævis* is occasionally found.

(b) The "Long Hills."

The "Long Hills" are a more advanced phase in dune fixation than those of the Headland, possessing a more extensive flora and a closer association of its members. As is usual at this stage, which is almost that of the "Grey Dune," lichens

and mosses are a pronounced feature of the vegetation, and with the additional phanerogams, bind and protect the surface, which the *Psamma*, knitting together the sand below, cannot, from its diffuse habit, effect.

The chief of these cryptogamic pioneers are *Cladonia rangiferina*, *Tortula ruraliformis*, *Dicranum scoparium*, and species of *Hypnum*.

Although far more stable than the main system, the position of the Long Hills is such that their seaward end and southern face are subject to considerable erosion, and furnish support for *Salsola Kali*, with which is occasionally associated *Solanum nigrum;* also on the less mobile parts of the edge *Stellaria Borœana* occurs in quantity, as elsewhere on the barer sand when relatively stable.

Environed as the Long Hills are by the laterals which form their base, the periphery is often half pebble, half sand, and supports a corresponding flora; also in the middle of these dunes there is a depression which in the centre lays bare the shingle, but, unlike the shallow sand of the outer edge, which is bare and mobile, that which surrounds this central region is sheltered and clothed.

On the outer margin are several species which are infrequent or absent from the central parts, and of these, some, like *Armeria*, *Arenaria*, *Atriplex*, *Rumex trigranulatus*, and *Silene*, may be regarded as due either to their relict character or to the mingling of sand and shingle; others, like *Senecio* and *Anagallis*, serve to indicate that here the conditions of the shifting dune are longest retained.

Several species are characteristic of the shallow fixed sand, around the central depression and elsewhere. These are *Filago minima*, *Plantago Coronopus f. pygmœa*, and *Agrostis maritima*, and their occurrence here is doubtless associated with the close proximity of the shingle below, since the first is a typical gravel heath plant and the remaining two are both frequent upon the older lateral banks.

A very pronounced feature of these dunes is the presence of several hummocks in the central region colonised by *Polypodium*

vulgare; in all there are nine such clumps, each of some considerable size, and all aggregated together in fairly close proximity.

In the following list of species it will be seen that several, viz., *Aira præcox*, *Bromus mollis*, *Cerastium vulgatum*, *Desmazeria loliacea*, *Geranium molle*, *Hypochæris glabra*, *H. radicata*, *Plantago Coronopus*, *Polypodium vulgare*, *Rumex acetosella*, *Taraxacum erythrospermum*, and *Veronica arvensis* are additional to those of the younger phases above described.

Enumeration of Species on the Long Hills.

Agrostis maritima (on edge of shingle patch)
Aira præcox (f.)
Anagallis arvensis (f., at edge)
Arenaria peploides (c., near edge)
Armeria maritima (f., near edge)
Atriplex hastata (f., near edge)
Bromus mollis (v.r.)
Carduus lanceolatus (r.)
Carex arenaria (c.)
Cerastium semidecandrum (c.)
„ tetrandrum (c.)
„ vulgatum (v.r.)
Cochlearia officinalis (loc., at edge)
Desmazeria loliacea (v.r.)
Erodium cicutarium f. glandulosum (f.)
Filago minima (loc., where sand is shallow)
Galium verum (loc.)
Geranium molle (f.)
Hypochæris glabra (f.)
„ radicata (r.)
Myosotis collina (f.)
Phleum arenarium (f.)
Plantago Coronopus (r., in centre)
„ „ pygmæa (f., at edge)
Polypodium vulgare (loc.)
Psamma arenaria (v.c.)
Rumex acetosella (f.)

Rumex trigranulatus (v.r., at end)
Sagina maritima (r.r., at edge)
Salsola Kali (f., at edge)
Sedum acre (f.)
Senecio Jacobæa (c., especially at edge)
„ sylvaticus (r.)
Silene maritima (c., especially at edge)
Solanum nigrum (occ., at edge)
Stellaria Boræana (c., on bare sand)
Taraxacum erythrospermum (occ.)
Urtica dioica (v.r.)
Valerianella olitoria (f.c.)
Veronica arvensis (r.r.)

It will be noted that even in the highest central parts the influence of the shingle flora is marked by the presence of a large proportion of gravel heath species, of which the most striking are *Hypochœris glabra*, *Plantago Coronopus*, *Rumex acetosella*, and *Senecio sylvaticus*.

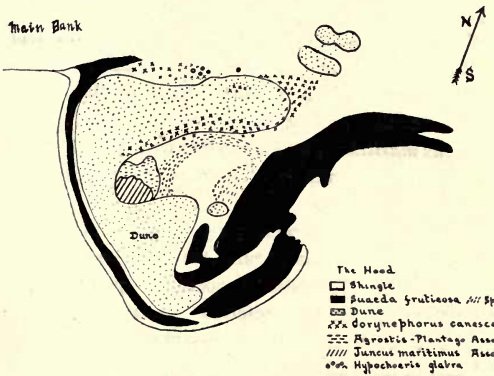

FIG. 9.—Sketch map of the Hood.

(c) The Hood. (Fig. 9.)

The area forming the Hood is roughly an isosceles triangle in outline, one of the longer sides abutting upon the main bank. The centre is occupied by a depression, Y-shaped in outline,

the two arms of which are directed landwards. From two sides the dune slopes towards this hollow, which is closed on the third by shingle, and thus forms a comparatively sheltered habitat. The face directed towards the main shingle bank is further protected as to its lower slopes by a thick growth of *Suæda* bushes at the western end, and by a group of small isolated dunes towards the east.

One of the chief interests of this spot is the occurrence here of *Corynephorus canescens* (fig. 11), which lines the lee slopes of the depression, and also occupies the sheltered patches resulting from the *Suædas* and dunes referred to above. (Text fig. 9.) In view of what has been already said as to the preference of *Carex arenaria* for sheltered situations, it is interesting to note that it is to these parts of the Hood that this plant is chiefly confined; they are also both present in a sudden dip or dell on the northern border of the Hood, which likewise affords them shelter.

As on the Long Hills, *Agrostis maritima* and *Plantago Coronopus f. pygmæa* are found on the shallow sand which borders the shingle where it is laid bare by the central depression; but *Filago minima*, which in the former locality was associated with them, is here rare. Next to the *Agrostis-Plantago* association, and between it and the dune, is a small area of *Juncus maritimus*, which, together with its accompanying species, will be dealt with in the section on the Salt-Marsh Formation.

On the whole the Hood probably represents much the same stage in dune colonisation as is exhibited over the greater part of the Long Hills. The latter support a larger number of species which can probably be referred to their greater extent; there are, however, several species present on the Hood which are not found in the other locality, the most noteworthy being *Aspidium filix-fœmina*, *Corynephorus canescens*, *Luzula campestris*, and *Veronica officinalis*, whilst at the same time the ephemerals in general are less common, and *Phleum arenarium* appears to be absent.

From a consideration of these facts, and from the more

proximal position of the Hood in relation to the shingle on which it rests, there seem to be good grounds for believing that the Long Hills are the more recent formation, but that, owing to the conditions in which smallness of area may have played a considerable part, the Hood has scarcely kept pace in the process of colonisation.

The relations between the two are best brought out by a comparison of the subjoined list of species and frequencies with that given for the Long Hills on p. 46.

Enumeration of Species on the Hood.

Agrostis maritima (loc.)
Aira præcox (v.c.)
Anagallis arvensis (f.)
Aspidium filix-fœmina (v.r.)
Bromus mollis (r.)
Carduus arvensis (f.)
Carex arenaria (c.)
Cerastium semidecandrum (f.)
„ „ v. glandulosum (r.)
„ tetrandrum (f.)
Corynephorus canescens (c.)
Erodium cicutarium f. glandulosum (f.)
Festuca arenaria (c.)
Filago minima (r.)
Galium verum f. maritima (c.)
Geranium molle (c.)
Hypochæris glabra (r.)
Luzula campestris (c.)
Lychnis alba (v.r.)
Myosotis collina (c.)
„ versicolor (r.)
Plantago Coronopus f. pygmæa
Psamma arenaria (v.c.)
Rubus fruticosus (v.r.)
Rumex acetosella (c.)
Sedum acre (c.)

Senecio Jacobæa (v.c.)
Sherardia arvensis (v.r.)
Stellaria Boræana (c.)
Taraxacum erythrospermum (f.)
Valerianella olitoria (c.)
Veronica arvensis (f.)
„ officinalis (c.)

General Characteristics.

The chief feature exhibited by the dune vegetation here, as elsewhere, is the reduction to a minimum of water evaporation from the leaf surface by various transpiration checks. Of the various forms which these assume, most types are represented by the Blakeney flora, and the absence of less protected species on the more stable parts, such as *Viola ericetorum* and *Trifolium repens*, which are frequent constituents of arenicolous floras elsewhere, is perhaps associated with the combination here of great exposure with the adverse conditions of the soil itself. The rolled type of foliage is represented in the Marram grass, *Triticum*, *Festuca arenaria*, *Corynephorus*, and *Galium verum*, whilst the succulent type, with abundant water-storage tissue, finds examples in *Cakile*, *Arenaria*, *Salsola*, and *Sedum*. By far the commonest transpiration check, however, is that furnished by the rosette type of foliage, which, whilst it admits of the maximal amount of assimilation, places the leaves in the plane of greatest humidity and their stomatal surfaces against the damp substratum.

The rosulate habit is frequent amongst the ephemerals, being found in *Cerastium*, *Erophila*, *Myosotis*, and *Valerianella*.

Amongst the biennial and perennial species this habit is found, either exclusively or during the vegetative period only, in *Armeria maritima*, *Carduus arvensis*, *C. lanceolatus*, *Convolvulus Soldanella*, *Erodium cicutarium*, *Geranium molle*, *Hieracium Pilosella*, *Hypochœris glabra*, *H. radicata*, *Plantago Coronopus*, *Rumex acetosella*, *Silene maritima*, and *Taraxacum erythrospermum*.

The close contact of the leaves with the soil in many of these rosettes is perhaps better illustrated by *Erodium* than any

other species. If a plant be uprooted, the lower leaves of the rosette immediately curl round towards the root, so that the plant assumes a ball-like form, shewing that by the increased growth of the upper surface of the leaves as compared with the lower they are as it were "sprung" on to the soil beneath.

All the species, except *Convolvulus*, which have the rosette habit pass the winter in that condition. In *Silene* the leaves remain through the winter, but the following year's growth is continued by hibernating buds usually subterranean in position. In *Arenaria peploides* all the leaves die back, buds similar to those of *Silene* forming the foliage of the next season. In *Carex arenaria* the leaves wither except at their bases, which persist as a protection around the new leaf bud.

Psamma, *Arenaria*, and *Convolvulus Soldanella*, which all possess extensive rhizomes in the dune substance, shew modifications of the growing apex. In the first two the outer leaves combine to form a tapering apex ending in a hard point, and thus eminently suited to sand penetration. In *Convolvulus* the growing apex bears a leaf which is bent back so that the petiole receives the pressure, as in many seedlings.

Before leaving the dunes it should be said that the whole system is riddled with the burrows of rabbits, which, when they fall into disuse, give lodgment for plants that there find shelter and possibly added moisture. Thus, *Aspidium* recorded above, which shares with *Epilobium hirsutum* the distinction of being the rarest plant on the area, is found as an isolated specimen situated in a disused rabbit-hole. The rabbits also no doubt profoundly affect the vegetation in other ways more directly, as by their actual depredations and by their excrements acting as manurial agencies.

IV. The Salt Marshes.

The septation of the Salt Marshes at Blakeney into separate portions by the lateral banks gives us a whole series of small isolated marshes in different stages of colonisation (fig. 1), the ages of which are broadly relative to those of the hooks which bound them. An exception to this generalisation is given by the large intervals where hook formation has not proceeded

with the usual regularity—these show the earliest stages of colonisation, consisting of a sparse scattering of *Salicornias* in very open formation, the only other plants being algæ, such as *Rhizoclonium*, *Chaetomorpha*, and *Enteromorpha*.

The next stage is that which forms the bulk of the saltings at the Headland itself. Here, besides the now much closer formation of *Salicornia europæa* and the scattered *Asters*, we find the *Glyceria* in greater quantity and *Statice Limonium* in fair abundance. In one part of this area, and there alone, *Statice humilis* occurs in considerable amount.

Salicornia perennis and *Suæda maritima*, though both present in the interior, are mostly confined to two successive zones at the edge, where *Obione* is also present. A marked feature here is the almost continuous carpet of algæ, some attached to the mud, consisting of *Pelvetia canaliculata* vars. *libera* and *coralloides*, and *Fucus volubilis*. (Cf. S. M. Baker, Jour. Linn. Soc. Bot., Vol. XL., p. 275, 1912).

For further stages in marsh building we have to pass to the series constituting the Marams. These, however, lose much of their value through being mostly overrun by *Obione*. The presence of this plant only at the edges of the younger stages, and its absence from the low-lying margins of the older, seems to shew that it is only when marsh formation has built up the level that this plant can flourish; and even in the maturer members of the Marams series there are patches near the centre where the centripetal advance of the *Obione* has not yet completely ousted the pioneer species. *Obione* may, in fact, be regarded as a weed which interrupts the proper sequence of colonisation, and having completely established itself, prevents the salting from passing, unless very slowly, into the state of pasture.

Relict patches are well seen in the last of the Maram saltings (alongside the Watch House), where the commonest plant is still *Salicornia*, but the individuals are small in size. Very common, too, are *Statice Limonium*, *Triglochin maritimum*, and *Armeria maritima*; whilst rather less so, *Plantago maritima*, *Spergularia media* and *Aster Tripolium*. Even in

these patches a few scattered *Obiones* mark the advance-guard of the enemy.

The older marshes are for the most part a thick carpet of *Obione* from one to two feet in height, amongst which the only plant which appears to grow with success is *Glyceria maritima; Plantago* and *Aster* are also present, but scattered and of rather rare occurrence.

The low patches unoccupied as yet by *Obione*, which are found near the centre, as in the fifth marsh, chiefly differ from those of the first in the abundance of *Plantago maritima*, and in the presence of a slight mulch of *Pelvetia*. The following is a list of the species of these patches, shewing their relative frequencies :—

Plantago maritima (v.c.)
Statice Limonium (v.c.)
Armeria maritima (v.c.)
Triglochin maritimum (c.)
Spergularia media (c.)
Salicornia europæa (r.r.)
Glyceria maritima } in patches
Obione portulacoides }

Nearly all the marshes are bordered where they abut upon laterals by a fringe of *Artemisia maritima* of varying width, the members of which frequently intermingle with those of the lowest or *Suæda* zone of the lateral hooks.

For the latest stages of salt marsh formation it is necessary to pass across to those on the opposite side of the Cley channel. Here, where the marshes are of much higher level, the increase of the *Glyceria* sward is a marked feature, as also the substitution of such species as *Salicornia ramosissima, S. gracillima, S. disarticulata* for the *Salicornia europæa* of the earlier phases.

The following list is fairly representative of nearly all the saltings on the far side (south) of the channel :—

Armeria maritima (v.c.)
Glyceria maritima (v.c.)
Spergularia media (c.)

Salicornia ramosissima (v.c.)
,, disarticulata (occ.)
Statice Limonium (v.c.)
Suæda maritima (r.)
Obione portulacoides (at edges).
Glaux maritima (c.)
Artemisia maritima (at edges).
Cochlearia officinalis (r.)

A *Juncus* association is present at the edge of these marshes, the principal species of which are the following:—

Juncus maritimus (d.)
Armeria vulgaris (v.c.)
Glyceria maritima (v.c.)
Glaux maritima (c.)
Salicornia spp. (c.)
Statice Limonium (c.)
Spergularia media (c.)
Plantago maritima (c.)

In the bay formed by the depression in the "Hood" there is the only *Juncus* association which the Blakeney Point area itself affords. *Juncus maritimus* is the dominant plant, growing in a short turf of *Agrostis maritima* and *Carex arenaria*, the occasional species being *Cochlearia officinalis*, *Sagina maritima*, *Anagallis arvensis*, and *Sedum acre*.

Further towards the lower edge is a zone of damp sand, in which the *Agrostis* is more scattered and the barer parts are occupied by *Glaux maritima*, *Plantago Coronopus f. pygmæa*, and *Sagina*, with a single specimen of *Juncus Gerardi*.

This *Plantago-Glaux* association is characteristic of damp hollows such as this, and is met with in several places on the Headland where the same physical conditions prevail.

The Samphire Marsh.

From the "Hood" landwards there extends out into the estuary the remains of what was once a lateral shingle bank. On the eastern side of this, near its extremity, is situated a marsh which presents several peculiar features.[16] On the whole

16. In view of its interest, this detached marsh requires a name. It is proposed to call it the Samphire Marsh, as it is here especially that the Sea Samphire (*Salicornia*) is collected by the local inhabitants.

the flora resembles that of a salt marsh in the primary stages of colonisation. *Salicornia europæa* is the commonest species growing, with which are *Aster Tripolium* (f.), *Glyceria maritima* (v.r.), *Salicornia perennis* (v.r.), *Enteromorpha* (v.c.), and *Fucus volubilis* (v.c.); also *Salicornia dolicostachya*, which is found on relict marshes on the other side of the estuary. From the above it will be seen that this marsh differs from the usual early phase in the presence of *Salicornia perennis* and *Glyceria maritima;* the latter especially is typical of late stages, whilst the former is seldom found on young saltings except at the high edges. The presence of these two species as great rarities on this marsh, which is of considerable extent, the deep channelling which it exhibits, and its situation relative to an eroded lateral, taken together, suggest that we have to deal here with the re-colonisation of a derelict marsh rather than the primary establishment of a new one. On this view the plants in question must be regarded as survivals from the former occupation.

V. Species: Rare, Local, or of Special Interest.

One of the most interesting features floristically that the Blakeney area presents is perhaps the occurrence here of *Mertensia maritima* (Fig. 17), furnishing its most southerly habitat on the eastern coast. It was recorded from this station in 1905 by Mr. W. H. Burrell, in the Transactions of the Society for that year. As an English plant the species is rare, but, as would be expected from its northern character, becomes much more frequent on the Scottish coasts.

Of the other plants rare or local in the county a most pronounced feature is the number of Mediterranean species which are here either at or near their northern limit of distribution. Of these the most striking is *Sucæda fruticosa*, which, by its luxuriance, would appear to belie climatic influence. Elsewhere it is also to be met with on the shingle of Suffolk and Essex, and on the great Chesil bank in Dorset. Another interesting example is the Hair Grass, *Corynephorus canescens* (Fig. 11), which is mentioned as occurring here and in other stations by Trimmer in his Flora of Norfolk (London, 1866,

p. 170). The plant has also been found in Suffolk, and has recently been recorded by the Rev. Riddelsdell from Glamorganshire. Two Sea Lavenders, viz., *Statice binervosa* and *S. reticulata*, which are also essentially Mediterranean, here approach their northern limit, though the former species extends its distribution into Lincolnshire, and on the west coast as far north as Wigton (Cumberland).

Here, too, we find both *Frankenia lævis* and *Spartina stricta* at the edge of their distribution; the latter is not strictly in the area dealt with above, but is found in the Blakeney channel adjacent to the reclaimed salt marshes on the opposite side of the estuary.

A number of other species met with, though of less distributional interest, are of infrequent occurrence in the county. Of these the chief are *Statice humilis*, *Hypochœris glabra*, *Filago minima*, *Lepturus filiformis*, *Desmazeria loliacea*, *Phleum arenarium*, and *Juncus maritimus*.

As we have already seen, the genus *Statice* is well represented, and the same may be said of two other genera, viz., *Triticum* and *Cochlearia*. Of the former, not only do we find the two common maritime species, *T. junceum* and *T. pungens*, but also *T. pungens* var. *aristatum*, and more than one type of hybrid. Of the genus *Cochlearia* there are three species, viz., *Cochlearia anglica*, *C. danica*, and *C. officinalis*. *Silene maritima* is of considerable interest floristically, as it is here found under such numerous forms, which chiefly depend on floral characters and appear to be constant on any one plant. Most of these have already been described by the writer (New Phytologist, Vol. XI., No. 1, 1912), and are distinguished by the overlapping or divergence of the petal lobes (*f. incumbens*, *f. divergens*), by their rolled margins (*f. involuta*), the presence of lateral lobelets (*f. lobata*), the abortion of the androecium (*f. fœmina*), or the double character of the flowers. Besides these there is a marked difference in the coloration of the calyx, which may exhibit a more or less pronounced purple tint (the usual condition), whilst on other plants, the foliage of which is as a whole of a much lighter

colour, the calyx is a pale yellowish-green. The writer has observed the same differences in flowers of *Silene inflata* and *Lychnis vespertina*, and in all cases the irregularity of distribution seems to preclude the possibility of soil influence.

Another member of the *Caryophyllaceæ* which exhibits interesting variation is *Arenaria peploides*. As is well known, one of the chief distinctions which separates this genus from that of *Stellaria* is the entire character of the petals in the former, and their bifurcation in the latter. At Blakeney, however, the petals of the *Arenaria peploides* frequently shew a deep notching—a feature that may extend to all or part of the flowers on a plant, and is not always constant for the individual petals of the same flower. This variation would appear to be influenced by seasonal factors, since it is most marked in the early part of the flowering period, and so far as observations go is not found in the later phase.

The prevalence of *Senecio Jacobæa* upon the dunes has already been a matter of comment, and amongst the numerous individuals there seems to be a marked variation in the form of the radical leaves. In some of these the terminal portion is almost undivided, and only a few lateral lobes are present lower down, whilst in those borne by other plants the leaf as a whole is cut up in a pinnate manner and each lobe is itself pinnatifid, resulting in the normal parsley-like appearance of the margin. Intermediates between these two conditions can often be found, which, however, does not of course preclude the possibility of the two forms being distinct varieties.

In the genus *Salicornia*, two species call for special mention, of which one is *S. disarticulata*, easily distinguished by the solitary character of the flowers, in place of the groups of three or more found in the other species. The second form which has just been described, *S. dolicostachya* (C. E. Moss, New Phytologist, Dec., 1912), occurs in two places at Blakeney, viz., on the Samphire Marsh near the Hood, and was found by the writer some three years ago on a denuded marsh at the south side of the estuary. This form is much branched with long spikes and, unlike other annual species, has the lateral flowers of the group separated by the median.

Description of Figures 10—17 on Plate I.

Fig. 10.—Zonation on the W. slope of the 7th hook on the "Marams." The main shingle bank stretches across the back of the picture. In the foreground (right) is the edge of the crest, with *Triticum*, followed (beyond the first *Suæda* bushes) by the *Statice binervosa* zone, with low sprawling plants of *Obione*. Beyond this the *Suæda fruticosa* zone. Above this, part of the marsh covered by *Obione*. At the edge of the main bank bushes of *Suæda fruticosa*, then the horizontal line of drift, and on the back of the bank scattered plants of *Rumex trigranulatus*, *Silene maritima*, and *Arenaria peploides*; on the crest, at the extreme right and left, bushes of *Suæda*.

Fig. 11.—The sea face of the Hood where the dunes abut on the main shingle bank. The tussocks consist almost entirely of *Corynephorus canescens*.

Fig. 12.—The main bank advancing over the last marsh of the "Marams." Note the fans of shingle, the drift lines, the bushes of *Suæda fruticosa* and *Obione portulacoides*.

Fig. 13.—The main bank advancing over the crest of the 4th lateral hook on the "Marams"; grasses on the right-hand side of crest are seen colonising the advancing shingle.

Fig. 14.—Part of the sea front of the dunes on the Headland. Beyond the inlet are the outer systems of embryonic *Psamma* dunes. On the left, part of the Beacon Hills range. Near the centre of the foreground is the drift line, with plants of *Salsola Kali* and *Cakile*.

Fig. 15.—The main shingle bank where the dunes of the Long Hills run on to it. In the foreground is a depression with low-growing bushes of *Suæda fruticosa*, between which are plants of *Statice reticulata* (not seen in the picture); then, two-thirds up the picture, the *Statice binervosa* zone. Beyond are sand dunes.

Fig. 16.—Open association of *Rumex trigranulatus* and *Silene maritima*. Main bank near the Watch House.

Fig. 17.—Flowering specimen of *Mertensia maritima* on the main bank; some of its leaves are nibbled by rabbits. The two darker veined leaves on the right, belong to a seedling of *Senecio Jacobæa*.

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NT—NORFOLK.