Plant Distribution in the Woods of North-East Kent.

PART I.

BY

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With Plates LXIV–LXVI and four Figures in the Text.

ALTHOUGH the subject of Plant Geography has, in recent years, attracted considerable attention in this country, comparatively few detailed descriptions of plant distribution in small areas have appeared. While the vegetation of large districts in the north of England and Scotland has been described and mapped, little or nothing has been published on plant distribution in the southern counties. This is especially the case with regard to Kent. In a county of this kind where almost the whole area is under cultivation, the woodlands form perhaps the most suitable subject for investigation.

Moss, Rankin, and Tansley (13) have recently published a general account of the woodlands of England, and have drawn attention to the great prevalence of coppiced woods in this part of the country. Considerable areas in North-East Kent are covered by woods of this description. The periodic felling which takes place in these brings about great alterations in the physical conditions, and the following paper will deal largely with the resulting changes in the vegetation.

Woodhead (17) has made one of the most important contributions dealing with the distribution of woodland plants. In this paper a detailed description of the vegetation of several woods in the neighbourhood of Huddersfield is given, and the effects of differences in illumination and in the soil composition respectively are discussed.

Cieslar (3), in 1904, gave a full account of the part played by light during the growth of the forests near Vienna. He has shown the great effect of shade in influencing the number of herbaceous species in a given situation; the origin of the ground flora is also discussed.

Fliche (6) has given an account of the reafforestation of areas in the Forest of Champfêtu, near Sens (France), and the consequent disappearance of certain species. This paper is of especial interest since it deals with

woods which, like those examined in the present investigation, occur on the Cretaceous and Eocene formations.

All the above communications deal with high forest, and, as far as can be ascertained, no papers have yet appeared describing the flora of coppiced areas and the changes consequent on the periodic felling which takes place in this type of woodland.

The woods on which the greater part of the investigations have been made occur in the neighbourhood of Faversham in North-East Kent. This district is especially suitable for an investigation of this kind on account of the great differences in composition of soils which are found in close proximity and in a comparatively small area. This part of Kent is included in maps Nos. 273 and 289 of the Ordnance Survey on the scale of one inch to one mile, and in Sheet 3 of the Geological Survey on the same scale. Additional observations have also been made on woods in the neighbourhood of Swanley in North-West Kent. This latter district is included in Map 271 of the Ordnance Survey, and Sheet 6 of the Geological Survey, both maps being on the scale of one inch to one mile.

The general underlying formation of the whole area under consideration is the Upper Chalk, but this is covered to a great extent by beds of clays and gravels, and by outliers of the Lower Eocene formations. In the Faversham district there is a gradual increase in altitude towards the south until the escarpment of the Chalk is reached about 10 miles distant; towards the north the area is limited by the Thames Estuary. The surface of the Chalk is deeply indented by numerous dry valleys which run down the dip slope towards the north. The bottoms of these valleys are generally occupied by river deposits, but on the sloping sides the Chalk is only covered by a thin layer of soil. One of these valleys is indicated on the lower left-hand side of the map shown in Text-fig. 1; its course can be traced by the deposit of alluvial material found along its bottom. On the ridges a deposit of stiff reddish clay is found, known as the 'Clay with Flints' on account of the numerous unworn flints occurring in it. Passing to the north towards the Thames Estuary the Clay with Flints gradually disappears, and is partially replaced by a deposit described as 'Loam on the Chalk' by the Geological Survey. The latter, in many places, is covered by deposits of brick-earth. Finally, in the close neighbourhood of the estuary, there is a comparatively deep layer of alluvium covering the earlier deposits (see Text-fig. 1).

In the immediate neighbourhood of Faversham the Tertiary (Lower Eocene) formations are only represented by small outliers, but farther to the east there is an Eocene deposit of considerable extent. The lowest of these beds, resting directly on the Chalk and known as the Thanet Sand, consists of a fine light-coloured sand typically without pebbles. The Woolwich and Reading series, which lie above and often pass almost imperceptibly into the

TEXT—FIG. 1.

Scale : 1 Inch=1 Mile.

The woods are shown in heavy outline.

former, are made up of alternating bands of coarse reddish clays and gravels with thin beds of clay; the uppermost layers are generally distinguished as the Oldhaven (or Blackheath) beds, and in the neighbourhood of Faversham consist largely of dark-coloured, well-rounded, flint pebbles. The map reproduced in Text-fig. 3 shows a Tertiary outlier made up of these three formations. The London Clay, the highest of the Lower Eocene formations, is usually not represented in the smaller outliers, but covers a large area to the east between Canterbury, Faversham, Whitstable, and Herne Bay. It consists of a stiff bluish clay which, on weathering, produces extremely heavy clay soils of a brown colour. The Swanley district only differs from the above in the relative areas of the various formations; here, while the Clay with Flints is almost absent, the Tertiary outliers are more numerous and larger in area.

Woods are of fairly general occurrence in both the above-mentioned districts, and their distribution offers some points of interest. As a general rule the Lower Eocene formations, with the exception of the Thanet Sand, do not produce soils especially suitable for agriculture, and, as a result, the larger woods are generally found occupying the Eocene outliers. This is particularly well shown in the Swanley district, where almost all the woods are confined to the Tertiary areas and cease abruptly at the boundary of the Chalk. In the Faversham district Perry Wood (Text-fig. 3) extends over the greater part of a Tertiary outlier, while the large London Clay area towards the east is almost entirely covered by the Forest of Blean. Woods are found both on the Chalk and the Clay with Flints, and although no general statement can be made for their distribution on these deposits, on the whole they are more abundant on the latter; wherever the soil on the Chalk is of sufficient depth cultivation has taken place. The river deposits and brick-earth beds are almost exclusively arable land, and are particularly suitable for the cultivation of Hops (Pl. LXIV; for explanation see description of plate). Woods are rarely found on the alluvial deposits in the neighbourhood of the Thames Estuary.

Since the general altitude of the district is low, rarely rising above 400 feet above sea-level, and the variations are comparatively slight, it seems probable that this factor has little or no influence upon the distribution of the types of woodland. With the exception of the shallow valleys previously mentioned, the surface of the Chalk is comparatively even and the hills are generally formed by the Lower Eocene outliers resting upon it. The Clay with Flints is a relatively shallow deposit, and on this account is only responsible for slight alterations in altitude.

The amount of rainfall is rather small; measurements taken at Selling, near Faversham, for the 13 years from 1897 to 1909 are given below:¹

¹ These statistics were supplied by Sidney Neame, Esq., of Harefield, Selling, near Faversham, to whom I desire to express my thanks.

<i>Year.</i>	<i>In.</i>	<i>Year.</i>	<i>In.</i>	<i>Year.</i>	<i>In.</i>
1897	26.84	1902	24.4	1907	26.61
1898	23.68	1903	40.89	1908	28.35
1899	27.4	1904	28.09	1909	36.29
1900	30.61	1905	29.24		
1901	24.94	1906	29.22		

The mean annual rainfall calculated for the 42 years ending 1909 was 29.13 in.

Almost all of the woods under consideration are of the copse type, felling taking place usually at intervals of 14-15 years. The larger growths thus obtained are used extensively as Hop-poles, while the rest is made into faggots. In the cases where felling is complete and all the trees are cut off, the resulting woodland may be described as 'coppice', the term being used as suggested by Nisbet (12). In the majority of the woods standard trees occur amongst the underwood which are only felled at considerably longer intervals; a wood of the latter kind may be distinguished as 'copse'.

As a result of felling there is a great increase in the number of herbaceous plants. The factors bringing about this increase will be discussed later, but it is necessary to point out here that in many cases the species which appear are not typical woodland plants. Comparatively few species can exist under the deep shade cast during the later years of the coppice growth, and, as a result of felling, a stretch of almost unoccupied soil is produced, which is rapidly colonized by plants from various sources. In the following description of the types characteristic of various soils, all the plants occurring in the woods will be considered, whether they are true woodland species or not.

In this part of Kent, where cultivation is widespread and has gone on for a long period, little can be said as to the original condition of the woodland. Probably all the woods under consideration are of comparatively recent origin, and it is extremely doubtful whether any of the primitive forest remains. It appears that planting went on fairly extensively in these copses until quite recent times, but that this has been largely discontinued of late years on account of the great decrease in prices obtained for the underwood. At the present time it consists to a great extent of merely filling in the gaps left by the death of some of the 'stools'. In many cases, too, little consideration is paid to the suitability of the soil to the particular species planted. As a result of these facts, it is usually difficult to distinguish certain species as characteristic of particular soils when trees only are considered. The occurrence of herbaceous plants is a much better guide for generalizations of this kind.

In this district the distribution of the various types of woodland is intimately connected with the differences in the soil composition. In the ensuing description, therefore, the different geological formations are taken as the basis for classification.

In the present communication the relative prevalence of plants will be indicated by the use of certain terms. These will be employed in the following order:—

1. Very abundant.
2. Abundant.
3. Frequent.
4. Generally distributed.
5. Sparingly found.
6. Occasionally found.

No numerical value can be attached to these terms, but as far as possible the same term will always be used to express the same degree of prevalence. It will be noticed that the term 'dominant' has been omitted from the above list. The use of this term is considered unsatisfactory in this sense. In the following description the use of this expression will not necessarily indicate that the plant is very abundant, but that its presence has a great and well-marked effect on the immediately surrounding vegetation. Every plant obviously influences the plants in its vicinity to a certain extent, but the term 'dominant' is reserved for extreme cases in which the existence of the surrounding species is threatened or even rendered impossible.

In this paper the plant names adopted are those given in the 'Manual of British Botany', by C. C. Babington, ninth edition, edited by H. and J. Groves, 1904. The Mosses are named in accordance with the 'British Moss Flora', by R. Braithwaite, 1887. 'The Hepatics of the British Islands,' by H. W. Lett, 1902, has been used for naming the Liverworts.

THE CHALK.

The woods on the Chalk soils in both of the districts investigated are fairly numerous, but usually not of great area. In almost all cases they are found on the sides of the dry valleys already referred to, since it is only in these positions that the Chalk is free from the overlying deposits. The soils vary considerably in depth; while in some places the Chalk is barely covered, in others there is a considerable depth of soil upon it. Many of the woods examined extend over two or more different deposits, such, for example, as the Chalk and the Clay with Flints or the Chalk and the Thanet Sand, and the Chalk soils probably vary in composition with the proximity of these other deposits. Considerable differences in depth of soil may also be found in one small woodland area.

The composition of various Chalk soils is given by Hall and Russell in their 'Report on the Soils and Agriculture of Kent, Surrey, and Sussex' (7). The percentage of calcium carbonate, although variable, is usually high; as a result of this fact these soils, even in woodland areas, are rarely or never acid. Mechanical analysis shows that the amount of finely divided material (fine sand, silt, and true clay) is usually large.

The following woods on the Chalk have been investigated:—In the Faversham district: Winding Hill Wood, portions of Badgin, Rice, Fox-burrow, Stocking, and Judd's Woods. In the Swanley district: portions of Rowhill and Joyden's Woods.

The woods on the Chalk consist typically of Beech interspersed with

TEXT—FIG. 2.

Scale. 6 Inches=1 Mile.

The woods are shown in heavy outline.

Yews. Moss, Rankin, and Tansley (13) have suggested that the original woodland of the Chalk was made up of Beech with an undergrowth of Yew, and the general occurrence of such woods in this neighbourhood bears out this conclusion. As already pointed out, the soil in these situations is often extremely shallow, and is therefore unsuitable for cultivation. On this

account it is possible that traces of the original woodland may remain in these spots, although its disappearance from the surrounding deposits is complete. The Yews give a characteristic appearance to the woods (Pl. LXIV ; for explanation see description of plate), being found in coppice as well as in high wood. In the former they frequently remain uncut during the felling, as Yew timber is at present almost useless.

The majority of the woods are regularly coppiced, but a few high woods are found. In these, although Beech is always abundant, a number of other species are found. Oak occurs where the soil is sufficiently deep, and in a few cases *Pinus sylvestris*, L., has been planted to a small extent. Small plantations of Larch are frequently found on the Chalk, these being, in most cases, of recent origin.

A detailed examination of Badgin Wood, near Faversham, has been made, and the southern part of this may be taken as an example of copse on the Chalk.

1. Badgin Wood, which lies about two miles to the south of Faversham (Text-fig. 1), is about half a mile in length, and varies from a quarter to a third of a mile in width. It may be noted that the boundaries of this wood shown in a map of the district published by Cowell (4) in 1839 in his 'Flora of Faversham' coincide exactly with those of the present day.

The wood is situated partly on the Chalk and partly on the Clay with Flints, while a very small area near the south-western corner lies on alluvial deposits (Text-fig. 2). The Clay with Flints forms a small plateau in the northern part of the wood, the whole of which lies at an altitude of rather more than 200 feet. The southern portion lies on a gentle slope, and here the Chalk is only covered with a thin layer of soil. The bottom of the dry valley, situated to the south of the wood, is occupied by alluvium (Pl. LXIV).

The whole of the wood consists of copse which is regularly felled at intervals of about fourteen years, and at the present time different parts of the wood show various ages of coppice growth. The depth of soil above the Chalk in the southern portion of the wood varies from six inches to two feet. Beech occurs most abundantly on the shallowest soil both as a standard and also as coppice growth, and at these spots the Yew is also found. These shallow soils are characterized by a considerable number of species among the underwood. The following occur frequently :—

Clematis Vitalba, L.

Acer campestre, L.

Euonymus europaeus, L.

Pyrus Aria, Ehrh.

Cornus sanguinea, L.

Viburnum Lantana, L.

Ligustrum vulgare, L.

Fraxinus excelsior, L.

Quercus pedunculata, Ehrh.

Betula verrucosa, Ehrh.

Corylus Avellana, L.

Towards the south-east corner the soil increases in depth to one foot to

eighteen inches, and here both Beech and Yew are absent, being replaced by Ash with occasional Hornbeam.

In addition to the above-mentioned species the following are generally distributed :—

Crataegus Oxyacantha, L.

Lonicera Periclymenum, L.

Prunus spinosa, L.

Ruscus aculeatus, L.

Rosa canina, L.

The following are occasionally found :—

Rhamnus catharticus, L.

Viburnum Opulus, L.

Hedera Helix, L.

Salix Caprea, L.

Betula alba, L., has been planted in one portion of the wood over a small area, and in another part *Acer Pseudo-platanus*, L., has been introduced ; the latter is regularly coppiced.

The distribution of herbaceous plants is greatly influenced by the age of the coppice, and in consequence different portions of the wood possess very different floras. In the tenth year after felling the coppice growth has attained a height of about twelve feet. A deep shade is produced, and the number of species which can exist under these conditions is comparatively small, the vegetation, as a whole, being poor and scanty. During the following four years before felling takes place again the conditions are fairly constant, the additional shade due to the increased height being almost inappreciable. The plants found during this period may be divided into two groups :—

(a) Plants little or not affected by the shade, in which flowering takes place early in the spring.

(b) Dwarf plants which persist in the vegetative state and rarely flower.

(a) The plants belonging to the first group are generally perennials possessing underground storage organs. Flowering takes place early in the spring before the leaves are produced by the trees, and during the later part of the season only the underground portions can be found. The following belong to this group :—

Primula acaulis, L.

Endymion nutans, Dum.

Mercurialis perennis, L.

Arum maculatum, L.

Mercurialis perennis is abundant, occurring in large patches and flowering and fruiting freely. This plant is the most conspicuous species of the shade flora as the stems and leaves persist until the late autumn. The remaining plants are found very sparingly where the soil is nine inches or less in depth, but occur more freely where the depth is greater ; even on the deeper soils they are not plentiful. *Adoxa Moschatellina*, L., has been occasionally found on the outskirts of the wood, but its occurrence on the Chalk soils is too rare to justify its inclusion here. *Daphne*

Laureola, L., is often present, and on account of the similarity in its time of flowering may be placed in this group.

(b) The following are included in the dwarf shade flora :—

<i>Anemone nemorosa</i> , L.	<i>Fragaria vesca</i> , L.
<i>Viola Riviniana</i> , Reich.	<i>Potentilla Fragariastrum</i> , Ehrh.
<i>Viola hirta</i> , L.	<i>Veronica Chamaedrys</i> , L.
<i>Geranium Robertianum</i> , L.	<i>Lamium Galeobdolon</i> , Crantz.
<i>Rubus fruticosus</i> , L.	<i>Ajuga reptans</i> , L.
<i>Geum urbanum</i> , L.	

These plants persist under the shade conditions for a number of years, flowering rarely or not at all, and producing stunted leaves and stems. With the exception of *Geranium Robertianum* they are all normally perennial, and it is probable that the latter plant under these peculiar conditions persists for several years. The distribution of *Anemone nemorosa* varies considerably with the depth of soil and the density of the shade. It is completely absent on the shallowest soils under deep shade conditions, but appears on these soils in the vegetative form wherever the illumination is slightly greater. Its abundance increases on the deeper soils, and here, even in the deepest shade, it occurs frequently and flowers occasionally. Finally, on the deepest Chalk soils it is abundant and a large proportion of the plants produce flowers.

Of the remaining plants none are found abundantly, and in situations where the *Anemone* is absent areas of bare soil are often found. *Viola Riviniana* flowers more frequently than the other species, but even in this case the number of flowers produced is much less than in situations where the light intensity is greater; *Viola hirta* is of rare occurrence. The plants of *Rubus fruticosus* are small and few in number, and, as a general rule, flowers are not produced.

Dobner (5), who has mentioned the occurrence of a similar dwarf flora in the Hochwälder of Germany, refers to the persistence of *Rubus fruticosus* in the vegetative state under shade conditions (footnote, p. 46).

A great change takes place in the character and abundance of the vegetation after the cutting of the copse. Felling takes place usually during December and January, and, with the exception of the standards and Yews (when these are present), the whole of the underwood is removed. This results in a great increase of the light intensity, and the mean temperature of the surface soil is raised. As a consequence, increased evaporation goes on from the surface, and the upper layers of soil are much drier in the cleared areas than in those still covered by wood.

The plants which are found in the following spring and summer are

partly made up of those formerly present during the shade condition, but in addition to these many others appear.

The plants previously mentioned as flowering early in the spring are not greatly affected by the changed conditions. The short interval of increased illumination elapsing since felling has not been of sufficient duration to allow for the increase of those species, such as *Primula acaulis*, which benefit by the brighter light. The leaves and stems of *Endymion nutans* show a considerable decrease in size in consequence of the increased illumination; the greater dryness of the soil probably adversely affects this species.

On the other hand, the dwarf shade flora spreads rapidly, and at the same time the individual plants increase greatly in size. These plants form a considerable proportion of the vegetation found in the succeeding years, and are often of striking appearance. This is particularly the case with *Veronica Chamaedrys* and *Fragaria vesca*, both of which flower freely. *Rubus fruticosus* usually flowers sparingly in the first year after felling, but never becomes abundant on the shallow Chalk soils.

In addition to the above a large number of plants appear as seedlings, chiefly in the late summer. A considerable number of these are species commonly found in the open spaces of the woods, but many are not woodland plants in the ordinary sense, being normally found in fields, hedgerows, and on cultivated land. The great majority of these are biennials or perennials, which generally pass the first season in the vegetative condition and flower for the first time during the second summer.

The following annual plants are also found, and these flower in the first season:—

Arenaria trinervia, L.

Linum catharticum, L.

Alchemilla arvensis, L.

Torilis Anthriscus, Gaert.

Erythraea Centaurium, Pers.

Odontites rubra, Gilib.

Galeopsis Tetrahit, L.

Of the above *Linum catharticum* is the only species which occurs frequently. *Alchemilla arvensis* is generally distributed, and the remainder are occasionally found.

The annuals form only a small proportion of the vegetation, and at the same time the plants are mostly small. Consequently, the general effect is given by the biennials and perennials. During the first season, therefore, the flora is characterized by great vegetative development and a general absence of flowers.

During the second season the reverse is the case. In the early spring *Mercurialis perennis* is abundant, spreading in large clumps over the whole Chalk area and on the deeper soils forming a complementary association with *Endymion nutans*. The latter species is, however, not abundant; it is

probable that it is adversely affected by the competition of the light flora. *Primula acaulis* and *Anemone nemorosa* occur frequently and flower freely.

The dwarf shade flora develops luxuriantly in the second season and flowers more abundantly than during the first year. *Veronica Chamaedrys*, *Viola hirta*, and *Fragaria vesca* are abundant. *Viola Riviniana* is of much less frequent occurrence, although during the shade period the latter is the more plentiful of the two species.

The following perennials are very abundant :—

<i>Helianthemum Chaemaecistus</i> , Mill.	<i>Teucrium Scorodonia</i> , L.
<i>Hypericum hirsutum</i> , L.	<i>Origanum vulgare</i> , L.
<i>Myosotis sylvatica</i> , Hoffm.	<i>Euphorbia amygdaloides</i> , L.

The following are abundant :—

<i>Hypericum perforatum</i> , L.	<i>Echium vulgare</i> , L.
<i>Senecio erucifolius</i> , L.	<i>Verbascum Thapsus</i> , L.

The following are frequently found :—

<i>Reseda lutea</i> , L.	<i>Dipsacus sylvestris</i> , Huds.
<i>Polygala vulgaris</i> , L.	<i>Carduus palustris</i> , L.
<i>Poterium Sanguisorba</i> , L.	<i>Inula Conyza</i> , DC.

The following are generally distributed :—

<i>Geranium columbinum</i> , L.	<i>Veronica officinalis</i> , L.
<i>Carduus nutans</i> , L.	<i>Clinopodium Calamintha</i> , O. Kuntze.
<i>Arctium majus</i> , Bernh.	<i>Prunella vulgaris</i> , L.
<i>Scrophularia nodosa</i> , L.	<i>Verbena officinalis</i> , L.

The following are sparingly found :—

<i>Aquilegia vulgaris</i> , L.	<i>Clinopodium Acinos</i> , O. Kuntze.
<i>Sagina procumbens</i> , L.	<i>Thymus Serpyllum</i> , L.
<i>Scabiosa columbaria</i> , L.	<i>Orchis pyramidalis</i> , L.
<i>Clinopodium vulgare</i> , L.	<i>Carex sylvatica</i> , Huds.

The following are occasionally found :—

<i>Daucus Carota</i> , L.	<i>Ophrys muscifera</i> , Huds.
<i>Galium Mollugo</i> , L.	<i>Habenaria bifolia</i> , R. Br.

During the first year the shoots from the stools grow rapidly, and at the end of the season have attained a height of 3–4 feet. The growth during the second year is not so great, the average height at the end of the season being 5–6 feet. The luxuriance of the herbaceous vegetation during the third year is as great as it is during the second, and is similar to it in character. But during the fourth year the effect of the shade produced by the underwood, which now reaches 8 feet in height, is beginning to be felt, and the number of the herbaceous plants begins to decrease.

An attempt was made to determine the order of disappearance of the various species in consequence of the increasing shade, but this was found to be impossible. The depth of the shade varies greatly at different spots; where the stools are far apart or where one has died the light flora persists in almost unaltered composition for several years, while in situations of deeper shade the constituent species disappear practically simultaneously. *Hypericum perforatum* seems to persist longer than the majority of the species. By about the tenth year the whole of the light flora has disappeared, and from this time until felling takes place the vegetation is almost in a state of equilibrium.

The number of Mosses occurring is comparatively small, but a few are worthy of mention. In this neighbourhood *Anomodon viticulosus*, H.T., is confined to woods on the shallow Chalk soils; this species is not found in deeply shaded situations. *Neckera complanata*, Hueb., has an almost similar distribution, but can exist in deeper shade.

2. Winding Hill Wood, near Faversham, may be taken as an example of high wood on the Chalk. The majority of the trees are Beech; Oak is sparingly found. Sycamore, *Pinus sylvestris*, L., and *Picea excelsa* have been planted to a small extent, but the two latter species do not flourish on the Chalk soils. The shade cast by the trees is, on the whole, not so deep as that produced by close coppice. In consequence the ground flora is more abundant than that found in the copses during the shade period, although closely related to it in composition.

THE CLAY WITH FLINTS.

The distribution of the Clay with Flints has already been shortly described. In the Faversham district it covers large areas of the Chalk, the thickness of the deposit varying from a few inches up to 20 feet or more. It consists of a stiff reddish clay containing a very variable proportion of large unworn flints. In composition it differs from the soils of the Chalk formation which it overlies, particularly with regard to the proportion of lime. Hall and Russell (7), in analyses of the clay from two woodland areas in Kent, find the percentage of calcium carbonate to be 0.06 and 0.002 respectively. Mechanical analysis shows a large proportion of finely divided material, the average amount of fine sand being 27 %, the silt 27 %, and the clay 16 %. In spite of these great differences in composition, the vegetation of the Chalk and the Clay with Flints shows considerable agreement.

The whole of the woods on the Clay in this neighbourhood are regularly coppiced.

The following woods on the Clay with Flints have been investigated in the Faversham district :—

Portions of Badgin, Rice, Foxburrow, and Stocking Woods.

A detailed examination of the plant distribution in Badgin Wood has been made, and in the first place a description of this wood will be given.

(a) The northern portion of Badgin Wood is situated on the Clay with Flints, the deposit thinning out towards the south, while it is 15 feet or more in depth at the northern boundary (Text-fig. 2). The highest point in this area reaches an altitude of 215 feet, and the western portion falls slightly below the 200 foot contour. On the whole the surface of the deposit is approximately level.

Standard Oaks (*Quercus pedunculata*, Ehrh.) are found over the whole area, probably about sixty years of age and 30-40 feet in height; the lowest branches in these are from 12 to 15 feet from the ground, so that they clear the underwood when at its greatest height. The copse shows considerable differences in its component species, the variation being probably partly dependent on the depth of the soil. At the southern limit of the Clay, where the soil is only about 2 feet in depth, the underwood is almost similar to that of the deeper Chalk soil. Here the Hazel is the most abundant tree, but Ash and Hornbeam are found, as well as several other species. Passing towards the north there is an increase in the amount of Ash and Hornbeam, and, where the soil is approximately 3 feet in depth, these two species together equal the Hazel in abundance; at this point the Oak, Maple, and Birch show a corresponding decrease, while the Beech, *Pyrus Aria*, Ehrh., *Euonymus europaeus*, L., *Cornus sanguinea*, L., and *Ligustrum vulgare*, L., have entirely disappeared. On still deeper soil Ash and Hornbeam are the most abundant species, although the Hazel is still found. In some small areas Hornbeam only is found, while in others, although Ash is the most abundant species, it is never exclusively present.

The following occur sparingly:—

Crataegus oxyacantha, L.
Prunus spinosa, L.
Prunus avium, L.
Ilex aquifolium, L.

Populus nigra, L.
Populus tremula, L.
Castanea sativa, Mill.
Ruscus aculeatus, L.

In many parts of England Ash is characteristic of calcareous soils, well developed woods occurring on the Chalk of Hampshire, Dorset, and the Isle of Wight (Moss, Rankin, and Tansley (13), pages 137 and 140). On the other hand, in North-East Kent, Ash is only found sparingly on the Chalk, while it is much more abundant on the almost non-calcareous Clay with Flints. In this district, where the rainfall is considerably lower than in the more northern and western counties, it is possible that scarcity of water is the limiting factor on shallow rapidly draining soils such as the Chalk. The Ash is a species which makes large demands on the mineral salts of the soil for its full development. In a situation where the water supply is abundant the necessary food can be obtained even on a poor soil. The Chalk soils, how-

ever, contain a small proportion of potash and phosphates, and this circumstance, in conjunction with the deficient water supply, probably accounts for the scarcity of ash in these localities.¹

It is probable that in this district the great majority of the woods on the Clay have been planted in comparatively recent times. In Badgin Wood the similarity in age of all the standard Oaks may be taken as evidence for this as well as the regularity in the distance between the stools. This fact, in conjunction with the considerable number of species now found occurring on this deposit, makes any statement as to the composition of the original woodland very difficult. The limited area studied in this investigation does not justify any conclusion.

The shade flora of the Clay resembles that found on the Chalk, but the species are found in considerably different proportions. The following plants are found flowering freely in the early spring :—

<i>Anemone nemorosa</i> , L.	<i>Arum maculatum</i> , L.
<i>Adoxa Moschatellina</i> , L.	<i>Endymion nutans</i> , Dum.
<i>Primula acaulis</i> , L.	<i>Orchis mascula</i> , L.
<i>Mercurialis perennis</i> , L.	<i>Orchis maculata</i> , L.

Endymion nutans and *Mercurialis perennis* occur abundantly, forming a complementary society, the rhizomes of the latter growing close to the surface some distance above the deeply buried bulbs of the Bluebell. *Arum maculatum* and *Primula acaulis* are present in considerably increased amount, while *Adoxa Moschatellina* is found frequently wherever the soil is more than 4 feet in depth. *Anemone nemorosa* is abundant and flowers freely ; it is interesting to note that under similar shade conditions on the shallow Chalk soils flowers are only sparingly produced by this plant.

Orchis mascula and *Orchis maculata* are occasionally found. *Daphne Laureola*, L., is absent, but sometimes *Monotropa Hypopitys*, L., a plant often abundant on the Chalk, is present.

All the plants of the dwarf flora given above (see page 866) are present on the Clay with the exception of *Viola hirta*, which is confined to the Chalk. Although *Lamium Galeobdolon* and *Ajuga reptans* are found in increased amount, the plants as a whole are not abundant.

The flora which appears after felling resembles, in general character, that already described on the Chalk. The majority of the plants which appear are biennial or perennial and flower for the first time in the second year. The number of annuals flowering during the first season is greater than that found on the Chalk.

¹ It is interesting to note in this connexion that Ash is found abundantly on calcareous alluvial soils which possess a good water supply. The copses occurring in the Valley of the Darent in the neighbourhood of Farningham (North-West Kent) contain a large proportion of this species both as standard and as coppiced trees. The soil in this situation is largely derived from the washing of the surrounding chalk slopes.

The greater part of the vegetation found in the first summer is made up of seedlings of biennials and perennials, but amongst these several annuals may be found in flower. *Anagallis arvensis*, L., occurs frequently in some spots, and *Sonchus asper*, Hill, is spread sparingly over the whole area.

The following are occasionally found :—

<i>Linum catharticum</i> , L.	<i>Melampyrum pratense</i> , L.
<i>Alchemilla arvensis</i> , Scop.	<i>Galeopsis Tetrahit</i> , L.
<i>Gnaphalium uliginosum</i> , L.	<i>Polygonum Persicaria</i> , L.
<i>Senecio sylvaticus</i> , L.	<i>Polygonum aviculare</i> , L.
<i>Lithospermum arvense</i> , L.	<i>Juncus bufonius</i> , L.

Although the great majority of the biennials and perennials of the light flora only exist in the vegetative condition during the first season, a few may occasionally be found just coming into flower in the late summer of the first year. During the latter part of August, 1910, a few flowering plants of *Hypericum perforatum* and *Sanicula europaea* were found in an area felled in the previous January ; solitary plants of *Lychnis alba*, Mill., and *Hypochaeris radicata*, L., were also seen in a similar condition. *Hypericum humifusum*, L., is the only perennial plant discovered in which flowering regularly takes place during the season in which it first appears. This plant is not abundant on the Clay, but is easily noticeable on account of this peculiarity.

Although plant distribution on the Clay is largely correlated with the depth of the deposit, a number of plants are found occurring in equal abundance over the whole area. These are included in the following list :—

<i>Anemone nemorosa</i> , L.	<i>Echium vulgare</i> , L.
<i>Dipsacus sylvestris</i> , Huds.	<i>Myosotis sylvatica</i> , Hoffm.
<i>Senecio erucifolius</i> , L.	<i>Euphorbia amygdaloides</i> , L.

The following have a similar distribution and are frequently found :—

<i>Polygala vulgaris</i> , L.	<i>Carduus nutans</i> , L.
<i>Geranium columbinum</i> , L.	<i>Scrophularia nodosa</i> , L.
<i>Bunium flexuosum</i> , Fr.	<i>Veronica officinalis</i> , L.
<i>Arctium majus</i> , Bernh.	

Others, while found over the whole area, increase in abundance with the increased depth of soil :—

<i>Sanicula europaea</i> , L.	<i>Nepeta Glechoma</i> , Benth.
<i>Carduus palustris</i> , L.	

The following are only found on the shallow soil in the near vicinity of the Chalk :—

<i>Linum catharticum</i> , L.	<i>Teucrium Scorodonia</i> , L.
<i>Hypericum hirsutum</i> , L.	<i>Habenaria bifolia</i> , R. Br.

Similarly several plants occur only on the deepest soil near the northern boundary of the wood :—

Gnaphalium uliginosum, L.
Rumex obtusifolius, L.
Rumex sanguineus, L.
Polygonum aviculare, L.
Polygonum Persicaria, L.

Juncus bufonius, L.
Bromus erectus, Huds.
Bromus ramosus, Huds.
Poa nemoralis, L.

Viola Riviniana and *Viola Reichenbachiana* are both found, the former occurring in abundance on the greater part of the Clay, while the latter is almost confined to the deeper soils. Over a considerable part of the area the soil is approximately 4 feet in depth, and several plants are found here which are usually absent from the shallower and deeper soil :—

Hypericum perforatum, L.
Digitalis purpurea, L.
Anthoxanthum odoratum, L.

Holcus lanatus, L.
Holcus mollis, L.
Pteris aquilina, L.

Digitalis purpurea is scattered, while *Pteris aquilina* is found in a few small clumps. Several Grasses, on the other hand, are abundant, especially *Anthoxanthum odoratum* and *Holcus mollis*. This latter is a widely distributed woodland species and its occurrence here is not unexpected, but this is not the case with *Anthoxanthum*. These species each possess a shallow root system and would presumably come into direct competition with each other ; the time of flowering is, however, different, and the growth of *Anthoxanthum* is to a large extent completed before the flowering period of *Holcus mollis* commences. As a result of the Rothamstead manurial experiments, Lawes, Gilbert, and Masters (10) found that *Anthoxanthum odoratum* became prominent in unmanured plots where there was small growth of herbage and little activity of struggle. In experiments carried out at Chiswick, where *Anthoxanthum* was grown separately, the highest degree of vigour was obtained when both mineral and nitrogenous manures were supplied. The rapid decomposition of the humus accumulated during the shade period would probably produce somewhat similar conditions to those of the latter experiment, and at the same time the competition here would be considerably less than in a meadow. These considerations, together with the wide distribution of *Anthoxanthum*, perhaps partly explain its abundance in this situation. *Holcus lanatus*, another shallow-rooting species, also occurs in considerable abundance. This plant, in the Rothamstead grass plots, grows best under manurial conditions which do not tend to general luxuriance ; it attains its greatest percentage with liberal nitrogenous and mineral manure.

Hypericum perforatum occurs in considerable quantity over the whole Clay area, but is especially abundant on soil varying from 3 to 5 feet in depth. On the shallow soils it is partly replaced by *Hypericum hirsutum*, while on

the deeper ones the great abundance of *Carduus palustris* probably has a detrimental effect on its distribution..

In addition to the above-mentioned plants, the following biennials and perennials are occasionally found :—

<i>Sagina procumbens</i> , L.	<i>Prunella vulgaris</i> , L.
<i>Hypericum pulchrum</i> , L.	<i>Orchis mascula</i> , L.
<i>Epilobium roseum</i> , Schreb.	<i>Orchis maculata</i> , L.
<i>Daucus Carota</i> , L.	<i>Gymnadenia conopsea</i> , R. Br.
<i>Dipsacus pilosus</i> , L.	<i>Listera ovata</i> , R. Br.
<i>Gnaphalium sylvaticum</i> , L.	<i>Funcoides pilosum</i> , O. Kuntze.
<i>Solanum Dulcamara</i> , L.	<i>Brachypodium sylvaticum</i> , Beauv.
<i>Veronica serpyllifolia</i> , L.	

A considerable number of weeds of cultivated ground, hedgerow plants, and plants of waste places (ruderal plants) are occasionally found on the Clay ; of these the following annuals flower in the first season :—

<i>Alliaria officinalis</i> , Andr.	<i>Matricaria inodora</i> , L. ¹
<i>Stellaria media</i> , Vill.	<i>Senecio vulgaris</i> , L.
<i>Arenaria serpyllifolia</i> , L.	<i>Solanum nigrum</i> , L.
<i>Torilis Anthriscus</i> , Gaert.	<i>Plantago lanceolata</i> , L.

The following perennials flower for the first time in the second season and generally disappear in the later years :—

<i>Lepidium heterophyllum</i> , Benth.	<i>Chaerophyllum sylvestre</i> , L.
<i>Viola tricolor</i> , L.	<i>Heracleum Sphondylium</i> , L.
<i>Lychnis alba</i> , Mill.	<i>Helminthia echioides</i> , Gaert.
<i>Vicia sepium</i> , L.	<i>Hypochaeris radicata</i> , L.

Few Mosses are found in the shade produced by the older coppice growth, but after felling there is a considerable increase in number. Some of those which appear behave similarly to the biennial flowering plants with regard to fruiting. *Catharinea undulata* (L.), Web. Mohr, exists for the most part in the vegetative state only during the first season, but fruits abundantly during the second year.

Polytrichum juniperinum, Willd., *Polytrichum attenuatum*, Menz., and *Mnium hornum*, L., also show this, but in a less degree. The distribution of these species is associated with differences in the depth of soil. *Polytrichum juniperinum* forms a narrow band on the shallow soil in the neighbourhood of the Chalk, but is not found on the deeper soil. On slightly deeper soil it is replaced by a similar band of *Polytrichum attenuatum*. *Catharinea undulata* is abundant, but occurs only where the soil is more than about three feet in depth. *Mnium hornum* is usually confined to soil from three to four feet in depth, but is not found abundantly. Finally, *Mnium undula-*

¹ This plant is occasionally perennial.

tum, L., occurs sparingly only on the deepest parts of the Clay. In addition to the above-mentioned plants, a considerable number of other species occur; *Stereodon cupressiformis* (L.), Brid., *Hypnum rutabulum*, L., and *Thuidium tamariscifolium* (Neck.), Lindb., are frequently found.

In the eastern part of the wood the age of the coppice over the whole extent of the Clay nowhere exceeds three years, and here a definite zonation of the vegetation can be found in consequence of the above described distribution. The following zones can be distinguished :—

I. The soil is less than two feet in depth. The flora is in many respects similar to that of the Chalk, although several plants constantly found on the latter formation, such as *Reseda lutea*, *Origanum vulgare*, and *Helianthemum Chamaecistus*, do not appear. *Teucrium Scorodonia* is abundant, and *Hypericum perforatum* is frequent. Large patches of *Polytrichum juniperinum* are found, and *Cladonia pyxidata* occurs sparingly.

II. Depth of soil from 2 to 3 feet. *Teucrium Scorodonia* is less abundant, and there is a considerable increase in the amount of *Hypericum perforatum*. *Holcus mollis*, *Holcus lanatus*, and *Anthoxanthum odoratum* occur sparingly. *Polytrichum attenuatum* replaces *Polytrichum juniperinum* and *Mnium hornum* is frequently found.

III. Soil 3–4 feet in depth. The Grasses (*Holcus mollis*, *Holcus lanatus*, and *Anthoxanthum odoratum*) are abundant, giving a characteristic appearance to the flora. *Hypericum perforatum* is also abundant. *Carduus palustris* and *Sanicula europaea* are frequently found. Both species of *Polytrichum* are absent, and are replaced by *Catharinea undulata* and *Mnium hornum*.

IV. Soil 4–6 feet in depth. *Carduus palustris* is abundant, while there is a decrease of the Grasses and of *Hypericum perforatum*. *Adoxa Moschatellina*, absent from the shallower soils, is found, while *Sanicula europaea* shows a considerable increase. *Catharinea undulata* is abundant, while *Mnium hornum* has disappeared.

V. Soil over 6 feet in depth. *Carduus palustris* is very abundant, the plants being tall and luxuriant. *Sanicula europaea* and *Adoxa Moschatellina* are also abundant. *Rumex obtusifolius*, *Rumex sanguineus*, *Polygonum aviculare*, and *Polygonum Persicaria* are sparingly present. *Mnium undulatum* is found in addition to *Catharinea undulata*.

Analyses of soil from the different zones are not yet available, and until these are obtained no definite statements as to the cause of the above distribution can be made. Meanwhile it may be suggested that the zonation is largely influenced by the variations in the water content. In the shallow soils the drainage through the easily permeable chalk will be rapid, and the water content correspondingly small, but, with the increasing thickness of the clay, the drainage will be slower and the percentage of water retained by the soil will be greater. The lifting power also will be increased.

In support of this view the greater luxuriance of the vegetation on the deeper parts of the deposit may be cited ; the similar increase in abundance of *Carduus palustris*, a plant commonly found in damp situations, may also be given.

The Moss distribution also leads to the same conclusion. *Polytrichum juniperinum*, found on the shallowest soils, is strongly xerophytic, possessing inrolled leaves provided with lamellae on the upper surface. In *Polytrichum attenuatum*, occurring on the slightly deeper deposit, the leaves are larger and flat but retain the lamellae. *Mnium hornum* and *Catharinea undulata* possess flat leaves of the usual structure and are typical mesophytic species. Finally, in *Mnium undulatum*, which is found on the deepest soil and is a commonly occurring species in damp woods, the leaves are large, flat, and very delicate in structure. These species form a series showing diminishing xerophytic characters with the increase in depth of the soil.

The Clay with Flints is known to vary considerably in composition and the percentage of lime may be another factor in determining the above zonation.

(b) Rice Wood lies a short distance to the south-west of Badgin Wood (Text-fig. 2). Here the Clay with Flints, instead of presenting a level surface, is found sloping to the north-east, and the flora occurring on it exhibits several differences from that found on the deposit in Badgin Wood.

Rice Wood consists of copse with standard Oaks, and while the species making up the underwood are generally similar to those occurring on the deeper Clay of Badgin Wood there is an increased amount of *Castanea sativa*, Mill. On the whole the wood is considerably damper, and although the soil is not more than eight feet in depth in any place the vegetation with some exceptions resembles that found on the deepest soil in Badgin Wood. *Anemone nemorosa*, L., occurs in great abundance and flowers freely under the shade condition. *Primula acaulis*, L., is found in only slightly smaller numbers. *Oxalis Acetosella*, L., a species not present in Badgin Wood, occurs sparingly.

A portion of the copse was felled during the winter of 1909-10, and this area is now at the commencement of the second year's growth. During the first season *Anagallis arvensis*, L., and *Gnaphalium uliginosum*, L., were abundant and flowered freely. *Hypericum perforatum*, L., *Carduus palustris*, L., and *Sanicula europaea*, L., occurred in abundance in the vegetative condition. Bryophytes are present in much greater numbers than in Badgin Wood. *Mnium undulatum*, L., is abundant, while *Plagiochila asplenoides*, L., and *Porotrichum alopecurum* (L.), Mitt., are frequently found.

Zonation of *Polytrichum juniperinum*, Willd., and *Polytrichum attenuatum*, Menz., similar to that already described in Badgin Wood occurs near the western limit where the deposit of Clay thins out in the vicinity of the Chalk (Text-fig. 2). The zone of *Polytrichum juniperinum* is found nearer to

the latter formation, while that of *Polytrichum attenuatum* occurs next to it on the deeper soil towards the north-east.

The differences in the flora of the two woods no doubt largely depend on the different aspects of the two areas. The north-eastern slope will receive less sunlight, and will in consequence be damper and colder than the approximately level area found in Badgin Wood. The increased humidity will account for the abundance of the bryophytic flora in this part of Rice Wood.

(c) A comparison has also been made with the vegetation of woods found on the Clay with Flints nearer to the Chalk escarpment and at a greater altitude. The most striking difference is due to the considerably greater amount of *Pteris aquilina* found in these woods; in some situations this species is the most abundant plant of the light flora. *Cardamine pratensis*, L., also occurs frequently in these woods and flowers freely during the second season after felling; this plant is not found in Badgin Wood.

THE LOAM ON THE CHALK.

The flora of the deposit described as Loam on the Chalk in the Geological Survey is usually indistinguishable from that found on the Clay with Flints. A portion of Stocking Wood near Faversham occurs on this deposit, and in this wood *Pteris aquilina* is generally distributed.

In Text-fig. 1 the Loam on the Chalk is included with the Clay with Flints.

THE LOWER EOCENE FORMATIONS.

A considerable area of woodland is found on the Lower Eocene formations in both of the districts under consideration. In the neighbourhood of Swanley the greater part of the wood is confined to these deposits, little or none being found on the Chalk. The Eocene beds are generally found as outliers of variable extent which form small hills on the approximately even surface of the Chalk. The Thanet Sand, Woolwich and Reading series, and the Oldhaven pebble beds are frequently all represented in such an outlier, but often only the first or first and second of these formations are found. Occasionally there is also a capping of London Clay, but usually this deposit is found in the main mass of the Eocene formations.

THE THANET SAND.

The Thanet Sand is well represented in both districts, and gives rise to soil which on the whole is well suited for agriculture and is particularly favourable for the cultivation of fruit. In consequence the woods on this deposit are not usually extensive.

TEXT—FIG. 3.

Chalk.	Clay with Flints.
Thanet Sand.	Woolwich & Reading Beds.
Oldhaven Beds.	300 Contours.

Scale: 3 Inches=1 Mile.

The woods are shown in heavy outline.

The Thanet Sand consists of a fine light-coloured sand without pebbles, and gives rise to a light, frequently loamy soil. Chemical analyses show a small amount of calcium carbonate varying from 0.02 to 0.38 % (Hall and Russell (7)), and the soil in these woods generally gives an acid reaction with litmus paper.

The woods in almost all cases consist of coppice, generally without standards, frequently made up almost of Chestnut (*Castanea sativa*, Mill.). Hooker, in his 'Students' Flora of the British Islands' (8), places the Chestnut in the list of excluded species, and it is highly probable that the whole of these coppices have been planted. In this part of England mature specimens of the Chestnut only produce ripe seed in unusually long and warm summers, and in the case of the coppice, where felling takes place about every fourteen years, seed is only rarely ripened. No seedlings have ever been found. The regularity in the distance between the stools may also be given as evidence for the artificial origin of this type of woodland.

Although stones are not found in typical deposits of the Thanet Sand, in several cases soils described in the Geological Survey as belonging to this formation contain a considerable proportion of rounded pebbles. Soils of this kind are usually found in proximity to the Woolwich and Reading beds, and in these cases a certain amount of admixture has probably taken place between the two formations. The vegetation occurring on such soils differs in some respects from that found on the typical deposits. Certain differences are also found in the flora where the Thanet Sand thins out in the vicinity of the Chalk. These variations in the composition of the vegetation, although seen both in the light and in the shade flora, are more pronounced during the shade period. This circumstance is not unexpected when the conditions under which the light flora is produced are considered. During the shade period little or no change takes place either in the abundance of the ground flora or in its composition. The factors on which its existence depends are almost constant, and in consequence the vegetation is in a condition of equilibrium. As a result of felling, large areas of almost unoccupied soil are rendered available for plant growth, and these are rapidly seized upon by species which possess an efficient method of distribution.¹ Although many of these plants are doubtless well adapted to the soil composition a considerable number are probably enabled to develop, not because of the special suitability of the soil, but rather on account of the slight competition existing for a short period after felling has taken place. The occurrence of ruderal plants similar to those mentioned in the light flora of the Clay with Flints is probably rendered possible by the feeble competition during the first few years of the coppice growth.

It is improbable that the light flora ever attains a condition of equilibrium. The elimination of the more unsuitable species will proceed for

¹ The origin of the light flora will be discussed in a later communication.

some time, but before the process is complete the increasing shade cast by the coppice growth will begin to adversely affect the whole of the light flora. The latter will finally completely disappear, and the woodland will again present the original shade condition.

In the first place, therefore, the vegetation found on the various soils during the shade period will be separately described, and a general account of the light flora on the Thanet Sand will then be given.

I. *Flora found during the shade period.*

(a) Woods on the typical deposits of the Thanet Sand. The following woods of this type have been investigated in the Faversham district:—

Sandbanks Wood, portions of Kemsdale and Bysing Woods.

In these woods the soil is of considerable depth, and consists of a light sandy loam without pebbles. The coppice is made up of Chestnut with a small proportion of Elder (*Sambucus nigra*, L.), the latter forming an ill-defined lower stratum which, in the early spring, is very obvious, as the leaves of the Elder unfold some time before those of the Chestnut. The shade flora is well represented. *Endymion nutans*, Dum., is in all cases extremely abundant, while *Adoxa Moschatellina*, L., and *Ranunculus Ficaria*, L., are usually almost as plentiful. *Arum maculatum*, L., is also present, although not in such abundance. All these flower freely early in the season. It is interesting to note that all possess a more or less tuberous rootstock, and it seems that sandy soils of this nature are particularly suited to the tuberous habit. *Veronica hederæfolia*, L., and *Listera ovata*, R.Br., are found sparingly, and both of these plants bloom under the shade conditions, although in the case of the former the flowers are few in number.

The abundance of *Ranunculus Ficaria* in these coppices is striking, as this plant is rarely or never found in the woods on the Chalk, Clay with Flints, and remaining Eocene formations. The distribution of *Adoxa Moschatellina* is peculiar. Although occurring in great abundance in some of these coppices, in others, where as far as at present determined the conditions are identical, it is altogether absent. The occurrence of *Anemone nemorosa*, L., is somewhat similar, for this plant, although absent from some of these woods, occurs in considerable quantity in others. In the Chestnut coppices where it is found the *Anemone* flowers freely during the shade period. As already described, on the shallow soils of the Chalk this plant is not found during the later stages of the coppice growth, although it appears after felling has taken place. The factors determining the distribution of these plants are at present being investigated, and will be fully discussed in a subsequent communication.

In addition to the plants already mentioned, several are found which flower rarely or not at all, and are comparable to the dwarf shade flora of the Chalk and Clay with Flints. Of these, *Nepeta Glechoma*, Benth., is

abundant, while *Lychnis dioica*, L., *Viola Riviniana*, Reich., *Geum urbanum*, L., *Rubus fruticosus*, L., *Rumex sanguineus*, L., *Urtica dioica*, L., and *Holcus mollis*, L., are found in smaller numbers.

The Honeysuckle (*Lonicera Periclymenum*, L.) is a characteristic plant of the Thanet Sand, occurring in much greater abundance on this formation than on the Chalk and Clay with Flints.

It will be noticed that the majority of the plants already mentioned are species in which development is completed in the early summer. In consequence, in the late summer and autumn these Chestnut coppices possess practically no ground flora.

(b) Woods on the Thanet Sand in the neighbourhood of the Woolwich and Reading beds. The following woods of this type have been investigated:—

In the Faversham district: portions of Bysing, Judd's, and Perry Woods.

In the Swanley district: portions of Farningham, Jordan's, and Row-hill Woods. In all cases pebbles are present in the soil to a variable extent. In other respects the soil is similar to that already described on the typical Thanet Sand.

As before, Chestnut (*Castanea sativa*, Mill.) is the chief constituent of the coppices, and this species is sometimes present in the form of standards; Oak (chiefly *Quercus sessiliflora*, Salisb., occasionally *Quercus pedunculata*, Ehrh.) is, however, the most frequently occurring standard tree. Elder (*Sambucus nigra*, L.) is not so abundant as on the typical soil. Beech, Hazel, Birch, and Holly are occasionally present. Both *Pinus sylvestris*, L., and *Pseudotsuga Douglasii*, Carr., are often planted in these copses, generally in small numbers, but sometimes forming clumps of considerable extent.

The ground flora is very scanty, and in some cases is made up entirely of Mosses. Of these, *Mnium hornum*, L., is the most abundant, and this, with smaller quantities of *Polytrichum attenuatum*, Menz., and *Leucobryum glaucum*, Schp., frequently covers more than half of the entire surface, giving a very characteristic appearance to these copses. In other cases, although the Mosses are still abundant, a few flowering plants are found. The following are generally distributed but never occur abundantly. These flower freely under the shade conditions:—

Anemone nemorosa, L.

Oxalis Acetosella, L.

Asperula odorata, L.

Primula acaulis, L.

Lamium Galeobdolon, Grantz.

Endymion nutans, Dum.

It is interesting to note that *Lamium Galeobdolon* flowers freely in the deep shade of the Chestnut copses on the Thanet Sand, although in the mixed copses of the Chalk and Clay with Flints it persists in the vegetative

condition only during the shade period. *Convallaria majalis*, L., and *Polygonatum multiflorum*, All., are found sparingly in the woods in the Swanley district; the latter blooms freely, but the former only occasionally produces flowers. *Neottia Nidus-avis*, Rich., is occasionally found.

The dwarf shade flora is only slightly represented; the following plants occur in small numbers:—

Rubus fruticosus, L.
Geum urbanum, L.
Solidago Virgaurea, L.
Lysimachia nemorum, L.
Nepeta Glechoma, Benth.

Ajuga reptans, L.
Rumex Acetosella, L.
Rumex sanguineus, L.
Holcus mollis, L.

These plants are present in a small stunted form and rarely flower. *Pteris aquilina* occurs on the more stony soils, producing stunted leaves destitute of sporangia.

(c) Woods on the Thanet Sand in the close vicinity of the Chalk. The following woods of this type have been investigated:—

In the Faversham district: portions of Bysing and Perry Woods.

In the Swanley district: portions of Farningham and Rowhill Woods.

Woods of this type generally occur on the outskirts of the Tertiary outliers and in situations where the deposit of the Thanet Sand is of slight depth. Analyses of these soils are not at present available, but it appears probable that the percentage of calcium carbonate is higher in these than in the typical soils of the Thanet Sand.

A considerable number of species make up the underwood of the copses. Chestnut (*Castanea sativa*, Mill.) is generally the most abundant, but Ash (*Fraxinus excelsior*, L.) and Hazel (*Corylus Avellana*, L.) are present in almost equal quantities, and in some cases form more than half of the underwood. Maple (*Acer campestre*, L.), Spindle (*Euonymus europaeus*, L.), Dogwood (*Cornus sanguinea*, L.), Oak (*Quercus pedunculata*, Ehrh., and *Quercus sessiliflora*, Salisb.), and Willow (*Salix Caprea*, L.) occur much less abundantly. *Viburnum Lantana*, L., *Ligustrum vulgare*, L., and *Clematis Vitalba*, L., are occasionally found. Oak standards (chiefly *Quercus sessiliflora*, Salisb.) are present in most of the copses.

The ground flora bears a close resemblance to that found on the deeper soils of the Chalk, but differs in the relative abundance of *Mercurialis perennis*, L. This plant, as already described, occurs in abundance on the Chalk soils, but on the Thanet Sand only forms isolated patches of small area. It is interesting to note that, apart from its occurrence on these soils of the Thanet Sand in the vicinity of the Chalk, *Mercurialis perennis* is altogether absent from the woods of the Lower Eocene formations.

II. *Flora produced during the light period.*

Felling takes place in the copses on the Thanet Sand at regular intervals of about fourteen years. The light flora produced agrees in general characters with that previously described in the copses of the Chalk and the Clay with Flints, but differs considerably in its specific composition. As before, it may be divided into—

(a) Plants of the shade flora persisting during the light period.

(b) Plants which can only exist during the light period.

(a) After felling has taken place the plants of the shade flora which flower early in the spring still persist, although in most cases in diminished numbers. The decreased abundance is particularly noticeable in the cases of *Adoxa Moschatellina*, L., *Endymion nutans*, Dum., and *Ranunculus Ficaria*, L. The coppices are generally cut in December or January, and in the spring of the following season little change can be observed in the composition of the flora. During the subsequent years, however, the species mentioned, which during the shade period were in almost undisputed possession of the soil, come into competition with the plants of the light flora. The decrease in number of these plants is due, not to the more brilliant illumination, but to the greatly increased competition. The Anemone, however, shows no decrease after felling has taken place, but increases both in the number of the individual plants and in the quantity of flowers produced.

The plants of the dwarf shade flora increase in abundance and flower freely during the first and subsequent years. *Lychnis dioica*, L., flowers during the first season, and in the next few years is one of the most striking species of the woods on the Thanet Sand; the plants are numerous and luxuriant, and flowers are produced in great abundance. On the more stony soils, *Solidago Virgaurea*, L., is widespread and flowers freely. *Nepeta Glechoma*, Benth., *Lysimachia nemorum*, L., *Rumex sanguineus*, L., and *Holcus mollis*, L., increase in amount and flower during the first summer. *Rubus fruticosus*, L., reaches its greatest development in the third and fourth year after felling. *Pteris aquilina*, L., develops rapidly with the increased illumination, and is present in abundance on the more stony soils.

(b) As already pointed out the flora which appears after felling agrees generally in its composition on the three varieties of soil already distinguished on the Thanet Sand. The plants making up this light flora are in many cases identical with those found during the light period in the copses on the Chalk and Clay with Flints. The resemblance between the vegetation of such dissimilar soils can no doubt be explained by the lack of competition during the years immediately following the removal of the underwood. As previously pointed out, under these conditions species with efficient seed distribution will seize upon the unoccupied areas and will

develop freely, although many of these plants under conditions of more severe competition would cease to exist, since they are not specially suited to the edaphic conditions.

As in the light floras already described, the majority of the species are biennial or perennial, and these flower for the first time in the second season after felling has taken place. A small number of annuals are found, and these flower during the first season. Of these the following are the most abundant :—

Gnaphalium uliginosum, L.
Anagallis arvensis, L.

Polygonum Persicaria, L.
Funcus bufonius, L.

The following are occasionally found :—

Cardamine hirsuta, L.
Galeopsis Tetrahit, L.

Chenopodium polyspermum, L.

Hypericum humifusum, L., occurs in considerable abundance, and, although perennial, flowers during the first season.

The following biennials and perennials are found abundantly :—

Hypericum perforatum, L.
Potentilla silvestris, Neck.
Circaea lutetiana, L.
Sanicula europaea, L.
Dipsacus sylvestris, Huds.
Senecio erucifolius, L.
Carduus palustris, L.

Echium vulgare, L.
Myosotis sylvatica, Hoffm.
Veronica officinalis, L.
Rumex obtusifolius, L.
Funcoides pilosum, O. Kuntze.
Holcus lanatus, L.
Holcus mollis, L.

The following are generally present, but do not occur in abundance :—

Hypericum pulchrum, L.
Fragaria vesca, L.
Arctium majus, Bernh.
Scrophularia nodosa, L.
Digitalis purpurea, L.
Stachys Betonica, Benth.

Anthoxanthum odoratum, L.
Agrostis vulgaris, With.
Aira caespitosa, L.
Aira praecox, L.
Melica nutans, L.

The following are occasionally found in small numbers :—

Cardamine pratensis, L.
Arenaria trinervia, L.
Lotus uliginosus, Schk.
Oenothera biennis, L.
Epilobium angustifolium, L.
Campanula Trachelium, L.

Hieracium umbellatum, var.
coronopifolium, Bernh.
Veronica Chamaedrys, L.
Veronica serpyllifolia, L.
Funcus conglomeratus, L.
Carex sylvatica, Huds.
Arrhenatherum avenaceum, Beauv.

The following plants are generally found on the more stony soils :—

Senecio sylvaticus, L.

Aira flexuosa, L.

Teucrium Scorodonia, L.

The following are found, generally in small quantities, on soils in the vicinity of the Chalk :—

Hypericum hirsutum, L.

Euphorbia amygdaloides, L.

Verbascum Thapsus, L.

In addition to the above a small number of ruderal plants, weeds, &c., are found. These are present in greatest quantity during the first two years after felling and disappear later. Annual, biennial, and perennial plants are included in the list :—

Viola tricolor, L.

Solanum nigrum, L.

Heracleum Sphondylium, L.

Polygonum aviculare, L.

Senecio vulgaris, L.

Polygonum Convolvulus, L.

Taraxacum officinale, Weber.

The great abundance of *Mnium hornum*, L., in some of the Chestnut coppices of the Thanet Sand has already been referred to. This is frequently associated with *Leucobryum glaucum*, Schp., *Polytrichum attenuatum*, Menz., and *Dicranum montanum*, Hed. On the drier, more stony soils, *Mnium hornum* is partially replaced by *Polytrichum juniperinum*, Willd., and *Dicranella heteromalla*, Schp. *Catharinea undulata* (L.), Web. Mohr., occurs abundantly on the sandy loam without pebbles, associated in the damper spots with *Pellia epiphylla*, L.; both these species are absent on the drier soils. *Georgia pellucida* (L.), Rabenh., and *Orthopyxis androgyna* (L.), Beauv., are generally distributed in small quantities; neither of these species has been discovered on the Chalk or Clay with Flints. *Isopterygium depressum* (Bruch), Mitt., is usually present. *Diplophyllum albicans*, L., occurs commonly on banks and cuttings associated with *Fungermannia ventricosa*, Dicks., and *Lepidozia reptans*, L.

THE WOOLWICH AND READING SERIES.

The Woolwich and Reading formation is made up of beds of coarse sands and gravels alternating with occasional thin beds of clay. In consequence the character of the soil produced varies considerably in different situations, the gravels and sands giving rise to light sandy loam in which the drainage is rapid, while the bands of clay produce heavy, badly-drained soils. In all these soils the amount of calcium carbonate is very small. In an analysis published by Hall and Russell (7) the percentage of lime is given as 0.1, a proportion lower than that found in the majority of the soils

of the Thanet Sand. As would be expected, an acid reaction is constantly given by the soils in woodland areas. The proportion of mineral plant food also is generally lower than in soils of the Thanet Sand.

The areas of woodland occurring on the formation are not extensive in the districts under consideration. In the majority of cases the Woolwich and Reading beds form a relatively narrow zone in the Lower Eocene deposits bounded on one side by the Thanet Sand and on the other by the Oldhaven beds. Occasionally, however, in the smaller outliers in which the Oldhaven beds are not represented, the Woolwich and Reading areas are more extensive. It has already been pointed out that there is in many cases a gradual transition from the Thanet Sand to the Woolwich and Reading deposits.

(a) Woods on the sands and gravels of the Woolwich and Reading series. The following woods of this type have been investigated :—

In the Faversham district : portions of Bysing and Perry Woods.

In the Swanley district : portions of Jordan's, Farningham, and Rowhill Woods.

The woods in many respects are similar to those occurring on the Thanet Sand. In the coppices, Chestnut is frequently the most abundant species, but it is mixed with a considerable proportion of Oak and Beech. The occurrence of Beech on a soil containing so small a proportion of calcium carbonate is of interest. *Pyrus Aria*, Ehrh., is frequently found ; this tree, although widespread on the Chalk, is not confined to calcareous deposits, but is of general occurrence on light soils. In some of the woods *Pinus sylvestris*, L., has been extensively planted, and here the coppice is more open and felling does not take place at regular intervals. In consequence the sharp distinction between the light and shade vegetation already described in the case of coppice on the Chalk, Clay with Flints, and Thanet Sand cannot in these cases be maintained.

The flora of the Woolwich and Reading formation is distinguished by the abundance of *Pteris aquilina*, L. This plant, which occurs sparingly or not at all on the Thanet Sand, is dominant in all situations where the illumination is sufficient to allow for its development. *Adoxa Moschatellina*, L., and *Ranunculus Ficaria*, L., are absent, while *Primula acaulis*, L., *Anemone nemorosa*, L., and *Endymion nautans*, Dum., occur very sparingly.

The light flora generally resembles that already described on the more stony soils of the Thanet Sand, but is more xerophytic in character. *Carduus palustris*, L., is rarely or never found, while there is a larger proportion of *Teucrium Scorodonia*, L., and *Solidago Virgaurea*, L., *Calluna Erica*, DC., and *Aira flexuosa*, L., are usually present. *Polytrichum juniperinum*, Willd., occurs in addition to the Mosses already noted on the Thanet Sand.

(b) Woods on the Clay soils of the Woolwich and Reading series.

An area of this type has been investigated in Farningham Wood, near Swanley.

The coppice on the Clay differs from that on the sand and gravel in the larger number of woody species present. Chestnut, Hazel, and Ash are of frequent occurrence, while Oak, Birch, Beech, *Populus tremula*, L., and *Salix Caprea*, L., are found sparingly. Many of the herbaceous plants found on the sands and gravels also occur on the Clay, but the vegetation, as a whole, is of the mesophytic type. *Calluna Erica*, DC., and *Aira flexuosa*, L., are not found.

After felling, *Carduus palustris*, L., is produced in great abundance, and *Lysimachia nemorum*, L., *Scabiosa Succisa*, L., *Circaea lutetiana*, L., and *Juncoides sylvaticum*, O. Kuntze, are usually present in considerable quantity. Small ponds are of frequent occurrence, and in their vicinity *Lysimachia Nummularia*, L., *Polygonum Hydropiper*, L., and *Juncus conglomeratus*, L., are characteristic plants.

Clay soils of this type usually support an abundant bryophytic flora. Several of the more xerophytic species of the sands and gravels, such as *Polytrichum juniperinum*, Willd., and *Dicranella heteromalla*, Schp., are absent, and these are replaced by *Catharinea undulata* (L.), Web. Mohr., *Mnium hornum*, L., *Mnium undulatum*, L., and other mesophytic species. *Pellia epiphylla*, L., frequently covers large areas, and *Riccia glauca*, L., is often found.

THE OLDHAVEN (BLACKHEATH) FORMATION.

In the districts under consideration the Oldhaven deposits consist largely of rounded flint pebbles. The soils produced by these beds are poor and stony in character and in consequence are rarely cultivated. The proportion of calcium carbonate is lower than in the soils of the two Eocene formations already described, varying from 0.02% to 0.05% of the dry weight (Hall and Russell (7)). The acidity in woodland areas is very pronounced.

In these districts the Oldhaven beds are of small extent and are found capping some of the Tertiary outliers. Farningham Wood, near Swanley, covers almost the whole of an outlier of this kind. Towards the outside of this wood there is a continuous zone of Thanet Sand; immediately within this is found a similar zone of Woolwich and Reading deposits, while the central and highest portion of the wood is situated on the Oldhaven beds. Perry Wood, near Faversham, has a similar conformation (Text-fig. 4).

The investigations made have been carried out in Farningham and Perry Woods. The woods occurring on the Oldhaven beds are of the Oak-Birch-Heather type referred to by Moss, Rankin, and Tansley (13). They consist for the most part of open coppice in which the trees are few in

number and are found at irregular intervals. In these coppices felling does not take place so regularly as in those on the formations already described.

The majority of the standards are *Quercus sessiliflora*, Salisb., although *Quercus pedunculata*, Ehrh., is occasionally found. *Pinus sylvestris*, L., has been planted extensively, and in some cases this gives rise to small areas of high forest, although it is generally intermixed with the deciduous species. In these situations *Pinus sylvestris* fruits freely and seedlings are of frequent occurrence. The Birch (*Betula verrucosa*, Ehrh.) is found in considerable quantity, although usually not so abundant as the Oak, while Beech, *Castanea sativa*, Mill., *Pyrus Aria*, Ehrh., and *Pyrus Aucuparia*, Ehrh., are usually present in small quantity.

Pteris aquilina, L., occurs in great abundance and is the dominant plant on these stony soils, except in deeply shaded situations. This, with *Calluna Erica*, DC., and *Teucrium Scorodonia*, L., makes up the greater part of the undergrowth. A society of this kind may be referred to as a *Xero-Pteridetum*, a term introduced by Woodhead (17) to describe the xerophytic type of vegetation, in which *Pteris aquilina* is dominant, found on the shallow sandy soils in the neighbourhood of Huddersfield. Although many of the species found on the Oldhaven beds differ from those described by Woodhead on the Millstone Grit, the general character of the vegetation is similar in the two areas.

The photograph shown in Plate LXVI gives a general view of the vegetation of the Oldhaven deposits. This photograph, taken in early spring, shows the dead stems and leaves of bracken in the foreground, the dark masses of *Calluna* in the middle distance, and Birch and *Pinus* in the background. On this soil *Endymion nutans*, Dum., *Anemone nemorosa*, L., and *Primula acaulis*, L., are almost absent. The abundance of *Rumex Acetosella*, L., demonstrates the acidity of the soil. The following plants are found in considerable quantity:—

Stellaria graminea, L.

Hypericum pulchrum, L.

Potentilla silvestris, Neck.

Solidago Virgaurea, L.

Funcoides pilosa, O. Kuntze.

Aira praecox, L.

Aira flexuosa, L.

Digitalis purpurea, L., and *Verbascum Thapsus*, L., occur sparingly. The Mosses found are of the xerophytic type; of these, *Polytrichum juniperinum*, Willd., and *Dicranum scoparium*, Hed., are the most widespread and cover large areas of the soil. *Cladonia pyxidata* (L.), E.Fr., is found in abundance amongst the Mosses, particularly in the vicinity of the groups of *Calluna*.

THE LONDON CLAY.

In the neighbourhood of Faversham the London Clay extends over a large area between Canterbury, Whitstable, and Herne Bay, forming the main mass of the Eocene deposits. This area is almost entirely covered by woodland known as the Forest of Blean.

The soil is reddish brown in colour and contains a large amount of true clay, the proportion in some districts in East Kent rising to over 40 % (Hall and Russell (7)). It is, in consequence, of a particularly heavy nature and presents great difficulties in working for agricultural purposes. For these reasons it is probable that the area occupied by the Forest of Blean has never been brought under cultivation, but has always been covered with woodland. The proportion of lime in these soils is small; the analyses given by Hall and Russell (7) show 0·2–0·3 % of calcium carbonate, but these were obtained from arable soils which had probably been limed; the amount in soil covered by woodland is probably considerably less.

The observations made on the vegetation of the woods of the London Clay have been confined to portions of the Forest of Blean in the vicinity of Holly Hill, near Faversham. The altitude of these woods varies from 200 to 300 ft.; the slope of the ground is towards the north-west. The Oak (*Quercus sessiliflora*, Salisb.) is the most abundant tree found in these woods. The standards are well-grown trees and produce Oak timber of good quality. The Oak also forms the greater part of the coppice growth. Hazel, Chestnut (*Castanea sativa*, Mill.), Beech, and Birch (*Betula verrucosa*, Ehrh.) are usually present, but in considerably smaller numbers. Honey-suckle is frequently found in these copses. *Pinus sylvestris*, L., has been planted in some situations.

The ground flora in the shade of the old copse is very scanty. The following are found, but in all cases the plants are few in number. These flower in the early spring:—

Anemone nemorosa, L.

Primula acaulis, L.

Endymion nutans, Dum.

In view of the abundance of the Bluebell on the Clay with Flints, its scarcity on the London Clay is striking. Although the two soils are very similar both in mechanical and chemical composition, the London Clay is much more compact and harder than the Clay with Flints; this is particularly the case with regard to the upper layers. The young bulbs of *Endymion nutans* would not meet with great resistance in their passage downwards, and this fact no doubt partially explains the scantiness of the species on this soil. *Mercurialis perennis* is absent from the London Clay in this district.

The dwarf shade flora is represented by the following plants:—

Viola Riviniana, Reich.

Rubus fruticosus, L.

Solidago Virgaurea, L.

Ajuga reptans, L.

Pteris aquilina, L.

All these species are found in small quantity. *Solidago Virgaurea* is the most abundant of the flowering plants, but this exists only in the vegetative condition. *Viola Riviniana* and *Ajuga reptans* occur sparingly and rarely flower. *Pteris aquilina* is found in considerable quantity, but only produces small stunted leaves without sporangia.

Felling takes place at intervals of about fourteen years, as in the copses on other soils in the neighbourhood. As before, the resulting flora can be divided into—

(a) The plants of the shade flora which persist under the light conditions.

(b) Species found only during the light period.

(a) After felling has taken place there is a great increase in amount of *Pteris aquilina*. This plant rapidly becomes dominant and in the late summer and autumn covers the whole of the soil. *Rubus fruticosus* also develops greatly, and flowers in the second and following years. *Solidago Virgaurea* becomes abundant, flowering to a small extent during the first season and freely in the later years. *Viola Riviniana* increases in amount, and flowers abundantly. *Anemone nemorosa*, *Endymion nutans*, and *Primula acaulis* show little or no alteration.

(b) The great majority of the plants which appear after felling are biennials or perennials, and these do not flower during the first season. Few annuals have been observed; of these, *Melampyrum pratense*, L., is generally distributed; *Myosotis collina*, Hoffm., is occasionally found. The following biennial and perennial plants occur in abundance:—

Hypericum pulchrum, L.

Calluna Erica, DC.

Teucrium Scorodonia, L.

Funcoides pilosum, O. Kuntze.

Funcoides sylvaticum, O. Kuntze.

Aira flexuosa, L.

The occurrence of *Calluna Erica* and *Aira flexuosa* on a heavy clay soil is unusual, and on this account a careful examination was made to determine whether the clay in this locality was overlaid by a sandy deposit. No such layer, however, was found. The upper layers of the clay become very hard and dry during the summer, and this fact perhaps accounts for the prevalence on the London Clay of species in which xerophytic characters are considerably developed. *Hypericum pulchrum* and *Aira flexuosa* flower at approximately the same date, and in the early summer form a conspicuous feature of the vegetation.

The following plants are of frequent occurrence :—

<i>Sarothamnus vulgaris</i> , Wimm.	<i>Anthoxanthum odoratum</i> , L.
<i>Veronica officinalis</i> , L.	<i>Holcus mollis</i> , L.
<i>Funcus conglomeratus</i> , L.	<i>Festuca ovina</i> , L.
<i>Agrostis vulgaris</i> , With.	

The Broom is occasionally found in the lighter portions of the full-grown copse. After felling, plants frequently appear, but these do not flower until several years have elapsed.

Several species are generally distributed :—

<i>Polygala vulgaris</i> , L.	<i>Stachys Betonica</i> , Benth.
<i>Senecio erucifolius</i> , L.	<i>Prunella vulgaris</i> , L.
<i>Carduus palustris</i> , L.	<i>Holcus lanatus</i> , L.
<i>Erythraea Centaurium</i> , Pers.	

The following species are scattered :—

<i>Sagina procumbens</i> , L.	<i>Lotus uliginosus</i> , Schk.
<i>Hypericum perforatum</i> , L.	<i>Epilobium angustifolium</i> , L.
<i>Euphorbia amygdaloides</i> , L.	<i>Dactylis glomerata</i> , L.

Hypericum Androsaemum, L., is occasionally found.

A good deal of the ground in the vicinity of the wood has obviously been cleared of the coppice growth within the last few years, and only the standard Oaks have been left. On this rough pasture *Aira caespitosa*, L., and *Pteris aquilina*, L., are of frequent occurrence.

The light flora of the London Clay is less abundant, both in quantity and in number of species, than those already described on the other soils of the neighbourhood. The most obvious feature of the flora is the great abundance of Bracken and Heather. These plants have a great and obvious effect on the surrounding vegetation, and the absence or rarity of many species commonly found on the Clay with Flints probably depends on their abundance.

The Moss flora of the London Clay is remarkable in the rarity or complete absence of several species which occur frequently on the neighbouring soils. *Mnium hornum*, L., and *Catharinea undulata* (L.), Web. Mohr., have not been found. On the other hand, *Polytrichum juniperinum*, Willd., *Polytrichum attenuatum*, Menz., and *Dicranium scoparium*, Hed., are abundant. *Thuidium tamariscifolium*, Lind., is generally distributed. *Cladonia pyxidata* (L.), E.Fr., and *Peltigera canina* (L.), Hoffm., occur frequently on this soil.

THE ALLUVIAL DEPOSITS.

In the Faversham district several small areas of woodland occur on alluvial soils. In most cases these form portions of larger woods, of which the greater part is found on one or more of the soils already described.

Two types of vegetation can usually be distinguished in these woods :—

(a) The flora includes most of the species found in the woods on the Chalk and Clay with Flints and particularly resembles that found on the latter deposit.

(b) The flora includes most of the species found in the woods on the Tertiary deposits and closely resembles that found on the Thanet Sand.

It is highly probable that these differences in the vegetation depend on the origin of the alluvial deposit in question. A soil derived by the washing of Tertiary beds will in general agree in composition with the formation from which it originated. Similarly, an alluvial soil found at the bottom of a chalk slope will in all probability contain a large percentage of calcium carbonate. No analyses of these soils are at present available, but the matter will be further considered in a later communication.

(a) Woods on alluvial soils possessing a flora allied to that of the Chalk and Clay with Flints. The following woods of this type have been investigated in the Faversham district :—

Portions of Badgin, Judd's, and Bysing Woods.

In the first two woods each of the alluvial deposits in question is situated at the bottom of a chalk slope. In these areas only the shade flora has been investigated. In each of these cases the species making up the coppice growth are similar to those occurring on the Clay with Flints: Ash and Hazel predominate. The ground flora differs from that of the surrounding chalk soil in the increased amount of *Mercurialis perennis*, L., and *Endymion nutans*, Dum., and in the occurrence of *Adoxa Moschatellina*, L., a plant absent from the Chalk.

In Judd's Wood *Ranunculus Ficaria*, L., is abundant on the alluvium, and *Mnium undulatum*, L., is occasionally found. In Bysing Wood small areas of alluvial soil are found in a deposit of Thanet Sand which lies in the close vicinity of the Chalk. On these areas the underwood principally consists of Chestnut (*Castanea sativa*, Mill.) and Hazel. *Mercurialis perennis* occurs in isolated patches, and *Endymion nutans*, *Adoxa Moschatellina*, and *Anemone nemorosa* are generally distributed. The light flora is intermediate in character between that of the Clay with Flints and Thanet Sand. The following plants are particularly abundant :—

Lychnis dioica, L.

Gnaphalium uliginosum, L.

Dipsacus sylvestris, Huds.

Carduus palustris, L.

Echium vulgare, L.

(b) Woods on alluvial soils possessing a flora allied to that of the Tertiary deposits. The following woods of this type have been investigated in the Faversham district :—

Willow Wood, portions of Kemsdale and Sandbanks Woods.

(1) Sandbanks Wood. The alluvium occurs at the bottom of a steep slope of typical Thanet Sand (see p. 880). Only the shade flora has been investigated.

On passing to the alluvium from the Thanet Sand, Ash appears, and to a great extent replaces the Chestnut (*Castanea sativa*, Mill.) ; Hazel is occasionally present. *Ranunculus Ficaria*, L., is found in great abundance. *Adoxa Moschatellina*, L., and *Mercurialis perennis*, L., are absent from all parts of the wood.

(2) Willow and Kemsdale Woods. The soils of each of these woods abuts on an area of Thanet Sand. The woods consist of copse, the standard trees being Oak (*Quercus pedunculata*, Ehrh., and *Quercus sessiliflora*, Salisb.), while the underwood is made up chiefly of Chestnut (*Castanea sativa*, Mill.). Ash, Hazel, and Willow (*Salix Caprea*, L.) are also frequently found. The following plants are abundant in the shade flora :—

Anemone nemorosa, L.

Primula acaulis, L.

Adoxa Moschatellina, L.

Endymion nutans, Dum.

The light flora closely resembles that of the Thanet Sand, but includes the following species commonly found on the Chalk soils :—

Hypericum hirsutum, L.

Inula Conyza, DC.

Euphorbia amygdaloides, L., is often abundant.

Although two types of vegetation can usually be distinguished on the alluvial deposits, a consideration of the plants just mentioned will show that a certain amount of admixture of the species has taken place. This is not surprising as it is unlikely that any alluvial soil has been entirely derived from one deposit. It may be provisionally concluded that the composition of the flora varies with the composition of the soil.

GENERAL OBSERVATIONS AND SUMMARY.

Attention has already been drawn to the morphological peculiarities of the plants making up the greater part of the shade flora of the Chestnut copses on the Thanet Sand, and their general distribution in the neighbourhood can now be discussed. The plants in question—*Endymion nutans*, *Adoxa Moschatellina*, *Ranunculus Ficaria*, and *Arum maculatum*—all agree in the possession of a bulbous or tuberous rootstock. As pointed out by Woodhead (17 and 18), the mature bulbs of the Bluebell are found at a considerable depth in the soil ; the rhizomes of *Arum maculatum* occupy an almost similar position. These two plants will, in consequence, come

into direct competition with each other. The rhizomes of *Adoxa Moschatellina*, on the other hand, are found at considerably less depth in the soil, while the tubers of *Ranunculus Ficaria* occur still closer to the surface. The society, as a whole, is complementary, the uppermost soil layers being occupied by *Ranunculus Ficaria*, the intermediate by *Adoxa Moschatellina*, and the lowest by *Endymion nutans* and *Arum maculatum*.

A full account of the life-history and morphology of *Endymion nutans* has been given by Woodhead (17 and 18), and this investigator has described the passage of the bulb downwards to the deeper layers of the soil during the development of the mature plant. A similar phenomenon has been mentioned by Oliver (14) in the case of *Adoxa Moschatellina*, and a similar process takes place in plants of *Arum maculatum* produced from seed (Scott and Sargant, 15). The soil found in copses on the Thanet Sand is particularly well adapted for the descent of the rootstock, since it consists typically of a loose sandy loam without stones of any kind. Little resistance is offered to the descent of the plant, and this circumstance probably partially explains the abundance of the species in question.

As already mentioned many of the areas described as Thanet Sand contain a considerable quantity of pebbles in the soil. The presence of pebbles evidently has an adverse effect on bulbous and tuberous species. In the case of *Endymion*, *Adoxa*, and *Arum* the sinking of the rootstock is obstructed both by the stones and the increased hardness of the soil. In consequence these species are absent or only occur in greatly decreased quantity wherever the soil contains a considerable proportion of pebbles. *Ranunculus Ficaria* also disappears from such soils, but in this case the limiting factor is, perhaps, the lower water supply. Of the four plants, the Bluebell can, apparently, best withstand the increase in quantity of the stones, for although absent on some soils of the Woolwich and Reading deposits, it is generally sparingly found both on these and on the Oldhaven beds.

As would be expected, these plants are absent from or only sparingly found on the majority of the Chalk areas, since in these situations the soils are generally shallow and contain numerous fragments of chalk. *Endymion nutans*, *Adoxa Moschatellina*, and *Arum maculatum* do, however, occur frequently wherever the soil is of greater depth. These three species are also found on the deeper soils of the Clay with Flints, but are absent from or only sparingly found on the London Clay. This fact is somewhat surprising as these two soils are so nearly similar both in mechanical and chemical composition. The soil of the London Clay is, however, much stiffer and denser than that of the Clay with Flints and, in consequence, offers more resistance to penetration by the rootstock. This circumstance alone, however, seems inadequate to explain the abundance of these plants on one deposit and their scarcity or absence on the other.

It has already been indicated that, in the districts in which the investigation has been carried out, a number of soils of different structure and composition are found in close proximity. The areas covered by the various geological deposits are usually small and interpenetrate to a large extent, thus producing a system of great complexity.

Since this is the case it may be concluded that the absence of any species from a certain area is determined by conditions existing in that area and not by any defect in its method of distribution. An example will help to render this point clear. *Mercurialis perennis* is entirely absent from Perry Wood (see Text-figs. 1 and 3), but is found abundantly in Stocking Wood and in Winding Hill Wood, neither of which is more than a mile distant. This species produces abundant seed, and at the same time possesses an excellent method of vegetative propagation. Its absence from Perry Wood must therefore depend on some edaphic factor and not on its inability to reach this area.

In the majority of cases the limits of the various geological formations are well marked. With the few exceptions already noted this is also the case with the types of vegetation found on these deposits. In consequence, in a woodland area extending over several formations the changes in the composition of the flora met with in passing from one deposit to another are often very striking. The woodland area shown in Text-fig. 4 affords excellent examples of these sudden changes. The woods on the right-hand side of the figure (towards the south-east) are situated on alluvial deposits (brick-earth and gravels), and here the vegetation approaches the Tertiary type. The underwood is made up chiefly of Chestnut (*Castanea sativa*), Hazel, and Ash, while *Endymion nutans*, *Primula acaulis*, and *Adoxa Moschatellina* are abundant in the ground flora; *Mercurialis perennis* is absent. The light flora also closely resembles the Tertiary type. The central part of the wood is situated on the Thanet Sand, which here contains a considerable proportion of pebbles. The underwood consists of Chestnut, and the ground flora is made up almost entirely of Mosses; *Endymion nutans* and *Adoxa Moschatellina* are absent. This band of Thanet Sand occupies the crest of a ridge running in a north-easterly direction and extends for a short distance down the slope towards the north-west. Lower down on the slope the wood is crossed by a band of Chalk, and here the vegetation is typically of the Chalk type. The copse is made up of Hazel, Ash, *Euonymus europaeus*, *Cornus sanguinea*, and *Ligustrum vulgare*, with standard Oak and Beech; Yews are also present. In the ground flora *Mercurialis* is very abundant, *Endymion nutans* is generally distributed, and *Adoxa Moschatellina* is absent. The line of demarcation between the Thanet Sand and Chalk is very sharp and can be determined to within a foot by the distribution of *Mercurialis perennis*. The photograph in Pl. LXV shows the Thanet

Sand on the right covered with dead leaves of the Chestnut, and on the left the Chalk soil with abundant *Mercurialis perennis*. Finally, at the bottom of the slope, a deposit of alluvium (river gravel) is found. The

TEXT—FIG. 4.

Chalk.

Alluvium.

100 Contours.

Clay with Flints.

Thanet Sand.

65. Altitude in Feet.

135? Estimated altitude in Feet.

Scale: 6 Inches=1 Mile.

The woods are shown in heavy outline.

copse here consists principally of Ash and Hazel, and in the ground flora *Mercurialis perennis*, *Endymion nutans*, and *Ranunculus Ficaria* are abundant. It is interesting to note that the flora of the alluvium on the south-east of the wood is distinctly of the Thanet Sand type, while on the

north-west the alluvial deposit carries vegetation closely allied to that found on the Chalk.

The woodland area just described is of small extent, and the distance across the whole of the different deposits does not exceed half a mile. In a case of this kind it is obvious that the composition of the flora depends on edaphic conditions and is not affected by difficulties connected with the distribution of the species.

The sudden disappearance of *Mercurialis perennis* in passing from the Chalk to the Thanet Sand has also been observed in the eastern part of Joyden's Wood, near Swanley. In this case a similar change takes place in the flora to that just described, but here the line of demarcation is not quite so sharply defined.

Reference has already been made to the constant occurrence of Yew on the Chalk. Its restriction to this soil is well exemplified by a consideration of its distribution in the woods shown in Text-fig. 2. Each of these woods is situated partly on the Chalk and partly on the Clay with Flints. Yews are found in the southern part of Badgin Wood (Pl. LXIV), the south-west portion of Rice Wood, and in the north-west corner of Foxburrow Wood, but do not occur on any part of the Clay with Flints. Another point of interest in connexion with the distribution of species in Badgin Wood is the occurrence of *Adoxa Moschatellina* on the very small area of alluvium found in the south-west corner of the wood, this plant being absent from the surrounding Chalk soil.

The changes in vegetation met with in passing from one Tertiary formation to another, although not quite so striking as those just described, are still well marked. Perry Wood, near Faversham (Text-figs. 1 and 3), covers almost the whole of a Tertiary outlier which is made up of Thanet Sand, the Woolwich and Reading series, and the Oldhaven beds. The presence of this outlier on the Chalk gives rise to a hill reaching 500 feet in altitude. The outer and lower parts of the wood on the Thanet Sand consist chiefly of Chestnut coppice, and the flora is similar to that already described on the more stony soils of this deposit. On passing to the Woolwich and Reading beds the Chestnut is partly replaced by Oak; *Endymion nutans*, *Primula acaulis*, *Adoxa Moschatellina*, and other species abundant on the Thanet Sand decrease greatly in quantity or disappear. The central and highest parts of the wood exhibit the Oak-Birch-Heath type of vegetation, and here *Pinus sylvestris* has been extensively planted; *Pteris aquilina* is particularly abundant, although only found sparingly in the lower parts of the wood. Farningham Wood, near Swanley, is situated on a similar outlier, and here the distribution of the vegetation is almost identical.

In view of the great resemblance of the soils of the London Clay and Clay with Flints in both mechanical and chemical composition, a comparison

of the vegetation of the two soils is of interest. The following species are found on the London Clay, but are absent from the Clay with Flints:—

<i>Potentilla silvestris</i> , Neck.	<i>Juncoides sylvaticum</i> , O. Kuntze.
<i>Solidago Virgaurea</i> , L.	<i>Aira flexuosa</i> , L.
<i>Calluna Erica</i> , DC.	<i>Aira caespitosa</i> , L.
<i>Stachys Betonica</i> , Benth.	<i>Festuca ovina</i> , L.

The following are abundant on the London Clay, but are only occasionally found on the Clay with Flints:—

<i>Hypericum pulchrum</i> , L.	<i>Juncoides pilosum</i> , O. Kuntze.
<i>Teucrium Scorodonia</i> , L.	<i>Pteris aquilina</i> , L.

Mercurialis perennis, L., and *Adoxa Moschatellina*, L., while abundant on the Clay with Flints, are absent on the London Clay, and the following, while found abundantly on the former deposit, are only occasionally present on the latter:—

<i>Anemone nemorosa</i> , L.	<i>Echium vulgare</i> , L.
<i>Sanicula europaea</i> , L.	<i>Euphorbia amygdaloides</i> , L.
<i>Dipsacus sylvestris</i> , Huds.	<i>Endymion nutans</i> , Dum.
<i>Myosotis sylvatica</i> , Hoffm.	

At present no definite reasons for the great difference in the vegetation of the two deposits can be given. It is, however, interesting to note that the flora of the London Clay is distinctly xerophytic in character, while that of the Clay with Flints shows few or no adaptations against drought. This matter will be further discussed in the second part of this paper.

The following species are, in this neighbourhood, found exclusively on the Chalk:—

<i>Viola hirta</i> , L.	<i>Clinopodium Acinos</i> , O. Kuntze.
<i>Helianthemum Chamaecistus</i> , Mill.	<i>Clinopodium vulgare</i> , L.
<i>Reseda lutea</i> , L.	<i>Thymus Serpyllum</i> , L.
<i>Poterium Sanguisorba</i> , L.	<i>Ophrys muscifera</i> , Huds.
<i>Origanum vulgare</i> , L.	<i>Taxus baccata</i> , L.
<i>Clinopodium Calamintha</i> , O. Kuntze.	<i>Anomodon viticulosus</i> , H.T.

The following are almost confined to the Chalk, but are occasionally found on other formations:—

<i>Hypericum hirsutum</i> , L.	<i>Cornus sanguinea</i> , L.
<i>Linum catharticum</i> , L.	<i>Viburnum Lantana</i> , L.
<i>Euonymus europaeus</i> , L.	

In several cases plants found abundantly on the Chalk are replaced on the non-calcareous soils by closely-related species. Such parallel species have been described by Kerner (9) in the Alps. *Viola hirta* is abundant on

the Chalk, and is completely replaced on the Clay with Flints by *Viola Riviniana*. Similarly *Hypericum hirsutum* is replaced by *Hypericum perforatum* on the Clay. These plants exhibit the distinctions which Kerner has shown to exist between calcicolous and non-calcicolous species. Both *Viola hirta* and *Hypericum hirsutum* possess pubescent bluish-green leaves, whereas in *Viola Riviniana* and *Hypericum perforatum* the leaves approach grass-green and are glabrous; the flowers of the calcicolous species are somewhat lighter in hue than those found on the non-calcareous soils.

The two other species of *Hypericum* found commonly in this neighbourhood also show a decided preference for certain formations. *Hypericum humifusum*, although occurring occasionally on the Clay with Flints and Alluvium, is abundant on the Thanet Sand; *Hypericum pulchrum*, which is occasionally found on all the different soils, occurs in abundance on the London Clay.

A general consideration of the plant distribution in the districts investigated leads to the conclusion that two main types of vegetation can be distinguished:—

- (a) That found on the Chalk and Clay with Flints.
- (b) That found on the Tertiary formations.

The inclusion of the Chalk and Clay with Flints under one heading may at first appear remarkable, but a consideration of the vegetation already described on these deposits will justify this conclusion. Although the soils of the two formations differ greatly in chemical composition, many points of agreement are found in the respective floras.

It might be expected that the vegetation of the two clay soils found in the Faversham district would show considerable agreement. It has been proved, however, that this is not the case. In fact, the flora found on the Clay with Flints more nearly resembles that of the Chalk than that occurring on the London Clay.

Although the Tertiary soils range from light sands to heavy clays, a considerable number of species occur throughout the four formations. These are frequently absent from or only occasionally found on the Chalk and Clay with Flints. The following lists will emphasize the difference between the two types.

(a) Plants found either on the Chalk or Clay with Flints, and absent from or only occasionally found on the Tertiary deposits:—

<i>Viola hirta</i> , L.	<i>Linum catharticum</i> , L.
<i>Hypericum hirsutum</i> , L.	<i>Euonymus europaeus</i> , L.
<i>Helianthemum Chamaecistus</i> , Mill.	<i>Cornus sanguinea</i> , L.
<i>Reseda lutea</i> , L.	<i>Viburnum Lantana</i> , L.

<i>Origanum vulgare</i> , L.	<i>Ophrys muscifera</i> , Huds.
<i>Clinopodium Acinos</i> , O. Kuntze.	<i>Orchis pyramidalis</i> , L.
<i>Clinopodium vulgare</i> , L.	<i>Habenaria bifolia</i> , R.Br.
<i>Clinopodium Calamintha</i> , O. Kuntze.	<i>Taxus baccata</i> , L.
<i>Thymus Serpyllum</i> , L.	
<i>Mercurialis perennis</i> , L.	<i>Anomodon viticulosus</i> , H.T.
<i>Quercus pedunculata</i> , Ehrh.	<i>Neckera complanata</i> , Hueb.

(b) Plants found on the Tertiary deposits but absent from or only occasionally on the Chalk and Clay with Flints :—

<i>Hypericum pulchrum</i> , L.	<i>Lysimachia nemorum</i> , L.
<i>Oxalis Acetosella</i> , L.	<i>Lysimachia Nummularia</i> , L.
<i>Potentilla silvestris</i> , Neck.	<i>Rumex Acetosella</i> , L.
<i>Oenothera biennis</i> , L.	<i>Quercus sessiliflora</i> , Salisb.
<i>Circaea lutetiana</i> , L.	<i>Neottia Nidus-avis</i> , Rich.
<i>Asperula odorata</i> , L.	<i>Funcoides pilosum</i> , O. Kuntze.
<i>Hieracium umbellatum</i> , var.	<i>Funcoides sylvaticum</i> , O. Kuntze.
<i>coronopifolium</i> , Bernh.	<i>Aira praecox</i> , L.
<i>Campanula Trachelium</i> , L.	<i>Aira flexuosa</i> , L.
<i>Calluna Erica</i> , DC.	<i>Aira caespitosa</i> , L.
<i>Stachys Betonica</i> , Benth.	<i>Festuca ovina</i> , L.

<i>Orthopyxis androgyna</i> (L.), P. Beauv.	<i>Georgia pellucida</i> , Raben.
<i>Leucobryum glaucum</i> , Schp.	<i>Diplophyllum albicans</i> , L.

A general consideration leads to the conclusion that plant distribution in the districts investigated is greatly influenced by the composition of the soil. This, however, is not by any means the only factor involved. Whether a species shall or shall not exist in a certain situation depends on the whole of the conditions obtaining in that place. Some of these, such as soil composition, altitude, water supply, and light intensity, evidently have a preponderating influence, but, in addition, many others are no doubt present, of which the existence is unsuspected. The variation of any one condition may determine the presence or absence if all the other conditions remain constant.

Since this is the case it is necessary to emphasize the circumstance that the present investigation has been confined to a comparatively small district. It is not desired to make any general statements as to the distribution of species outside this area. It will be apparent to those familiar with other types of vegetation that many of the peculiarities of distribution here described do not hold good for other localities. The absence of a plant from a particular formation in the district investigated does not necessarily imply that the species is absent in other districts and under other conditions.

In the present contribution a general account has been given of the vegetation found in the woodland areas. In a second paper it is proposed to deal in detail with some of the factors influencing the distribution. In this latter communication the whole of the results obtained will be fully discussed.

In conclusion, I wish to express my thanks to Professor Farmer, F.R.S., for his help and advice throughout the progress of this investigation.

I also wish to acknowledge my indebtedness to the late John Rigden, Esq., for his kindness in permitting free access to the woods on his estate.

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DESCRIPTION OF PLATES LXIV-LXVI.

Illustrating Mr. Wilson's paper on Plant Distribution in the Woods of North-East Kent

PLATE LXIV.

Photograph of the south-west portion of Badgin Wood, near Faversham, taken from the middle of the north side of Rice Wood and looking north-east (cf. Text-fig. 2). The foreground shows a portion of Rice Wood on the Clay with Flints covered by copse which has recently been felled. The alluvium in the valley is under cultivation and carries a crop of Hops. The lower portion of Badgin Wood, on the Chalk, is covered by copse in which the Yews are well seen. The background shows coppice on the Clay with Flints with standard Oaks.

PLATE LXV.

Photograph taken in the western part of Judd's Wood, near Faversham, looking north-east and showing the junction of the Thanet Sand and Chalk (cf. Text-fig. 3). On the left the Chalk soil is seen covered with *Mercurialis perennis*. On the right the Thanet Sand is shown covered with the dead leaves of the Chestnut (*Castanea sativa*). The limit of the *Mercurialis* is sharply marked.

PLATE LXVI.

Photograph taken in the early spring in Perry Wood, near Faversham, showing the vegetation of the Oldhaven pebble beds. The dead leaves of Bracken are shown in the foreground. In the middle distance *Calluna Erica* and *Betula verrucosa* are seen. The background is occupied by *Pinus sylvestris*.

Clay with
Flints

Chalk

Alluvium

Clay with
Flints

Clay with
Flints.

Chalk

Alluvium

Clay with
Flints

M. W. phot.

Huth, coll.

WILSON — PLANT DISTRIBUTION.

Chalk with *Mercurialis perennis*

Thanet Sand covered with
dead leaves.

Chalk

Thanet Sand.

M.W. phot.

WILSON — PLANT DISTRIBUTION.

Chalk with *Mercurialis perennis*

Thanet Sand covered with
dead leaves.

Chalk

Thanet Sand.

M. W. phot.

WILSON — PLANT DISTRIBUTION.

M.W. phot.

WILSON — PLANT DISTRIBUTION.

Huth. coll.

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