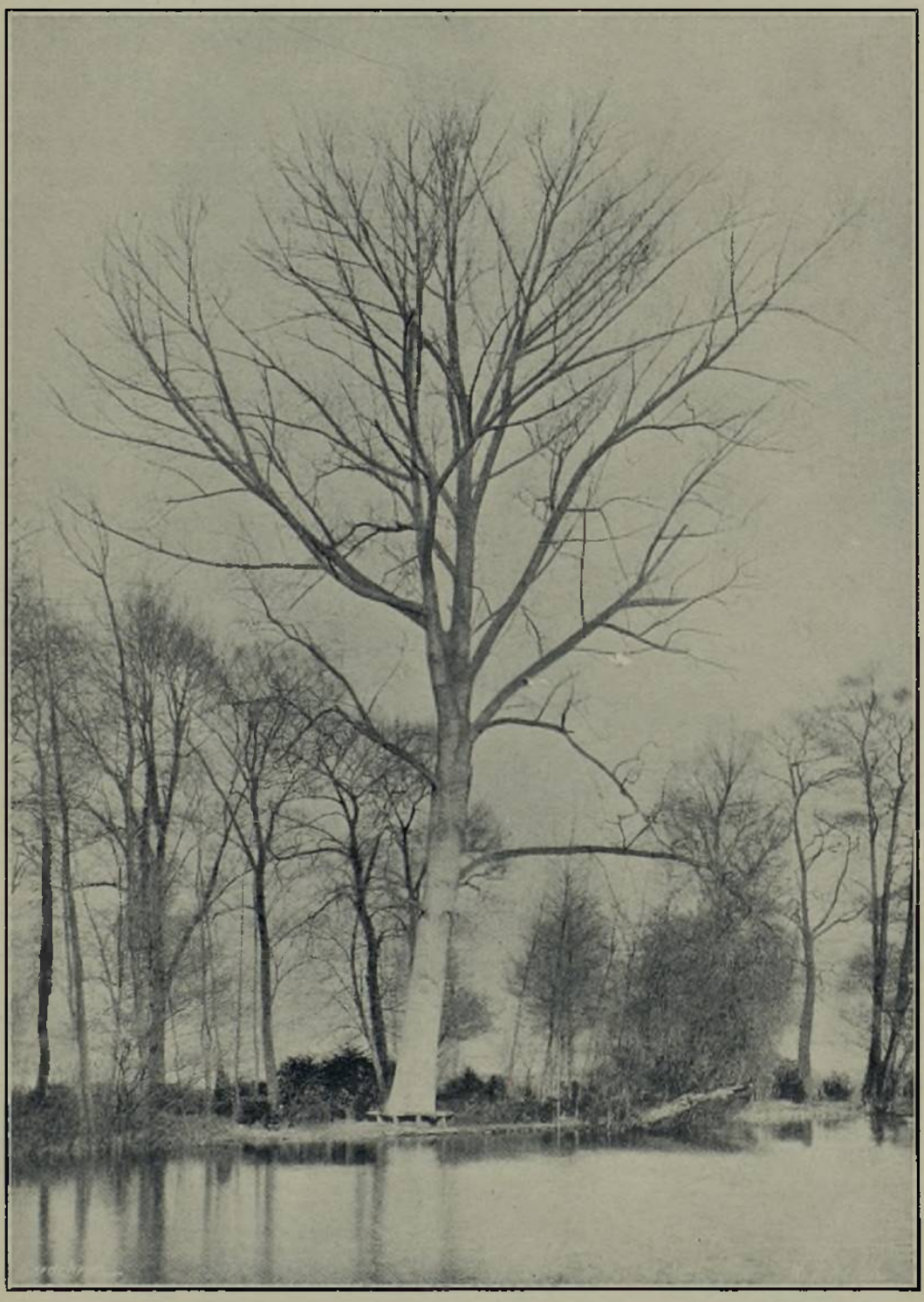

Black Italian Poplar (*Populus serotina*) **at Belton.**

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[*Frontispiece.*

FORESTRY COMMISSION.

BULLETIN No. 5.

POPLARS.

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POPLAR cultivation is a form of timber production which might with advantage receive more attention in Great Britain. The procedure presents no particular difficulty, and timber of large dimensions may be obtained in a comparatively short space of time. Although poplars may be grown in plantations, they are perhaps even more suitable for planting along roads, watercourses or the margins of fields, and they are distinctly useful for filling in small pieces of land which would otherwise remain derelict.

The procedure to be followed in cultivating poplars differs in some respects from that adopted in the case of other species, and necessarily varies somewhat according to local circumstances. In this bulletin an attempt is made to indicate which kinds of poplar it is advisable to cultivate and how they should be planted and treated with a view to the economic production of timber.

Owing to lack of reliable records, it has not been found possible to obtain full information on certain matters; for example, on the rate of growth of poplars.

The Commissioners are indebted to Professor A. Henry for the botanical description of the poplars and to Mr. W. H. Dallimore, of Kew, for the chapter on the character and uses of the timber. Mr. W. H. Guillebaud, who has specially investigated the growth of poplars in the North of France, is responsible for the section on sylviculture; Dr. J. W. Munro has dealt with the insect pests, and Mr. W. E. Hiley with the fungus diseases of poplars. The bulletin has been edited by Mr. Fraser Story.

R. L. ROBINSON,
Commissioner.

Forestry Commission,
22, Grosvenor Gardens,
London, S.W. 1.
May, 1923.

BULLETIN No. 5.

POPLARS.

CONTENTS.

POPLARS.

CHAPTER I.

BOTANICAL DESCRIPTION.

Poplars constitute the genus Populus, and are deciduous trees, with long-stalked alternate simple leaves, which may be lobed, dentate, or serrate in margin. The twigs, which are angled, rounded, or ridged, bear buds of two kinds, those terminating the branchlets being larger than the lateral ones, and covered with scales, the lowest of which form one or two opposite pairs.

Poplars are dicœcious, male and female flowers being borne on separate trees and, of course, only the female trees produce seed. The flowers, many together in long catkins, appear in spring before the leaves. Each flower is subtended by a membranous scale soon shed, and is without calyx or corolla, having instead a disc, which bears in the male several (4–60) stamens, and in the female a one-celled ovary, with a short style, and 2, 3, or 4 stigmas. The male catkins drop off, as soon as the pollen escapes. The female catkins remain on the tree, and ripen in about two months, generally before June 1, when the capsules, splitting into 2, 3, or 4 valves, let out the minute seeds. These are surrounded with tufts of white hairs, which enable them to sail away in the wind.

Fertile seeds, sown as soon as ripe on moist sand in full sunlight, germinate in 12 to 48 hours. The seedlings, which have two-stalked, rounded cotyledons, grow slowly in their first season, attaining a height of only 2 to 5 inches by October. Poplars are seldom raised commercially from seed and self-sown seedlings are rare in this country, natural regeneration in most cases being effected by root-suckers.

Poplars are typical light-demanding trees, incapable of bearing shade, the branchlets and leaves dying when not exposed to full light. This intense demand for light explains the natural pruning of the smaller branches in autumn, when many twigs fall to the ground, leaving peculiar circular scars on the main branches.

About thirty species of poplar are known, inhabiting the northern hemisphere outside the tropics. Towards the extreme north certain species often form great forests ; elsewhere poplars are most common in small groves or narrow belts in alluvial land bordering rivers, lakes, and swamps ; but occasionally they form part of the deciduous forests.

A considerable number of hybrids have arisen in cultivation and some of these, on account of their vigorous growth, are more used in planting for timber than the wild species. In the following account, attention will only be directed to the species and hybrids which are of interest to foresters in this country.

The poplars fall naturally into certain groups, known as Black Poplars, Balsam Poplars, and the White Poplars and Aspens.

Black Poplars.

Black Poplars are known by their leaves, green in colour, with both surfaces nearly of the same tint; margin regularly serrate and surrounded with a narrow translucent border best seen with a lens; stalks flattened laterally. The buds are viscid but do not exhale the strong balsamic odour of the Balsam Poplars. The bark of mature trees is deeply and regularly furrowed.

The two wild species of Black Poplar, with which we are chiefly concerned, occur, one in Europe, *Populus nigra*; the other in eastern North America, *Populus deltoidea*. These differ markedly in leaves and flowers.

In distinguishing these two species, and their important hybrids, special attention must be paid to the shape of the leaf, and to the presence or absence of cilia, which are minute hairs fringing its margin, and to the occurrence or not of glands on the base of the blade in front, on each side of the insertion of the stalk.

Populus nigra L.—The European Black Poplar has leaves rhomboidal in form, wedge-shaped at the base, and gradually tapering from below the middle into a long narrow point at the tip. The essential parts of the flower are stamens, 12–25; stigmas, 2, fewer in number than in the American species. Two geographical forms of the European Black Poplar occur in the wild state, namely, *P. nigra typica* and *P. nigra betulifolia*.

P. nigra typica Schneider.—Twigs and leaves without hairs. This glabrous variety seems to be limited in the wild state to southern and eastern Europe, being widely spread on alluvial land bordering the great rivers, such as the Po, the Danube and its tributaries, and the Volga. In its ordinary wild form, with wide-spreading branches, it is rarely if ever seen in cultivation in this country. The Lombardy Poplar (*P. nigra italica* Du Roi), now so much used in landscape planting, is a sport, characterised by vertical branches, which originated as a single tree in Northern Italy about the beginning of the eighteenth century, and has since been propagated by cuttings and introduced into many countries. In Chile and Kashmir its timber is utilised but in England it is only planted for ornament.

P. nigra betulifolia Torrey.—Twigs covered with short hairs, and usually orange in tint in the second season; leaf-stalks slightly hairy. This poplar is apparently indigenous in France, where it is met with on the borders of many rivers. If not originally a native, it has long been planted in England, and, accordingly, is often spoken of as the English Black Poplar. It is decidedly slower in growth than the best hybrid poplars, attaining about the same size in 200 years as they do in 100 years. Trees of *Populus serotina* have measured 100 feet in height and 9 feet in girth, when English Black Poplars alongside were only 70 feet by 6 feet. At the present day, it is seldom, if ever, planted for the production of

timber. The trunk when old is usually covered with unsightly burrs.

Populus deltoidea Marshall.—The American Black Poplar bears leaves, deltoid-ovate in outline, about as broad as long, contracting abruptly at the apex into a short point, and with a slightly cordate base. The margin of the leaf has fewer and coarser serrations than the European species, is densely fringed with cilia, and at the base two glands are invariably present. Each male flower has 40 to 60 stamens; and each female flower has 3 or 4 stigmas.

There are several forms of this poplar in North America, but none is in cultivation in this country except as a rare specimen. On the Continent, the hybrids are often erroneously considered to be the American species, and are sold under names implying that origin. *P. deltoidea* is, however, not used in commercial plantations in Europe. The few specimens noted show it to be of slow growth in England; and its only interest to foresters here lies in the fact that it is one of the parents of certain of the hybrid poplars.

Populus angulata Aiton.—The Carolina Poplar is easily distinguished by its angled, often ribbed twigs, and by its large leaves, very late in falling in autumn, triangular-ovate in outline, cordate at the base, short-pointed at the apex, with ciliate margin, and 2–6 basal glands. The flowers have peculiar small toothed scales, unlike the other Black Poplars, which have scales with long fringes; stamens, 30–40; stigmas, 3 or 4.

The origin of this poplar is doubtful. It has been known in Europe since 1738 as the Carolina Poplar; but no species occurs in the wild state in North America or elsewhere with similar flower-scales or with exactly the same foliage. It closely resembles, however, in its leaves, the southern form of *P. deltoidea* and is possibly a sport of this species, or may have been derived as a hybrid from it, the other parent being typical *P. nigra*. It is of no value for the production of timber in this country; but is of interest as having been the mother parent of the hybrids *P. generosa* and *P. robusta*.

Hybrid Black Poplars.

As mentioned above, the Black Poplars, which are so extensively cultivated for their timber in Europe, are almost invariably of hybrid origin, as is proved by their history.* I need here only indicate the characters wherein they differ from their parents, one of which is either the glabrous or the pubescent European Black Poplar.

The hybrids have leaves intermediate in shape, never cordate at the base, and with serrations not so coarse as in *P. deltoidea*; cilia on the margin sparse and irregular, often disappearing in

* *See* Elwes and Henry, *Trees of Great Britain*, vol. vii, p. 1814 (1913): and *Trans. Roy. Scot. Arbor. Soc.*, vol. xxx, pp. 14–17 (1916).

summer ; basal glands variable, absent or one or two, never always present as in *P. deltoidea*, nor invariably absent as in *P. nigra*. The flowers are also intermediate and variable in the number of the stamens and stigmas.

The hybrid Black Poplars that can be readily distinguished are six in number : Four with glabrous twigs (*P. serotina, P. regenerata, P. Eugenei*, and *P. marilandica*) and two with pubescent twigs (*P. robusta* and *P. Lloydii*).

Populus serotina Hartig.—A male tree, which is always known in England as the Black Italian Poplar, and in France as *Peuplier suisse*, or sometimes erroneously as *Peuplier de Virginie*. It shows, when isolated, a characteristic habit, having ascending branches and a wide head (see frontispiece). It has glabrous twigs and foliage, and is the latest of all the poplars in unfolding its leaves, which have at first a fine bronzy tint. The leaves are ovate-deltoid, with a short point at the apex, and a truncate or nearly straight base. The flowers have usually 20–25 stamens. It is the commonest poplar planted in England, and is the oldest of all the hybrids, having originated about 1700.

Populus regenerata Schneider.—A female tree exactly resembling the Black Italian Poplar in twigs and leaves ; but the latter open more than a fortnight earlier. It also differs in habit, being narrower in the crown. The stigmas of the flower are usually 2, rarely 3.

Most of the so-called Eucalyptus Poplars in continental nurseries are in reality this hybrid, which originated as a stray seedling in a nursery at Arcueil near Paris in 1814. Plants propagated from it passed into commerce under the name *Peuplier régénéré*. A very fast-growing poplar is said to have been obtained at Pontvallain in 1880 by the continuous selection from the most vigorous trees of this hybrid, of the straightest branches as sets for planting. Whether selection thus carried out resulted in enhanced vigour is uncertain ; but there appears to be some ground for the belief that in France *P. regenerata* gives better results than *P. serotina*.

Populus Eugenei Simon Louis.—A narrow tree, with short ascending branches. Leaves smaller than those of *P. serotina*, with a slightly wedge-shaped base and a longer, more slender point at the apex. It is a male tree, each flower having about 20 stamens.

This was found in 1832 as a chance seedling in the nursery of Simon Louis at Metz. It apparently grew from the seed of a *Populus regenerata*, the male parent having been an adjoining Lombardy poplar. The original tree at Metz, when 80 years old, measured 130 feet in height and 25 feet in girth at breast-height.

Populus marilandica Bosc.—A female tree, with a wide-spreading crown and irregular branches. It resembles *P. nigra* in the outline of its leaves, which are rhomboid, wedge-shaped at the base, and gradually tapering to a long point at the apex ; but they are larger than in that species, and have variable basal

glands and stray marginal cilia. The stigmas are 2, 3, or 4 in number.

This hybrid is unfortunate in its name, as it is not an American tree, but originated in Europe early in the nineteenth century. It has erroneously been identified by German writers with *P. canadensis*, one of the later names of the true American Black Poplar. It is not very vigorous, and cannot be recommended as a tree for timber production.

Populus robusta Schneider.—A male tree with a remarkably narrow, almost columnar crown and very short ascending branches. The leaves unfold early with a red tint, and resemble those of *P. serotina* in outline, but are readily distinguished from that species by their hairy stalks. Stamens about 20.

Populus robusta originated at Metz in 1895, as a stray seedling of *P. angulata*, the other parent being a fastigiate variety of *P. nigra betulifolia*, from which it derives its narrow crown and hairy twigs.

Populus Lloydii A. Henry.—A female tree with a wide-spreading crown, bearing leaves similar to those of *P. robusta*, but smaller in size. Stigmas usually 2, but occasionally 3. This hybrid is an extremely rare tree, of unknown origin, but evidently having the English Black Poplar as one of its parents. It attains a large size, and appears to be fairly vigorous ; but has never been used in plantations, and is not on sale in nurseries. It merits trial on an experimental scale.

Balsam Poplars.

The Balsam Poplars are readily recognised by their fragrant foliage and very viscid buds, which exhale a strong odour of balsam. The leaves are characterised by a peculiar pale or whitish tint beneath, with occasionally rusty areas ; margin serrate and without a clearly-defined translucent border ; stalks rounded with a channel on the upper side. The bark of mature trees is furrowed. Several species of Balsam Poplar are of importance in the wild state, as a source of cheap soft-wood timber ; but practically none has ever been used in British forestry. One species, however, and one hybrid are worth notice.

Populus trichocarpa Torrey et Grey.—This is readily distinguished by its leathery ovate leaves, which are the whitest of all the Balsam Poplars on the under surface and are conspicuously net-veined. The twigs are without hairs, angled, and with five prominent ridges on vigorous shoots. It is the largest deciduous tree of the Pacific Coast of North America and attains its greatest size at low elevations on alluvial soils in Western Oregon and Washington, where trees 220 feet in height and 18 to 24 feet in girth are of frequent occurrence.

Populus generosa A. Henry.—A hybrid between a Black Poplar and a Balsam Poplar, artificially produced by dusting the stigmas

of *P. angulata* with the pollen of *P. trichocarpa*. It is distinguished by its large ovate leaves, cordate at the base, pale grey beneath, and with rounded stalks, in these respects resembling the male parent. The margin of the leaf is coarsely serrate and surrounded with a translucent border, characters inherited from *P. angulata*. The original seedlings were raised first in 1912, and again in 1914, and have grown with great rapidity.

White Poplars.

White Poplars have two kinds of leaves on the same branch, those towards the top of the twig covered beneath with a dense woolly coating, whilst the inner leaves towards the base of the twig are less woolly and different in tint and shape. The twigs and buds are also woolly, and the bark on mature stems is broken on the surface into peculiar small rhombic cavities. Root-suckers, which can be used for propagation, are produced very freely. Two species are wild in Europe ; both are large trees.

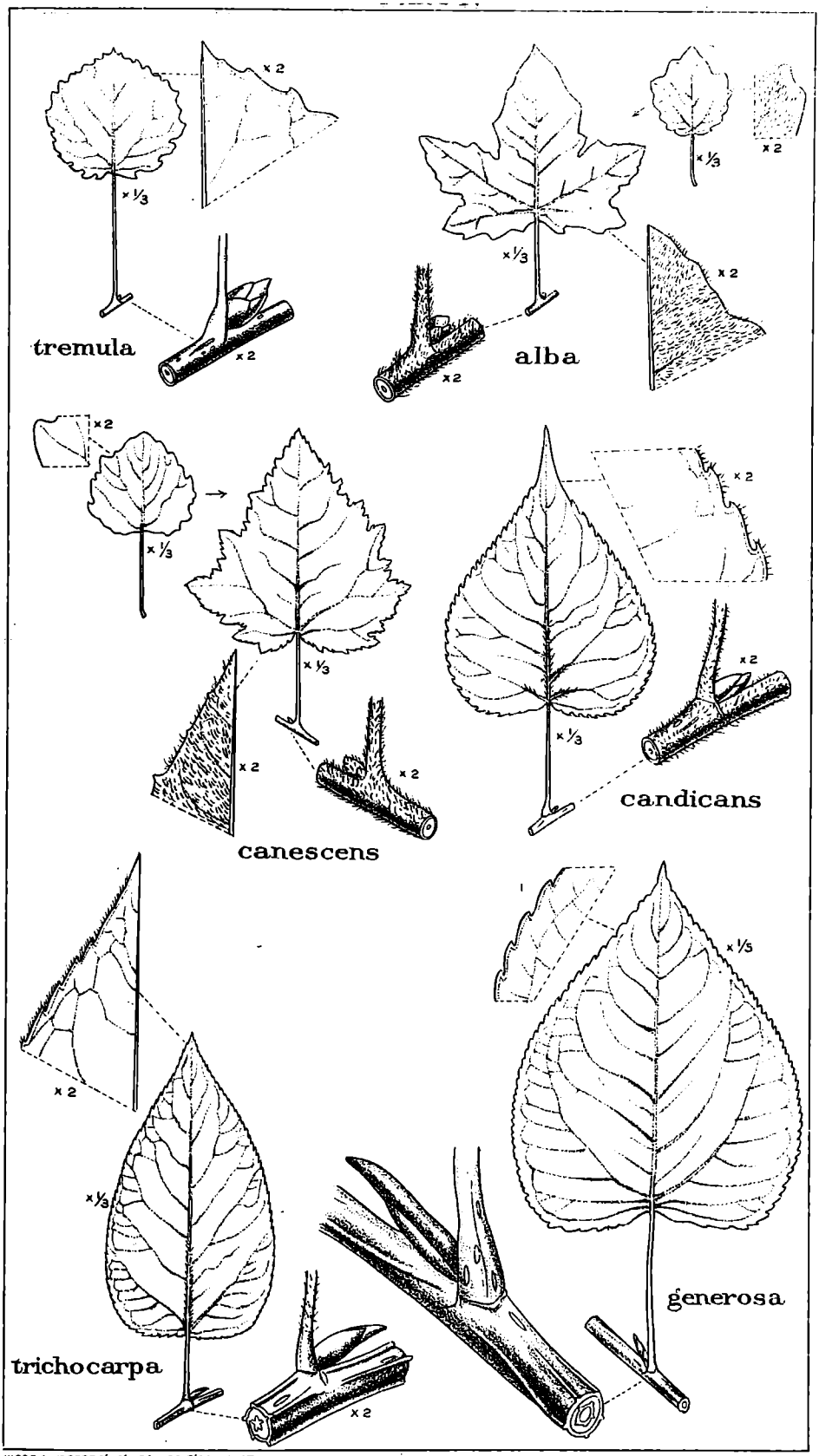
Populus alba L.—The White Poplar has the outer leaves palmately divided into five lobes, and snowy white beneath, owing to a dense coating of finely matted wool. The inner leaves are ovate, toothed in margin, and greyish beneath. It is a native of southern Europe, and when planted in this country is very ornamental.

Populus canescens Smith.—The Grey Poplar has the outer leaves ovate in outline and not lobed ; margin with small irregular serrated teeth ; lower surface greyish-white. The inner leaves are more rounded, with a few teeth on the margin, and are grey or green beneath, most of the matted wool having disappeared. On old trees most of the foliage is of the latter character. It is a native of western Europe, and is probably indigenous in England.

Aspens.

The Aspens resemble the White Poplars in bark and in flowers, but differ in the leaves being uniform on the same branch, green and without wool when mature, the lower surface being paler in tint than the upper surface. Only the native species, which is widely spread throughout Europe and in Siberia, needs to be considered.

Populus tremula L.—The Aspen has rounded small leaves, thin in texture and pale or glaucous on the under side ; margin with a narrow translucent border and a few rounded or sinuate teeth ; base with two glands ; stalks long and flattened laterally. The buds are slightly viscid, and the twigs are without wool. It is a small tree in Britain, rarely exceeding 60 feet in height, occurring scattered in woods and nowhere abundant, and reproduced almost invariably by root-suckers.



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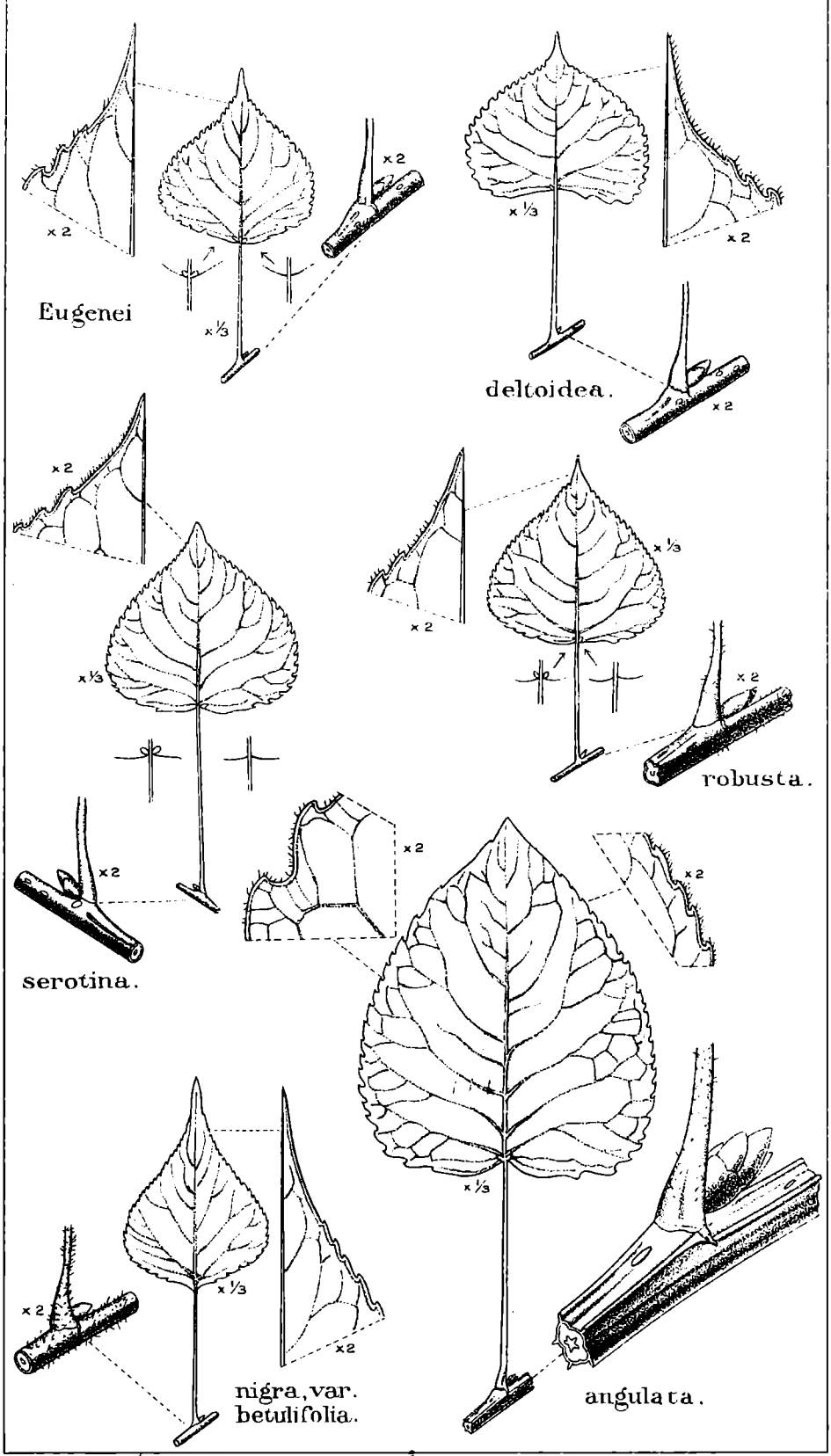
The Forestry Commissioners are indebted to the Director of the Royal Botanic Gardens, Kew, for the figure of P. generosa. The remaining figures in the above plate have been reproduced, by permission, from Trees of Great Britain and Ireland by Elwes and Henry.



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CHAPTER II.

SYLVICULTURE.

Choice of Species.

Assuming that a given locality is suitable for the growth of poplars, the first question that arises is which is the best species to plant. The only species or hybid which can be safely recommended, except for use on a small scale, is *P. serotina*, the Black Italian Poplar. This tree grows very fast on a wide range of soil; it is hardy against frosts and little susceptible to disease, while the timber is of good quality and useful for many purposes. The remaining species are all in the experimental stage; little is known as to the quality of their timber, resistance to disease, etc., and caution is therefore necessary in planting them. On the other hand, some of the more recently introduced species or hybrids appear very promising, and it is quite possible that one or more may ultimately prove superior under certain conditions to the Black Italian Poplar.

In the notes which follow dealing with the principal species of poplar other than the Black Italian, the results of existing experience are briefly given and an attempt is also made to indicate the conditions in which each species is likely to succeed in this country.

P. regenerata.—The large number of varieties of this hybrid now cultivated on the Continent appear to differ in respect of colour of bark, rate of growth, straightness, etc., and it is impossible to say which of them will succeed best under British conditions. In the north of France, *P. regenerata* is replacing, in many districts, the Black Italian Poplar. Thus the large nursery at Faverolles in the Seine Valley propagates two forms of *P. regenerata* (termed *Peuplier Raverdeau A Écorce Blanche* and *Peuplier Raverdeau A Écorce Brune*) and also *P. robusta*, but not the Black Italian Poplar, for which there appears to be no demand. On moist alluvial soils *P. regenerata* appears to grow considerably faster than *P. serotina* and to produce timber of equal value. The tree is said, however, to be much more liable to wind damage in exposed situations, and most of the plantations seen in France contained a high percentage of forked and broken stems. Certain diseases also attack *P. regenerata* from which *P. serotina* is comparatively free. The particulars of the Culford plantations of *P. regenerata* given on p. 30 show that under suitable conditions this hybrid makes extremely rapid growth and that it is well worth a more extensive trial, especially on the better classes of soil in the south of England. It is doubtful whether *P. regenerata* will grow as well as *P. serotina* in the colder climate of the north of England and east of Scotland.

P. robusta.—This hybrid, like *P. regenerata*, is being largely planted in northern France, where it is considered by many

foresters to be a better tree than *P. regenerata*, although the growth is usually less rapid. *P. robusta* is one of the straightest growing of the poplars, with a symmetrical narrow crown, which is much less subject to breakage by wind than *P. regenerata*. It appears likely to be a very promising tree for use in this country, but in general the same remarks apply to this as to *P. regenerata*, i.e. cultivation on alluvial soils in the south of England until more knowledge is available as to its growth and behaviour on poorer classes of soils and in colder climates.

P. Eugenei.—Is largely cultivated in France in the neighbourhood of Metz, but is not grown to any appreciable extent in the north of France. The rapid growth of trees planted in Kew Gardens (see p. 31) is encouraging, but it appears doubtful whether *P. Eugenei* will be as frost hardy as the other hybrids dealt with. Experiments are required to determine the value of this hybrid in Britain.

P. trichocarpa.—Is apparently better known in England than on the Continent, though even in England few specimens are to be found outside botanic gardens and arboreta. Experience seems to indicate that the tree is extremely hardy and will thrive in upland valleys, as at Colesbourne in Gloucestershire and Dawyck in Peeblesshire ; in the latter district it outstrips all other poplars in rate of growth.

P. generosa.—Appears to be the fastest growing of all the poplars in early youth. Professor Somerville at Oxford found that as a result of cutting back one-year rooted cuttings the shoots which developed in the following year averaged 8 ft. 3 in. in height while the cutting back of three-year rooted cuttings at Bangor resulted in the production in a single season of shoots averaging 9 ft. in height. At the same time it must be remembered that this hybrid was first obtained artificially by Professor Henry in 1912 to 1914, so that no plants over 10 years of age are in existence, and it will be some time before its value as a timber tree can be determined.

P. alba.—Has little if any value as a timber tree, but is said to have proved useful on the Welsh and Yorkshire coasts for providing shelter against the sea winds. It forms a short, densely-branched growth in exposed situations.

P. canescens.—In France and Belgium this species has been largely grown as a standard over coppice in wet, marshy land and also as a roadside tree. It appears to be less sensitive to stagnant water conditions than *P. serotina*, and may be useful for planting in wet, undrained hollows. It is usually much slower growing than *P. serotina*, and the large number of root-suckers which the tree produces make it unsuitable for use in many situations. It is worth trying in this country as a standard over coppice on clay soils. *P. canescens* is much used in the formation of shelter belts on the sea coast in Wales, being superior to *P. alba* for this purpose.

P. tremula.—This Aspen occurs naturally in the Highlands of Scotland and also sporadically in England. Though usually a tree of small size and relatively slow growth, it produces timber superior to that of any other poplar for the purposes of the match industry. It is very hardy, thrives in countries with a short growing season and will establish itself on drier soils than the other species dealt with.

Generally speaking, the Aspen is considered as a weed in this country ; it propagates itself freely from suckers on bare ground or in newly formed plantations, and, by its rapid growth in youth and spreading crown frequently injures the more valuable species associated with it. Recently, however, the planting of *P. tremula* on a large scale at Sandbank in Argyllshire has been undertaken by Messrs. Bryant & May, with the object of obtaining timber for the manufacture of matches ; this enterprise will be followed with much interest. It is doubtful if the cultivation of Aspen would pay the ordinary landed proprietor, as upland situations which would favour this species are usually capable of producing more profitable crops of conifers, while the higher exposed slopes on which conifers do not readily thrive would be equally unsuitable for the Aspen.

Sylvicultural Requirements.

Climate and Situation.—The poplars are moisture-loving trees, which attain their greatest size in low-lying sheltered localities with an abundant water supply. They are hardy, withstanding severe frosts both in winter and during the growing season, and are thus useful for planting in frosty localities where other species are difficult to establish. The most hardy species are *P. trichocarpa, P. canescens*, and *P. serotina.*

Although not particularly liable to be uprooted by wind, their branches are so brittle and easily broken that the trees are quite unsuitable for use in exposed situations. Certain species, such as *P. trichocarpa* and *P. tremula*, occur naturally at high elevations but growth in such places is much slower than in the plains.

Soil.—For their best development poplars require an abundance of moisture and a well-aerated, fertile, loamy soil. These conditions are generally provided by river silt and similar deposits in the neighbourhood of streams. A certain amount of free drainage is essential ; if the roots reach a level where the water is stagnant, growth is at once checked and decay frequently sets in, followed by the early death of the trees. On the other hand, flooding during winter and spring is not injurious to growth, there being usually a constant flow of water round the roots, while the silt deposit, when the waters recede, is of value to the plants. In northern France poplars have been extensively planted in the wide, marshy valleys of the Seine and its tributaries, where inundations are of annual occurrence, and the splendid growth of the trees is a proof that they suffer no injury from winter or spring flooding.

Although it is true that alluvial soils generally produce the fastest growth of poplars, the majority will grow well on almost all classes of soil at low elevations, given an adequate supply of moisture and sufficient drainage. Very rapid growth of *P. serotina* has been observed on peaty soils in the Fen country, on the sandy heaths of East Anglia, and on stiff clays in many parts of the country.

Light requirements.—Intolerance of shade even when growing under the best conditions is characteristic of poplars and accounts for the poor results which are obtained when the trees are grown too closely together. In order to produce large-sized timber as quickly as possible it is important to keep in mind the light-demanding nature of the trees.

Methods of Cultivation.

PROPAGATION.

Poplars may be raised either from seed, root suckers or cuttings, the most frequent method being the propagation from cuttings.

Propagation from Seed.—The propagation of poplars from seed presents more difficulties than in the case of almost any other species of tree, owing mainly to the fact that the seed loses its germinative capacity in the course of a few days. Somewhat special methods are also required to induce germination. As far as the hybrid poplars are concerned (and the majority of the most useful kinds are hybrids), propagation from seed is out of the question, and the others are more readily propagated in other ways. That the Aspen may be successfully raised from seed has, however, been proved by Mr. McBeath, forester to Messrs. Bryant & May. Seed collected by him in Russia and spread out in a sunny room for completion of the ripening process was sown as in the case of other small seeds, and produced plants which were 3 inches in height at the end of the first season and 23 or 24 inches high when two years old.

Propagation from Root Suckers.—White Poplars, Grey Poplars, and Aspens should be propagated from root suckers rather than from cuttings, because the latter do not produce roots readily, and the trees in question are prolific in the production of root suckers. Poplar roots often grow for great distances in a horizontal direction just below the surface of the soil. *P. canescens*, for example, has been known to produce suckers at a distance of 50 yards from the parent tree. Root suckers when separated from the parent root should be lined out in a nursery for a year or two in order to obtain strong plants.

Propagation from Cuttings.—This is the usual method of raising all the poplars with the exception of the species mentioned above. As a rule the cuttings are lined out in a nursery, where they remain for one or more years before planting out.

Material used for making Cuttings.—Cuttings may be taken from stool shoots, or from the side branches of young trees. Side branches are always used for cuttings in the French nurseries, being obtained from three- and four-year-old plants when these are pruned on lifting, but British growers, for the most part, prefer to use stool shoots. There is probably little to choose between the two sources of material. A third source sometimes used for making cuttings is from the twigs of old trees when these are felled, but usually a large percentage of the twigs fail to root when planted in the soil and much better results are obtained by using material from young plants. Wood of the current year or of the last year's growth may be used for cuttings; older wood is not so good for the purpose.

Size of Cuttings for Lining out in the Nursery.—The practice varies greatly both in this country and in France, the size of cuttings employed in different localities ranging from 8 inches to 6 feet; the large cuttings almost invariably consist of a complete shoot, including the terminal bud, while the short cuttings have a cut surface at both ends. The bulk of the evidence available is strongly in favour of short cuttings from 8 to 12 inches in length, with a truncated upper end, so that after planting in the nursery the new shoot develops from a lateral bud close to the ground level. Large complete cuttings, especiallybranch cuttings, are often crooked to start with and may leave a permanent bend in the young tree. The short cuttings have also the great advantage that many more plants can be raised from the same quantity of stock (stool shoots or lateral branches).

In making the cuttings, which should be not less than a third of an inch in diameter, the shoots should be cut through with a sharp knife at an angle of 45°; it is preferable to make the top cut just above, and the bottom cut just below a lateral bud.

Season for making Cuttings and Lining Out.—The actual preparation of the cuttings may take place any time from the fall of the leaf in autumn up to the end of February; they can be kept heeled-in in a shed with the lower ends in moist sand until required for lining out. The best season for lining out in the nursery is February and all the cuttings should be in before the end of that month. When cuttings are sent from a distance it is advisable to keep the lower ends in water for a few days before putting them in the soil.

Preparation of Soil in the Nursery.—Poplars require somewhat special conditions as regards soil in the nursery if plants of good quality are to be raised. The very light sandy soils which often produce good coniferous plants are not suitable for raising poplar. A deep sandy loam is required, with, above all, an abundant underground water supply. Under favourable conditions of soil and climate at least 90 per cent. of the cuttings planted in the nursery take root and produce strong, vigorous shoots, but on light dry soils the losses are often heavy and the growth slow. The deeper and more thorough the cultivation the better. If a poplar

cutting is lifted at the end of the first season in the nursery it will be observed that the majority of the roots arise from round the edge of the cut surface. Usually from three to five long, whip-like roots spring out, penetrating the soil to a great distance both downwards and in a lateral direction. A length of root of 3 feet was observed on a one-year-old plant lifted in Esher nursery, the root extending to a depth of about 2 feet. During the first year there is usually a very scanty formation of fine fibrous roots; these develop more and more abundantly with each year the plants are left in the nursery. A few short, weak, horizontal roots also develop during the first or second year from the stem of the cuttings just below the soil level. There is much scope for investigation into the early root development of poplars growing under different conditions as regards soil and moisture.

Spacing in the Nursery.—The correct spacing for poplar cuttings varies with the soil and locality and also with the length of time the cuttings are to be left in the nursery. Close spacing, such as 3 inches between the plants in the lines and 12 inches between the lines, is certainly a mistake. In a good season the plants may attain a height of 4 feet or more, and if they are crowded in the lines weakly plants result. A spacing distance of 12 inches in both directions is the minimum which should be given for cuttings which are to stay one or two years in the nursery. Plants which are to remain three years in the nursery should be set at least 18 inches apart, and more space still may be desirable. In France the usual spacing distance is 3 ft. to 3 ft. 6 in., but the plants are usually left three to four years in the nursery and lifted when 15 to 20 ft. in height, and the weeding both within and between the lines is done with horse labour.

Transplanting.—Though possibly advantageous, transplanting is not carried out in France, presumably owing to the extra cost involved.

Method of Lining Out.—If the soil is very friable the cuttings can be pushed straight in to a depth of 7 to 9 inches, leaving about 2 inches above soil level; care must, of course, be taken to see that the cuttings are put into the ground with the buds pointing upwards. With most soils, however, it is inadvisable to push the cuttings straight into the ground, owing to risk of damaging the bark at the base of the cuttings, and a hole should be prepared either with a spade or dibble, or, still better, the cuttings may be lined out by the open trench methods employed with conifer seedlings. The soil should be well firmed around the cuttings, but care is necessary to avoid damaging the bark.

Tending in the Nursery.—It is advisable to inspect the plants after frost and to firm in those which are loose; this is particularly important in the spring just before growth commences. Where frost is feared the cuttings should be buried so as to leave only an inch above the ground, and the tops covered with a little straw or moss, which should be removed early in the following spring.

Newly planted lines should be examined in the latter part of June or in July, and all superfluous shoots pruned off, leaving a single vigorous shoot on each cutting. The lines should be well hoed during the growing season to keep down weeds and reduce evaporation from the soil. During the first winter (January or February) the lines must be inspected and all weakly plants cut back to 2 inches above soil level. Some nurserymen in France believe in cutting back all the plants in the first winter, but this is not the general practice, except in the case of root suckers of the Grey Poplar and Aspen, which are invariably so treated. The growth in the following season of the plants which have been cut back is often astonishing and may exceed that of plants which have not been so treated. After the first year the plants do not require to be pruned until they are ready for lifting. They should be kept under observation for signs of insect attack and counter measures taken where practicable.

PLANTING.

Poplars may be planted out as (1) small cuttings, (2) large sets (termed *plançons* in France), or (3) rooted plants. Small cuttings are rarely successful and should not be used. Large sets differ from cuttings mainly in respect of size. They consist usually of complete shoots, including the terminal bud, and are either cut from stools or from plants growing in the nursery, and have no roots attached. Large sets are much more susceptible to drought than rooted plants and should only be used in moist, permeable soils. When sets are used they should be from 15 to 18 feet in height and not less than 2 inches in diameter at breast-height. For planting in most situations, especially on the heavier classes of soil, rooted plants are preferable.

Age and Size of Rooted Plants.—Much uncertainty exists as to the best size of plant to use for field planting. In Britain the general practice has been to use small plants—either one-year-old or two-year-old rooted cuttings—the average height ranging from 3 to 5 feet. On the Continent large plants are almost invariably used, most of the authorities recommending plants from 12 to 15 feet in height, while in actual practice much larger plants are often employed. Large plants have certain undoubted advantages; thus, by virtue of their greater fibrous root development they are less affected by drought than small plants, and start more quickly into full growth; further, their leaders are well above any competing vegetation, so that no cleaning is necessary, and protection against ground game or livestock is required for a much shorter period. On the other hand, large plants are expensive to raise and plant and can only be used in well sheltered situations. For average British conditions the most suitable size of plant would appear to be from 6 to 8 feet in height, obtained by leaving the cuttings at least two years in the nursery. The use of one-year rooted plants is not recommended. In windy localities where the use of small plants may be essential, the plants should

be cut back in the nursery at the end of the first season and planted in the second winter.

Lifting from Nursery Lines preparatory to Planting Out.—Before lifting, the plants should be heavily pruned, with the object of reducing transpiration during the first few years after they have been planted out and also in order to lessen the surface exposed to the wind. The lower branches should be cut off level with the main stem and the upper shortened to stumps 3 to 4 inches in length. The stronger branches removed in the pruning can be used for making cuttings. The plants should be lifted in the usual way, due care being taken to preserve the roots intact as far as possible. If it is proposed to plant with sets instead of rooted plants, the former should remain in the nursery lines until they have attained the required size, when the stems are cut through above the ground level and the ends trimmed to the form of a wedge. A strip of bark is left on each side of the wedge and it is from the callus formed at this point that the new roots spring.

Season of Planting.—Rooted cuttings and sets can be planted out any time between November and the middle of March, but autumn planting is probably preferable on all except very wet soils or in localities where late frosts are known to be severe.

Preparation of Ground before Planting.—If rooted plants of moderate size, e.g. from 6 to 8 feet in height, are used it should be unnecessary to deal with the surface vegetation before planting, but in low-lying, wet localities it may be necessary to drain in order to give the plants a good start. The French attach great importance to drainage as a means of bringing under poplar cultivation much marshy, water-logged land which must otherwise lie derelict. Where the natural drainage conditions are bad, and especially where the soil is peaty, drainage is essential for rapid growth. A good example of the effect of lack of drainage was observed in the Seine Valley. A line of poplars had been planted along a road the ground level of which was raised three or four feet above that of a flat, marshy pasture field. The trees were planted 34 feet apart, and at the age of 27 years they had attained an average height of 85 feet and a girth of 4 feet 4 inches at breast-height and looked healthy and vigorous. There was also a number of poplars planted two years later (i.e. 25 years' old) in the field below; these trees looked unhealthy and unlikely to live much longer, their average height was only 30 feet and their girth 1 foot 10 inches; there could be little doubt that the bad drainage conditions were responsible for the inferior growth of the younger trees.

The early growth of poplars on undrained land is often deceptively good; the real test is whether the trees will attain a profitable size on such ground; generally speaking, the evidence is against the planting of poplars on land where aeration is bound to be deficient during the growing season, and while it may or may not pay an owner to drain a swampy tract, it is very doubtful if it will pay him to plant poplars upon it without draining.

The danger of over draining must always be guarded against ; a crop of poplar absorbs an enormous amount of water from the soil, and if there are any signs of lack of water the flow of the drains should at once be regulated.

If an area is to be drained the drains should be so laid out that the poplars can be planted at regular intervals along them, i.e. if the planting distance is 20 feet the drains should, if possible, run parallel to each other at that distance apart. The drains should usually be from 3 to 4 feet deep and the earth removed from them piled into mounds 3 feet from the side of the drains. The poplars are then planted on the mounds. If this thorough drainage is impracticable on account of cost, mound planting with drains at wide intervals may be tried.

Planting Methods.—The rate of growth of poplar in early youth is largely dependent upon the care with which the plant hole or pit has been prepared for the reception of the tree. The young poplar requires abundance of loose soil round the roots, and only if this is provided are the best conditions given for rapid growth. For plants that have been two or three years in the nursery, holes should be dug 18 inches to 2 feet in depth and the soil in the bottom of the hole loosened. The diameter of the hole should be from 2 feet to 2 feet 6 inches at the top, tapering down to 18 inches at the bottom. While this may appear a costly method, owing to the large size of the pits, it must be borne in mind that poplars will not usually be planted less than 15 feet apart, so that the cost per acre is not unduly high. The ends of the main roots may be pruned before planting to promote the formation of fibrous roots.

If sets are used instead of rooted plants the same methods should be followed, except that the pits should be deeper. Sets are often planted by driving an iron bar of the same diameter as the base of the set into the soil and then inserting the set into the hole so formed, but this method is only suitable for very soft, friable soils ; on stiffer land the use of the bar leads to consolidation of the soil and the normal development of the roots is checked.

After planting, whether with rooted plants or sets, the earthing up of the plants is a practice strongly advocated by some of the French poplar growers. Top soil, taken from a number of spots between the plants, is spread round the base of each stem to form a mound 12 to 15 inches in height at the stem and sloping away on all sides to a distance of 3 or 4 feet. The mound is very useful in providing additional support against the wind and may be a necessity where large plants are used in exposed localities. Roots also develop in the loose soil of the mound and the vigour and growth of the plant are increased. It remains to be proved whether the results obtained by earthing up will justify the extra expense involved. Some authorities recommend keeping the soil round the base of the plants free from herbage during the first three years after planting, but here again experiments are required to determine whether this is worth the additional cost.

Planting Distance.—In no branch of poplar cultivation is there a greater cleavage of opinion than as regards the spacing of poplars in plantations. In Britain the usual practice in the past has been to adopt a planting distance of from 4 to 8 feet, and where 8 feet spacing has been adopted, other species have generally been planted between the poplars. The minimum planting distance adopted in France, on the other hand, is 12 feet, and the maximum as much as 40 feet.* The average spacing of poplars in the valleys of the Seine and the Oise is about 22 feet.

Many factors affect the question of planting distance, of which the most important are :—

(1) Rate of growth.
(2) Objects of management.
(3) Cost of planting and pruning.
(4) Provision against failures.
(5) Pure or mixed plantations.

(1) *Rate of Growth.*—This is discussed in detail in a subsequent section (*see* p. 27), but it is desirable here to emphasise the importance of allowing the trees ample growing space, especially during early life. During the first ten to fifteen years from one-half to two-thirds of the total height of each tree should be covered with crown if growth is to proceed unchecked, and this necessitates freedom from contact with neighbouring crowns during that period. When planted under suitable conditions of soil and climate, poplars develop their crowns with great rapidity; for example, the branches of trees planted 10 feet apart may interlace after five or six years' growth, and an unremunerative thinning be necessary in order to maintain the increment.

Current practice in France and observations both in that country and in England lead to the conclusion that unless the trees are to be thinned out during the first five years or so after planting, 12 feet is the minimum planting distance which should be adopted for most species of poplar. It is possible that some of the more fastigiate forms, such as *P. robusta* and *P. serotina* var. *erecta*, could be planted closer without the branches meeting at an unduly early age, but definite information is lacking.

(2) *Objects of Management.*—The planting distance is largely affected by the uses for which the timber is required and the existence of a local market for timber of small size. Thus in France, where paper mills are in the vicinity of poplar plantations, the trees are usually planted 12 feet apart and felled at an early age. In most districts, however, there is not a good market for small stems, but only for timber of large dimensions; where this is the case planting distances of 15 to 30 feet or more are adopted and the trees grown on a longer rotation. At the present time, owing to lack of

* Breton Bonnard, *Le Peuplier*, pp. 91–95.

demand for the smaller sizes of poplar timber in Britain, wide planting for the production of big timber seems indicated; later on uses may be found for small material and closer planting may then be justified.

(3) *Cost of Planting and Pruning.*—The distance apart at which to plant poplars is largely regulated by cost. There is no sylvicultural reason why poplars should not be planted say 5 feet apart, provided they are thinned out sufficiently early and drastically, but the cost would be needlessly high, for the reason that 80 to 90 per cent. of the plants would have to be cut out in the first few years in order to give the remainder sufficient growing space. Practically all the money spent in raising and planting the trees removed in the thinnings would thus be lost. Plants of, say, 6 to 8 feet in height, such as are here recommended, are necessarily somewhat expensive to raise and plant, but the cost per acre is not excessive if the trees are planted at fairly wide intervals. Plants (rooted cuttings) of the above size can be raised in a home nursery for approximately 25s. per 100; assuming that 200 of these are planted per acre and that planting can be done at the rate of 20s. per 100, the cost will amount to £4 10s. per acre. This sum does not allow for expenditure on transport of plants, draining and fencing, the cost of which vary greatly according to circumstances. The total cost, however, in most localities is not likely to exceed £10 per acre.

The necessity for pruning is discussed on p. 25, and the cost of this operation has a very definite bearing upon the question of spacing-distance. The first few prunings cost comparatively little, but later on when the trees are tall it becomes a very expensive operation, and the number of trees to be pruned must therefore be kept as low as possible.

(4) *Provision against Failures.*—One of the arguments frequently advanced in favour of close planting is that an ample margin should be allowed for failures and the weeding out of badly shaped, damaged, or diseased trees before the crop comes to maturity. Provision should be made for possible losses in a poplar plantation just as in crops of other species, and though by adopting elaborate planting methods the risk of failure during the first few years is minimised, later on many accidents may befall the trees, and it is desirable to have a reserve upon which to fall back in case of need. For this reason it seems doubtful if the very wide planting distances adopted by some of the French growers should be followed in this country.

(5) *Pure or Mixed Plantations.*—Without entering at this point into a discussion as to the desirability or otherwise of planting poplar in mixture with other species (*see* p. 22), it is clear that if another species can be profitably grown with

poplar, a wider spacing is permissible than if the poplar is grown pure. If any of the poplar stems should fail, the auxiliary species will benefit by the increased light resulting from the removal of the former and there should be no appreciable loss in total increment. Further, the more widely the poplars are spaced the better chance will the auxiliary species have of attaining a marketable size before the poplar crowns close over and check their growth.

When planting poplar in mixture with other species a minimum planting distance of 25 to 30 feet for the poplar is suggested.

Consideration of the above points shows that the decision as to the spacing of poplars in pure plantation depends primarily upon the rate of growth of the trees, the cost of planting, and the necessity for providing a margin against damage or disease affecting the trees during the life of the crop. Generally speaking, the poorer the soil and the smaller the plants the closer should the poplars be planted, but it is doubtful if in any circumstances the distance apart should be less than 12 feet.

On average soils and using poplar plants from 6 to 8 feet in height, it is believed that with careful planting 15 or 16 feet spacing (say 170 to 200 plants per acre) will give satisfactory results with all the fast-growing species of poplar. For planting in single lines or small groups a distance of 25 to 30 feet is recommended. It is often held that poplars can be crowded together when planted in single lines, e.g. along road sides or water courses, because their crowns have free space on two sides in which to expand, but examination of poplar avenues in this country and in France does not support this view. A number of examples were noted in France of lines of poplar planted 15 feet apart and now twenty to twenty-five years old. The trees ranged in height from 60 to 80 feet or more and all showed much the same character, i.e. very flattened crowns on the two inner sides and spreading crowns on the free sides, the majority of the stems were also markedly crooked, bending toward the light either on one side or the other, a natural consequence of the disturbance of balance due to the abnormal shape of the crowns.

Mixture with other Species.

In dealing with this question it is important to consider at the outset the type of stand which will be produced by such a mixture. In the first place, when planted on suitable soils and in sheltered localities, poplars will outgrow any species with which they are planted. At the end of, say, twenty-five years' growth, a mixed plantation of poplar and alder or poplar and spruce has the appearance of a two-storied forest, the poplar trees being usually more than twice the height of the other species. There is thus no question of an ordinary mixed plantation resulting; given suitable conditions for its growth the poplar will always form the

upper story in the crop and the other species, which may be termed, for convenience, the subsidiary species, the lower story. Assuming that in most cases the whole crop will be felled when the poplar is mature, the subsidiary species can only yield small pitwood or fencing material, or, in the case of coppice, the usual minor produce.

It is clear, then, that somewhat special conditions are required if a mixture of poplar with other species is to be successful. The subsidiary species must be suitable for planting in the wet, low-lying and often frosty localities in which poplars are usually planted ; it must be at least a moderate shade bearer ; there must be sufficient soil moisture to support both the poplar and the subsidiary species and, finally, there must be a convenient market for the small-sized material which the latter will yield. There is one species, namely, the common alder, which can fulfil most of these requirements, and this is the only tree which is largely grown with poplar in France and Belgium, where it is invariably treated as coppice. In this country there is a plantation 6 acres in extent, on the Brocklesby Estate, Lincolnshire, where Black Italian Poplar was planted thirty-four years ago with common alder, ash, birch, elm, and other hardwoods. The area is low-lying and very wet in winter and the soil rather peaty.

The following table shows the average number of trees per acre and their dimensions :—

Species.	Number of Trees per Acre.	Average Girth at Breast-Height.	Average Height.
		ft. in.	ft.
Black Italian Poplar	36	4 2	83
Alder (not coppiced)	58	2 2	45
Other hardwoods (not coppiced)	70	1 8	40

The wood was planted uniformly with poplar about 8 feet apart, the other species being planted between the poplars. The stocking is now irregular owing to a fungus disease having attacked the poplars, many of which have been removed, but the other species have thriven in the gaps. The area as a whole is fairly well stocked, and there is no doubt that the total production from the area has been increased owing to the presence of the subsidiary species.

The late Mr. H. J. Elwes of Colesbourne recommended grey alder, *Alnus incana*, in preference to the common alder (to be coppiced) as a species for planting with poplar. Another species which might give good results as coppice under poplar, especially on clay soils, is the sweet chestnut.

In France and Belgium coniferous trees are not planted with poplar, one of the reasons probably being that in those countries poplar cultivation is almost exclusively in the hands of private

individuals who have no experience in growing conifers. That conifers will, under favourable conditions, grow beneath the shade of poplars is clear from the mixed forests of the Pacific Coast of North America. In many of the valleys of British Columbia, for example, poplar (*P. trichocarpa*) is a pioneer species on alluvial deposits ; at a latter stage various trees, chief of which are *Tsuga heterophylla, Thuya plicata* and Douglas fir, establish themselves under the poplar, eventually replacing it.*

There are several plantations in this country in which Norway spruce has been planted with poplar, the latter being spaced usually not more than 8 feet apart ; the result in most cases has been that the spruces are more or less completely suppressed. With wider spacing of the poplar the spruces would have a much better chance of growing to a useful size, but, in any case, this tree is an indifferent shade bearer and some of the West American conifers, such as *Thuya plicata*, or *Tsuga heterophylla* could be used with greater prospects of success. Thuya and Tsuga would seem especially suitable for planting with poplar because they are extreme shade bearers and also will grow on wet, heavy soils. Whatever species of conifer may be selected the poplar should not be spaced closer than 25 feet apart in the crop, the subsidiary species will then enjoy direct overhead light for a considerable number of years before the poplar crowns close over, while the failure of any of the poplars should not result in a serious loss of production over the area.

Tending.

Thinning.—The necessity for thinning depends mainly upon the planting distance and the objects of management. Thus, in France, trees grown for the manufacture of pulp are planted usually at 12 feet apart and are not thinned before the crop is cut. If large timber is required the trees may either be planted 25 to 30 feet apart, in which case little, if any, thinning is required, or they may be planted more closely, in which case regular and frequent thinnings are necessary in order to maintain the growth. The majority of the French poplar plantations are not thinned at all, often with disastrous results to the more closely planted crops ; it is difficult to draw any hard and fast line as regards the relationship between planting distance and the necessity for thinning, but in general, 25 feet may be taken as the minimum planting distance permissible if thinnings are to be entirely dispensed with.

As an illustration of the effect of over-crowding upon the size of the trees the following particulars are given ; they refer to the girths at breast-height of the outside and inside trees of a plantation of *P. regenerata* at Culford (*see* p. 30), planted originally 8 feet apart. The outside trees enjoyed full light on one side, while the inside trees were hemmed in on all sides by neighbouring trees.

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* Commission of Conservation, Canada, *Forests of British Columbia*, 1918.

The area investigated contained 115 trees per acre, equivalent to an average spacing distance of about 20 feet. The average height of the trees was 91 feet :—

	Girth of Largest Tree at 4 ft. 3 ins.	Average Girth at 4 ft. 3 ins.	Girth of Smallest Tree at 4 ft. 3 ins.
	ft. in.	ft. in.	ft. in.
(1) 15 Outside trees ..	6 7	5 0	3 10
(2) 43 Inside trees ..	5 7	3 10	2 6

Thus the outside trees, although they had well developed crowns only on one side, averaged 14 inches more in girth than the inside trees ; other plantations examined showed a similar difference between the dimensions of the inside and outside trees.

It has already been stated on p. 21 that it is better to plant more trees to the acre than will finally be needed. Thinning will therefore be necessary in order to maintain the growth of the crop. The stage at which the thinnings should be made, their frequency and the number of trees to be removed must depend upon the density of the crop on the ground, the rate of growth, risk of windfall, etc. ; but in any case thinning must not be delayed beyond the time when the crowns of the majority of the trees begin to touch. In general the object of thinning should be to remove backward trees and to allow those which are to form the final crop as much light and growing space as possible.

Pruning.—The subject of pruning raises several important questions of an economic character. Pruning is a costly process, and is only justifiable if it results in a sufficient increase in the price of the trees when they come to be sold to show a profit on the operation. Much, then, depends upon the uses to which the timber is put and on the demand for clean grown as contrasted with rough material. In Chapter IV it is shown that in all probability ply-wood, veneers, and the match industry will absorb large quantities of poplar wood in the future, and that for these and many other purposes clean grown timber can alone be used.

On the Continent, where the commercial utilisation of poplar timber is much more highly developed than in Britain, the principal demand is for clean timber, and pruning is almost universally adopted. That pruning is necessary in order to obtain timber of good quality from trees which have been given sufficient growing space for rapid development cannot be controverted. Even if the trees are grown close there is much doubt as to whether the branches will become suppressed and fall off soon enough to enable the trees to yield timber sufficiently free from knots to command good prices.

The French distinguish three types of pruning : *Émondage*, *Élagage* and *Ébourgeonnage*.

Émondage or crown pruning consists in the trimming of the crowns of young trees so as to give them a conical shape, and includes the removal of double leaders. Rapidly growing young trees often develop one or more large branches, which overweigh the side from which they spring, and unless these are lightened by pruning, curved ill-shaped stems result. Crown pruning is carried out during the winter when the trees have been planted four or five years.

Élagage or stem pruning consists in the removal of lateral branches, with the object of obtaining clean timber. Pruning should start early and be repeated at frequent intervals, so that the branches are removed before they grow to a size which prevents rapid healing over of the wounds. It is important that the branches should be cut off flush with the bark; if snags are left, decay is very liable to pass into the bole of the tree; pruning is usually required for the first time after the plantation is five or six years old, and should thereafter be repeated at intervals of three or four years until a sufficient length of clean bole is obtained. Stem pruning is usually carried out between November and April, but summer pruning is also permissible.

Much uncertainty exists as to the correct proportion of stem and crown which should be maintained. In France pruning is often carried obviously to excess and trees 20 to 25 years old left with as little as 20 per cent. of the total length covered with crown. A rough rule of thumb prescription adopted by many French growers is that young trees up to 12 to 15 years of age should have two-thirds crown and one-third clean bole; from say 15 to 20 years the proportion of stem to crown should be equal, and after that age two-thirds of the stem should be free from branches. This prescription probably errs on the side of over-pruning in the older trees; it is doubtful if the proportion of stem to crown should be more than 50 per cent. if the diameter growth is to be fully maintained, and it is also doubtful if the pruning of trees over 20 to 25 years of age is an economic proposition, owing to the height of the trees and consequent cost of the operation.

M. Henri Lafosse, late Conservator des Eaux et Forets, and a keen advocate of poplar cultivation in France, recommends the following method of stem pruning. The first pruning is made when the trees are six years old and two whorls of branches are removed; the second pruning is made in the ninth year and two more whorls removed; the trees are similarly pruned at the end of the twelfth and fifteenth years, when the operation is considered to be complete. This procedure is not intended to be rigid, sometimes more than two whorls of branches should be cut, sometimes less, according to the growth of the trees. When practicable the wounds should be dressed with coal tar to exclude fungus spores.

Ébourgeonnage consists in the removal of the secondary or epicormic shoots which develop on the main stem of the tree. Stem pruning often leads to the development of large numbers of

small shoots, which spring from the edges of the wounds. Failure to remove these epicormic branches impairs the quality of the timber and also robs the trees of much of their vitality. *Ébourgeonnage* is carried out in the month of August following each stem pruning.

Cost of Pruning.—An estimate of the present cost of pruning was obtained in France, and though much weight cannot be attached to a single estimate it may give an indication of the probable cost of the operation. The estimate allows for six prunings in all :—

Cost of first two prunings = 2 × 0·5 fr. = 1·0 fr. per tree
Cost of second two ,, = 2 × 1·0 fr. = 2·0 fr. ,, ,,
Cost of third two ,, = 2 × 2·0 fr. = 4·0 fr. ,, ,,

Total = 7·0 fr. per tree.

At the rate of 50 francs per pound sterling this represents a total cost of about 2*s.* 10*d.* per tree.

Rate of Growth and Yield.

It must be admitted that very little information is available as to the rate of growth of the different kinds of poplars in this country. The Black Italian is the only poplar which has been planted at all extensively in the past, and even so it has been mainly as scattered clumps or single rows of tree, for which few records as to date of planting exist. Any reliable estimate of normal rate of growth or yield has been rendered difficult in most cases by the trees in the plantations having been overcrowded. As regards the other species, except in a few instances only single trees are to be found. In the absence of fuller information the following notes on individual plantations may be of interest :—

Black Poplars.

Black Italian Poplar (*P. serotina*).

(1) Line of poplars planted along the side of a ditch in deep fen peat on the Ryston Hall Estate, Norfolk. Age 4 years. The trees were planted at a distance of 15 feet apart. Large slips without roots were used. The trees are now 20 to 25 feet high, with an average girth of 12 inches.*

(2) Mixed plantation of poplar and ash at Brocklesby, Lincolnshire. Low lying on peaty soil over clay. The poplar (8 feet apart) are 10 years old and about 25 feet in height and 14 inches in girth.

(3) Mixed plantation of poplar and Norway spruce on the Raby Estate near Barnard Castle. Soil a wet clay loam. Age 13 years. Poplar planted 10 feet apart, spruce 4 feet

* In all cases the girths recorded refer to measurments at breast-height over bark.

apart. Average height of poplar 24 feet and girth 20 inches. The crowns of the poplars nearly touch each other. Many of the leading shoots of the spruce have been whipped and damaged by the poplar branches.

(4) Pure plantation of poplars on the Sarsden Estate in Oxfordshire. Soil stiff lias clay. Age 15 years. Height 32 feet. Average girth 12 inches. Planting distance 6 feet. The early growth of this plantation was relatively slow, the trees having taken 6 years to reach a height of 10 feet; the subsequent rate of growth was rapid.

(5) Mixed plantation of poplar and common alder at Brocklesby. Low lying, on clay loam. The poplars were planted 8 feet apart. Age 16 years. Average height 41 feet and girth 19 inches. The maximum height and girth were 46 feet and 2 feet 5 inches respectively. The alders averaged 33 feet in height, but are now showing marked signs of suppression by the much taller poplar.

(6) Plantation of poplar on the Sarsden Estate. Soil stiff, wet clay. Trees planted 6 feet apart and failures filled up after 6 years' growth with grey alder, many of which are growing well. Age 18 years. Height irregular, varying from 30 to 40 feet, with a maximum height of 47 feet. Average girth about 20 inches. Maximum girth of outside trees 3 feet.

(7) Poplar in a mixed plantation on poor sandy soil (probably in Morayshire).* Age 24 years:—

Species.	Average Height.	Average Girth.	
	ft.	ft.	in.
Poplar	60	3	6
Larch	48	3	4
Beech	40	2	6
Sycamore	34	2	1
Elm	33	3	0

(8) Poplars planted in a wet, cold valley on the Colesbourne Estate, Gloucestershire, at 550 feet elevation above sea-level.† Age 25 years, height 65 to 70 feet, girth 4 feet to 4 feet 9 inches.

(9) Plantation of poplar at Benefield, Northamptonshire.‡ Soil stiff clay. Age when felled 29 years. Originally planted with 338 trees per acre, i.e., 9 feet apart; this number was reduced by deaths or thinning to 206 trees per acre. The trees when felled had an average timber length of 45 feet and girth at breast-height of 2 feet. The volume per acre was

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* Grigor, *Arboriculture*, p. 326.
† Elwes in *Quarterly Journal of Forestry*, 1917, p. 283.
‡ Henry, *Forests, Woods, and Trees*, p. 165.

1,300 cubic feet quarter-girth. Close planting and insufficient thinning were doubtless mainly responsible for the poor growth of these trees.

(10) Mixed plantation at Brocklesby, of poplar with alder, birch, ash, elm, oak, etc. Soil peaty clay loam. Situation low-lying and very wet. A small, sample plot was taken in a part of the wood consisting of almost pure poplar, and the following measurements per acre obtained. Age 34 years. Height 84 feet. Average girth 4 feet. Number of stems per acre 98. Volume 2,390 cubic feet per acre quarter-girth under bark. The original spacing of the poplars was 6 to 8 feet, and, although the crop had been frequently thinned to remove stems affected by canker, the stocking in this portion of the wood was still much too dense for rapid growth in girth.

(11) Mixed plantation recorded by Michie* in 1869 in Cheshire. Situation low-lying. Soil wet clay. Age 35 years. The following table shows the average volume per tree of the different species in the crop :—

Species.	Average Volume per Tree.
	Cubic feet.
Poplar ..	35
Oak	3
Ash	3
Alder	5
Lime	4
Scots pine ..	4
Spruce ..	2½
Larch ..	2

The planting distance of the poplar is not recorded, but it was probably fairly wide, so that the crowns would have had plenty of space for development after the first year or two.

(12) Small plantation of poplar standing over Austrian pine near Denver Hall, Norfolk. Soil medium loam. Age 40 years. Poplars spaced 30 feet apart, the crowns of the trees almost meeting. Height 90 to 95 feet. Average girth 7 feet 10 inches. Austrian pine 40–50 feet in height.

(13) Mixed plantation of poplar, spruce, and larch on the Raby Estate near Barnard Castle. Soil varying from a fairly dry, light loam to a wet clay loam or clay. Age 43 years. The distribution of the poplar was very irregular and there appeared to have been many failures. On the drier soils the spruce were only 5 or 6 feet shorter than the poplars and were

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* Michie, *Report on the Management and Value of Poplar* in *Transactions of the Highland and Agricultural Society of Scotland*, 1869, p. 133.

hemming in the latter; the poplars girthed not more than 2 to 3 feet, with a height of about 55 feet. On the wetter soils the poplars were much more vigorous and had suppressed the spruce at an early age. A group of four trees at the corner of the wood ranged from 3 feet 10 inches to 5 feet in girth and averaged 68 feet in height.

(14) Poplars planted at Colesbourne.* Soil clay. Age, when felled, 48 years. Trees planted in a locality subject to early and late frosts. Average cubic contents per tree 120 feet.

(15) Avenue at Heron Court, Hampshire.† Soil moist alluvial loam. Age 49 years. Average height 115 feet. Tallest tree 125 feet. Average girth 6 feet, and volume quarter-girth 80 cubic feet.

(16) Line of poplar at Strathfieldsaye in Hampshire.‡ Soil stiff clay. Age 55 years. Planting distance 45 feet. Measurements of height and girth are lacking, but the average volume of 31 trees felled was just under 200 cubic feet quarter-girth over bark. The largest tree contained 417 cubic feet.

(17) Plantation near Gainford, Yorkshire.§ Soil alluvial. Age 65 years. Twelve trees were felled containing an average volume of 87 cubic feet.

(18) Group of poplar in Hampshire.|| Soil deep alluvial loam. Age 80 years. Height 110 feet, girth 6 feet 11 inches. Number of trees per acre 52. Average volume per tree under bark 107 cubic feet. During the last 30 years the rate of growth was very slow and many of the trees, when felled, were unsound at the butt.

P. regenerata.

(1) Mixed plantation of *P. regenerata* and Norway spruce on the Culford Estate in Suffolk. Area of plantation between 4 and 5 acres. Soil a coarse black sand very rich in humus, probably of alluvial origin. A sample plot was measured and the following data obtained. Age 23 years. Height 91 feet. Girth 4 feet 3 inches. Number of stems per acre 113. Volume per acre quarter-girth under bark 3,010 cubic feet.

The original planting distance of the poplar was apparently about 8 feet with alternate spruce. The spruce are still alive, but entirely suppressed, and not more than 10 to 15 feet in height. No regular thinning of the poplars appear to have been made and probably only dead trees, killed by suppression, have been removed. The largest tree measured,

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* Elwes and Henry, *Trees of Great Britain and Ireland*, p. 1818.

† P. T. Maw, in *Quarterly Journal of Forestry*, 1917, pp. 212 and 286.

‡ W. R. Brown, in *Quarterly Journal of Forestry*, 1920, p. 170.

§ From information supplied by Mr. T. Bewick, forester on the Raby Estate.

|| P. T. Maw, in *Quarterly Journal of Forestry*, 1919, p. 137.

which had a girth of 6 feet 9 inches and a total height of 102 feet, was growing in a corner of the plantation, so that it had free growing space on two sides. If the wood had been widely planted in the first instance, or kept heavily thinned the average girth would doubtless have been well over 6 feet.

A ring count on a felled tree showed that the tree grew 50 feet in height in the first 10 years and 41 feet in height in the next 13 years, so that the rate of growth was falling off to some extent. Measurements of the growth of the leading shoots show that the trees are still growing at the rate of about 3 feet a year.

(2) Smaller plantation of the same species near Culford Hall. Soil black sand. Age believed to be 16 years. Height 46 feet and average girth of the outside trees 3 feet 2 inches.

P. robusta.

As far as is known this hybrid exists only as specimen trees in Britain. (1) Tree at Ryston Hall, Norfolk. Age 8 years. Height 30 feet. (2) Tree at Glasnevin, Dublin, growing on shallow soil in an exposed situation. Age 26 years. Height 46 feet. Girth 2 feet 4 inches.

P. Eugenei.

(1) Two trees growing in dry, sandy soil in Kew Gardens measured in 1912. Age 24 years. Height 90 feet and 84 feet and girth 5 feet 3 inches and 4 feet 5 inches respectively. The same trees remeasured in 1922, at the age of 34 years, were found to be 95 feet and 90 feet in height and 7 feet 2 inches and 6 feet 7 inches in girth respectively.

(2) Tree planted at Glasnevin, Dublin. Age 24 years. Height 55 feet. Girth 4 feet 5 inches.

Balsam Poplars.

P. Trichocarpa.

(1) Small plantation at Dawyck, Peeblesshire. Soil, gravelly. Elevation 750 feet. Spacing distance 10 feet. Age 8 years. Height 31 feet. Girth 18 inches.

(2) Trees on the Much Hadham Estate, Hertfordshire. Soil London clay. Age 14 years. Height 50 to 60 feet.

(3) Sample plot measured on the Minto Estate, Cleughhead, Hawick, Scotland. Elevation 500 feet above sea level. Soil, loamy clay on boulder clay. The following measurements were obtained: Age 14 years. Height 56 feet. Girth 2 feet 2 inches. Number of stems per acre 475. Volume quarter-girth under bark 2,720 cubic feet per acre.

(4) Trees on the Colesbourne Estate. Soil clay. Elevation 500 feet. Age 15 years. Height 72 feet. Girth 4 feet 2 inches.

(5) Tree on the Brocklesby Estate. Soil clayey. Age 10 years. Height 35 feet. Girth 2 feet 2 inches. This tree was crooked and badly cankered with *Nectria*.

P. generosa.

Trees in Kew Gardens. Soil moist sand. Age 7 years. Height 36 feet. Girth 21 inches.

White Poplars and Aspens.

White Poplar (*P. alba*).

No measurements have been taken.

Grey Poplar (*P. canescens*).

(1) Mixed plantation in Morayshire, on low-lying land, subject to frequent inundation. Age of plantation 28 years.

Species.	Average girth at 3 feet from the ground.	
	ft.	in.
Grey Poplar	5	2
Black Italian Poplar	4	4
Lombardy Poplar	2	5
Lime, Ash, Beech, and Birch ..	2	3

(2) Small plantation adjoining the above and similarly situated. Age 32 years.

Species.	Average girth at 3 feet from the ground.	
	ft.	in.
Grey Poplar	6	8
Black Italian Poplar	5	2
Birch	3	2
Alder	2	8

Excess of moisture had produced dead wood on every kind of tree except the Grey Poplar, which was in a healthy and vigorous state.*

The Aspen (*P. tremula*).

No measurements have been obtained.

It is scarcely possible on the very scanty data given above to form any close estimate of the production to be expected from the growth of poplars. Sufficient evidence is given, however, to show that poplars make rapid growth even on stiff clay soils, and that timber of large dimensions can be produced at a relatively early age. Extravagant estimates are often met with as to the volume of timber which may be yielded by a unit area of mature poplar trees, but these estimates are rarely based on actual measurements

* Grigor, *Arboriculture*, pp. 319, 320.

and the light-demanding nature of the tree is evidently not taken sufficiently into account. It is not permissible, for instance, to take the measurements of isolated trees or of trees planted in an avenue and to assume that an equivalent number of trees of the same size and at the same spacing distance could be grown on an acre of ground, for, even if apparently ample allowance is made for growing space, the light conditions are always less favourable inside a plantation owing to the shade cast by the crowns of adjoining trees. As a poplar stand grows towards maturity the crowns of the trees spread out enormously, and, if this is prevented by keeping too many trees on the ground, the rate of growth is greatly checked until the dominant trees can suppress their weaker neighbours and once more enjoy full light. The final number of trees on an acre of land under poplar is bound to be very low (say 40 to 50 trees per acre or even less), and to expect a volume of even 3,000 cubic feet per acre is to make great demands on the size of the average trees. From a careful consideration of the poplar plantations examined both in this country and on the Continent it would appear doubtful if the volume of a mature crop (at the age of 30 to 40 years) will on the average exceed 3,000 cubic feet per acre, quarter-girth measurement under bark.

Rotation.

The rotation to be selected for any species of trees planted in a given locality depends partly upon the rate of growth and method of treatment of the crop and partly upon such factors as the market value of the timber and the objects of management. The rate of growth and the price obtainable for the timber require to be fairly accurately known before an owner can decide which is the most profitable rotation upon which to grow his trees, and even then considerable difficulties are often met with. In the case of the poplars the data available both as regards rate of growth and future value of the timber are insufficient for purposes of detailed calculations of the financial rotation. Apart from the fact that the number of poplar plantations in this country is very limited, their past treatment in respect of growing space renders these woods of little value as a basis upon which to determine the best age at which to fell normally spaced crops. Probably the best method of approach is to consider what size of bole is required at the present time to command a good price from the timber merchant or manufacturer. For most purposes this may be put fairly confidently at between five and six feet girth at breast-height. In France timber merchants regard a tree of five feet girth at breast-height as the most useful size for transport and conversion. It is a great mistake to allow poplar trees to grow to an excessive age and size ; very large trees are much more expensive to handle than trees of moderate size, while from the financial point of view quick returns are usually more profitable. The length of time required to produce trees of five to six feet in

girth will vary with the species, soil, and locality and method of treatment; it is thus impossible to fix the rotation with any precision, but it would seem possible to produce on suitable soils (excluding the stiffer clays) trees averaging five feet in girth in 30 to 40 years, provided that the trees are given ample growing space throughout life.

It will probably be necessary in the case of crops grown on clay soils to raise the rotation by about ten years, varying with the nature of the clay, drainage, etc. As regards the newer hybrids, such as *P. regenerata* and *P. generosa*, there seems every reason to believe that on fertile, permeable soils rotations of twenty to thirty years will suffice to produce the size of timber required. In the north of France, where the climate does not differ greatly from that of the south of England, rotations vary from eighteen to thirty years.

The Grey Poplar develops more slowly, and probably requires a somewhat longer rotation than the Black Italian Poplar.

The Aspen, though of much slower growth than the Black Italian Poplar, is marketable in relatively small dimensions for the manufacture of matches, so that it is possible that a rotation of thirty-five years may prove sufficient.

CHAPTER III.

PROTECTION.

Insects Injurious to Poplars.

A number of insects occurring on poplars can scarcely be regarded as forest pests. The injurious forms fall naturally into two categories—those which feed on the leaves and those which bore into the timber. The leaf-feeders are particularly harmful in nurseries and young plantations; the wood-borers in established plantations and older woods.

Of the insects feeding on the leaves the sawflies may be taken first.

More than twenty species of sawflies have been recorded as feeding on poplars. Of these only two are commonly injurious, namely the Poplar Sawfly (*Cladius* (*Trichiocampus*) *viminalis* Fall) and the Birch Sawfly (*Crœsus* (*Nematus*) *septentrionalis* L.). These two insects may be distinguished in the adult state by their colour; in *C. viminalis* all the segments of the abdomen are yellowish red; in *C. septentrionalis* the first three and the last two segments of the abdomen are black and the remainder reddish yellow. In *C. septentrionalis*, moreover, the last joints of the hind legs (i.e., the tibia and first tarsal joint) are remarkably broad and flat (Fig. 1). *Cladius* lays its eggs in the leaf-petiole, causing regular swellings on each side (Fig. 2, c). *Crœsus* lays its eggs in the veins of the leaf.

The larvæ of the two species are distinct, both in their appearance and habit. Those of *Cladius* are hairy and pale

green in colour when newly hatched, the legs being also light coloured. When half-grown they are orange yellow in colour, except for the head and the last segment, which are black. They feed in rows on the underside of the leaves (Fig. 2, a). When full grown the caterpillars moult and become orange in colour with black spots.

The larvæ of *Crœsus* when newly hatched are whitish or pale green, with the legs black, and are almost destitute of hairs. When half-grown they are greenish in colour, with black and yellow spots. They feed singly on the edges of the leaves with the tail erect (Fig. 2, b). The full-grown larvæ are greenish-yellow in colour, with prominent black patches.

Cladius viminalis appears to have two broods in the year and *Crœsus septentrionalis* has also two broods, at least in the South of England.

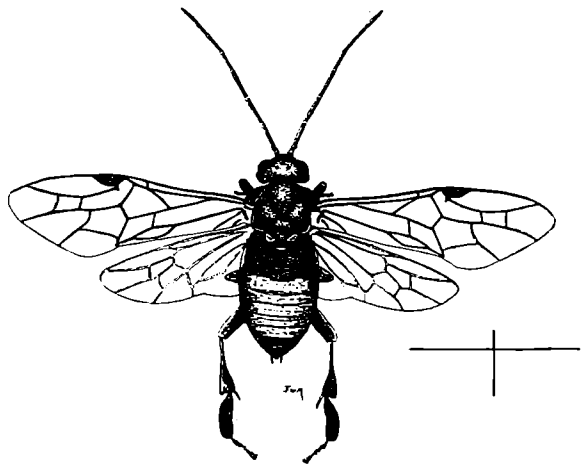

FIG. 1. *Crœsus septentrionalis*. The lines on the right show natural size.

At Kew in 1921 *C. viminalis* was heavily parasitised by a Tachinid fly (*Ptychomyia selecta* Mg.), which undoubtedly reduced its numbers. Unfortunately, neither *Cladius* nor *Crœsus* caterpillars appear to be eaten by birds, which are probably repelled by the brilliant colours of the caterpillars and, in the case of *Crœsus*, by the habit which they have of adopting a " terrifying attitude " and when disturbed of everting a row of glands situated between the abdominal feet or pro-legs.

C. viminalis and *C. septentrionalis* are likely to prove seriously harmful only in nurseries and young plantations, where they may defoliate young plants. The best measures to be taken against them are the crushing of the larvæ by hand and the removal of leaves bearing their eggs. Such measures if promptly applied usually prevent further trouble.

In the case of ornamental trees which are liable to be disfigured by the attacks of these sawflies spraying may be resorted to. A

good spray for this purpose is one consisting of lead arsenate paste (1 lb.) and water (20 gallons). It is advisable to use a force sprayer with a fine nozzle, as this ensures the formation of a fine film on the leaves. Lead arsenate being a deadly poison, its use should be strictly supervised and all spraying materials and utensils kept under lock and key when not in use.

The Puss Moth (*Dicranura* (*Cerura*) *vinula* L.) is at times distinctly harmful to willows and poplars. The caterpillars feed on the leaves until mature and then, when constructing their cocoons, frequently gnaw the shoots to such an extent that the twigs break off at the point of attack. The moth gets its name from its furry appearance and colour, which is grey with darker

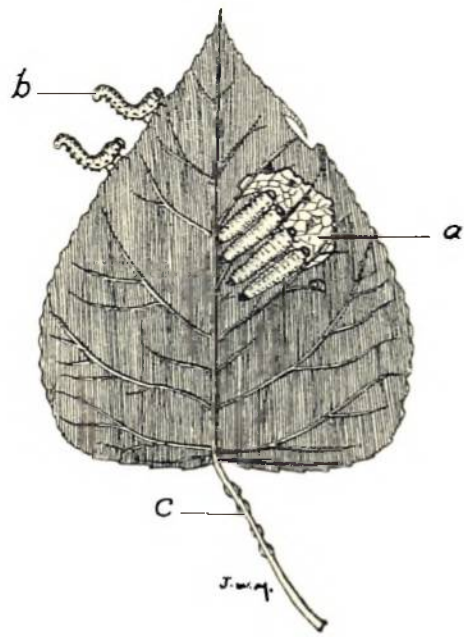

FIG. 2. Larvæ of *Cladius* (a) and *Crœsus* (b) on poplar leaf. Egg slits of *Cladius* on petiole (*c*). Natural size.

and lighter bands. It measures 2½ to 3 inches in expanse of wing. The female lays eggs on the leaves in May and June; the caterpillars hatch out in a few days and feed until August and September. They are remarkable both in colour and in shape (Fig. 3). The ground colour is green, with a purplish band edged with white running along the back. The third segment of the body is raised, forming a hump, and the last segment bears a pair of retractile whip-like organs.

When fully fed the caterpillar constructs a cocoon in which it pupates. This cocoon is composed of chips of bark and wood glued together and is attached to a branch, to the bark of the trunk or any convenient support. The insect remains in the cocoon all the winter, emerging in May of the following year.

According to some authorities, the life cycle may occupy two years. The large size and striking colour of the Puss Moth caterpillar render it easy of recognition, and in nurseries and young

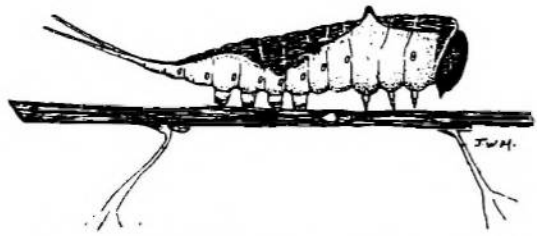

FIG. 3. Caterpillar of Puss Moth. × 3/2.

plantations hand-picking of the caterpillars is the best means of keeping them in check. Cocoons should be looked for in the autumn and winter and destroyed.

Several leaf-feeding beetles belonging to the family Chrysomelidæ, which are injurious both in the larval and adult stages, occur on poplar. Of these the Poplar Leaf Beetle (*Chrysomela* (*Melasoma*) *populi* L.) is frequently a serious pest in nurseries, feeding on the leaves of various poplars and willows. The adult beetle measures about one-third of an inch in length. The head and thorax are shining blue-black or black in colour, and the wing-covers are brick red, with black tips. The yellowish eggs are laid in May and June on the leaves and hatch in about ten

FIG. 4. *Chrysomela populi*, adult and larvæ on leaf of poplar. Natural size.

days. The larvæ are plump, greyish-yellow in colour, and have three pairs of legs. They feed exposed on the leaves, generally on the underside (Fig. 4). When touched they commonly evert a

number of glands occurring on the back and sides of the body, which then stand out like beads and secrete an acrid fluid. The larva feeds for about a month, when it pupates within the larval skin suspended from a leaf or twig. Finally, this skin cracks and shrivels exposing the pupa. Two broods may occur in the year.

Destruction of the eggs and hand-picking of the beetles and larvæ as soon as they are observed is an effective way of combating the Poplar Leaf Beetle. Spraying with lead arsenate, as recommended above (p. 36) for sawfly attacks, may be adopted, but should not be necessary if hand-picking is undertaken in time.

Three species of Willow Leaf Beetles occur in Britain, but only two are widely distributed and common, namely, *Phyllodecta vitellinæ* L. and *P. vulgatissima* L. These closely resemble each other both in appearance and life history and may be considered together. The *Phyllodecta* beetles are oblong-oval in shape, less than a quarter of an inch in length, of a bright metallic blue or bronze-green colour, and have moderately long antennæ. The wing-covers are punctured in rows. In *P. vulgatissima* these rows are less regular than in *P. vitellinæ*, and this is in fact the main distinction between the two species. The larvæ of *Phyllodecta* resemble small *Chrysomela* larvæ in general appearance, but are more elongate in shape.

The Willow Leaf Beetles occur as frequently on poplars as on willows. Both adults and larvæ skeletonise the leaves, and the adults cause further and more important injuries by gnawing the tender growing shoots. The beetles lay their eggs on the underside of the leaves, where the larvæ commence feeding in regular rows. Two broods occur in the year, of which the second is the more injurious, as the beetles of that brood destroy the late summer growth. These beetles hibernate under stones, especially in dry stone walls, in crevices in the bark of trees, and under the loose bark of fencing posts. On this account they are difficult to eradicate.

Remedial measures consist in beating or shaking the beetles off infested plants into a tray, shallow box, or outstretched apron and in spraying the trees with arsenate of lead (*see* p. 36). Spraying, if done early, is the better measure where the insects are numerous.

Two species of Flea Beetles (*Crepidodera helxines* and *C. aurata*) occur on poplars, causing injury similar to that of *Phyllodecta*. These Flea Beetles are smaller than the latter ; are more roundly oval in shape, and may be recognised by their reddish-golden thorax, which shows a transverse depression. They get their name of Flea Beetles from their habit of jumping when disturbed. Their life histories are not fully known.

Of the insects attacking the wood of the stem and branches two Longicorn Beetles belonging to the family Lamiidæ are injurious to poplars in Britain, namely, the Large Poplar Longicorn (*Saperda carcharias* L.) and the Poplar Gall Longicorn (*Saperda populnea* L.).

The Large Poplar Longicorn is widely distributed in Britain, but is somewhat local in its occurrence. It is possible that it may increase in numbers in districts where poplars are planted on a large scale. It is one of our larger long-horned beetles, measuring about an inch in length. Its ground colour is black, but this is obscured by a thick covering of yellowish hairs. The wing-covers have two transverse bands or patches of lighter yellow hairs, a broad band near the middle and a narrow one between it and the tip. The antennæ are eleven-jointed, as long as the body in the female and longer in the male (Fig. 5).

The Large Poplar Longicorn lays its eggs in a slit cut by the female in the bark near the base of the tree. The larva on

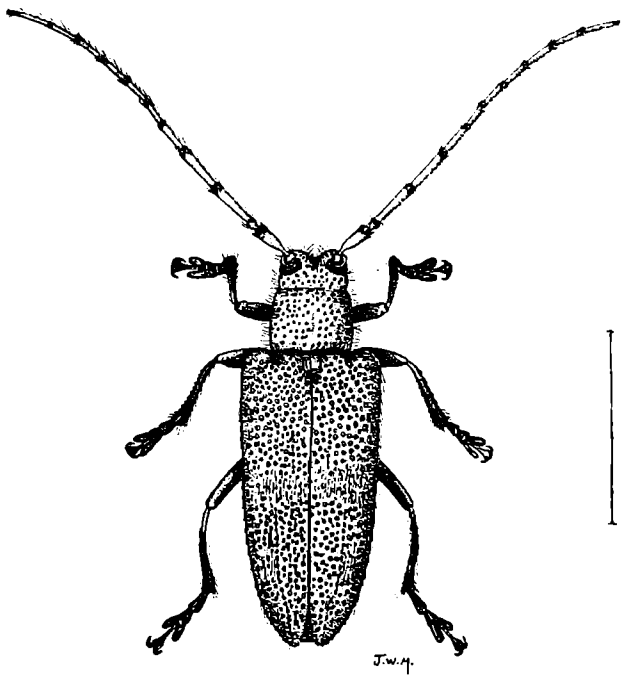

FIG. 5. *Saperda carcharias*. The line on the right shows natural size.

hatching gnaws into the bark and cambium and later, penetrating the sapwood, continues boring inside the stem for eighteen months or more. This larva is a legless, pale yellow grub, with its sides almost parallel. On the dorsal and ventral surfaces are rows of pad-like protuberances, which aid it in moving in its tunnel and in obtaining purchase in tearing the wood fibres. The last segment of the body is much narrower than the others, a character which is peculiar to the larvæ of these beetles (Fig. 6). The larva in cutting its tunnels rejects the digested wood fibres, and this excrement or "frass" projecting from the mouth of the tunnel is often the only sign of attack. When fully fed the grub pupates in a roomy chamber cut in the wood, from which an

exit tunnel leads to the outside of the stem. *Saperda carcharias* takes from two to four years to complete its life-cycle, and attacks trees from three to twenty years of age. Although the trees may not be killed by the insect the value of the timber is frequently impaired.

Remedial measures against the Large Poplar Longicorn consist in the felling and burning of attacked stems. In some cases where the injury is not severe, the larvæ may be killed by pushing a stout wire into the burrows and spearing them. They may also be fumigated by inserting small pieces of sodium or potassium cyanide into the burrows, which should afterwards be plugged with cotton wool and clay. As cyanide salts are deadly poison their use requires care. Measures for the prevention of attack have been recommended, but are less trustworthy than those which aim at the destruction of the grubs. They consist of repellent smears and washes painted on the bark of the trees, but

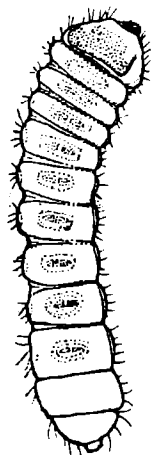

FIG. 6. Larva of *Saperda populnea*. × 6.

are liable to burn the bark of young trees if carelessly applied. They also need frequent renewal. Most of these smears have coal-tar or creosote oil as a basis, and some of them are sold as proprietary articles under various names.

The Poplar Gall Longicorn (*Saperda populnea*) is an enemy of young plantations. It lays its eggs in young branches and twigs, and the tunnelling of the larvæ in these may cause them to break over. In all cases deformation of the affected branch or shoot results. This insect resembles its near relative *S. carcharias* in general shape, but is only half as large, and is differently coloured. The ground colour is black, but this is masked by greyish-yellow hairs, which give the beetle an ashy or yellowish-grey colour. The thorax is black, with three longitudinal bands of yellow, and the wing-covers have each from three to four spots or patches of dense yellow hairs (Fig. 7). The pest is common only in the Midlands and South of England, where it

appears to be local in its distribution. The beetle lays its eggs in slender branches of poplars and willows. Prior to depositing its eggs the beetle cuts a series of slits in the bark, forming a horse-shoe shaped scar, within which it lays a single egg. These slits reduce or altogether stop the flow of sap past the region affected, diverting it into the other parts of the stem's circumference, and this action, together with the irritation produced by the larva in emerging from the egg, produces a swelling or galling of the shoot. Several galls and their contained larvæ may be found on one branch. Such gall formation, however, occurs only on poplar. On willow twigs little or no galling is noticeable. In the case of poplars the swelling of the gall is usually the first sign of attack; at a later stage, however, the extrusion of rejected wood fibres indicates the presence of the larva (Fig. 8). On hatching it feeds under the bark; it then

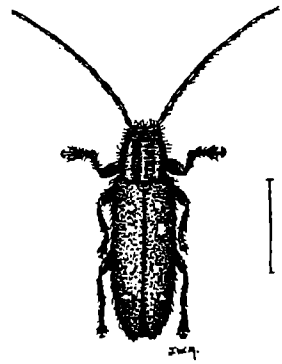

FIG. 7. *Saperda populnea.*
The line on the right shows natural size.

enters the sapwood, and finally bores up the pith, where it pupates. The life-cycle occupies two years.

A good deal of damage may be done in the retardation of growth and deformation of the leading shoots and branches. Remedial measures consist in the cutting off and burning of gall shoots and branches. Woodpeckers are useful in destroying *Saperda* larvæ, and the marks of their work in extracting the grubs from the galls is evident in many poplar copses in the Surrey district. At Esher, in Surrey, *S. populnea* larvæ are frequently parasitised by a Tachinid parasite (*Billæa irrorata* Mg.), which may also occur in other districts. Its small brown, barrel-shaped cocoons may be found by opening the galls in autumn and winter.

The Willow or Osier Weevil (*Cryptorhynchus lapathi* L.), a well-known enemy of osiers, is also at times harmful to poplars. In the United States of America it has, in fact, proved a serious pest in poplar nurseries and plantations, and while, in the absence of extensive plantations of poplar in Britain, its capacity for injury under British conditions is uncertain, it must, nevertheless,

be regarded with suspicion. It belongs to the Curculionidæ, beetles which have the head prolonged into a snout or rostrum, and are pre-eminently plant feeders. It is a somewhat conspicuous insect owing to its variegated colouring, and measures from $\frac{1}{3}$ to $\frac{1}{2}$ an inch in length. The ground colour is black, with dense scales of black and pink, or pale yellow. The thorax is black with a sprinkling of paler scales. The wing-covers are parti-coloured, the basal two-thirds being black with a transverse band of paler or pinkish scales, the apical third pinkish. Dense tufts

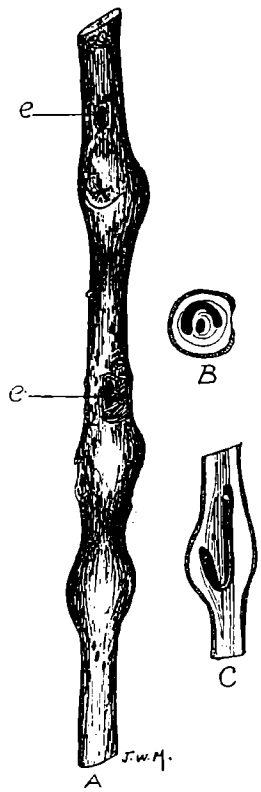

FIG. 8. Galls of *Saperda populnea*. × $\frac{1}{2}$.
A. Shows the galls and woodpecker work (e).
B. Shows a gall in cross section.
C. Shows a gall in longitudinal section, exposing the larval tunnels.

of black, scale-like bristles occurring on the thorax and the wing-covers give the beetle a warty appearance (Fig. 9). The snout is curved and the antennæ, which are inserted about the middle, are elbowed. When at rest the insect draws its snout into a groove between the front pair of legs. This habit gives the beetle its name of " Cryptorhynchus " or " hidden snout."

The Osier Weevil has a variety of host plants. Alders and willows are the most usual of these, but birches and poplars are also attacked. The following poplars are recorded as having

suffered : *P. balsamifera* L., *P. alba* L., and *P. deltoidea* Marsh. The beetle attacks trees of two years' old and upwards and may be very destructive. *C. lapathi* is widely distributed in Britain, but is curiously local in its occurrence. Its life history in Britain is not definitely known. It may take one or two years to complete its life-cycle. The adult beetles spend the winter in their tunnels, emerging in spring, when they pair and commence egg-laying. Pairing and egg-laying may continue throughout the summer. The eggs are laid in a small hole bored by the insect in the bark, but it is uncertain whether they hatch soon after being laid or not until the following spring. The larva of *Cryptorhynchus* is a typical weevil grub, legless, with a wrinkled, curved body of a yellowish-white colour. The head is darker and the jaws are brown. On hatching the larva feeds for a time just under the bark, girdling the stem and later penetrating the sapwood. In this it bores a tunnel two to four inches in length. The tunnels

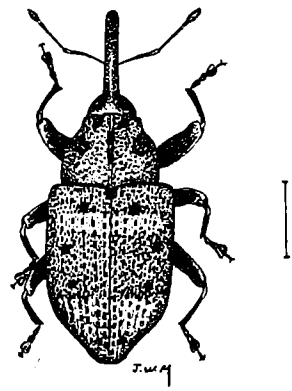

FIG. 9. *Cryptorhynchus lapathi*. The line on the right shows natural size.

usually run vertically, but in some cases the grub may reverse its direction, producing a hook-shaped tunnel. The larvæ pupate in their tunnels with the head facing the direction of exit. Two broods in three years may be produced in some districts.

The removal and burning of infested stems is the only efficient remedial measure against this pest. Painting the trees with carbolineum has proved effective in America.

The Hornet Clearwing (*Sesia* (*Trochilium*) *bembeciformis*), commonly attacks willows, but is sometimes injurious to poplars, its caterpillar causing damage which is similar to that caused by the Large Poplar Longicorn. The moth measures about 1½ inches across the expanded wings, and in colouring somewhat resembles a hornet or wasp (Fig. 10). The female moth lays its eggs, as a rule, at the base of the tree and the caterpillars on hatching feed in the bark and crambium. Later they enter the wood, tunnelling it for a considerable distance in a vertical direction (Fig. 11). The early work of the larva is also injurious, as it

reduces the sap-flow. The caterpillar is pale yellow in colour and has three pairs of jointed legs on the thorax and five pairs of pad-like feet on the abdomen. It can thus be readily

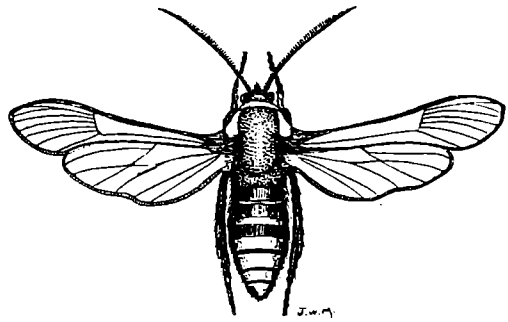

FIG. 10. Hornet Clearwing. × 2.

distinguished from the grub of the Poplar Longicorn Beetle. The life-cycle of the Hornet Clearwing extends over two years.

Remedial measures against this moth are similar to those recommended for the Large Poplar Longicorn, but as the caterpillars of the Clearwing may occur in the roots special care should be taken to grub these up.

The caterpillar of the Goat Moth (*Cossus ligniperda* L.) causes injuries to various trees, including poplars, which are similar to

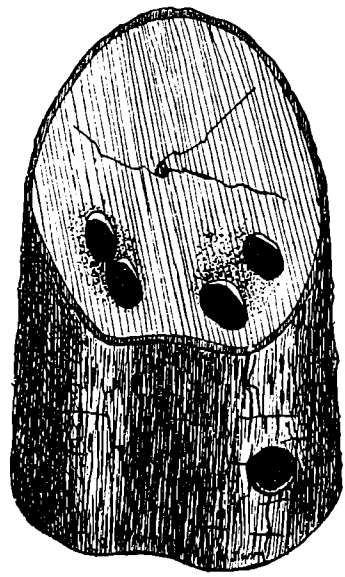

FIG. 11. Base of poplar stem, showing tunnels of Hornet Clearwing. Slightly reduced.

those caused by the Hornet Clearwing. As, however, the Goat Moth caterpillars may occur in considerable numbers in a single

stem, and as they attain a large size more damage is done. The Goat Moth is one of our largest and heaviest moths, measuring over 3 inches across the expanded wings. The forewings are pale brown, mottled with ashy grey, and have numerous irregular black streaks and marks; the hind wings are darker greyish-brown. The thorax is densely hairy, brown and grey in front, with a darker band behind. The abdomen is grey with paler rings (Fig. 12). The female moth lays its eggs in clusters in crevices of the bark near the base of the tree.

Isolated or avenue trees or trees on the margins of plantations are preferred by the moth to trees in close stands, though these

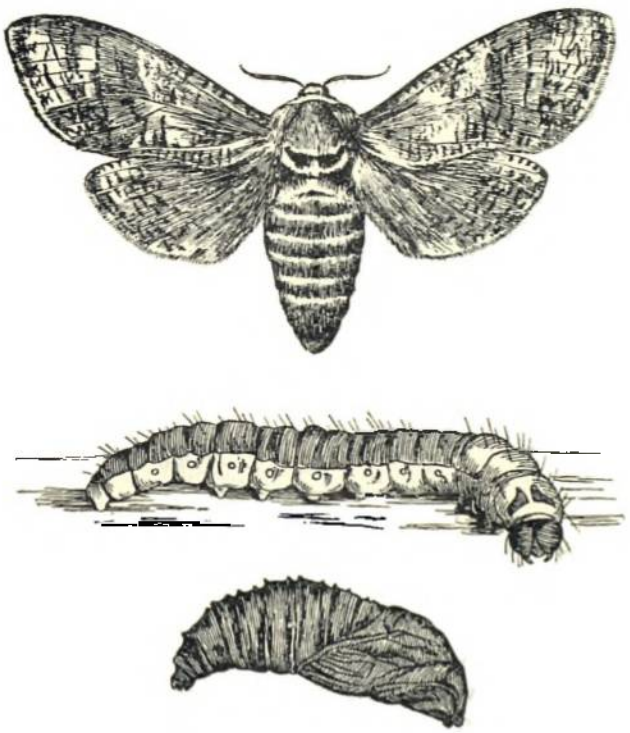

FIG. 12. Goat Moth, larva and pupa, all natural size. The larva is not fully grown. (*Reproduced, by permission, from Leaflet No. 60 of the Ministry of Agriculture and Fisheries.*)

also may be attacked. The caterpillars on hatching feed for a time under the bark, but later enter the wood. Their tunnels are usually oval in cross-section, owing to the flattened shape of the caterpillars' bodies. The caterpillars are at first pinkish in colour, but later become reddish-purple, with yellow sides and under-parts. The head is black and the segment immediately behind it bears a dark plate. When full grown the caterpillar gnaws a tunnel to the outside of the tree and pupates, and prior to the emergence of the moth the pupa is frequently found projecting from the stem. The life-cycle occupies from two to four years and appears to vary with the district and climate.

Remedial measures against the Goat Moth are the cutting out and burning of infested trees and the fumigation of the caterpillars by means of cyanide as described for the Poplar Longicorn Beetle (p. 40). As the tunnels of the Goat Moth caterpillar are frequently irregular it is not always possible to destroy the caterpillars by probing the tunnels with wire.

The Leopard Moth (*Zeuzera æsculi*), like the Goat Moth, attacks a number of different kinds of trees, including poplars. It appears to be local in its distribution and is not uncommon in the London district. The moth measures 2 to 3 inches in wing expanse. The forewings are white, with blue-black spots, the hind-wings are also white, with the spots fainter. The thorax is white, with three pairs of spots on each side and a small mark between the last of these (Fig. 13). The Leopard Moth lays its eggs singly on stems and branches in June and July. The caterpillar at first bores into the bark and in spring burrows into the

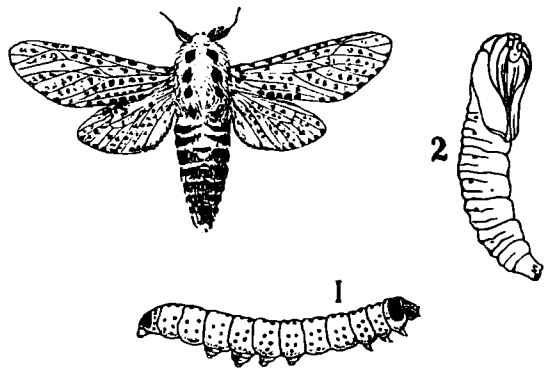

FIG. 13. Male Wood Leopard Moth : (1) Caterpillar ; (2) Chrysalis. All natural size. (*Reproduced, by permission, from Leaflet No.* 60 *of the Ministry of Agriculture and Fisheries.*)

sapwood, cutting a vertical tunnel 6 to 8 inches long. The caterpillar is yellowish-white in colour, with rows of black spots. The segment behind the head bears a black plate and the last segment is black. The life-cycle occupies from two to three years. The remedial measures recommended for the Hornet Clearwing apply to the Leopard Moth.

The following insects while they cause little injury to poplars, frequently attract attention, and on that account are worthy of notice here :—

Two aphides cause galls or swellings on the leaf-stalks and occasionally appear in large numbers. One of these, *Pemphigus spirothecæ* Pass., causes the formation of a spiral gall on the petiole. Within this the aphides are found. The gall is often prettily coloured and opens when mature. *Pemphigus bursarius* L. causes a pouch-shaped gall on the petiole. The gall is rounded and has an opening to one side. The aphides live within it. A third species, *P. affinis* Kalt., causes distortion of

the leaf. The leaf-margins roll up and blister and enclose the aphides.

A small Tortrix moth, *Gypsonoma aceriana*, causes swellings on the young shoots and sometimes bores into the twig. It occasionally causes distortion of the shoot, but appears to be of small importance from the timber producer's point of view.

A bark beetle, *Cryphalus* (*Trypophlœus*) *binodulus*, cuts its egg-tunnels in sickly and dying poplars. It appears to be strictly local in its occurrence in Britain, and is so far as is at present known of little importance. It is, however, worthy of attention. In France in the valleys of the Somme and Oise, the Elm Bark Beetle, *Scolytus destructor*, has been recorded by Breton-Bonnard as attacking poplar.

The wood-wasp, *Xiphydria dromedarius* F., lays its eggs in dying and felled poplar stems, causing considerable damage owing to the tunnels made by its larvæ. It is considered of somewhat rare occurrence in Britain, but is probably more widely distributed than is supposed.

Fungus and Bacterial Diseases of Poplars.

The following organisms, which are the cause of cankers on poplars of various species, are of sufficient economic importance to warrant special mention :—

(i) canker due to a bacterium *Micrococcus Populi ;*

(ii) canker and die-back due to *Dothichiza populea ;*

(iii) canker and die-back due to *Cytospora chrysosperma.*

Micrococcus Populi Delacroix.—The canker caused by this bacterium has only, as yet, been found on *Populus regenerata*, and is only known in France, Belgium and Italy. The first indication of the disease on young stems is the appearance on the bark of elongated oblong spots which are distinguished by their yellow colour. The bark is subsequently ruptured, and the canker spreads both longitudinally and transversely and becomes sunken in the middle. The border is then very rough, with thin longitudinal excrescences. This disease has not yet been reported in Britain, possibly due to the fact that *P. regenerata* has only been cultivated here on a very small scale, but every effort should be made to prevent its introduction. If the disease is found in this country all infected parts of the tree or trees should be immediately removed and burned.

Dothichiza populea Sacc. et Briard.—This fungus causes disease on several species of poplar in France, Italy and in the United States. In France it is chiefly found on *Populus angulata* ; in Italy it attacks *Populus deltoidea* ; while in America it occurs on *Populus nigra*, especially the Lombardy variety (*Populus nigra*, var. *italica*), and other species, including the Black Italian Poplar (*Populus serotina*). Fructifications of this fungus have

been found on dead branches associated with cankers on trees of Black Italian Poplar in a Lincolnshire plantation, and also on some trees in Berkshire (Fig. 14). Apart from these instances *Dothichiza* cankers have not been reported in Britain.

Infection takes place through wounds. The bark in the infected area turns yellow and, by the collapse of the cells underneath the spot, becomes depressed. These spots rapidly grow larger and frequently several coalesce. Later the patches become paler and greyish-white in colour, and at this stage the reproductive bodies appear. These are round, irregular black cushions (pycnidia). They are formed under the thin papery bark, which becomes ruptured, leaving the frayed edges standing erect round the pycnidium, the exposed part of which is flat and dull on the surface. The upper part of the pycnidium breaks away by an irregular cleavage and the spores are exposed in a pale, jelly-like mass, which swells in wet weather. In dry weather these masses contract and harden and probably the spores are blown away singly. The external appearance of a diseased stem varies greatly. Sometimes the infected area is cut off by a cork layer before the mycelium reaches the wood, in which case little harm is done ; but if the mycelium reaches the wood it generally causes a typical canker, not unlike that produced by *Micrococcus Populi* The fungus is not a virulent parasite and is incapable of killing vigorous trees, but trees of any age growing under unsuitable conditions are liable to suffer more or less damage when attacked. Thus it is common in nurseries and young plantations on slips which have not yet developed an adequate root system. Old trees are liable to attack when growing on too dry or on waterlogged soil. This canker can best be avoided by growing poplars on land which is at the same time retentive of water and adequately drained. Cuttings should not be taken from trees which are cankered or from infected areas. When cuttings are bought they should be carefully examined for incipient cankers and any which are affected should be destroyed. In plantations in which the canker has appeared it is worth while to collect and destroy all cast branches, as the fungus grows rapidly on dead poplar branches and spores from them may infect growing trees.

Cytospora chrysosperma (Pers.) Fr.—This fungus has been reported in America as a cause of disease on many species of broad-leaved trees, especially poplars and willows. In Britain it occurs as a parasite on cricket-bat willow and as a saprophyte on other species, but it has not so far been recorded as a parasite on poplars. The first sign of attack is the appearance of small, frequently irregular, dead patches on the bark, which become slightly sunken ; these patches enlarge until the branch is girdled and thereby killed. Cankers are only formed where the spread of the fungus is restricted to a few inches in each year and the tree is constantly attempting to heal the wound. Fructifications of the fungus may be found at any time of the year on dead

FIG. 14.—Canker on Black Italian Poplar caused by *Dothichiza populea*.

[To face p. 48.

twigs still covered with bark, or on the bark covering a canker. They appear as fine black points piercing the bark (quite different from the broad, flat fructifications of *Dothichiza populea*). Yellow threads of mucilage, about $\frac{1}{8}$ inch in length, may be seen to emerge from these points in wet weather. On sectioning the bark parallel to its surface the black points are seen to connect by a tube with nearly circular, chambered pycnidia. In America the disease is worse where poplar trees are growing under unsuitable conditions. Severe pruning, such as pollarding, renders trees susceptible. Like *Dothichiza* the disease is also liable to attack recently planted trees or cuttings. The same control measures as are suggested above for *Dothichiza* may be adopted.

In the several cankers dealt with the species causing the damage cannot be definitely ascertained until the fructifications have appeared.

The following diseases of poplars are also sufficiently important to demand attention :—

Armillaria mellea.—The roots of poplars in overcrowded stands are liable to be attacked by this fungus.*

Polyporus sulfureus.—This fungus is easily recognised in summer by its large, soft bracket-shaped fructifications, which are orange-red on the upper side, and sulphur yellow on the lower side ; the latter is pierced by innumerable fine holes. Attacked wood exhibits a red rot and longitudinal and transverse cracks, caused by contraction, which become filled with white, felty mycelium.

Fomes igniarius (False tinder fungus).—This fungus also produces bracket-shaped fructifications, but these are perennial and very hard, brown or grey in colour, hoof-shaped or flattened, with a very rounded margin. Attacked wood becomes soft and remains yellowish-white in colour.

Pleurotus ostreatus.—The fructification of this fungus is bracket-shaped and bears white gills on the lower side. It also causes a white rot in poplar wood.

Most of these wood-rotting fungi enter the tree through large wounds, such as are caused by the fall of branches. Consequently they are found most commonly on more or less isolated trees which develop large branches and are subject to wind damage.

There are certain leaf diseases of poplars, but none of these is sufficiently virulent to cause serious damage to the trees.

Exoascus aureus Pers. causes bladder-like deformations in the leaves of *Populus nigra* and other species. The fructifications of the fungus are borne on the concave surface of the depression and they give to this surface a bright golden colour, from which the fungus derives its specific name.

Rusts.—The only rusts which are known to attack poplars in Britain are species of the genus *Melampsora*. All these are

* For a description of *Armillaria mellea* (Honey Fungus), *see* Forestry Commission's Leaflet No. 6.

heteroecious, i.e., they complete their life-cycle on a second or intermediate host. During the summer the disease may be carried from one poplar to another by means of uredospores, and it is only in the spring that the intermediate host is necessary. Hence leaf rust may be common on poplars in localities where the intermediate host is infrequent. The rust gives the leaves a generally yellowish appearance, as numerous little bright orange-red or yellowish spots are formed on the lower surface of the leaves. These spots are less frequent on the upper side of the leaves.

The intermediate hosts of interest to the forester are the larch and the Scots pine. The life history is a somewhat complicated one, but, shortly put, the larch leaves, which are attacked in the spring, bear small yellow fructifications containing the secondary spore form which reinfects the poplar. In the case of the Scots pine it is the shoot which is attacked and deformed. However, no record of such infection of Scots pine exists in Britain, although the poplar stage of the fungus is known.

CHAPTER IV.

CHARACTER AND USES OF POPLAR TIMBER.

The poplars belong to a group of timbers characterised by light, soft wood ; a group that includes also horse-chestnut, lime, alder, willow, silver fir and spruce.

The general characters of poplar wood are :—

Wood odourless, not strong, woolly, straight-grained, white, pale brown or light red, in some species showing no distinct difference in colour between heart-wood and sap-wood. Dry weight variable, usually between 23 and 34 lb. per cubic foot. Live knots are firmly fixed, harder than normal wood, and cause considerable derangement of structure. Dead knots are often loose and surrounded by decaying wood. Burrs, characterised by very intricate structure, are common in some species.

With the aid of a pocket lens the following characters may be observed :—Annual rings faint, autumn wood very narrow in comparison to summer wood. Pores, as seen in transverse section, small, numerous, evenly distributed, rather smaller in the aspen than in other groups of the genus ; in the tangential section appearing as faint irregular lines or scratches. Medullary rays numerous, very fine, invisible to the naked eye, but easily seen with a lens, giving no pronounced " figure " to the radial or quarter-cut surface. Ripple marks (butterfly grain) fairly common on the tangential surface as irregular-shaped lustrous bands. Pith flecks common. Small dark marks are present in some species, either as isolated dots or in groups. These are often caused by the occlusion of epicormic shoots.

Poplar wood can be easily distinguished from silver fir and spruce by the presence of pores ; from alder by its lighter colour ; from lime by the broader and firmer medullary rays of the latter, which are very distinct on the radial surface ; and from both lime and horse-chestnut by its woolly character, and less satiny finish under the plane. From willow it can only be distinguished by microscopic examination.

Poplar wood is easily dented, but does not readily fracture, while there is a tendency for small holes to close up. Its woolly character makes it difficult to cut with a closely-set saw, and it takes the edge off saw and plane fairly quickly. It splits easily, however, takes glue, paint and polish well, and holds nails excellently. The wood is one of the least inflammable of home-grown timbers, absorbs moisture rather quickly, decays rapidly in contact with the soil or in damp places, but stands well under cover. In a close atmosphere it is as liable to early attack by dry rot as the softest pine. Although not normally a building timber, it can be utilised in building operations where great strength is unnecessary. Until thoroughly seasoned there is a good deal of shrinkage, and green timber cut into planks warps badly if not carefully stacked. After it has been properly seasoned there is little fear of serious warping during manufacture.

Poplar wood can be utilised for many purposes, notably for box-boards, packing-cases, flooring boards, ply-wood, the bottoms of carts and trucks, tubs, dry cooperage, fence rails, fence posts (when creosoted), matches and match boxes, wood-wool, paper pulp, strawberry baskets, brake blocks, bowls and other articles of turnery, the heels of boots, sabots, butchers' trays and for glass polishing.

Although it has been proved that poplar wood can be grown in the British Isles suitable for any of the required purposes, much of that utilised at the present time by the largest manufacturers is imported. Foresters should realise that manufacturers require definite sizes and qualities of wood and are quite prepared to take timber of home production provided it has the necessary qualities. Manufacturers cannot be blamed for placing orders outside the country if by so doing they can obtain timber more suitable for their purpose than that of home growth. The supply of a few samples of really good home-grown timber followed by consignments of inferior quality are valueless to the manufacturer ; he must be able to secure a regular supply in the species, sizes and qualities necessary for his work, and if forestry in the British Isles is to become a real living business, foresters must make up their minds to produce the kind of timber required by the manufacturer, and not to expect the latter to be content with anything they may choose to offer. Neither will it do to supply a few thousand feet of excellent timber of a certain species, and when a further supply is required, fill the order with wood of a closely allied species. As in other genera, so in poplar, each kind should be marketed alone, for although the wood of two

allied species, or a hybrid and a species, may be indistinguishable, they may possess very different working and wearing qualities. In an allied genus this difference is very noticeable in the cricket-bat willow. In that tree we have a hybrid between *Salix alba* and *Salix fragilis*, with timber infinitely superior to either parent for the manufacture of bats, and if such a quality appears in a hybrid willow, it may very well occur also in a hybrid poplar. Moreover, whilst the wood of two distinct species or a species and a hybrid may answer equally well for a definite purpose when used alone, they may be quite unsuitable, owing to unequal wear, if mixed. This can be illustrated in pulley manufacture. A pulley is built up of numerous small sections of wood. If these do not wear equally, the smooth surface so necessary for the even running of the belting with the minimum of friction soon disappears and the usefulness of the pulley is spent. Again, *Populus tremula* is regarded as the most suitable species for matches, although the wood of *P. alba* and *P. serotina* can also be used.

Therefore, although there are many kinds of poplar suitable for planting for commercial purposes in the British Isles, and several of them grow equally well, it would be unwise for intending planters to mix them. If a grower can plant 5,000 trees it would be better to rely upon one, or at the most two, kinds rather than plant a mixture of a dozen species. This will enable him to produce timber of a uniform quality, and manufacturers will come to rely upon his produce.

The timber of the various species is usually marketed as poplar without any attempt at differentiation, although they are sometimes grouped as "aspen," "white poplar," and "black poplar." In the following notes reference is made to the more important species:—

Aspen (*Populus tremula*).—This is one of the most useful species. The wood, except in very old trees, is white, straight-grained, and splits easily and cleanly. It is extensively used in the manufacture of match-sticks, match-boxes, strawberry and other fruit and flower baskets, wood-wool, veneer, turnery, dry cooperage, boxes, pails, carving, paper pulp, and other objects. For matches, match boxes, baskets, and for wood-wool, only the best quality timber can be used. It must be free from knots, discoloration, and disease, and be straight-grained. Most of the wood used in this country is imported from Northern Russia, and it usually arrives in lengths of 7 to 9 feet, with a diameter of 8 to 16 inches. The larger dimensions are most profitable for the match industry, but wood of smaller diameter can be used for wood wool and for fruit baskets. Home-grown timber has been found to be quite suitable for these purposes, but it is difficult to procure in the right sizes. For other purposes the timber of less perfect trees can be utilised, and wood of small dimensions can be used for pulp for the manufacture of paper and for cellulose. Providing the right quality of wood is produced, there would appear to be every prospect of a good and continuous outlet for

the match, fruit basket and wood-wool industries, whilst the same class of wood could be utilised for other purposes if desired. Although a good deal of wood-wool is manufactured from spruce, that made from aspen is of superior quality and commands a higher price. In addition to its increasing value as packing material, wood-wool is used very extensively as a stuffing material in upholstery, and requirements are likely to be greatly extended in the future. In America the substance is often marketed under the name of " excelsior," and a good deal of American aspen is put to this use.

White Poplar.—Two species, *Populus alba* (White Poplar or Abele) and *Populus canescens* (Grey Poplar), are included under this term, although the wood of the two trees should be kept separate. The wood can be utilised for most of the purposes for which aspen is used, but as the heart-wood of old trees has a distinctly reddish tinge it is not suitable for objects where colour is one of the deciding factors of quality. As both trees grow to a larger size than aspen the timber can be used for purposes for which that wood is too small, and it enters into wheelwrights' work, coach building, floor boards, box wood, furniture and carving. Of the two trees it is probable that *P. canescens* would prove the more profitable. Timber from comparatively young, but not too quickly grown, trees is most suitable for work that entails splitting into small dimensions or cutting into veneer. Clean and moderately slow grown wood has been found suitable for the match industry.

Black Poplar.—As at present applied in this country this term includes timber of any poplar other than *P. tremula*, *P. alba* and *P. canescens*, but most of the black poplar is provided by two trees, *Populus nigra* var. *betulifolia* (English Black Poplar) and *Populus serotina* (Black Italian Poplar). The typical *P. nigra* is less well known in the British Isles than the variety *betulifolia*, whereas *P. nigra* var. *italica* (Lombardy Poplar) is of practically no value as a timber tree, the wood being very coarse and knotty. The mixing of these trees by both foresters and timber merchants has doubtless a great deal to do with the inequality of consignments of timber supplied to manufacturers, and explains in a great measure why manufacturers find certain planks from a parcel of timber much more suitable for their work than others, although all appear to be of equal quality. In what proportion the different trees stand to each other in the production of timber it is difficult to say. The timber at present realises 10*d.* to 1*s.* a cubic foot in the forest, but as this price includes trees in their prime and over-aged trees it is probably below what would be received for wholly first-class wood.

The timber of old trees is often coarse and knotty, with discoloured and decayed areas, but these defects are usually due to faulty treatment. Providing proper care has been bestowed upon the removal of lower branches, the timber of trees fifty years of age or even more may be clean and white throughout. The

stems of well-tended trees are very cylindrical, thus lengths of six to eight feet can be cut showing little variation in diameter at the two ends. Such wood is excellent for cutting into veneer for ply-wood or as a base for fancy cabinet woods. It is also useful for coach building, for the bottoms of carts, colliery tubs in which the coal is brought from the seam to the surface, for flooring boards, to some extent for building purposes, brake blocks, glass polishing, and for other purposes. The best grades have been successfully used in the manufacture of matches and for wood wool, but experiments are needed to determine which is the best tree and the most suitable age for cutting for these purposes. Of well-known kinds *P. serotina* appears to be the best for general planting.

In the United States poplar wood is used very extensively for box and crate making, and it is probable that a great deal of poplar wood will be utilised for similar purposes in this country. Poplar wood boxes withstand a good deal of rough handling; moreover, there is no odour to affect fruit or fats, such as lard and butter. The manufacture of potato barrels would appear to offer another outlet for the wood, as the use of these instead of the old familiar willow hampers is becoming more popular year by year.

A further possible use of small-sized poplar timber is for pitwood. Some tests carried out in a Midlothian colliery with poles of *P. trichocarpa* supplied by Colonel F. R. S. Balfour gave encouraging results. The report of the colliery manager states that the poles seem to be quite suitable for props, especially if they are withdrawn as the coal face advances. Crushing tests were also made by Professor Hudson Beare, of Edinburgh, on poles of the same species of 3 to 5 inches diameter; these stood a crushing load of 2,200 to 2,400 lbs. per sq. in.

For flooring boards the wood might be extensively used instead of pine, for it is of clean appearance, stands well, and is less inflammable than the woods usually used for the purpose. It was at one time in request more than at present for structural work in farm buildings, and for mangers, feeding troughs and racks, while barn floors were often made of poplar wood when flail threshing was in vogue, as the wood withstood the continued beating better than the majority of timbers. In addition to its use as flooring in dwelling houses, it might be used more extensively than at present for indoor finish, particularly for mantel-pieces and other woodwork exposed to open fires. Turnery will continue to take a quantity of timber, whilst there are many minor uses, such as the manufacture of toys, pulleys, clogs, heels for boots, household and shop requisites, etc., that will absorb a regular supply. As is the case with other poplars, the black kinds are excellent for pulp wood and a good deal could be utilised in the production of cellulose and paper. Poplar wood has been used for fencing, although not a first-class wood for the purpose. Branches from which the bark has been removed have been known to last

indefinitely as rails for strengthening hedges, but they lack strength for a continuous fence. On the other hand, stout posts inserted in the ground may rot and break off in eighteen months, whereas similar posts treated with creosote before insertion remain sound after being many years in the ground.

The timber of certain other species referred to in this bulletin is of importance in the countries to which the trees belong, but up to the present time there has not been an opportunity of testing them, except as isolated trees.

Of the newer hybrids *Populus Eugenei* is one of the best known. It has been widely grown in France for many years, and from the way in which it thrives as an ornamental tree in this country it will doubtless become valuable from a commercial standpoint. The timber is known to be of good quality and, as the branches are small, the wood is not likely to be so knotty as that from larger branched trees.

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