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EDITING COMMITTEE

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EDITORIAL

Royal Visit to the Forest of Dean

Her Majesty the Queen, accompanied by H.R.H. Prince Philip, received a tremendous reception on arrival at the historic Speech House in the Forest of Dean on April 24th. The Royal party was greeted by the Lord Lieutenant of Gloucestershire, the Duke of Beaufort, and he presented the Senior Verderer of the Forest, Lord Bledisloe, who is now 90 years of age and has held the office for almost 50 years. Also honoured to meet The Queen were other Verderers and officials including our Deputy-Surveyor, Mr. Sanzen Baker.

Her Majesty and His Royal Highness each planted an oak tree near the Speech House. These two young trees were grown from acorns from a tree planted at the same Speech House by H.R.H. Prince Albert in 1861, which tree was itself grown from an acorn produced by the famous royal tree at Panshanger Park, near Hereford, planted by Queen Elizabeth the First.

Honours

In the Birthday Honours for 1957 Mr. A. H. H. Ross, who recently retired from the post of Director, Scotland, became a Commander of the Order of the British Empire (C.B.E.) in recognition of his services to forestry.

Head Forester A. A. Parry, who started with the Commission in 1927 and who, since 1949, has been in charge of the five forests in the Isle of Wight, has received the M.B.E.

Head Forester J. M. Reid, who worked for many years at Ardgartan in Argyll, and is now in charge of the Forest of Ae near Dumfries, has also received the award of an M.B.E.

The Commissioners

There have been several changes in the composition of the Forestry Commission during the past year. Mr. J. M. Bannerman, O.B.E., who had served as a Commissioner since 1942, retired on the expiry of his latest term of office: Mr. Bannerman has also served on the Commission's National Committee for Scotland, and on the Scottish National Forest Parks Advisory Committee, and he is well known for his work—as Chairman of An Comunn Gaidhleach—in the promotion of Gaelic speech and music. Mr. Stanley C. Longhurst also retired on the conclusion of six years' service. The new Commissioners are Mr. Robert Taylor, J.P., who has been associated with the Trade Union movement in Scotland, and Mr. Edward Bryan Latham, who is well known as a member of the timber trade in London.

The Commission is now constituted as follows :—

The Earl of Radnor, K.C.V.O. *Chairman*
Major D. C. Bowser, O.B.E.
Lt. Col. Sir Richard Cotterell, Bt., J.P.
Mr. A. P. F. Hamilton, C.I.E., O.B.E., M.C.
Mr. Lloyd O. Owen, J.P.
Major Sir John Stirling of Fairburn, K.T., M.B.E.
Mr. W. H. Vaughan, C.B.E., J.P.
Mr. Robert Taylor, J.P.
Mr. Edward Bryan Latham
Mr. H. A. Turner, *Secretary*

Mr. W. H. Vaughan, who already held the O.B.E., has been promoted to Commander of the British Empire (C.B.E.) in recognition of his services to Wales, which have included ten years' work as a Forestry Commissioner and member of the National Committee.

We regret to report the death of Lord Clinton, a leading woodland landowner in Devon. Lord Clinton was one of the original Commissioners appointed under the Forestry Act in 1919, and served as Chairman from 1927 to 1930.

Promotions and Transfers

Mr. G. I. Mackenzie, who was formerly a Divisional Officer in West Scotland, has been promoted to Conservator and is now stationed at Headquarters in London.

Mr. T. A. Robbie, formerly a District Officer in East Scotland, has been promoted to Divisional Officer and now has charge of the Commission forests in the westerly portion of the West Conservancy, Scotland.

Mr. J. B. Wharam, a Senior Executive Officer with the Work Study Section. is now stationed at Dolgelley.

Mr. F. C. Redd, formerly Chief Clerk in the office of the Deputy Surveyor Dean Forest, has moved to the South-West Conservancy Office at Bristol. His place in the Dean has been taken by Mr. M. A. E. Gubby, who was formerly at Aberystwyth.

Retirements

Mr. F. E. B. de Uphaugh, Divisional Officer in the New Forest since 1950, retired after 30 years' service with the Commission. Before going to the New Forest he had served at Thetford and in South East England.

District Officer D. L. Shaw retired after 32 years' service with the Commission in North Wales. He worked as a Forester at Tintern for a year, then transferred to Gwydyr where he became Head Forester and, in 1940, District Officer. Later he was appointed Private Woodlands Officer for the Conservancy.

Two Head Foresters went into retirement: Head Forester A. E. Walker of the Forest of Dean retired on his 65th birthday after serving with the Office of Woods and the Forestry Commission for a total of 51 years. Mr. John F. Macintyre, B.E.M. retired from the post of Head Forester, Newcastleton Forest, South Scotland. Starting with the Commission in 1920 he went to a bleak and treeless stretch of Border country which the years and patient toil have clothed with the spruces, pines, and larches that comprise Newcastleton Forest today. He will be remembered for his kindness and consideration, as also will be Mrs. Macintyre who throughout the years must have dispensed thousands of cups of tea and home-baked scones to the Commission people who " . . . dropped in to see Mac.".

Mr. S. M. O. Mackenzie, a Higher Executive Officer in the Finance Branch at Headquarters, retired in April 1957 after thirty-five years' service in the Commission. Mr. Mackenzie's duties in recent years included the payment of all monthly salaries throughout the country, and in this capacity he was regarded by many of us as the most important member of the staff!

The Seventh British Commonwealth Conference, 1957

This Conference was held in Australia and New Zealand and opened in August, 1957. The United Kingdom delegation, led by the Director-General, Sir Arthur Gosling, included Mr. James Macdonald, Director of Research and

Education; Mr. G. B. Ryle, Director of Forestry for Wales; and Mr. C. D. Begley, the Secretary of the Conference Standing Committee.

Other members of the delegation were the Colonial Office Forestry Adviser, Mr. Christopher Swabey, Dr. F. Y. Henderson, Director of the Forest Products Research Laboratory; Mr. R. G. Miller, Deputy Director, Forest Air Survey Centre, Directorate of Colonial Surveys, and, as an associate delegate, Professor Mark L. Anderson of Edinburgh University. The Imperial Forestry Institute, Oxford, was represented by Sir Harry Champion; the Commonwealth Forestry Bureau by Mr. F. C. Ford Robertson; and the Empire Forestry Conference by Mr. W. MacFarlane Robertson.

Articles on their experiences in the southern hemisphere, by Messrs. Begley and Ryle, will be found on pages 6 and 14.

Visit to Russia

Three officers, Divisional Officer E. G. Richards, Utilisation Section; Divisional Officer J. W. L. Zehetmayr, Work Study Section; and Col. R. G. Shaw, Machinery Research Officer, set off in September for the U.S.S.R. to attend a Joint F.A.O./E.C.E. Committee on forest working techniques and forest workers training from 9-14th September. This was followed by a study tour for about two weeks, based on Moscow and Leningrad. Visits included timber research establishments and timber production units, with one "off-duty" event, a visit to the Kremlin.

An article on this visit, by Colonel Shaw, will be found on page 21.

The First Hundred Thousand Acres in North Wales

A commemorative stone to mark the completion of the first 100,000 acres planted in the North Wales Conservancy was unveiled by Mr. Henry Brooke, Minister for Welsh Affairs, at Gwydyr Forest on 24th September 1957. Lord Radnor and Mr. F. C. Best, the Conservator, greeted the guests. After the unveiling ceremony, trees were planted to mark the event and there was penillion inging.

It was at Gwydyr Forest, in 1921, that the Commission's first planting in North Wales took place. Today Gwydyr is one of the largest forest areas in North Wales, covering 20,000 acres. When fully productive the annual thinning output will rise to one million hoppus feet.

The following day the Minister travelled to Queensferry in Flintshire to open the new insulation board mill of J. R. Gordon and Company, Ltd. which is making use of large quantities of thinnings from our forests in North Wales and Northern England.

National Forest Parks

During the summer of 1957, two camping grounds were opened in the National Forest Parks. One is in the Queen Elizabeth Forest Park in Scotland, being situated on the eastern shore of Loch Lomond, in Rowardennan Forest. The other, in the Border National Forest Park, is at Lewisburn in the heart of Kielder Forest. Already both have proved popular with campers and with caravanners.

Lyndford Hall Forester Training School

The Forester Training School at Lynford Hall in Thetford Chase Forest, having served its purpose, has been closed. Some 500 students have trained at the school since it was opened soon after the 1939-1945 war, and many now hold appointments in the Commission's forests throughout the country.

Civil Service Lifeboats

Is it widely known that the Civil Service Lifeboat Fund has contributed to the Royal National Lifeboat Institution since 1886? So far 31 lifeboats have been provided, 10 being in service, including the "Dunnet Head" at Thurso, which cost about £32,000. The Civil Service Fund operates by voluntary annual subscription, organised on a Departmental basis. The February issue of the "Slasher" appealed for a volunteer collector in every Conservancy Office. Worthwhile? Over 2,500 lives have been saved by Civil Service lifeboats. Incidentally they are all, even today, made of wood, and English oak is still chosen for the stem and the stern.

The Staff Suggestions Scheme

The Staff Suggestions Committee is continually on the look-out for new ideas that will help the Commission to carry out its work more efficiently and economically, and it offers monetary awards in appropriate circumstances. So if you have any brainwave that you think may qualify, send it along to: The Secretary, Staff Suggestions Committee, Forestry Commission, 25, Savile Row, London, W.1. The suggestion need not be typed, but it is often an advantage to attach drawings or photographs showing how the new method or machine actually works.

Please note, however, that proposals from industrial staff, which may merit monetary awards, should not be sent to Headquarters but to the Monetary Awards Committee at the appropriate Conservancy Office.

The scope of the suggestions scheme is shown by the following samples received in recent months:

(i) The use of motor horns to give code signals as part of the forest fire alarm system.

(ii) The provision of first-aid boxes at all operational centres.

(iii) A machine for bracken beating.

(iv) Labels for bags of forest tree seed, reminding people of the need to store it in a cool dry place.

(v) An improved skid pan for tushing poles, provided with serrated teeth inside to help hold them.

For various reasons, only a small proportion of the ideas received are found to merit a reward, but all receive careful scrutiny and consideration. We hope, from time to time, to include, at least in outline, selected suggestions that have come in. Ideas, as the saying goes, have legs, but we should like to speed them on their way so that they may be adopted as early as possible, wherever they will fit in.

A Glimpse of the Cowal-Ari Sawmill

Recently your editor was privileged to pay a brief visit to the new sawmill established by a commercial timber company, with the encouragement and financial support of the Commission, at Strachur in the Argyll National Forest Park. The first sign of activity was the presence of the new timber structure with its attendant stacks of logs and sawn timber, and a new group of thirty-six modern houses built by the Argyll County Council, mainly to house the sawmill workers. One of the reasons for building the mill out in Cowal, close to the forests that supply its timber, rather than in a town nearer to the firms that use its produce, was the desirability of retaining some of the population amid the western glens. It is true to say that forestry, and the sawmill, have brought new life to a lonely corner of the Highlands.

The operations of the mill itself are not easy to describe in non-technical terms. The Swedish "Ari" method is esentially a *system* of sawmilling rather than a special sort of saw. It has been designed for the rapid and economic handling of large quantities of small coniferous logs of varied sizes, and every operation is geared to keep pace with the next one in the chain. The essentials are that all logs shall be reasonably straight, and that there shall be enough of them to keep the process going continually. The range of diameters taken is from $5\frac{3}{4}$ inches minimum top to 22 inches maximum butt; and the range of lengths is 6 to 30 feet. The saws are raised one floor up above ground level, and this means that all waste, and also the finished products, are easily disposed of by gravity. It also means that every log must be carried upwards to reach the saws, and this is done by a simple endless chain or "jack ladder". Logs are fed on to this chain by workers, and it stops automatically as soon as each log reaches the first saw bench, restarting as soon as the log is removed.

There are only three groups of saws in the system, and the feed to each group is automatic. Logs always move forward, and there is no running back of a bench. However, most pieces of timber have to be returned for re-sawing, and therefore an automatic "by-pass" is provided for their speedy return. The saws are all of the circular type and cut at the high speed of 180 feet a minute. Let us follow a log through the system.

It runs through the first, or breakdown, saw, and a slab is cut off. Both log and slab are returned on the "by-pass", and the slab is sent forward on an automatic conveyor to the second saw. The log, however, has to go back through the first saw for two more cuttings, yielding three slabs in all, before it is ready to proceed to the second saw. Each sawing is so arranged as to give it a definite width in inches.

This second saw has a cunning adjustment for width of cut, and when the log reaches it, it is set as wide as possible so that when the final fourth rough side is sawn away a batten of the greatest possible cross-section is cut out. This finished batten goes out of the stream on to the pile of sawn timber, while the slab is returned on a "by-pass" for re-sawing.

It is now the turn of four *slabs* to run through the second saw, and it is therefore adjusted to give a narrower cut, so as to get the best thickness of small timber from each. The minimum thickness accepted is half an inch. Once this cutting is done, all the *slabs* have been sawn on two sides only; they still carry two rough, unsawn edges.

The slabs, therefore, must go through a further edging process, and this is done by two parallel circular saws arranged to work together so that both edges are neatly trimmed off at one time. The resulting thin and narrow pieces, suitable for such uses as packing cases, then proceed to the stock pile, where they are sorted into appropriate sizes. The rough short ends are neatly cut off with a swinging cross-cut saw, and then these short ends, together with the side trimmings, are dropped into waste bins below the main platform.

The whole business goes on continually, requiring about eight men active on the saws, others bringing in logs and stacking sawn timber, and a saw doctor constantly at work re-sharpening spare saws. Much of the timber is subsequently seasoned by a simple progressive process, whereby it passes on trucks through three chambers, each hotter and drier than the preceding one. It spends 24 hours in each chamber, thus needing 72 hours for complete kiln seasoning. The necessary heat for the kilns is derived from burning the waste wood.

Naturally the bulk of the output from this mill is in small sizes but it has proved suitable for house-building and box making, and a steady demand has arisen. It is transported away by lorry to places as far distant as Lincolnshire.

The main species used are Norway and Sitka spruces, Scots pine and Douglas fir, and about 650 cubic feet of sawn timber, in true measure, are obtained from every thousand hoppus feet that goes in.

Wooden Ships are not Dead Yet!

Early in 1957 there was launched from the boat yard of Messrs. Aitkens at Anstruther in Fife, the 97-foot vessel *Radiation*. Although described as a "liner" we understand that her function will be the transport of up to 1,000 hundredweight of fish from trawlers out at sea to Aberdeen or other landing ports. Three such vessels are being built by Aberdeen owners as part of a programme to modernise their fleets. All of them can, if desired, be modified for actual trawling.

The *Radiation* has been built from Scots-grown oak and larch for her frame and "skin". Her deck and masts have been cut from imported Douglas fir. One reason for using wood rather than steel is economy; the *Radiation* cost £40,000 whereas a steel vessel of equal capacity would have cost £70,000. A second reason is durability, for it is estimated that a wooden craft, properly looked after, will have twice the life of a steel one. A third reason was that the timber was readily available, whereas steel was in short supply.

Everyone who knows the sturdy little drifters—again built of Scots-grown oak and larch—that put out from the small Scottish fishing harbours, will realise that wooden craft are still very much to the fore on the stormy northern seas. Wood is still preferred for the great majority of yachts and other pleasure craft launched by Scottish builders from small yards such as those at Sandbank and Clynder on the Firth of Clyde. It is apparent that, despite the invention of plastics and the widespread use of steel and aluminium, wood still holds its own as a constructional material for the smaller sea-going craft.

Wood on Wheels

In the days of horse transport much skill and craftsmanship went into the building of wooden wheels for waggons, cabs and chaises. Elm for the hub, oak for the spokes, and ash for the felloes that make up the rim, were the wheelwright's choice, and everything had to be of the highest quality to withstand the shocks of the road.

Now wood is back on, if not in, the wheels that carry so much of the world's traffic. Rubber tyres need reinforcement, and rayon cord—made from spruce pulp—is one of the strongest and most serviceable of the various materials that are used for this purpose.

Slow-grown or Fast-grown Timber ?

From District Officer J. D. Macnab, in South Scotland Conservancy, we have received the interesting suggestion that our plantations might be divided into two groups—fast-growing ones aimed at producing the largest amount of timber in the shortest possible time, for such uses as pulping, and slow-growing ones where quality of timber is the first consideration.

We put this idea to C. D. Begley, a District Officer in the Utilisation Development Section, and his reply suggests that the problem of "quality versus speed" may not be quite so straightforward as Macnab's proposal implies. "To begin with", he writes, "the rate of growth, measured by the usual criterion of rings per inch of radius, falls off after an initial spurt, even in the fastest-growing trees.

"Forestry Commission Yield Tables show:—

(i) Rates of growth, for most softwood species, involving less than four rings to the inch occur, usually, only in the early years of a plantation's life, and then in the main crop trees rather than the early thinnings.

(ii) Rates of growth giving less than eight rings to the inch seldom occur even in the main crop trees of such fast-growing crops as Sitka spruce of Quality Class 1, after 40 years of age. Such rates are even less frequent in other species or lower Quality Classes.
A paper by J. Bryan of the Forest Products Research Laboratory, Princes Risborough (*Quarterly Journal of Forestry* Vol. L. No. 2 April 1956) tells us that:—

Indications are that where the number of rings to the inch exceeds four or five, the effect of growth rate on compressive strength is of little practical significance.

"We also have reason to believe that a rate of growth not faster than 8 rings to the inch should make a timber satisfactory for all working properties. We can therefore expect nearly all our timber to be satisfactory as far as compressive strength is concerned, and much of it to have satisfactory working properties, even for joinery, insofar as these properties are influenced directly by growth rates. Growth rates and knottiness are to some extent interrelated, and the presence of many large knots can be an adverse factor in fast-grown timber."

There is clearly much food for thought or perhaps for argument here. But one thing on which both parties are agreed is that growth must be even. That is to say, there should be no sudden transition from fast-grown to slow-grown timber, or vice versa, in the same stem. Our thinning regimes should be so ordered as to make that unlikely. We should neither release our fast-growing trees too suddenly, or let them get too much hemmed-in for too long. Nor should we change our thinning grade in mid-course, so that the general rate of timber formation on the main crop trees is altered.

Cutting Peat in the 1700's

We are informed by Mr. A. D. S. Macpherson, a Forest Worker at Tulliallan, that a wooden spade found by Mr. Holmes at Strathyre Forest is now in the Glasgow Museum and Art Gallery. The Curator of Archaeology at that Museum writes:—"We have never been able to place the wooden spade exactly, but the general opinion of those who have seen it is that it is not of vast age, perhaps eighteenth century. Its blade may have been framed and rimmed with iron, all trace of which has perished. If so strengthened, it would probably have been suitable for peat-cutting".

It is interesting that this spade—probably of native oak—has been preserved so long in the peat and that wood may outlast metal in such circumstances.

Broken Glass as a Forest Fire Cause

Can broken or unbroken glass on the forest floor cause a forest fire? An Ontario inspector, visiting a towerman one day, noticed a small wisp of smoke rising from the grass at the base of the tower. When they climbed down to investigate they discovered a portion of a broken milk of magnesia bottle lying on the grass in the sunlight. Behind the glass individual blades of grass were being ignited about half way up the stem. Each blade as it burned died out completely. There was nothing else growing on the area, but had there been other light fuels besides the grass it is logical to assume a fire might have occurred.

This was the only time this official had ever seen this happen. For this type of fire to occur, all causative factors must be in the right sequence, but it remains as a possible cause of some otherwise unexplained fires.

We owe this interesting information to *Sylva*, the beautifully produced magazine of the Ontario Department of Lands and Forests, which is regularly received by exchange and filed in the Alice Holt Library.

"The Forester"

As most of our readers will be aware, forestry in Northern Ireland has been, since 1922, in the charge of the Forestry Division of the Ministry of Agriculture of the Government of Northern Ireland. Their small but enterprising staff has recently begun the production of a departmental journal on similar lines to our own, under the title of *The Forester*. We have received the first two issues which show that the problems facing foresters just across the North Channel are much the same as our own; fire protection, larch canker, and the awakening of a forest sense in the general public are among the many topics discussed. Copies are being lodged, for convenience of reference, in the Library at Alice Holt.

"Tales of a Wildfowler"

Arthur Cadman, a Divisional Officer on the staff of Director Wales, at Aberystwyth, is the author of the book with this intriguing title, published in November, 1957, by Messrs. Collins and priced at 21*s*. As the reminiscences of an expert ornithologist and sportsman, this is a book that will appeal not only to all wildfowlers but also to everyone interested in the wild life of moors, marshes, and lakesides. It gives valuable hints on the training of gundogs and also on the keeping of wildfowl, of which Mr. Cadman has a notable collection. There are forty-two striking illustrations of the birds and animals of the marshes by our leading wildfowl artist, Peter Scott.

Pamphlets on Roadside Tree Planting

Although the planting and tending of ornamental trees and shrubs is rather a side-line to the Commission's main work of timber-growing, it is a subject on which the public expect every forester to be an expert. As an aid to answering the frequent queries that many of our staff receive in this field, we commend three booklets published by the Roads Beautifying Association. They are obtainable from that body at: 41 Kipling House, 43 Villiers Street, London, W.C.2., at the prices stated, plus postage.

(1) *Practical Instructions for the Planting of Trees and Shrubs* (with special reference to roadside conditions). 6*d*.

(2) *Advice on the Pruning of Roadside and Street Trees.* (Unpriced)

(3) *Suggestions for Commemorative Tree Planting.* 6*d*.

Surveys of Private Forestry Costs, Prices and Piecework Rates in England and Wales

Many readers will be aware of the surveys of the economic factors of forestry on private estates that are being carried out by Mr. J. J. Macgregor and his colleagues of the Forest Economics Section, Imperial Forestry Institute, South Parks Road, Oxford. All these contain in a handy form, and at a reasonable price, information that is often very useful for those who have to advise private woodland owners; indeed, they provide valuable comparisons with our own costings. The figures quoted are based on returns sent in by a representative sample of private estates, which, however, are identified only by a code number, and not by name. Prices received for timber of various species and grades, prices for minor produce such as peasticks, piecework rates for jobs such as planting and fencing, and the average overall costs of afforestation on private estates, are examples of the information included in one or other of these helpful and factual surveys.

In detail, the titles and prices of the Surveys recently issued by the Section are:—

(a) *Reports of the Survey of Private Forestry Costs* .... 7*s*. 6*d*. (postage 6*d*.)
(latest issue received is the *Fifth Annual Report* covering 1954-1956)

(b) *Survey of Private Forestry Prices: Third Report*, 1956 .... 5*s*. 0*d*. (postage 6*d*.)

(c) *Piecework Rates*, 1956 .... 2*s*. 6*d*. (postage 4*d*.)

Survey of Private Forestry Costs in Scotland

A parallel series of reports covering costs, though not prices, in Scotland, is issued by the Costings Survey Team of the Department of Forestry, Aberdeen University. Their *Fifth Annual Report*, covering 1954-1956, which is the latest we have received, is priced at 6*s*. 6*d*. post free.

Publications of the Empire Forestry Association

During the year this Association has brought out two reference books on forestry, namely:

The Empire Forestry Handbook, 1957. Price 20*s*. (21*s*. 2*d*. post free)
British Commonwealth Forest Terminology Pt. II. *Utilisation*. Price 30*s*. (31*s*. 2*d*. post free)

Previously, in 1953, the Association issued Pt. I of the *Terminology*, on *Silviculture*, price 21*s*. (22*s*. 2*d*. post free). All these works contain much information on the standard use of timber names and technical terms.

Helicopter over the New Forest

The oldest forest still makes history. District Officer J. C. Harrison hovering in a helicopter maintained two-way communication between an ordinary two-way pack-set radio and a radio-equipped Land-Rover. Neighbouring aircraft caused some distortion, but the exercise proved that air to ground radio control would be of value in the event of a serious outbreak of fire.

Contributions to the Journal

The Editorial Committee invites contributions from any member of the staff on any subject connected with the Commission's work. These should be forwarded through the usual official channel (normally the Conservancy office) to: Mr. H. L. Edlin, Editor of the Forestry Commission Journal, 25, Savile Row, London, W.1.

Contributions should preferably be typewritten on one side only of foolscap sheets, using double spacing throughout; but if this is not possible articles in manuscript will be considered. The usual length is anything from 250 to 2,000 words, and we are keen to accept brief accounts of simple practical jobs in the forester's daily work, as well as more lengthy and more highly technical material.

A note of the writer's name and initials, his official position, and address for correspondence, should be appended. We can also accept sketches and photo's and are prepared to re-draw pictures if necessary for reproduction.

Our Photographs

This year you may notice a small innovation on the photograph pages, in that each picture is linked to its relevant article and author by a brief note in the caption. Unless otherwise stated, each photo has been contributed by the named author, to whom our thanks are due.

Acknowledgments for the following photo's are made to: Mr. J. Viney, for Plate 16, timber felling; the Commission's photographic staff at Alice Holt for Plates 17 and 18, disc plough; the staff of the Kratte Masugn Forestry School, Sweden, for Plate 25, saw sharpener's bench; South Dorset Photographic Services, for Plate 26, fire notice; Mr. R. Worsley for Plates 27 and 28, fire at Alice Holt; the Eastern Daily Press for Plate 29, Lynford Hall; the Farmers Weekly for Plate 30, Glen Trool School.

Plates 31 to 39 inclusive, showing Staple Howe, have kindly been provided by Mr. T. H. Brewster, of Flixton near Scarborough, the author of the related article. Mr. Brewster also provided the line drawings and the plan which appear in his text.

Plate 24, illustrating the peculiar malformation that results when pines are exposed to hormone weedkillers applied to cereal crops, was contributed by Mr. W. P. K. Findlay, of the Forest Products Research Laboratory, Princes Risborough. The actual specimen was collected by Head Forester C. Heavener, from a five-year-old plantation of Scots pine adjoining an oatfield near Marlow in Buckinghamshire.

Most of the drawings in the text have been contributed by the respective authors. Those showing forest operations in Sweden were prepared by Mr. Marc Sale, after photos taken by Mr. M. E. S. Dickenson.

JOURNAL OF THE FORESTRY COMMISSION, No. 26, 1957

FORESTRY, AGRICULTURE, AND MARGINAL LAND

An important Report by the National Resources (Technical) Committee, (the Zuckerman Report) was published in 1957, *under the above title. We give below the Introduction, Summary, and Conclusions, by kind permission of the Controller, H. M. Stationery Office. Copies of the full report are obtainable from H.M.S.O., price* 4*s.* 0*d.* (4*s.* 5*d. post free*).

Introduction

Products of the soil account for one half of the total import bill for the United Kingdom,[1] which in 1955 was about £3900 millions. We buy from abroad one half of all our food at a cost of £1250 millions; and we import upwards of 85 per cent of our requirements of timber and wood products[2] at a cost of approximately £430 millions. These imports are crucial to the problem of our balance of payments. The importance of their reduction, where economically possible, and of the maximum economic use of our soil, needs no emphasis.

Over the past five years the Natural Resources (Technical) Committee has been considering what ways of increasing the use of indigenous sources of timber (cellulose) products are technically and economically feasible, and how any increases in the production of such products, for example through the extension of forestry, would affect the agricultural use of marginal land. Different aspects of this question have now been touched on in the recently published Reports of five other bodies. These are the reports of the Commission on Crofting Conditions in Scotland (Cmd. 9091), of the Welsh Agricultural Land Sub-Commission on mid-Wales (Cmd. 9631), of the Nature Conservancy for the year ended 30th September, 1955, of the Forestry Commission for the year ended 30th September, 1955, and of the Committee on Hedgerow and Farm Timber.[3] In the report on crofting conditions it is stated that these outlying parts of Great Britain are in imminent danger of becoming completely depopulated, with a total loss of their agricultural output. In order to counteract this trend, the Commission recommended a number of measures of which one of the most important is that programmes of afforestation should be speeded up in the areas concerned. The report of the Welsh Agricultural Land Sub-Commission makes the same point. Once again attention is drawn to the occurrence of progressive depopulation, and to the value of afforestation in stabilizing population, and, indirectly, in helping to maintain agricultural output. These two enquiries thus highlight, for the particular areas with which they are concerned, a theme that may be applicable on a national scale to all our less populated areas. The Report of the Nature Conservancy expresses the view that the fertility of some of these areas has been seriously reduced. The Report on Hedgerow and Farm Timber contains a warning of the danger that this important source of hardwood timber is likely to

(1) United Kingdom (Great Britain and Northern Ireland) figures are used in this paragraph but elsewhere the report relates to Great Britain only.

(2) i.e. wood and cork, paper and pulp, and rayon.

(3) The report of the Committee on Marketing of Woodland Produce (H.M.S.O. 1956), which was published while the present report was in the press, presents yet another aspect of the problem.

become exhausted unless it is better managed than it now is. Finally the Forestry Commissioners' Report shows that a variety of factors are preventing the Commissioners from maintaining a planting programme at the level which accords with the Commission's directive from the Government.

The purpose of the present report of the Natural Resources (Technical) Committee is to bring these separate conclusions into the perspective of a general study of the use to which the marginal land of Great Britain is now being, or could be put. In its examination of the problem, the Committee has been conscious of the fact that the density of population is falling fast in many outlying areas. Associated with this depopulation is a decline in the intensity of land use and, even more significant, a progressive deterioration of the fertility of the soil and of the vegetative cover. The more this trend continues, the less propitious become the possibilities of any future economic exploitation of our marginal acres. On the other hand, we have also reached the view that the isolated development of agriculture is not by itself an effective answer to all these problems; and that in some areas the amalgamation of farm units is a necessary corollary of economic development. The particular issue on which we have focussed our attention is the possibility that the integration of forestry with agriculture in certain districts might be more economically rewarding, and might have better social consequences, than would the independent development of either alone.

We realize that available information about the cost of and returns for this kind of investment is both meagre and heterogeneous, and that detailed investigation would be essential before any particular scheme was started. But we consider that enough evidence is already available to call for a reorientation, or a re-definition, of long-term national policy with regard to our marginal lands.

In the body of the Report, we therefore review current policy on the use of land for agriculture and forestry, with particular reference to the less cultivated marginal areas; the prospects of supply and demand for food and forest products; the relative profitability of investment in farm and forestry; the possibilities of integrating agriculture and forest development; and the social benefits that might be expected to result from such an integration.

Summary

Introduction

The present report summarizes the results of an extensive study of the problems involved in increasing the use of indigenous sources of timber, and of the repercussions of afforestation on the agricultural use of marginal land.

Background of Agricultural Policy

During the 1939-45 war the main goal of agricultural policy was the maximum output of milk and of crops for direct human consumption. The emphasis of the post-war expansion programme has shifted in recent years to the production of livestock. The hill and upland livestock rearing areas are of vital importance to this policy, of which the general aim is to achieve the greatest economic production possible.

Forestry Background

It has long been customary to import most of the timber we use, but shortages in two world wars have emphasized the need for domestic supplies. The Forestry Commission were therefore charged in 1945 with a fifty-year planting programme designed to supply essential requirements of timber, given that we might once again have to fight a war of several years' duration. Strategic considerations have changed since then, but on the other hand, there is a greater economic reason now, than before, for investment in the planting of trees.

Upland Marginal Lands of Great Britain

The upland districts of Britain are already sparsely populated, and the trend is towards further depopulation. Soil fertility in these areas is generally low, and in some districts is progressively deteriorating. In view of the ever-recurring threat of trading difficulties, we cannot view with equanimity the under-use, amounting in places to abandonment, of much marginal land made up of rough grazings and waste lands. These categories of land, extending over 20 million acres, constitute almost two-fifths of our land surface.

Possibilities of Agricultural Development

Various surveys of rough grazings and marginal land have shown that the productivity of some 4 million acres could readily be improved, and that much of this land could be dealt with at less than £30 per acre (at the prices ruling in 1949 when the relevant survey was carried out). These acres play an essential part in domestic meat production as a breeding and rearing ground for cattle and sheep, and their depopulation is a source of increasing anxiety. Population and agricultural production can be maintained only by more capital investment, but the development of agriculture will not, by itself, be sufficient to correct the situation.

Development of Forestry

Although physical conditions in Great Britain are more favourable to the growth of trees than in many European Countries, the proportion of the land surface of Great Britain which is under forest is less than in any other Western European country. Even so, much of the land classified as woodland is at present unproductive. The planting programme of the Forestry Commission is, however, being delayed by the difficulty of acquiring suitable land. It is estimated that more than 4 million acres of rough grazing are suitable for afforestation. Much of this land is on livestock hill farms, but areas of coppice and commons also provide opportunities for forestry.

Financial Return from Agriculture and Forestry

Comparisons between the financial returns of agriculture and forestry are difficult, because of the great difference in the length of their production cycles. Studies by the Committee of a number of selected areas in Great Britain suggest that on marginal upland areas, forestry may have a slight advantage over agriculture in returns on invested capital. Although the assessment of the relative import-saving value of forestry and agriculture on such land is very difficult, in the long term, forestry would apparently show an advantage over agriculture.

Market for Home-Grown Timber

Imports of wood and wood products cost at present about £430 millions per annum, including about £180 millions for saw timber. There is likely to be a continuing domestic demand for any sound commercial saw timber that can be produced, and even the Forestry Commission's full programme of five million acres of productive forest would meet only one-third of present requirements. The main problem is to dispose of the increasing quantity of thinnings. A substantial proportion will continue to be used for pit-props, and new factories are being erected for the manufacture of building board and chip board. Wood pulp for paper and for man-made fibres comprises a large part of our imports of timber products. If certain technical difficulties were solved, there would appear to be scope for a substantial increase in the production of wood pulp for paper.

Other home sources of pulp for paper production are waste paper and surplus straw, but these are unlikely, in normal circumstances, to provide a greatly increased contribution to our supplies of pulp. Commonwealth sources of pulp, particularly rayon pulp, are likely, however, to continue to be competitive with home-produced supplies. The further development of wood pulping plants in this country based on the use of home produced timber will depend on the economics of relatively small scale pulping units and on the encouragement given by the home timber industry and by appropriate Government Departments to the establishment of such factories.

Obstacles to Afforestation

A number of practical difficulties are hindering the Forestry Commission's planting programme and the development of private woodlands. Lack of immediate financial advantage, the need for large capital investment, and the shortage of skilled forest workers make it improbable that private interests will engage in afforestation to any significant extent.

The programme of the Forestry Commission is hampered by the difficulty of acquiring suitable land; by competition from other interests for the type of land required; by the need for extensive consultation before acquiring land; and in some areas by the hostility of local people to the idea of afforestation. If present conditions continue, it is unlikely that the rate of planting originally envisaged will be achieved.

Integration of Forestry and Agriculture and the means of achieving it

A number of reports concerning particular areas in Scotland and Wales draw attention to the importance of forestry, when properly integrated with agriculture, as a means of strengthening the social and economic fabric of the countryside. The Committee regard this as generally applicable to all similar land in Great Britain. Afforestation of the less fertile areas of such regions would provide shelter for livestock and supplies of timber for fencing, etc. It could also lead to economies in capital services such as roads and schools; to an increase in the rural community; and to the possibility of sharing heavy equipment between forestry and agriculture. Even though integration would involve higher costs of afforestation than the planting of trees in large compact areas, the advantages appear to outweigh the extra costs.

If proper integration is to be attained, the Forestry Commission and the Agricultural Departments would have to co-operate more closely in the future than they have in the past. A few farms might be used for the purpose of demonstrating the value of the policy of integration to the agricultural community. The Forestry Commission might also assist private owners by undertaking forestry development on an agency basis, with the possible assistance of Government loans. Technical advice on the advantages of forestry should also be more readily available to landowners and farmers.

If the best use is to be made of our marginal hill lands for forestry and agriculture, attention will have to be directed to the continuing existence of small and uneconomic farm units. The Committee believe that the solution of this problem is closely related to the integrated use of marginal hill land for forestry and agriculture which they advocate.

Conclusions

The field that has been covered by the present report is marginal in the extent to which it figures in the financial affairs of the country, and all but marginal to the preoccupations of the bulk of the population. The issues raised are nevertheless vital to our national well-being. Increasing rural depopulation: and in some cases virtually the total depopulation of vast hill areas that were once actively worked: an acreage of forests and woods which in total extent covers relatively less of our land surface than does the tree-cover of every other European country, including even Holland: yet obstacles to afforestation which unless overcome imperil the fulfilment of our forestry programme: and a declining interest in the farming of marginal hill farms, in spite of the fact that these constitute a main breeding reservoir for the cattle and sheep reared on the lowlands—these trends have already changed the pattern of our national life, and will do so at an increasing rate if they continue. The social and physical effects of the transformation that has already taken place have been regretted and deplored by all the official bodies by which they have been considered. From the economic point of view the extent to which they are tolerated nationally is simply a reflection of decisions, implicit rather than overt, that the resources necessary to prevent the ill effects of the underuse of our marginal lands are in present circumstances better directed to more profitable causes. But in the long and short term the neglect of our marginal land, however remote it may often be geographically, represents a neglect of natural resources whose cultivation might be urgently called for in conditions of blockade, or if our position in world trade were to worsen materially.

The main conclusion of our study is that each item of forestry and agricultural development in marginal land should be planned as a cohesive operation. Next in importance is the view that end-uses for forest products additional to those that are already being exploited should be found.

Opinion is undivided that our first conclusion implies a greater demand for, and a greater diversity of rural labour, with richer opportunities for those who would continue to live in the outlying areas concerned. In turn this implies more economic investment on social services, such as roads, schools, and health; and the need to find effective measures for dealing with those farm-holdings which are uneconomic either because they are too small or too badly laid out. The second point that we have underlined here refers especially to pulping mills. The technical and economic problems that have so far deterred their establishment in this country can hardly be insuperable. The initiative for which their solution calls would in itself do much to revivify interest in useful investment in our marginal lands.

The State accepts a large measure of responsibility for the use of this land and for the welfare of the people who continue to inhabit it. Much public money is channelled to these areas by such Government bodies as the Agricultural Departments, the Ministry of Housing and Local Government and the Forestry Commission. It is implicit in what we have already said that the Departments of Agriculture and the Forestry Commission in these districts should in future co-operate even more closely than they have in the past. It has been argued that there is a need for a new genus of executive body which would discharge all administrative responsibilities, including those of the central Government Departments in marginal hill areas. While we recognize that there is a need for close consultation at regional levels between the Departments concerned, we do not subscribe to this view. Events are already moving in the direction of greater co-ordination, and it will be time enough to consider the need for a new type of administrative machinery when, and if, it becomes national policy to divert to our millions of acres of marginal and hill land a greater proportion of national revenue than they now attract. In the long run the value of this land to the nation is bound to appreciate, rather than decrease, as the demand for food and timber increases in the world.

NOTES ON THE SEVENTH BRITISH COMMONWEALTH FORESTRY CONFERENCE, 1957, IN AUSTRALIA AND NEW ZEALAND

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In the summer of 1957 I was privileged, as the Secretary of the Standing Committee on British Commonwealth Forestry, to attend the Seventh Conference.

It was indeed a privilege to cross the world and to see these two countries so full of interest to the forester and indeed to anyone with an interest in the countryside and people. It would be difficult to imagine a more exciting and pleasurable journey. Even the swift journey by air was a stimulating experience, passing over lands and seas, which evoke many memories of history and legend to arrive after a journey measured in hours, in Australia, a country so different from this island in almost every feature, and to meet people at once so alike and so different to one's own people. The next stage of the journey, to New Zealand, was yet another adventure, for here was a land hardly larger than Great Britain and yet a thousand or more miles from the nearest land mass, Australia, and with a climate, flora and fauna as different to Australia's as is our own.

None of the interesting things which abounded in both these countries would have meant much to the traveller if it had not been for the eagerness of our hosts to show us as much of their countries as they could in the brief time available. But this eagerness was, in fact, only a part of the great friendliness and indeed affection with which we and all other Commonwealth delegates were treated.

There was, in fact, a family feeling about the Conference which gave its deliberations a sense of purpose. If nothing else, this spirit enables criticism and advice to be freely and candidly exchanged, as indeed they were. What did this mean in tangible terms to the British delegation? I think I can best give my account of this Conference by answering this question with illustrations from our conference proceedings and the tours in which we took part.

On the 26th August, in Adelaide, the capital city of South Australia, Sir Herbert Mayo, as Governor's Deputy, opened the first session of the Conference. Most of the proceedings were an exercise in patience for the members as they consisted of recitals of facts and figures on the progress in forestry by all the participating countries. These proceedings were enlivened by the efforts of the representatives of the various Australian States, to surpass their colleagues, in good natured, but scathing references to the insignificance of all other Australian forest services but their own. Two important themes did emerge from all these dry if important facts—the rapid development of proper forest management throughout the world even in the less wealthy territories and the keen realisation that timber must become strongly competitive in price and quality in present world market conditions.

The Australian Tour

South Australia

This began in the State of South Australia and was perhaps the part of the tour with the greatest significance for the British delegation. South Australia has a very small indigenous forest area and it has virtually no native softwood forest. The Government have therefore been faced with a situation not unlike our own—that is choosing between a virtually complete reliance on import for softwoods (and, in South Australia, for hardwoods too) or supplying some if not all the timber from their own resources. They met the problem as we have done by embarking on a programme of afforestation, choosing exotic conifers for the purpose. The choice eventually narrowed down to a few species—and principally *Pinus radiata*—and, so far, their wisdom has been evident, for the tree grows rapidly (mean annual increments on a 40 year rotation of 200-400 cubic feet) and without serious diseases; furthermore it is easy to regenerate rapidly.

A good deal of the plantations lie in the South-eastern part of the State and most of them are within 40 miles of the pleasant country town of Mount Gambier, where we spent some days housed in the comfortable and well kept hotels which that prosperous town supports. Mount Gambier is a microcosm of present day Australia—growing rapidly and with evident signs of a high standard of living. Alongside shops and office blocks in modern design are some of the earliest buildings but these are fast disappearing. The pavements, on a Saturday morning, are thronged with people enjoying their relaxation after a five day working week and more than one European language can be heard alongside English of two or three different origins. This is a typical Australian scene today.

The first plantation visited was Penola Forest Reserve, nearly all *Pinus radiata*, and there we saw a few of the 296 permanent sample plots used for the investigation of yields under various thinning treatments, a measure of the intensity of management of these fine stands. I must confess that there did not seem a great deal to choose between the various grades—the moderately thinned one gave the best all round return but the margin was not sufficiently high as to be conclusive. Very heavy thinning is, generally speaking, in disfavour in South Australia, and an extract from an official report may be of interest.

"It cannot be too strongly emphasized that enthusiastic advocates of very heavy thinning, without adequate reliable data to support them, may not only unwittingly lose increment, but may in addition seriously affect future yields and the later supply of logs to large mills designed for a definite future intake." The writer of this was encouraged to utter this *obiter dicta* by the rather surprising yield of large saw logs (15 per cent log volume, or about one-sixth of all the logs in logs *above* 15 inches diameter under bark) in a clear felling at the end of a forty year rotation.

At this forest we also saw some experiments in methods of natural regeneration, and here and elsewhere in Australia we learnt that natural regeneration, even when it is easily come by, is not always as welcome as we in this country might think. A difficulty of some fashionable interest is that natural regeneration makes the stand form and quantity more hazardous than with artificial regeneration, where tree breeding can be used more easily. We were to hear more of this and of the subject of tree breeding when we visited Queensland.

The history of milling developments associated with these *Pinus radiata* plantations held some interesting lessons for us. When we visited the saw mill at Nangwarry where the Penola forest produce is milled, we learnt that it was one of several departmental sawmills. In the early days of logging these *Pinus radiata* plantations, they had no option but to mill the stuff departmentally. The South Australian timber industry originated and grew upon supplies imported from interstate and overseas. As the official handbook says, it was not altogether surprising therefore, when the first artificial forests of a relatively unknown tree such as *Pinus radiata* began to reach a stage when preliminary yields could be expected, that the industry showed no particular enthusiasm in its utilization. The grower had to learn by direct experience and at his own expense what the snags were in putting a new timber on the market, and what techniques were needed to make his logs into acceptable sawn timber. It took years rather than months to make *Pinus radiata* a generally acceptable timber, and a turning point of their efforts was the introduction of kiln seasoning. We were shown both at Nangwarry and at the Mount Burr Mills, extensive banks of kilns which can handle if necessary the whole output of the mills. Another feature of the milling of these logs is the accuracy of the sawing and the production of boards free from wane. The general standard of the timber produced was good and there was no doubt that the sawyers had done everything to help the foresters justify their claim that radiata pine is a timber which is eminently suitable for all purposes except perhaps where great beauty or durability is required. Inherently good working properties of a timber are, of course, prerequisites for its marketability but sound milling and seasoning techniques, we were assured, are indispensable aids, especially when the timber is new to the market.

Victoria

Our next tour was in the State of Victoria and here we stayed in Melbourne, a most impressive city with a metropolitan and sophisticated air about it (at least to a provincial like myself) which would make some of our provincial towns look very shabby and parochial. It is well endowed with art galleries, museums, libraries, etc., but to foresters its biggest attraction is the first-rate Forest Products Research Laboratory, one of the finest in the world both in equipment and in its achievements. Perhaps of greatest interest to the forester is the work that has been and is being done on the anatomy and inherent properties of the tree and their relation to the wood properties both for timber and for pulp. A subject on the conference agenda was "Is forest products research serving the needs of the forester and the timber trade?" Here, in this laboratory, at any rate, was a forceful reply. By precise examination of the small but critical features of the wood the scientist was evaluating, in terms the forester could appreciate, what was needed to produce the right kind of tree. By close liaison with the geneticist and silviculturist the forest products worker was able to give valuable guidance on the effects of tree breeding, thinning techniques, etc.

A good example of this work is the studies undertaken on fibre length at this and other laboratories. The paper technologist knows that long fibres are best suited to certain kinds of pulp manufacture. The wood anatomist has learnt that at an early age the tree exhibits a tendency towards shorter or longer fibres which will, it is believed, persist into the later life of the tree; in consultation with the geneticist he finds that this is an inheritable feature; in consultation with the silviculturist he finds that thinning techniques can upset the development of long fibres so that a mature tree can revert to producing "juvenile" shorter-fibred wood. It is not difficult to see how this team can co-operate to produce the kind of tree the pulp manufacturer wants.

We were to see many examples of this kind of commonsense approach to solving the problem of timber producer and consumer. But the brilliant sunshine which Victoria produced made us thankful to leave the city and visit the the forests in the hills which surround Melbourne.

The most memorable of these forests were the giant Mountain Ash, *Eucalyptus regnans*, which were seen in Upper Yarra forest district, 3,000 feet above sea level. These were indeed things of great beauty and it was sad to hear that what we saw were only remnants of extensive mature stands which had been logged or extensively damaged by savage fires in recent years. Fires and fire protection were a constant theme throughout our tour of Victoria and it is not surprising when one hears of the terrible loss of life and property that Victoria has suffered in relatively recent times. A grim reminder of this was the well equipped dugout we were shown. They are to provide shelter for anyone trapped in the forest during a fire and by law must be maintained in the forest.

Mountain Ash grows in the wetter areas with rainfalls up to 60 inches, but we also visited some drier areas where the hardwood grew at rates with which we were more familiar—diameter increments of the order of ¼ inch per annum. Also of interest to British visitors were the derelict coppice stands of various eucalyptus species peculiar to these slow-growing dry areas. The all too familiar problem of thinning and cleaning without a market for the produce was present here, but it was considered essential to undertake these operations in the early stages of reclaiming this coppice. Thereafter the availability of markets for produce (mainly poles, fencing timber and fuels) governed subsequent treatment. Incidentally wood is still extensively used as a fuel in Australia and foraging for wood fuel is a time-honoured pastime by some urban dwellers on their country excursions at the weekend. I was amused to see more than one car boot bulging with branchwood as I sat in a car crawling back to Melbourne from the coast one Sunday afternoon. Australia is well endowed with all the pleasures of modern civilisation including traffic jams.

This question of markets and silvicultural treatment was a recurrent theme in our tours through Australia and also New Zealand. It occurs in its most acute form in the smaller sizes of softwood and with low grade hardwoods and, as with us, the pulping industry looks like being a great help. I saw some interesting examples of this in the activities of the Australian Paper Manufacturers Ltd., at Maryvale near Gippsland, Melbourne, Victoria. Apart from using young fast-grown pole-stage eucalyptus for their process, the company also perform a useful salvage operation in logged-over areas by buying logs, which are otherwise of no value, for conversion into pulp billets. This enables the forester to do his preparation of planting ground at a profit. The sale of cordwood to the pulp mill now being built at Sudbrook will we hope serve a somewhat similar purpose, with perhaps the same happy result!

The same company also buys softwood thinnings, going as far afield as the neighbouring State of South Australia, whose plantations I have already described. The Company (A.P.M.) go as far as to claim that without the market for small thinnings which they and other companies provide, the thinnings of young plantations could not be carried out economically except on a very small scale for specialised local markets. All this had a very familiar ring to British ears and we reflected, gratefully, that the N.C.B. to some extent play the same role in this country, as the pulp companies do in Australia.

New South Wales

We travelled from Victoria to New South Wales visiting the bustling city of Sydney—a great city with a population numbered in millions and growing apace. "The Bridge" is of course the sight all visitors must see but to me the most memorable experience was a trip on the ferry across the great harbour, so unlike the murky industrial harbours of England with which I am familiar, and where to my delight I saw hundreds of sailing boats spread as far as the eye could see and treating the ferry boats with cheeky disregard for their bulk and speed. From the indignant hooting of the ferry's steam whistle I gathered that the skipper was not amused.

Most of the forest visits made in New South Wales concerned problems of regenerating and exploiting the eucalypts, many species of which abound in the forests which extend westwards from the moist coastal valleys, across the snowy peaks of the Great Dividing Range towards the dry interior. The event of outstanding interest to me was to see the sub-tropical rainforest in virgin condition in the Moonpar State Forest. An unexploited stand of 150 acres of this forest had been permanently set aside as a memorial to Norman Jolly, an Australian forester and one of the founders of systematic forestry in Australia. We were privileged to witness the unveiling of a memorial to this great forester at a moving ceremony held in the midst of the tall trees of great beauty. I was reminded of the inscription on Sir Christopher Wren's tomb in St. Paul's Cathedral:" If you seek his monument, look around you". This grove of mature forest trees with trailing vines, a rich understorey of shrubs, ferns and trees and a cloudless sky above, was one of the most beautiful natural scenes I can remember, and a fitting monument to a forester.

Queensland

Queensland we shall remember as the land of sunshine, for the brief time we spent there was in their spring which means a felicitous climate that would charm the most thin-blooded soul, warm days and cool nights and brilliant blue skies, day after day. Queensland is also a state full of interest for the forester with its wide variety of forest types, from the sub-tropical hardwoods to the more workaday softwood plantations. Two items in particular were to stimulate our interest. Firstly the sawmill at Imbil in the beautiful Mary Valley. This was a country mill running exclusively on thinnings of Hoop pine, Kauri Pine and Bunya Pine and with a capacity of 2,300,000 super feet hoppus (12 super feet=1 cubic foot). The size of the thinnings was interesting; they were sawn from logs trimmed to a 4 inch top and of lengths down to 10 feet or less, The mill was rip-sawing these logs into box shooks, accurately and efficiently. and the boards were moved to the re-saws, the edgers and sorting tables by conveyors throughout. The timber of these species is of good quality, some of it pruned from an early age (the Kauri Pine is a self pruning tree), and blessed with a high proportion of dense summer wood which means few worries about rates of growth. But it was impressive to see such large quantities of small-dimensioned logs moving rapidly through the mill using only simple equipment —the breakdown rig for example consisted of two small circular saws on the same spindle.

The second item of interest was the activity in Queensland in the field of tree breeding, with special emphasis on quality coupled with a policy of high pruning. I have already referred to studies on this subject at the Commonwealth Scientific and Industrial Research Organisation, Melbourne, and here we were to see some of the field work including some impressive stands of second generation elite trees in the pole stage—something of a novelty to the delegates from Britain, where much slower rates of growth mean that it will be some years before we can see this sort of thing. The high pruning, as always, aroused controversy, but as the foresters here were for the most part concerned with growing peeler logs for plywood, which command a very high price, they seemed to have cause for expecting a good return on the undoubtedly expensive operation.

Australian Capital Territory

Finally we came to Canberra where a good deal of the conference sessions were held. Canberra lies in a political "no man's state" as it were, the Australian Capital Territory (much as Washington is a disfranchised area, from a Federal point of view, in the United States of America). But in the small compass of the Territory lie some 18,000 acres of well-managed forests, and we were to see some of these too. We were most interested to see their experimental work on the effect of drought on trees, because it had a bearing on some of the problems we have here in Britain, and which we suspect are connected with the water supply to the tree. The Australians have gone to the lengths of deliberately cutting off the supply of rainfall water to some standing trees by building a waterproof shelter above the root systems, clear of the ground—in appearance the device is rather like a small shed with trees growing through the roof. There seems little doubt that drought thus produced results in symptoms similar to those shown by the affected *Pinus radiata* (the species under test) under natural conditions in areas of very low rainfall.

The New Zealand Tour

New Zealand meant a complete change in climate, countryside and people but still the same friendliness and efficient organisations geared to ensuring that we saw all that could be seen. Everything here was overshadowed by the vast man-made forest of Kaingaroa (250,000 acres) and the industrial plants designed to convert the large volume of produce, much of it sawlog size, which is now pouring out of the forest as it is thinned or clear-felled. Kaingaroa forest is on the Kaingaroa Plains in the eastern central area of the North Island. At one time this was a desolate expanse of wasteland with a poor, sparse vegetation; it had previously been denuded of vegetation by severe volcanic eruptions. Planting began on an appreciable scale in 1901 and the tempo increased from 1924 onwards when tens of thousands of acres were afforested annually until the present total of 250,000 acres was reached. Over 100,000 acres is *Pinus radiata* and the balance is made up of *Pinus ponderosa* and Corsican pine and Douglas fir, with a few thousand acres each of *Pinus contorta*, European larch and other species.

The growth rate of trees here, as in Australia, was striking—*Pinus radiata* can produce in under 40 years a gross yield of over 14,000 cubic feet (4 inch top) and Corsican pine can produce gross yields of 13,000 cubic feet in little over 44 years. These are yields from unthinned stands and many of the tens of thousands of acres of mature trees (rotation 40 years and over) are in this category.

Since 1946 many of these unthinned stands have suffered severe attack by the European wood wasp, *Sirex noctilio;* the insect attack has now diminished considerably and one happy consequence of the depredations of the insect has been to thin out the overcrowded stands, with some benefit, by way of larger crowns and increased basal area, to the survivors. This plague was the occasion of an experiment in biological control when two parasites *Rhyssa persuasoria* and *Ibalia leucospoides* were released in the forest.

A less pleasant consequence of the pest was the number of dead snags which were left, and this gives some of the stands an unsightly appearance. In fact, to the eye of a forester used to "regiments of conifers" the sight of these overcrowded stands is an uncomfortable one. The obvious difficulty as far as utilisation was concerned was that there had been no opportunity at an early stage to weed out and dispose of the undesirables, and although there were undoubtedly many good trees in these stands so there were many bad ones. Unfortunately these cannot easily be weeded out and the evidence of this is made obvious when the sawn boards come under the grader's eye in the mill—a painful way of learning the merits of thinning as far as the miller is concerned!

Thinning is being done wherever possible, and we saw an example of the well-planned logging system used. A gang consisting of three men use one-man chain saws for felling and cross-cutting, and a TD/6 tractor with small logging arch for extraction. The two fallers move with astonishing speed from tree to tree, the sawyer cutting through the butt in seconds; the second man pushes against the tree with a stout pole if there is any sign of pinching of the saw, and the tree, seventy or eighty feet high, is soon down. The gang moves, on an average, 1,000 cubic feet from the stump to the lorry, per day. The servicing of tools is done by a mobile squad which includes a saw doctor. All forest blocks are on the forest telephone system, and so maintenance and repairs cause the minimum of delay. Roading (50 per cent of which is metalled for winter work) is essential to the speed achieved in this operation.

Roading both in New Zealand and Australia is now regarded as of paramount importance in logging, even for thinning operations, and it was gratifying to realise that this was something which our own service had been quick to realise and implement in our thinning operations.

The European larch stands, both at Kaingaroa and also in the South Island, were well worth seeing. Unthinned though they were, they were otherwise healthy and the millers I spoke to at the Departmental saw mill near Dusky Forest, Tapaniui District, Kelso, were high in their praise of the timber which was no trouble to convert and commanded ready markets—this is contrary to some of the disparaging remarks I have heard about sawing and selling European larch board, at home.

The Douglas fir we saw was well and quickly grown, giving 11,800 cubic feet to the acre (4 inch top) after 36 years at Kaingaroa. At Dusky Forest also, I saw some with a mean annual increment (6 inch top diameter) of 175 cubic feet after 50 years. It had first-rate form, was fine branched and tapered only gradually. As at home, it does not do too well at high elevations; the limit is 1,500 feet which is none too high in localities with a timber line well above what we are used to.

Our visit to Kaingaroa was completed with a tour of the giant integrated saw mill, pulp mill and newsprint mill at Kawerau. This £37,000,000 project is an awe-inspiring site; one of our party found the ruthless efficiency with which the sawmills sorted and spewed wood hither and thither, quite horrifying. Figures are poor tools for conveying an impression of the scale of the project and the insatiable appetite of the two mills for great logs scores of feet in length and butt diameters of 15 inches and over. The power consumption of the plant is perhaps the most succinct measure of the mill's scale of operating—2 steam generators rated at 150,000 lb./hr. and 650 pounds per square inch pressure and 750°F. superheat, supported by a chemical recovery boiler supply, and two 12,500 k.w. turbo-generators. The saw mill at full capacity can produce 72 million super feet per year and the newsprint mill can produce 75,000 tons of newsprint per year; the pulp mill supplies 36,800 tons of sulphate pulp in addition. We expect these figures when talking of large North American mills but they are impressive in the content of a man-made forest started barely half a century ago.

The visit to Kaingaroa and Kawerau by no means exhausted the features of interest in forestry and forest industries in New Zealand. We had yet to see the

Research Laboratories at Rotorua, the well managed co-operative and municipal forests built originally for shelter in the grazing lands of the South Island, the beech forests of the Westland, and the remains of the forests of giant Kauri pine in the north of the North Island.

The numbers of things to see, hear and discuss were bewildering, but nothing could distract our attention from the ever-changing scenery which we passed through on our grand tour. The British are given to boasting about the beauties of their native heath (if nothing else) and rightly so, but it would be a grudging visitor from any corner of the globe who did not grant that New Zealand is incomparably endowed with beautiful scenery, almost everywhere one goes. Some of us were lucky enough to visit the Southern Alps and later the Fiordland National Parks. Here in pleasant sunny weather with mild temperatures were mountains and snow fields of unforgettable grandeur, forming in Fiordland a setting for wide and deep fiords and lakes of serene beauty. Worth crossing the world to see, indeed.

To end with the prosaic but important task for which the 80 or so foresters were assembled, I must refer to the conference proceedings themselves. It would be impossible to summarise them and pointless too, for a summary of the proceedings will be published in 1958 by the Australians. But I would, at the risk of sounding pompous, advise the earnest few who read technical papers not to neglect the proceedings when they are published for some at least of those who spoke were world authorities in their subject, and the clash of opinion which took place in the friendly atmosphere of the conference room did produce one or two gems of wisdom. Of especial interest, if I may make invidious distinctions, were the discussions on tree growth characteristics and their influence on wood structure and properties, a high-flown title for "what the buyer wants and how to give it to him" with its corollary "The influence of markets on silviculture". Also worth hearing was the discussion on "Forest tree disorders", with some astringent exchanges on the folly or otherwise of experimenting with too many or too few exotics, and, as a bon bouche some of the wry remarks of Dr. Orchard of the British Columbia Forest Service, scattered throughout the report like the occasional currants in a very dry bun.

BEGLEY: AUSTRALIA: FULL DETAILS OF ILLUSTRATIONS

Plate 1. Le Tourneau electric logging arch in Kaingaroa Forest, North Island, New Zealand. The 6-ft. wheels are each driven independently by an electric motor in the hub. It is claimed to haul 12,000 cubic feet for 20 to 30 chains, per 8 hour day. It carries its own generator.

Plate 2. *Pinus radiata*, 31 years old, with two-year-old regeneration, under the shelterwood system. Mount Burr Forest Reserve, South Australia.

Plate 3. Mechanical sorting and handling of sawlogs up to the headrigs at Nangwarry Saw Mill, South Australia.

Plate 4. *Eucalyptus grandis*, mountain ash, about to fall. The tree is 200 feet high, 90 feet clear bole. Little Yarra, Victoria.

Plate 5. Log and Timber yard of sawmill at Imbil, Queensland. The mill handles thinnings only. Logs are hoop pine and bunya pine (*Araucaria* sp.) 10 feet in length, 4 inches top diameter.

Plate 6. Shadows cast by bright sunlight through high shelter in nursery at Little Yabba, Queensland. The seedlings are *Araucaria* sp.

A TOUR OF TASMANIA AND NORTH AUCKLAND:

SEVENTH BRITISH COMMONWEALTH FORESTRY CONFERENCE, 1957

By G. B. RYLE
Director of Forestry for Wales

The pre-Conference and post-Conference tours arranged by our Australian and New Zealand hosts enabled delegates to obtain a more domestic picture of activities than was possible in the large gatherings of the full Conference party. The writer has no regrets that he opted to visit Tasmania before the Conference opened and to finish with a tour in North Auckland prior to returning home via British Columbia and the North Pole route.

Tasmania, 18-22nd August, 1957

Our small party set off by air from Melbourne and was welcomed at the Tasmanian airport of Wynyard by the Chief Commissioner, Alec Crane and several of his officers. It took us but a few hours to realise that the Tasmanian Forestry Department makes up for its small size (28 Officers are listed in the *Empire Forestry Handbook* for the management of 8,932 square miles of State and Crown Forests) by an unusual degree of keenness and team work. The main theme of the tour was arranged around the several huge pulp and plywood industries, but as the Companies concerned also manage their own private forests or operate long-term concessions in the Crown Forests, we were able to see the whole range of the works from the felling, exploitation and regeneration in the woods to the finished products of the mills. The native *Eucalyptus* forests in Tasmania have suffered terribly from fires in past years, and in its early days the Forestry Department made itself unpopular with the graziers by instituting severe fire prevention measures. It is however now gaining a proper place in popular public opinion and it is receiving acclamation for its activities in replacing the areas of scrub Eucalypt species by large forests of exotic conifers. Praise also goes to the forest and the agricultural services for their completely realistic methods of rabbit extermination. Nowhere in Tasmania (or in the other countries visited for that matter) did we hear anything but amused derision for the half-hearted methods adopted in the Home Country.

The Associated Pulp and Paper Mills Ltd., with its subsidiaries, operates its own private forests of some 220,000 acres and has concessions over large areas of adjoining Crown forests near Burnie. The main species are Stringybark *Eucalyptus obliqua*) and Myrtle (*Nothofagus cunninghamii*) on the North coastal belt, with Ash (*Eucalyptus gigantea*) becoming dominant in the Surrey Hills. While much of the virgin timber now being exploited may be around 300 years of age there is no commercial advantage in growing such huge logs for pulping and it is probable that a general rotation of about 75 years will finally be adopted, especially if the right kind of material can be obtained by natural regeneration followed by just one commercial thinning. We saw fine natural crops of 30-year Stringybark and Myrtle carrying 20,000 cubic feet per acre in the process of being thinned (for the first time) down to 10,000 cubic feet and giving the opportunity to reduce the percentage of Myrtle which tends to smother the Eucalypt, especially by intense root competition. Though the A.P.P.M. Ltd. goes in for a high degree of mechanisation it was interesting to find that they have reverted to horses for thinning extraction. The forest roads struck me as being very similar in construction to ours, though occasionally gradients were allowed at which we would frown. The widths were slightly greater but so is the maximum permitted width of the vehicles. So far as one can compare roading costs, there was little difference between theirs and ours.

While much of the logging was followed quickly by a good natural regeneration, the A.P.P.M. Ltd. is not neglectful of its responsibilities. Clearance of undesirable scrub species, normally by dozer-rake before logging, is necessary in some places. Elsewhere artificial re-stocking with Eucalypt, using ½-year seedlings in paper tubes, or with *Pinus radiata*, follows very quickly after a clear felling.

The Australian Newsprint Mills Ltd. operates in a Crown Forest concession of 340,000 acres in the Derwent Valley but only about one-third of this territory contains merchantable forest of Mountain Ash (*Eucalyptus regnans*), Stringybark (*Eucalyptus obliqua*) and Ash (*Eucalyptus gigantea*), with subsidiary Myrtle (*Nothofagus cunninghamii*) and Sassafras (*Antherosperma moschata*) which are useless for groundwood pulping. Under the terms of the concession the Company has to manage the forest in accordance with a Working Plan, which is rather extensively supervised by the Forestry Department, and it is under obligation to provide stated quantities of milling logs to other trade mills. It runs subsidiary factories to consume the Myrtle and Sassafras which are not required at the pulpmill and notable amongst these we inspected a factory which uses Sassafras for supplying 90 per cent of the world's requirements in spring-clip clothes pegs. We were highly impressed at the Company's care for the welfare of its employees: the village of Maydena with its trim bungalows, single men's quarters, community hall, school and shops for its 280 employees struck us as a model of perfection. Here again in the forest it was difficult for a stranger to ascertain whether the wise policy of changing the virgin growing stock from a maximum age of maybe 300 years to a rotation of 75 years was being achieved with or without regard to a sustained yield policy; but it was evident that the Department will need to keep a close control on the long-term Management.

The short fibre of the *Eucalyptus* species needs an admixture of long fibre from softwood pulp to give paper a necessary degree of strength. At present pulp of *Pinus radiata* is imported from Kinleith in New Zealand, but the Tasmanian State forests of *P. radiata* and other exotic softwoods are rapidly reaching a productive stage and it is hoped that the island State will soon be self supporting in its needs for this purpose. We visited several of these conifer plantations where formation, maintenance and thinning were receiving really keen attention. It was not till we came to a certain private forest of *P. radiata* which was being systematically devastated that I discovered that the Department has no control whatsoever over the activities of the private owner.

Another writer will doubtless mention the status of the wood-boring *Sirex noctilio* in New Zealand. In Tasmania this insect has recently arrived, probably imbedded in packing cases of *P. radiata* from the land of the Kiwi. We hope that the Forestry Department will find means to cope with it before it attains supremacy over their pine crops.

And so, after a grand reception in Parliament House, Hobart, given by that Grand Old Man the Premier, the Rt. Hon. Robert Cosgrove, we departed from Tasmania to join the other 70 delegates for the main Conferences in Adelaide.

North Auckland, 12-16th October, 1957

This peninsula of rolling country with steep ridges and gullies was originally the home of the Kauri pine (*Agathis australis*) but much of it had certainly been denuded by fire before the arrival of Europeans in the early nineteenth century. Discovery of its wonderful qualities for ship building and other purposes was quickly followed by intensive slaughter of the Kauri forests. The story of uncontrolled forest exploitation and water transportation in difficult country is beautifully told and illustrated in *The Story of the Kauri* by A. H. Reed (A. H. & A. W. Reed, Wellington, New Zealand).

But the Kauri and its associated sub-tropical rain forest species demanded everything from the soil and though forest was followed for a short time by good grazing, much of the land quickly became infested by native Manuka or Tea Tree (*Leptospermum ericoides*) and in places by Gorse (*Ulex europaeus*) and Broom (*Cytisus scoparius*) which had been thoughtlessly imported from Europe. The recent discovery of the absence of the trace element cobalt has changed the agricultural potential of much of this land and there is now a wise land-use policy by which agriculturist and forester work together to decide on the allocation of the available land between the two industries. However much of the country is dedicated as "Maori land" and cannot be appropriated for economic management.

Large scale afforestation of this Manuka-infested land with *Pinus radiata* occurred, notably at Riverhead Forest, in the period between 1926 and 1933, before the soil limitations were properly appreciated; and we were shown areas of extremely sickly plantations. Some were so bad that they were being "written off" and replanted after dressing with superphosphate: others, not quite so degenerate, showed remarkable recovery after top dressing from the air. Nevertheless much of the soil is heavily podsolised and has a highly impervious claypan; I felt strongly that any new planting should wisely be preceded by deep sub-soil ploughing. This is an operation which the New Zealand foresters have not tried, but as they habitually crush the Manuka (where the ground is not too steep) by the use of heavy caterpillar tractors, the cost of ploughing would be a very small extra expense.

The New Zealand Forest Service is rapidly extending its exotic pine forests on this Manuka land, and as we had all seen so much of their thinning—or lack of thinning—problems during the main Conference tour around Rotorua in Whakarewarewa and Kaingaroa Forests, we were interested to find out what early preparations they were making in this far more rugged country. Though there were obvious systems of ridge-top "jeep tracks", some of them at fearsome gradients, for fire protection access purposes, we thought that a carefully graded network of pre-roading tracks in the valleys would have been inestimably more valuable. They would have served better for fire accesses and could later have been developed into real haulage roads.

At Waipoua Forest and Trounson Park we were treated to a real feast in inspecting some of the all too small remnants of the virgin Kauri pine stands—a single tree carrying over 9,000 cubic feet is a sight not soon forgotten and a stand containing scores of trees measuring well over 3,000 cubic feet apiece is none the less impressive because it has taken a thousand years or so in its development. That day too we sat down to lunch at the very spot where the 1928 Conference had been wined and dined under the trees: the original table legs still stood firm in the soil after 29 years, even though the table top had rotted away to form a grand seed-bed mulch for a mat of wee Kauri seedlings. I thought of the late Lord Clinton who had sat at that table and seen the magnificent giants which had shed those seeds.

Good work is being done to solve the intractable problems of Kauri regeneration, both natural and artificial, and we all felt that even if there was doubt about the pure economics of growing this tree, some expense was fully justified simply because it is such a fine tree and yields such a fine timber. A large area of Waipoua Forest has been reserved as a sanctuary wherein no live tree may be felled, but we were not convinced that this was necessarily the best way to ensure the preservation of a species or of a forest. However the Forest Service has alternative land to work on and we hope that they will accept the challenge.

Though, on the one hand we were shown at Kiapara, an area of *Pinus radiata* in ownership of a company, that the Forest Service has no jurisdiction over private forest devastation, we saw on the other hand that a North Auckland farmers' forestry association has begun to take a really lively interest in shelter-belting and the proper use of small woodlots. We were entertained by this pioneer association and found that its members were full of interest and enquiries about co-operative forestry developments in Britain.

North Auckland includes amongst its population a very high proportion of Maoris who work with and alongside the Europeans and are particularly expert in the use and care of the mechanical equipment in the forests. As the only delegate from Britain I was honoured to plant an English Oak (seed ex Windsor Park) in front of the forest office at Glenbervie, and we later visited the spot where the Treaty of Waitangi was signed by the Maori chiefs and the Queen's officers in 1840. May this oak flourish and grow to cast its shade upon the delegates of some future Commonwealth Forestry Conference.

HE IWI TAHI TATOU

(Maori: *We are one people*)

A YEAR WITH AMERICAN FORESTERS

By B. R. FEAVER

Divisional Officer, East Scotland

[*This article has also appeared in* Arbor, *the magazine of the Aberdeen University Forestry Society.*]

In September, 1953, the Commonwealth Fund granted me a Fellowship to study the "Mechanisation of American Forestry" and I was able to spend a year travelling through most of the main forest regions except the South West, seeing all types of operations. American hospitality and friendliness are proverbial but I was quite astonished to find such a tremendous welcome, enthusiasm and willingness to help all along my route. Not only is the United States Forest Service most forthcoming with help and information but the logging contractors for example will also freely give you facts and figures and are always ready to talk about their work.

An Aberdeen graduate had already blazed a trail along part of my route and I met many foresters who remembered and enquired for Faulkner, having met him in 1951.

American forestry today is demanding more skilled attention than it has ever had in the past. The Forest Service was only established in 1905, following the creation of the first forest reserves in 1891, and their initial work was closely tied to the great lumbering trade that in little more than 100 years cut over nearly all the vast areas of virgin forest. One competent graduate forester made me think deeply when he said it was a good thing that all the old growth had been cut over, as there had been no value in the timber to the growers, whereas today there was far more employment in their new forests where all sizes of produce from pulp to saw timber provided steady employment for far more men, including higher trained men. This is quite a good subject for debate but I quote it only because it shows a very fresh outlook. The American mind is quite free of traditional practices and it was a pleasant surprise to read a published article dealing quite seriously with the use of domestic geese for weeding transplant lines in the nursery. From the economic angle it was most profitable as the conclusion of the weeding season saw the slaughter and eating of the "workmen"! The system had some drawbacks though and was not the answer to the nurseryman's problem.

Another radical I met was a graduate forester employed by a big southern pulp company. He was complaining about the early costs of cleaning dense pine natural regeneration without any yield and was convinced it was more economical to plant in nine foot rows so that anything cut in early thinnings could be easily taken out on trucks that could pass between rows. His task was to grow as much bulk in as short a time as possible for the least money and within those limits he was possibly right, but it seemed almost sacrilegious to hear of copious natural regeneration being unwanted when we go to such trouble in Britain to get any at all.

Because American forest areas are so vast their forestry is on an extensive scale and cannot bear the formation costs we incur with our intensive forestry and high value of the produce. For example you will never see any field drains being dug to make ground suitable for tree growth; there is no fencing against rabbits to be paid for; little fencing is done even against stock, but I did see some against hogs in the south. Field planting is not on a big scale, as in many areas the forest regenerates freely after felling, but planting of desirable species often has to be done if no seed trees remain. It was astonishing to see shortleaf pine (*Pinus echinata*) being planted in north Mississippi beneath a heavy canopy of scrub oaks. The oaks were to be girdled immediately to release the pine. In many instances I saw pines regenerating or being planted where we would only have risked a most shade-tolerant species like beech or Douglas fir. Both Eastern White pine and shortleaf pine had amazing powers of recovery after release from shade, so tree girdling was widely practised and was very successful because the climate encouraged rapid decay of the dead trees.

One of the main silvicultural problems is to secure the regeneration of valuable species, as indiscriminate fellings have resulted in a great brush problem. Chemical sprays are widely used and 2-4-D and 2-4-5-T are the most efficient for the control of brush or unwanted coppice by spraying either from the ground or even from the air for large areas. I did not see any scrub-clearing machines whose cost and performance were suitable for our forest use, but heavy discs or brush cutting rollers would give temporary relief.

Silviculture in the Southern pine areas, where Longleaf pine (*Pinus palustris*) and Slash pine (*P. elliottii*, syn. *P. taeda*) are grown, now makes use of fire for maintaining these subclimax species. It was very interesting to see the unwanted shrubs, vines, etc., controlled by burning and seed bed conditions obtained. Young pines were almost unhurt if burning was skilfully done and really small Longleaf pines, in what is known as the "grass stage"—when they look more like tussocks of grass than trees—benefited directly by having their rust-infected needles burnt off. I examined the terminal buds after burning and found them green and alive, being protected by the densely packed needles.

There is great interest and argument in American silvicultural circles regarding the place of fire in the management of their forests, as the forests were sub-

Beech tends to be dominant on the northern slopes; on the south-facing slopes and at lower elevations, hornbeam dominates. This was our first opportunity of examining the eastern beech, a tree which has been strangely neglected in Great Britain, where it might grow very well. It does not differ very much in appearance from the European beech and in habit it is very similar, but it does not seem to form pure crops as readily as *F. sylvatica* which makes me think that it may be less intolerant of competition and may throw a less dense shade. This suggestion gains some support from the presence of numerous other species in this type of forest, among them being *Acer pseudoplatanus*, *A. laetum*, *A. campestre*, *Quercus iberica*, *Quercus petraea*, *Q. hartwissiana*, *Fraxinus excelsior*, *Tilia caucasica*, *Ulmus glabra*, *U. effusa* (scarse) and *Prunus avium*. In the shrub layer were *Ostrya carpinifolia*, *Prunus divaricata*, *Staphylea colchica* and *Euonymus leiophleus*. Among the herbaceous vegetation, *Sanicula*, *Polygonatum*, *Scolopendrium*, *Trachystemon orientale*, *Epimedium colchicum*, a species of *Bromus* and various others were noted.

Where we were standing, the soil occurred in pockets among boulders and outcrops of limestone. It seemed to me a typical rendzina and it was surprisingly moist. Like the beech, the oaks fare better on the north-facing slopes. From the tower on the top of the hill, there was a very fine view to the north and north-west, of the foothills of the Caucasus, wooded, like ours, to the top and with cultivated valleys between. There were various patches which had been clear-felled, but these were some way off, for clear felling is not allowed near the holiday resorts. On the way down, we had a better view of the forest than we had coming up, and one feature, at the lower levels, is the profusion of climbing plants—*Clematis vitalba* chiefly, and *Smilax*, but I was able to pick out one specimen of *Periploca graeca* which is more characteristic of the sub-tropical plain. I saw one tree of *Pterocarya caucasica* but I am sorry to say I saw no specimens of *Zelkova crenata*, that other well-known tree of the Caucasus.

On our way to the Adler airport for our return flight to Moscow we visited the yew and box grove of Khosta, which is possibly the best example of the mixed broadleaved forest with evergreen undergrowth. We turned off up a side valley and along a very bad piece of road to arrive at a kind of small car-park before a gate leading into the Khosta reserve. There were good paths through the forest, recently made up, and we had not gone far along the track before we discovered that this bit of woodland was one of the regular ports of call for the tourists. We met several parties of them on the path and, at one place where there was a clearing provided with rustic seats, another group were sitting down listening to a lecture given by a woman guide. There is something rather fine about this organised pursuit of knowledge and, to a forester, it is most gratifying that an interesting type of forest should be made the subject of study by the general public.

The hardwood trees, beech, hornbeam, sycamore and Norway maple are old but very fine, some of them being quite large and handsomely shaped. Beneath them is the yew, running up to 70 feet or so, and beneath the yew a layer of box trees 30-40 feet high at the most. In places the box forms a very dense complete undergrowth. There are some patches of *Prunus lauro-cerasus* and holly, while we were told that *Rhododendron flavum* occurs. Ivy, *Clematis*, and honeysuckle are the common climbers. Unfortunately we did not have time to discuss with the Russians how they were going to preserve it without changing its character. Nor could we discover how the ecological tide was flowing, whether it would help or hinder the measures taken for preservation.

A VISIT TO GERMAN FORESTS
JUNE 1956

By G. W. BACKHOUSE
Conservator, East England

General. The visit, which took place between June 4th and 9th, was made at the invitation of His Royal Highness The Margraf of Baden. Forests visited were:

- I Salem Estate north of and abutting on Lake Constance.
- II Eberstein on the northern slopes of the Black Forest.
- III Zwingenberg in the Neckar Valley again owned by the Margraf of Baden.
- IV Three Communal Forests in the Neckar Valley to the east of Zwingenberg.
- V Karlsruhe State Forest.

The tour of Salem was conducted by a well-known German forester, Forstdirektor Meiss, who is in charge; the eldest son of the Margraf, Prince Maximilian, acted as interpreter. The tour of the remaining areas was conducted by Forstmeister Houtenmans of Zwingenberg who speaks excellent English.

The object of the tour was to study the natural regeneration of beech and to see something of the management of pine forests in Germany.

Description of the Forests

I. Salem Estate

The area under forest management totals 10,800 acres and comprises no less than seventy separate blocks. It is the second largest forest unit in West Germany. These woods fall into two main groups:

(a) the Salem group reaching down to the shores of Lake Constance and including a very varied hill system with many small valleys of glacial origin. Agriculture here is mainly fruit and vine growing and the forest is largely confined to the steeper slopes, and average altitude is 1,500 feet.

(b) the upland group slightly further north and on the steeper and more rugged hillsides reaching up to the Heilingenberg plateau; here altitudes average 2,250 feet. In both areas there is a noticeable absence of anything more than a large stream. Agriculture in the region of the upland groups is largely corn growing.

Climate. Over an area of 40 by 20 miles it is to be expected that the climate will vary greatly. Down by the lake the climate is mild; in the uplands it is relatively harsh though exposure is never severe. The high mean temperatures in the Salem group produce optimum growing conditions for beech and other valuable hardwoods. This area is considered to be too hot for optimum growth of spruce. The lower mean temperatures on the upland zone produces excellent growing conditions for spruce and silver fir. There is little doubt that the presence of Lake Constance produces a more equable climate in its vicinity—indeed on a small island in the lake semi-tropical plants thrive. It has also been shown that the "lens effect" of this large stretch of water increases the light intensity up to six miles away; this is said to be sufficient to affect tree growth.

Rainfall varies between 28 and 44 inches per annum, average 36 inches, and is well distributed over the year.

Close to Lake Constance little snow falls but in the upland areas there are heavy falls.

Geology and Soils. The geological basis is morainic alluvium and diluvium. There is very considerable variation even locally; thus there are chalky clays and sands, sandstone and pebble beds. Soils are generally very fertile brown forest soils though locally on the highly calcareous types rendzinas are distinguishable.

Silviculture and Management. The chief species is beech with Norway spruce, Scots pine, European larch and some oak, ash, sycamore and Douglas fir. The system on which the woods are worked is in the main a strip felling system with natural regeneration though at times group regeneration may be used. The Forstdirektor has full freedom to adapt the method to be used to the particular circumstances.

Starting with the young regeneration this will probably consist of 95 per cent beech with groups of Norway spruce, European larch and some Scots pine. Infrequently there may be groups of ash, oak and sycamore. This regeneration is relieved of all cover quite early in its life—when 12 to 18 inches high.

In spite of the quite excellent conditions for regeneration over almost the whole area there are always a few gaps, usually not more than a metre or two across, and there are always weaker patches in addition. Advantage is taken of such gaps to introduce conifers, e.g. Douglas fir, Japanese larch, Norway spruce, European larch and Scots pine where these are lacking in the regeneration.

All planted trees, and Norway spruce, Scots pine and European larch if scarce, must be protected against rubbing by roe deer.

The ideal is considered to be dense regeneration really well established before grass has had time to become established. However dense mats of grass were rarely seen even on the heavier soils and if a herb layer did manage to get established it was predominantly woodrush, *Luzula* sp.

The regeneration is weeded if below the grasses and weeds, even twice a year if necessary. Subsequently the regeneration is gone through each year—weed species are cut as necessary, the more valuable conifers relieved (particularly European larch) and rough forked beech are cut back. This work is mostly done at this stage with long-handled secateurs.

Gradually this improvement treatment drops to a three year cycle and the wood develops into a dense thicket of rather drawn beech of fine quality with the conifers out on top. Great emphasis is placed on keeping the European larch free and maintaining deep crowns on every one.

The treatment proceeds gradually, removing the weaker unwanted beech until a pole wood forms. So treatment passes from Stage I—the negative stage, to Stage II the positive stage which aims at removing all trees which would damage the final crop. Damage to the final crop is always anticipated and action is never delayed until damage has occurred. The thinnings in Stage II—always crown thinnings—aim at the retention of the minor constituent of the crop. This treatment gradually produces stands which ideally consist of three definite layers—the uppermost of scattered European larch—Scots pine, all fine clean poles ultimately reaching a height of 140 feet or so and having fine crowns, the middle or main layer of beech, Norway spruce and such other shade-tolerant species as the crop may contain, and then the lower layer of suppressed beech which provides perfect soil cover. The persistent crown thinnings enable this understorey to survive and great emphasis is put on its maintenance. Often regeneration will come in also but it is never cared for until required—age and growth of the overwood only determines this, and the staff is safe in the knowledge that good regeneration can always be obtained with little trouble when required. On this point it seems reasonably obvious that, though bumper mast years may be but little more frequent than in Britain, years in which there is no mast are rare. It is equally obvious that at Salem masts which in Britain would produce negligible regeneration produce there excellent crops. This is almost certainly due to better management of the soil and soil cover and absence of such enemies as the pigeon and grey squirrel. There being no winged game, raptorial birds are not controlled, and this may well result in low population of vole, etc. Sometimes regeneration produces a stand of pure Norway spruce, pure beech or ash, but the total area is never large and this rarely repeats in the subsequent rotation. The aim is always for this mixed forest and it was noted that in the younger stands there were fewer areas of pure species than in the older crops.

At the higher elevation silver fir (*Abies alba*) comes in, tending to replace the Norway spruce but never doing so entirely and the general effect is as before.

The general objective in the mixed woods is to remove any Douglas fir at 70 years and the Norway spruce between the 70th and 100th years, but this is not a hard and fast rule and removal is always adjusted to allow the crop to close up quickly. Stocking at all ages is very dense by British standards.

There is no definite rule as to when regeneration shall commence. The Forstdirektor starts when he feels (senses) that it is opportune. Occasionally he may start with a group which he has made, or which has occurred naturally, and from this work outwards gradually, coalescing it with similar groups and so moving on a wide front through the wood. However the more usual method is a strip system; strips three or so chains wide at right angles to the prevailing wind. The first step is to cut all advance regeneration and much of the lower storey to let in light; at the same time the upper storey is lightened. Regeneration comes quickly and then two to three years later the remaining overwood is removed.

The group system tends to be used more at higher elevations but even here there is no hard and fast rule.

Successive strips of regeneration are always 'merged' by cutting in the margin of the older strip and indeed this policy is applied to groups also so that after treatment the group is like an inverted saucer.

Where the young regeneration does not contain the desired proportion of such species as Scots pine, a mother tree may be left—often 100 feet high with a fine cylindrical stem. Such a tree rarely blows and is left to be cut with the advance portion of the next crop.

Occasionally the advance regeneration contains Scots pine up to 20 feet high perhaps 20 to 30 years old. Such are of course, slow-grown, partially suppressed individuals with fine branches. These trees are greatly prized; they are pruned and cared for and retained as part of the new crop. They are said to be the type which grow on to make the finest and biggest trees at an age of 130 years or more.

Pruning of pole woods is often carried out with the object of maintaining one-third of the stem clean, but never pruning higher than one dead whorl below the living crown.

Production. The aim is fine cylindrical poles of top quality in all species. Beech is only valuable in big sizes.

Control of production is based on the "Methode du Controle".

Assessment is made every ten years and one was recently completed though the results had not been worked up at the time of the visit.

The cut has been fixed at 924,000 hoppus feet per annum for some time—this over 9,750 acres. Increment averages 112.2 hoppus feet per acre per annum over the whole and the standing volume 4,350 per acre (all ages).

The 924,000 hoppus feet cut each year is made up as follows:

Norway spruce, silver fir, Douglas fir	40%
Scots pine sleepers and joists	2%
Scots pine and European larch logs	10%
Various conifer poles	7%
Conifer pulpwood	9%
Beech logs	7%
Beech sleepers	2%
Various hardwood logs	1%
Hardwood pulpwood	1%
Firewood (conifers)	5%
Brushwood (fuel?)	8%
Hardwood firewood	8%
Hardwood brushwood	6%

Overcutting is always avoided and a reserve is always available to meet an emergency and hence the last war had no serious effect.

All felling is done by the forest staff and extraction is by horse and provides useful seasonal work for the local farmers. Tractors and winches are however coming in but are not liked as causing more damage.

Rotations. The following rotations are average only; there are always exceptions as local circumstances dictate.

Norway spruce	80—100 years
Douglas fir	60— 70 ,,
Scots pine	140 ,,
European larch	140 ,,
Beech	130 ,,
Oak	140 ,,
Poplar	60 ,,
Ash, etc.	90 ,,
Silver fir	120 ,,

Protection. The mixed nature of the stands and the high standard of management produces woods which are remarkably free from diseases. The only major insect pest is a bark beetle (*Ips* sp.?) which attacks spruce, and has given much trouble in the province in recent years, necessitating heavy clear fellings on neighbouring estates. At Salem no really serious damage has occurred but any trees showing signs of attack are felled and all felled trees are peeled at once.

Rabbits are non-existent, pigeons are scarce and squirrels uncommon.

Sporting. From the 16th to 18th centuries sporting had precedence over silviculture in the Salem Wood and indeed this appears to have been normal over the whole of Germany at that time.

The Grand Duke ordered the reduction of the deer stock (red deer) in 1835 and this order was carried out within three years. But they increased again until in the year 1848 the revolution resulted in uncontrolled hunting over a very wide area and the head of deer was again greatly reduced. Many of the fine stands seen on the estate today date from this period.

Today, however, destruction by deer is rarely seen in the Salem Woods. To some extent this is due to the nature of the woods but mainly to the fact that deer are kept within proper bounds. The owner is an enthusiastic hunter but first and foremost is a forester and farmer.

The annual kill each tenth year up to 1943 was:

1943	—	223
1933	—	137
1923	—	58
1913	—	94
1903	—	65
1893	—	47
1883	—	97
1873	—	34
1863	—	33

The increase in the last two decades—in spite of a reduction of total area of woods, is noteworthy and it is recognised that the population of roe deer is by no means small. However there is no conflict between forestry and game and the latter maintains its proper place in the forest community.

Very careful costing of the sporting has been made at Salem for over 80 years and the figures show that it is always run at a loss. This in spite of the fact that roe venison is the most expensive meat in Germany.

Browsing of young beech is unimportant as there is always almost an unlimited amount of this available. However the more uncommon species such as European larch, Japanese larch, Douglas fir and Scots pine have always to be protected. Even Norway spruce is protected when in small numbers. This protection against browsing is confined to the first few years of the life of the trees and usually takes the form of smearing the trees with a mixture of clay, lime or chalk, mixed with liquid cow manure. Each forester has his favourite specific. When the trees to be protected get slightly larger they are protected from browsing and rubbing by various means—strips of tinfoil wound round the branches, spiky wire contraptions, spirals of wire round the leaders, very often augmented by a stake driven into the ground close to the tree. Without such measures there is little doubt that the desired proportion of these valuable species could not be maintained.

Roads. There is tremendous emphasis on the importance of roads in the forest and on extraction facilities generally. Within the forest all roads are merely dirt roads and in spite of the heavy rainfall they stand up very well. Some 160 miles of such roads have been constructed in the last thirty years. The great intensity of roads means that no road gets continuous heavy use and hence maintenance is less. There is a definite policy of avoiding wide unplanted strips along road sides which would be necessary if wide metalled roads of a higher standard were adopted.

These roads cost 10*s*. to 40*s*. per running yard for the formation and 10*s*. to 20*s*. per yard for surfacing.

Miscellaneous. Each gang of workmen—usually not more than six in number is provided with a portable wooden hut. Such a hut can be dismantled and re-erected within an hour. It saves the cost of large numbers of shelters scattered over the forest and provides a higher standard of comfort than would these latter. Each hut has a portable stove—an essential in a country where the mid-day meal is the main meal of the day.

II. Forest of Eberstein

General. Situated on northern edge of Black Mountains, 825 acres only. Granitic soils. Exposure never severe, as sheltered by Black Forest mountains to South and South West. Vegetation varies from bracken on the better soils to *Vaccinium/Deschampsia flexuosa* on dry ridges.

There was some heavy felling during the war years, much windblown and some felled due to attacks of spruce bark beetles; hence there is an undue proportion of young plantations.

Species and Silviculture. The older plantations consist of silver fir, beech, spruce and European larch and are up to 140 years old. Generally they are even-aged and often have a sparse understorey of beech regeneration. Growth is moderate only, though better in the hollows, and there are some larch on the ridges.

Strip fellings some 100 yards wide are used, and regeneration which is sparse is completed by planting. Planting is an opportunity to introduce exotics and every effort is made to thus enrich all young crops. Thus the natural young crops of European larch, beech, Norway spruce and silver fir also contain a proportion of Scots pine, thuya, Douglas fir and Weymouth pine. Young plantations of red oak were also seen.

Miscellaneous. Again great emphasis is put on the importance of a good road system to enable timber merchants to get their equipment close to the stump.

Bird-boxes to encourage the nesting of coal-tits are widespread. Roe deer are present in such numbers as to necessitate deer fencing of all newly planted or regenerated areas. Trees introduced as enrichment have to be protected individually—either by sleeve netting or one of the many other means employed.

III. Forest of Zwingenberg

General. The forest covers 5,000 acres in 16 blocks and is situated in the south-east part of the Odenwald. Elevations range from 400 to 1,500 feet though most is between 900 and 1,500 feet.

Generally the forest is on the steep slopes of the valley of the Neckar and its tributaries.

Climate. Rainfall 36 to 40 inches per annum. The climate is not severe anywhere though the tops are fairly exposed and here snow can lie for long periods.

Soils, etc. The underlying rocks are variegated sandstones which are soft and erode easily. There is loess over the sandstone in places. Soils are deep sandy loams which are lacking in lime.

Silviculture and Management. The forest was originally coppice oak, beech, hornbeam, birch and hazel but was converted to High Forest during the early nineteenth century. Generally the forest now consists of beech, larch, spruce and Scots pine with some stands of mixed spruce and silver fir. There is one stand of 50 acres of red oak. The annual cut is fixed at 320,000 hoppus feet, i.e. 64 hoppus feet per acre. In the four years 1951 to 1955, however, over 1 million hoppus feet were lost because of gale damage and snowbreak.

The forest has been the subject of a Working Plan since 1839. Each plan covers a ten year period and an essential preliminary to the preparation of a new plan is a complete stocktaking of the whole forest. Great care is taken to ensure that the increment is not overcut, while the opposite evil of over-stocking is avoided. From time to time the local state forest "Conservator" is called in to give a full report on management. Regeneration is carried out by a system of strip fellings moving progressively from North-East to South-West. Regeneration usually comes readily provided "the wind is kept out and the moisture in". A mixed wood is always the aim and again great emphasis is placed on the importance of a small proportion of European larch, Scots pine and Douglas fir to produce the early financial returns, these being planted if necessary.

On the hot dry slopes regeneration of beech is not easy and an overwood is essential. In some such sites strip cultivation is carried out and it is noteworthy that in such areas the beech are virtually confined to the cultivated strips.

Regeneration once established is given much the same treatment as seen at Salem—cutting out bad beech for the benefit of better ones and also to keep a deep crown on the European larch, etc. Adjoining strips of regeneration are 'merged' by cutting into the older strips.

The comparative depths of rooting of the three main species was illustrated in soil pits on the loess plateau—Norway spruce shallow and both beech and silver fir very deep.

The silver fir suffers from *Adelges* damage, but its share in the woods is strictly limited by maintaining an uneven canopy, mixing plantations and avoiding large even-aged blocks.

Every tree introduced as enrichment has to be protected from deer and it is recognised that the population of red and roe deer necessitates expensive counter-measures if the plantations are not to suffer.

Where the soil is considered to be deteriorating due to base deficiency, powdered lime is applied by blowing into the plantation from the rides, using a power-blower, at the rate of 32 tons per acre.

Roads. Great emphasis is put on the value of a good road system which has been greatly extended in recent years. The intensity of roads is greater than in neighbouring State Forests. Each of the six beats has a roadman whose job is first aid repairs—particularly to see that all gutters are open and water kept off the road.

Utilization. All timber is felled by the forest staff and extracted to roadside by the ubiquitous Unimog tractor. There is a ready sale for all timber except red oak.

Miscellaneous. All foresters are provided with motorcycles. There is a scheme whereby workers are helped to buy motorcycles by loans. Birds are encouraged by provision of nesting boxes and it is found economical to purchase boxes made from sawdust brickettes.

IV. Communal and Church Forests

Several Communal and one Church Forest were visited. All were situated in the Odenwald and in each the general object of management is to produce beech forest mixed with other species, though on areas at higher elevation this gives way to spruce and silver fir. Regeneration is usually by strip fellings though some groups were seen.

In the Church Forest heavier stockings of larch were seen and damage by *Ips* was pointed out. A few badly damaged trees had been felled to act as traps; the bark was sprayed, and before breeding was completed the logs were peeled and all sprayed again. Most larch in forest were suffering from a severe attack of leaf-miner and it was gathered that this is usual. Young larch plants are protected from weevil attack by placing strips of spruce bark, with twigs of Douglas fir inside, around the area. When prepared, the bark is sprayed with an insecticide which kills the weevils and obviates the necessity of hand collection.

Parts of these Communal Forests are at high elevation and a vegetation of *Vaccinium* under the mixed beech woods was not uncommon; such areas were being improved by application of lime as previously described. The last forest visited, that of Neckareltz, is situated on limestone and here the most extensive and dense regeneration of beech was seen. It resulted from removal of firewood by the local populace in 1946 coinciding with a good mast year. In this forest good beech mast occurs on an average every five to six years.

General Note on State Control of Private Forestry in Germany

The State Forest district officer generally prepares the Working Plan for the Communal Forests and the Commune pays a small fee for his general aid. Each year this officer produces an annual working plan which has to be approved by the burgomaster before passing on to the forester who will have to carry out its prescription. If the burgomaster and district officer do not agree the latter's superior officer gives his decision.

Over the large private estates control is light but each must have a Working Plan approved by the State Service. The State only steps in when the estate fails to restock a felled area and when necessary in the interests of forest hygiene.

The smaller estates are subject to closer control. The careful supervision is aimed at preventing devastation and the spreading of disease. These small estates usually are without working plans and hence any clear felling is subject to licence to which suitable conditions are attached. A guarantor is required by each applicant. The State can take over control if things go wrong.

There is extensive forest legislation over the whole of West Germany but the provinces have additional laws. In Baden the present law enables the State to say what land shall be forest land (the local Agricultural Officer takes the decision) and a grant for new planting following such an order is made by the State—about £4 per acre followed by a smaller maintenance grant for three years.

Conclusion

Of the many lessons learned, the following have been chosen as applying most readily to conditions in England.

The importance of managing beech woods so as to enable regeneration to be obtained when wanted. The maintenance of an understorey to protect the soil is obviously the most important single factor—many of the beech woods in England are completely bare underneath a tall dense canopy, or else growing dense grasses or brambles if the canopy is open.

The great value of enriching even perfect beech regeneration both to obtain a more valuable return from the area and to maintain a healthier wood.

The importance of early treatment of beech regeneration in order to obtain a crop of fine stems from which an elite crop can later be selected.

The value of a really adequate network of dirt roads for all management reasons.

On the question of deer the lesson to be learned is that even in mixed woods with a normal series of age-classes and more or less perfect conditions for roe deer the price which can be paid to maintain a heavy stock is high. It seems unlikely that our own even-aged forests, often with large blocks of one species, can sustain even a moderate head of deer without serious damage resulting.

GIBRALTAR

By E. J. HALE

Clerical Officer, Alice Holt

Tarik ibn Zeyad! How gratifying such a name must have been to its owner —a Moorish leader of the 8th century—for when emphasis is placed on Zeyad! it rings out like a war cry that this bearded warrior, astride his restless arab horse, may often have used when he captured and held as a fortress the mighty bluff of rock twixt his homeland and Spain. From the flowery title of this rollicking cut-throat came the name Gebel Tarik (Tarik's hill) and from this was derived Gibraltar, a name as hard and heavy as the rock itself. Mention Gibraltar and someone is almost sure to say "But surely very little can grow in such a place". I too until I lived there for a year imagined it to be but a military and naval base. My first big surprise was on a brilliant morning when I looked through my cabin porthole and found we were at anchor close in; the steep western slopes of "Gib" filled my circle of vision so that only by craning my neck could I discern a strip of blue sky. I saw plenty of rock but also to my amazement large expanses of sunlit greenery stood out boldly against the white limestone.

For the next twelve months I spent many pleasant spare time hours roaming the rock from the seabirds' nesting places on the East side around Europa point with its dangerous swirling currents and tiny bays where octopus could always be found, up and down the western slopes where a multitude of plants, shrubs and trees were flourishing in the scanty soil, over the unstable screes of north front, water catchment areas, sandy beaches, and the comparative subtropical lushness of the public gardens—flora and fauna in plenty I discovered everywhere and I had thought it was mostly bare rock.

Gibraltar is only three miles long by about a mile wide with a total area of under three square miles and the highest point is 1,396 feet but the natural and artificial works that exist in this tiny space are truly remarkable. The population of over 30,000 is daily augmented by an influx of thousands of Spaniards who work in the dockyards and town. There is a cathedral and a number of churches, the streets are full of cars and there are many shops, cinemas, theatres, clubs, hotels, schools, barracks, workshops and hundreds of houses to make a busy built-up area, but there are also many acres of public gardens and steep hillside covered with vegetation.

The climate is one of the most enjoyable one could wish for as most of the annual rainfall of 28-30 inches occurs in November, December and January and the rest of the year is mostly dry, the temperature range being between 40°F and 80°F, for the summer heat is tempered by a sea breeze. As there is a negligible rainfall for eight or nine months every year water supply is a real problem and large catchment areas have been laid out which have piped outlets to tanks in the rock. The prevailing wind in the summer is from the East and sometimes a warm breeze laden with moisture known as the "Levanter" strikes the eastern face of the rock, condenses in the sky above and causes a cloud pall to hang over the city and bay. During this period the climate is humid and relaxing.

The geological formation of Gibraltar is of a basic rock of white/grey limestone. Above this is a mixture of shales, grit, sandstone and limestone with here and there limestone breccias, bone breccias and calcareous sandstones as well as loose sand and debris. The whole place is honeycombed with caverns the greatest of which is St. Michael's cave with its entrance 1,100 feet above sea level on the western face. A steep slope at the entrance leads to a hall 200 feet long and 70 feet high containing a wonderful display of stalactites and this cave is connected by twisting passages to four other caves and deep pools of water but now it is all electrically lit and something of a tourist attraction.

A century ago Dr. E. F. Kelaart in his *Flora Calpensis* listed over 400 flowering plants and ferns as indigenous to Gibraltar and about 50 as introduced. Since then the former have decreased but introduced species have doubled or even trebled. At all times of the year there is colour and verdure. In autumn the "Pepper tree", *Schinus molle*, has its gracefully drooping branches laden with clusters of red berries and in summer the aloes flaunt long spikes of scarlet. Fig trees grow out of old walls everywhere and the wild olive is a welcome shade tree. The stone pine grows well in and around the public Alameda gardens and here too can be seen a few date palms, the dwarf palm, *Chamaerops humilis*, orange, lemon and banana and most colourful of all hedges of bougainvillea with flowers of most brilliant mauve and red. What a place this is too for geraniums, nowhere have I seen better whilst high up in the rock white drifts of "rock lilies", *Narcissus bulbocodium*, were a delight to the eye. The tall variety prickly pear, *Opuntia monocantha*, which is I believe not a native but was introduced from South America, flourishes all over the place and has quite handsome golden yellow flowers.

Here and there are odd trees of Scots pine but the flat spreading crown and scaly bark of *Pinus pinea* is more in evidence. There are too a few old trees of the Carob or locust bean, *Ceratonia siliqua*, an evergreen that is hung with brown beans 6 to 9 inches long in the autumn. A peculiar tree with an odd name is *Phytolacca dioica*, thought to have been introduced by General Don and also known as bella-sombra. It is a very fast growing evergreen with a butt-ressed trunk up to six feet thick and leaves like those of black poplar. A relation of the elms, *Celtis australis*, or the nettle tree, is found here and there but never grows very tall, the bark is smooth and grey and there are small greenish flowers, but it is the fruit which is of interest for it is a drupe about as long as a pea, almost black, sweet to the taste and is said to have been the lotus of the ancients—that delicious fruit which . . . "made those who ate it forget their own country". On the upper rock are native oaks, *Quercus ilex*, which bear burdens of long pointed acorns in September ; lining the roads that zig-zag to the top of the rock are blue gums whilst on the western side are some mountain cedars—in actual fact the juniper—*Juniperus oxycedrus*, another native and a hardier form of *Juniperus cedrus*. It grows up to 25 feet and has reddish brown berries about half an inch across. Shrubs were plentiful and grew on all but the steepest slopes—*Cistus albidus* sported large pink flowers in May with white downy leaves and *Genista scorpius* grew up to 6 feet high having many spreading spiny branches and clusters of yellow flowers in spring. I found three or four kinds of *Cytisus*, one 8 feet tall and all having yellow flowers. There were a few castor oil plants with thick stems and green leaves tinged with purple and some shrubby sages with violet flowers which were, I think, *Salvia triloba* var. *calpeana*. Another herb I noticed was pennyroyal, but this was a prostrate variety with deep green leaves and pale purple flowers, probably *Mentha pulegium* var. *gibraltarica*.

Of wild orchids I saw only two—*Orchis speculum*—the looking glass orchid which bears yellowish-green flowers in April and *Orchis lactea* with pale lilac flowers in March, but I understand that at least six kinds have been seen growing on the rock. I must also mention two lovely little irises that grow on the upper rock, one of them bears pale lilac flowers and the other has blooms of violet-purple with yellow bands.

Barbary apes which are protected, like the cows in India, roam everywhere, hoopoes strut and flourish their crests in the Alameda gardens and blue rock thrushes sing in the sunshine, whilst a climb to a thousand feet will reveal a brilliant blue sea on three sides and the sunburnt Spanish countryside on the fourth with the little town of San Roque a startling white in the middle distance framed by the high Sierras beyond. Across the straits distance lends enchantment to the African coastline which is dominated by the Atlas mountains, deep blue snow-capped and magnificent.

FORESTRY IN GREAT BRITAIN

A REVIEW

By H. L. EDLIN
Publications Officer

The forestry situation in Great Britain is remarkable for two factors. First, the net quantity of timber and timber products imported is the largest for any country in Europe, or indeed the whole world. Second, the proportion of land devoted to the raising of tree crops is little more than 6 per cent and so almost the lowest in Europe, and home-grown timber consequently forms only a small proportion, less than 10 per cent, of the total consumption of wood. The forest policy of Great Britain is directed to redressing this unfavourable situation by large scale replanting and afforestation.

The Natural Setting

Situation, Topography, Geology and Soils.

The mainland of Great Britain forms an island of very irregular outline extending for 700 miles from North to South, and being 300 miles from West to East at its widest point. It lies between 50° and 58° 20′ North in latitude and 2° East and 6° West in longitude. Although only 20 miles from the coast of France at its nearest south-easterly point, it is separated from Scandinavia by distances as great as 400 miles further North. It may thus be regarded as an insular projection of the main European Continent far out into the Atlantic Ocean, and this circumstance gives it a maritime climate very different from that of other European countries in the same latitudes. The maritime influence of the warm Gulf Stream in the North Atlantic gives a generally mild winter climate, but the situation of Great Britain at the meeting point of continental and oceanic air masses results in very unstable weather conditions, characterised by sudden changes at any season of the year. Further Britain's isolated and insular position renders it liable to high winds and gales.

Politically, Great Britain is divided into three countries which will be used for convenience in the descriptions that follow. The ancient kingdom of Scotland extends to the North of a boundary running from the Solway Firth on the West to the River Tweed on the East, occupying about 30 per cent of the island. Wales, occupying about 10 per cent, lies to the West of England, between the River Dee and the River Severn, while England comprises the remaining Southern and Eastern areas, or some 60 per cent of the whole.

Most of England consists of plains or low hills seldom exceeding 1,000 feet in altitude, but in the North and also in the South-west, moorlands and mountains reaching 2,000 or even 3,000 feet are found. Both Wales and Scotland are mountainous, with many peaks reaching 3,000 feet and a maximum height of 4,400 feet on Ben Nevis in the West of Scotland. The hills and mountains occupy roughly half of the island, and all lie towards the North and West.

Although the elevations are not high by European standards, they combine with the Northerly latitude and severe exposure to the Westerly gales to form a major limiting factor to tree growth. The upper limit of economic afforestation is nowhere higher than 2,000 feet, and locally in the West of Scotland it may be as low as 500 feet. It follows from this that in Scotland, the North and West of England and Wales, forests are confined to the valleys amid the higher mountains, or to the lower hills; whereas in the South and East of England there is no altitudinal limit to tree growth.

The pattern of geological strata is very complex, since all geological periods are represented, though often by fairly narrow bands or small areas of each particular stratum. But broadly speaking it follows the main topography. The older and harder rocks, which are most resistant to erosion and yield the least fertile soils, lie towards the North and West, where they build up the mountain ranges. The South and East have younger and softer rocks, with on the whole gentler slopes and more fertile soils. Throughout the country, the general run of the strata is from South-west to North-east. Most of the rocks are siliceous in character, but there are several groups of calcareous rocks, lying mostly in the South-eastern or lowland portion of Great Britain. One is the chalk, which forms the famous white cliffs of Dover in the extreme South-east; bands of chalk forming low hills known as "downs" or "wolds" are found as far West as Devon and as far North as Yorkshire. The others consist of Carboniferous and Jurassic limestones, which outcrop as long narrow bands from the South coast across the Midlands to the North of England, and locally in Scotland and Wales. In Scotland, North Wales, and South-west England, there are considerable areas of volcanic rocks, while metamorphic rocks prevail over most of the Scottish Highlands.

It is not possible to indicate any broad distribution of soils in Great Britain, for they are spread in an intricate pattern that is not always closely related to the underlying rocks. One reason for this is the extensive glaciation that affected nearly all the country during the great Ice Ages. There is often a thick deposit of clay, morainic gravel, or even blown sand, covering the underlying rock; and it is this deposit, and not the main stratum, that forms the soil's parent material. Organic soils formed more recently from peat also cover great areas, and hide both the glacial drift and the main rock formation. These peaty soils are most frequent under the high rainfall of the North and West, and because of their low agricultural value are frequently available for afforestation. Podsolized soils, usually associated with a vegetation of heather, *Calluna vulgaris*, are common over glacial drifts in the East of Scotland and North-east England, and also locally over sandy strata farther South in England. Gley soils, associated with waterlogged sites, are found on glacial clays along the Borders between England and Scotland, and also on other clays in the English Midlands and elsewhere. Rendzina soils are common on the chalk and the limestones, while sand dunes or sandy deposits have been afforested at several points along the coast and locally inland. Brown earths are found under standing tree crops in many districts, but are seldom available for new planting. In general, the more favourable soils in Britain have been cleared for agriculture, and the forester is usually concerned with the less fertile or less tractable soil types.

Climate

Although the climate of Great Britain is often described as temperate, that conclusion rests on average values for temperature, rainfall, and wind, which conceal wide extremes. The main climatic features vary to a surprising extent and within short periods of time, in an unpredictable fashion, so it would be misleading to attempt any simple account. The British climate includes some characteristics which are favourable to tree growth, but others very adverse to the forester's work.

The extreme range of temperature is from 10°F to 100°F, the means varying from 40°F in January to 60°F in July. Since the temperatures, even in winter, are generally above freezing point, it is possible to dig the ground and therefore to carry out nursery work and tree planting from Autumn through Winter to Spring; but this favourable circumstance cannot be entirely relied on, for work is apt to be stopped by a spell of frosty weather that may last for several weeks. Brief and often local night frosts are apt to occur very late in the Spring, in May or even in June, and these do severe harm to young shoots of trees that may have proved quite hardy to winter cold. Severe winters occur with sufficient frequency to rule out several kinds of exotics from the warmer temperate zones, in particular the Australian *Eucalyptus* genus.

Rainfall shows great local variation; some districts on the East coast receive only 20 inches a year, whereas certain Western mountains get 200 inches. Average values are 30 inches for the South-eastern lowlands and 50 to 60 inches for the Northern and Western hills. It has been customary to regard these amounts as everywhere adequate for tree growth, but it has recently been appreciated (R. F. Wood, 1957) that during the main growing season, from April to September, the loss from evaporation exceeds the gain from rainfall over most of South and East England, though not elsewhere. This may explain why the rate of growth of spruces and other moisture-loving trees is higher in the North and West.

Although the rainfall is fairly evenly spread around the year, there is usually a pronounced dry spell during the spring months, between March and May. This renders nursery work more difficult and tree planting less certain, and it greatly increases the risk from forest fires. Occasional summer droughts can also be serious. Snow seldom lies for long in winter below 2,000 feet, but heavy snowstorms are fairly frequent, particularly on the eastern side of the country. Damage to branches and foliage caused by clinging wet snow or hoar frost is occasionally severe.

Average wind speeds range from 10 miles per hour in the Midlands of England to 15 miles per hour on the West coast of Scotland. The prevailing winds are warm, moisture-laden, south-westerly ones, but cold, dry, north-easterly winds may blow for several weeks on end, particularly in spring. Gales with wind speeds up to 80 miles per hour occur quite frequently, and on extreme occasions speeds of 100 miles per hour have been recorded. During an average winter most parts of the country suffer two or three severe gales, usually from the South-west but occasionally from the North-west or North-cast. The risk of damage to tree crops from windblow is therefore a constant concern of the forester, and is a subject of current research.

The native forest flora of Britain, having been derived originally from the neighbouring continent of Europe, appears well suited to the climatic conditions of the South and East. But it is perhaps less well adapted to the Northern and Western highlands, from which indeed certain species, such as beech, black poplar, and field elm, are absent. The introduction of new timber-producing trees from abroad has involved their testing under our uncertain climate. Generally, it has been found that trees from regions with a clearly defined march of summer and winter temperature, such as Eastern North America, thrive poorly in Britain. But those from regions with a maritime climate, being accustomed to more fluctuating conditions, succeed; in particular, conifers from Western North America have done well.

Historical Review

Natural Forest Cover

Over the whole of Britain the processes of deforestation by grazing, burning, and clearances for agriculture, timber or firewood, have been carried to a point further than is found in most European countries. So little natural forest cover remains that it can contribute nothing substantial to the country's timber supplies. It is of little more than academic interest to botanists, ecologists, and of course, to foresters. But much research has been carried out on it, particularly through the medium of pollen grains and fragments of wood preserved in peat bogs. Dealing with the historical period only, from the beginning of the Christian era onwards, the following broad picture can be drawn.

The principal tree growing in the South and East of Britain was the pedunculate oak, *Quercus robur*, which formed extensive forests on the heavier soils; towards the North and West, and particularly in the Scottish Highlands and in Wales, its place was taken by the sessile oak, *Quercus petraea*, which is more at home on the lighter soils. Associated with these oaks, in different parts of the country, were various kinds of elms (*Ulmus* species), poplars (*Populus* species), limes (*Tilia* species), and birches (*Betula* species), and also ash (*Fraxinus excelsior*), beech (*Fagus sylvatica*), and hornbeam (*Carpinus betulus*). Hazel (*Corylus avellana*) was common as an undershrub. Some of these trees formed pure woods in certain situations, notably ash on limestone and beech on chalk. Alder (*Alnus glutinosa*) and several kinds of willows (*Salix* species) prevailed in moist places. This kind of woodland is regarded as an extension of the deciduous broadleaved forest of Europe.

Over the Scottish Highlands, and locally farther South, a different type of woodland was found. This is regarded as an outlier of the northern coniferous forest of Europe, but possessed only one important coniferous tree, the Scots pine, *Pinus sylvestris*. The spruce (*Picea abies*), the silver fir (*Abies alba*), and the larch (*Larix decidua*), common in continental Europe, are not native to Britain. With the evergreen pines was associated the deciduous birch. Small areas of this primeval natural forest survive in certain Scottish glens, where they are the subject of much interest and some research.

Planted Woods under Private Ownership

The early development of silviculture in Britain was based on the artificial establishment of coppices and plantations, rather than on the management of existing natural woods. In this respect it provides a contrast with European practice. The underlying reason was probably the more complete devastation of the original forest cover, particularly in the more closely settled areas. Evidence of early concern with the formation and protection of woodlands is found in an "Act for enclosing of Woods" in hunting grounds, passed by King Edward IV in 1482, and a further "Act for the preservation of Woods" passed by King Henry VIII in 1543. In Scotland, which was then a separate country, an Act was passed by King James IV in 1504 requiring every landowner to establish at least one acre of wood "where there are no great woods nor forests".

At first attention was directed to the management of coppices, mainly of hazel, but also of hornbeam, ash, sweet chestnut (*Castanea sativa*), birch and oak, with the object of securing small-sized material for hurdle-making, fencing, firewood, charcoal and bark for tanning leather. A rotational system of cutting was followed to ensure an annual supply. Later, as the original forest cover became further diminished, it became customary in the South of England to preserve large oaks, ashes, and sweet chestnuts, known as "standard" trees, to provide occasional large timbers for building houses, barns, or ships.

Originally, much of the open forest land used for hunting had been owned by the king, but a steady process of enclosure went on, accompanied by the disposal of the royal lands to the great landowners. It was these landowners, therefore, who undertook the planting and management of the new woods, until eventually nearly all the country's woodlands were under private ownership. During the seventeenth century, these landed proprietors began to take an interest in forming high forest plantations, and this work was greatly expanded during the prosperous eighteenth century, and has been continued ever since. The principal broadleaved trees grown as high forest were oak, ash, beech and sycamore, the latter having been introduced from Europe certainly as long ago as the fifteenth century. The planting of coniferous trees began with the native Scots pine, but during the eighteenth century the Norway spruce and the European larch were used on a growing scale. These seven trees comprised the bulk of the planting for timber, others being used only as auxiliaries or for ornament.

It is rather surprising to note that there was little regional variation in the selection of trees for planting, the same seven kinds being used to a greater or less degree, in every county. This was only possible because many of these new woodlands were formed on fairly good sites that are not limiting for any of these species. It was customary for each landowner to select for planting some of the better ground close to his mansion house, where woods would provide shelter for his park and garden, and cover for his game birds, as well as a supply of timber for estate use or sale. Besides these "home woods" there are, on many estates, others more remotely situated and concerned mainly with commercial timber production, and these are usually on poorer ground, such as hillsides too steep for agriculture.

Towards the close of the nineteenth century, the private woodland owners began to use, on a small scale, four new conifers namely Douglas fir (*Pseudotsuga taxifolia*), Japanese larch (*Larix leptolepis*), Corsican pine (*Pinus nigra* var. *calabrica*), and Sitka spruce (*Picea sitchensis*), but as yet there are few mature woods of these kinds. It should be noted that out of the eleven trees commonly planted on private estates, seven have been introduced from abroad. Because so many privately owned woods were developed by separate individuals, each planting up some of his better and usually some of his poorer land to suit the economy of his agricultural estate or his personal taste, they tend to be individually small and scattered. Large woods are rare, and even where they occur are often divided between several landowners. A recent investigation by Dr. F. C. Hummel (1957) showed that in seven English counties the average area of woodland held by each owner was only some 50 acres. This scattered distribution, and small-scale ownership, adds greatly to the difficulties of management by the individual, and to the encouragement of better management by the state. A feature of the English landscape is the prevalence of small woods, often occupying less than 5 acres, and of timber trees growing along the hedgerows of hawthorn that enclose the agricultural fields. No individual county has more than 20 per cent of its surface under tree crops.

Despite the scattered character of the woodlands, and their varied composition, they constituted a large reserve of timber. This was found invaluable during the two World Wars of the present century, first between 1914 and 1918, and again between 1939 and 1945. But the timber supplies essential to the survival of the country were only secured by serious overfelling and this has brought major problems of forest management in its train. Between the two World Wars, from 1918 to 1939, the amount of re-planting done on the private estates was disappointing: indeed it has been estimated that it only kept pace with current felling and did nothing to make good the wartime losses. But jected to natural fires or even those set by the Indians long before they were exploited by the white man. Rigid fire control has resulted in heavy brush growth and invasion by unwanted hardwoods, especially as the coniferous species has been the one consistently removed by logging. Use of controlled burning however raises social problems, as the State and Federal forest services have spent many years slowly driving home to the American public the loss caused by forest fires and it would be difficult to change this policy.

The bulk of the planting programmes are in the Southern States where quick growth of pines promises early returns for the expanding pulp industry. Out of a national total from 48 states of some half a million acres planted in 1952 the nine Southern states of Louisiana, Arkansas, Mississippi, Alabama, Tennessee, Florida, Georgia and North and South Carolina accounted for almost 50 per cent. On old agricultural land tree planting is mechanised and a tractor and planting machine with a crew of two will reach a daily out-turn of 16,000 trees, planted at about 1,200 per acre. The land is level, free of stones or rocks and vegetation is slight. Hand planting, without exception, used a steel "planting bar" very similar to the Schlich vertical notching spade; I never saw a garden spade used. The quality of the hand planting was quite good but I was not so impressed with the machine planting. Under our conditions of exposure we would have suffered disastrous losses from some of the work seen. Practically all the plants used are seedlings, except in the Northern States, where White pine and spruce need transplanting. There is very little planting of hardwoods. Most of the shelterbelt planting was carried out during the 1930's as a relief measure in the Great Plains area of the mid-west and little is being done today.

The logging industry is active and highly mechanised and I was interested to find nearly all felling is done with a power saw. The one-man model of 4 to 5 h.p. with a straight blade and chipper chain and weighing at most 30 lb. is the most popular, although there are several makes and models ranging from the standard beaver-tail to bow-saw models or attachments and two-man saws of both types. I did not see any saws with ordinary scratcher teeth and the chipper tooth has the advantage of being suitable for cutting either softwoods or hardwoods without any alteration to the set. Two makers have most of the market and there is little to choose between them. Designs are compact and aero-type carburettors and fuel pumps make cutting possible from any angle without relevelling the fuel tank and carburettor. Because woods crews are the backbone of fire-fighting squads research is aiming at making the power saw motor suitable for fitting to water pumps. Extraction follows normal lines seen here but power is increased and bigger loads moved often resulting in considerable damage to the regeneration or residual growth, but extensive caterpillar disturbance of the ground is very useful for improving natural seed bed conditions. Horses and mules were rarely seen except on small operations or very steep ground and I saw no mechanical solution to British problems of working early thinnings off steep and difficult ground. Similar crops would be left until their size made an economic operation—probably clear felling—quite feasible. Extraction of pulpwood was made easier, because the level ground of the south enabled trucks to be taken well into the forest with only simple road making and so pulpwood was felled and bucked (crosscut) at stump and either loaded direct on to lorries, or put in pallets and the pallet loads skidded out to where they could be winched on to a lorry at roadside. Pallets are simply U-shaped cradles made of tubular steel which will hold about a cord of pulpwood. Once loaded the pulpwood remains in the pallet until delivered to the mill or concentration yard, being winched or handled by crane or yardster. With some adaptation the system suggests itself for our pitwood handling or pulpwood when this market is opened up here. Small pulpwood (below say 10 inches diameter at stump) is still cut by bow saw and this is reckoned to be the most economical way. In the level forests of the south a wheelbarrow saw is the most productive type but it is dangerous to use. A large circular saw (36 inch diameter) is driven by a belt from a motor, all mounted on a carriage with two wheels. The saw can be swivelled to cut horizontally—for felling, or vertically for crosscutting. Costs are low, maintenance is simple and production is high. It is better suited to clear felling than thinning, as it is slow to move about.

Most saw logs go away to the mill in 8 to 16 foot lengths and long length logging is only seen on a small scale except in the west. To take advantage of long logging full truck loads going to the mills would be over the weights allowed by the State Highway authorities, but when big companies have their own forest roads leading right to the mills I saw loads of nearly 2,000 cubic feet transported on huge diesel trucks. Many small operators set up mills on the sale areas and these "peckerwood mills" are a feature of the South where good weather even allows them to dispense with a roof over the mill. These mill crews are eight to ten men and cut 8-10,000 board feet per day, taking their power from a stationary gasolene or diesel engine and usually burning mill waste. I saw one big mill in northern California converting redwoods and Douglas fir and milling 120 million board feet (say 10 million hoppus feet) per year. Waste here was negligible as they also made presto-logs for fuel and insulating material from the bark.

Fire fighting equipment and techniques have made rapid advances since the war and with improved radio of high frequency, frequency-modulated type now in wide use many look-out towers are becoming obsolete and patrol spotting and reporting is done from the air. Ground telephone lines are dispensed with and all the Forest Rangers who took me round in their pick-up trucks kept in constant touch with their fire dispatchers by radio. In roadless and mountainous country parachute smoke jumpers are now depended on for first attack, supplies and equipment being parachuted down to them. Helicopters, although very desirable, are still too expensive for everyday use. Main methods of fighting fires are to establish fire lines or traces around them and so ploughs and bull-dozers have been widely used and method devised for transporting them quickly to the fires.

In the nurseries there is a high degree of mechanisation for ground preparation, bed formation, seed sowing and either inter-row cultivation or chemical control of weeds. Plants are loosened with lifter bars similar to our own tractor attachments, and bundling and tying both employ jigs and machines. The demand is mostly for pine seedlings, except on the west coast, and the plants generally were bigger than we would like and had strongly developed tap roots. All species had their roots chopped off at eight inch depth when lifted. Overhead sprinkler systems gave the nurseryman great assistance when transplanting, avoiding frost damage or getting correct seed bed consolidation, quite apart from their principal use for watering. It was interesting to find most sowing was done in the Fall as the brief spring season did not allow enough time for all operations.

I cannot conclude without referring to the widespread campaign for safety in American Forestry. Woods crews wear protective helmets, girdling crews have aluminium shinguards and strengthened boots, all operators wear gloves, notices are everywhere exhorting men to work safely and avoid lost time through injuries. Many mirrors bear a little sticker with the grim question, "Are you looking at the next Forest Service accident victim?" This campaign is producing very worthwhile results.

I have only been able to touch briefly on the main points of interest to a visiting British forester. Of lasting memory will be the many fine men I met all along my journey, the help they so cheerfully gave me and the friendships we established.

A VISIT TO RUSSIA

By R. G. SHAW
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Some reminiscences on a visit to Soviet Russia to attend the Second Session of the F.A.O./E.C.E. Joint Committee on Forest Working Techniques and Training of Forest Workers, 9th—25th September, 1957

A visit to Russia at the present time is something that anyone would like to do and the opportunity of a three weeks' visit on official business seems like a dream come true. Small wonder then, that I received instructions to attend this meeting with undisguised pleasure.

The preparations were more complicated than for a normal continental visit. A visa for Russia apparently is something that just must be done at the last minute and to provide the most modest financial requirements seemed to call out all the resources of the Foreign Office and the Embassy in Moscow.

However, the scene was set and with Mr. Zehetmayr (Mr. Richards having gone ahead) I set out shortly after 11 a.m. one Sunday morning to fly the first leg of the journey to Copenhagen. The machine was a brand new Viscount 800 and apart from the fact that the seats are designed for frailer figures than mine the journey was entirely enjoyable. An excellent lunch was served on board and we found adequate transit arrangements in the modern airport at Copenhagen. With only two hours to wait we were not allowed to leave the transit lounge so had to spend the time being tempted by the attractive shops put there for just that purpose.

In due time we were called for the second leg to Helsinki and there was the usual scrimmage to be first in the aircraft. This struggle for the outside seats seems to be an inseparable incident in air travel and the only difference between London and the Continent is that whilst here we scrum with some slight pretence of reserve, over there it is fought out a little more wholeheartedly. However with 15 stone to move I did not come out of it too badly and when we came up for air in the aircraft I was at one of the prized window seats and Mr. Zehetmayr had turned up beside me.

This flight was in a Finnair Convair machine which, though smaller and slower than the Viscount, provides seats for travellers of full stature. Another excellent meal was served on board during a flight in which we saw the Southern part of Sweden. We commenced the usual practice when travelling Eastwards of putting on our watches and so were never quite sure what the time really was. At Helsinki it was getting dark and we again had a two hour wait in a transit lounge. These transit lounges are, of course, necessary because travellers passing through do not pass through customs. Helsinki provided nothing to equal the Copenhagen Airport but we survived the boring two hour wait. Eventually the Moscow flight was announced and we went out to our first excitement, a flight in a Russian plane. I eyed it fairly critically in the dusk and formed the opinion of a fairly shabby crate. This, however, proved quite wrong as the Russians have a remarkably high record of flying safety and once inside the aircraft all seemed well. We were soon up above the clouds in clear air with a full moon and were following the usual flight custom of being offered a good meal served by a charming stewardess, in this case a Russian to make it all more exciting. We had our first introduction to Vodka served free with the meal. When I asked for a second glass it was very politely but very firmly refused. Whether this was the rule or whether the girl thought that I looked as if I had had enough I never found out.

Flying into Moscow was a most unusual sight. We had dropped below the cloud a long way away and owing to the extreme flatness of the country, the lights of Moscow could be seen for nearly the last hour. We were very glad to find Mr. Richards waiting for us with a senior official of the Ministry of Timber Production, of whom we were to see a great deal during our stay. This official had been instructed to see that no difficulties were placed in the way of any delegates to the meeting. He opened up by "chewing up" all the officials at the Airport and through his activities we were away from the Airport long before our less fortunate fellow passengers had even been looked at. It was V.I.P. treatment in a big way and our feeling of self importance grew almost visibly.

We arrived at the Sovetskya Hotel at about midnight and there found a most modern hotel with lavish use of marble and every luxury. Mr. Zehetmayr and I shared a room which was provided with private bathroom and a row of bells to call every kind of service. The following morning we tried one of the bells and it immediately brought a waiter with an excellent breakfast for two. We tried the same bell on every succeeding morning with the same result and it was not until the day we were leaving that we found that we had been confused with someone else and were not supposed to have received this V.I.P. treatment. Our feeling of self importance received a shock!

Having arrived on Sunday evening the meeting started on Monday morning with an opening address by Mr. Orlov, the Minister for Timber Production, who immediately seized the attention of everyone by the casual remark that the annual cut in Russia is, at present, over 300,000,000 cubic metres (about 300 million tons). This aroused a few incredulous gasps, so to drive home the point he mentioned that this figure could be doubled without eating into reserves. A simple calculation showed that the present output means cutting and extracting a million tons a working day, a figure which makes our scale of operations seem child's play. It must be remembered, however, that this is one of the major industries in a country of vast acreage so this output is not really very surprising.

At the beginning of the Session, Mr. Richards, who was well known to most of the delegates, was elected chairman and thereafter the meeting ran like clockwork. The items discussed included working methods, testing of tractors and forest machinery, application of machinery, transport of timber in mountainous regions, International Labour Office Scholarship Scheme and Accident Prevention. Every afternoon an hour or so was devoted to the showing of films. Most of the countries represented had brought interesting films showing various aspects of forestry and we were fortunately able to show the Machinery Research film supported by two Ford newsreels showing, amongst other things, the long County Tractor performing in bog. One of the items which drew the greatest interest was our experiments in extraction of timber by helicopter. This was a subject which many countries said that they had thought about but no one else had actually done it so our figures were eagerly devoured.

The meeting lasted a week and some sort of entertainment was laid on by the Russians every evening. In fact, it was seldom possible to sit down to dinner without some "whipper in" rounding everyone up to get into the coach to go to whatever performance was on the programme.

We went to the ballet and saw a first class performance of Swan Lake. A circus occupied another evening and this included a young lady swimming in a pool with a live tiger who did not seem to regard the incident as particularly amusing. We were also taken to see the semi-final of a Moscow football tournament at the Lenin Stadium. This was between the Moscow Locomotive Works and the Army. It was an exhibition of clean hard football with both teams going "all out" from the first whistle. As so often happens here the only really unpopular figure on the field was the referee, who was hooted by all the spectators from beginning to end and finally left under police protection.

I do not think anyone is allowed to leave Moscow without being shown the Metro, their equivalent to our Underground. The Russians are rightly proud of this sample of their engineering and artistic skill. Every station resembles the lounge of a luxury hotel being built largely of marble and having a painted ceiling and mosaics on the walls. The whole place is spotlessly clean as no smoking is permitted once inside the entrance at ground level.

We were taken for a ride on the Metro on a journey involving five changes (mainly to show us the magnificent stations) but it seemed to be very much the "rush hour". It was a constant anxiety lest one of us was left behind either on a train or at a station, mixed up with the surging mob, without an interpreter.

The Moscow meeting having closed at 4 p.m. on Saturday, September 14th (a six day week is worked in Russia) we were taken to the Kremlin before starting on the study tour. It was a visit that none of us will forget as it was so unlike the conception that most of us have of the Kremlin. It is now, in fact, a vast treasure house filled with collections gathered in Tsarist days. Apparently all the valuable art collections in Russia were not destroyed in the revolution but were preserved and are now kept most carefully in places like the Kremlin and the Winter Palace at Leningrad which are maintained in perfect order as museums.

The study tour commenced with a visit to the Central Research Institute of Mechanical and Power Research for the Timber Industry at Moscow. This is a vast organisation covering every aspect of mechanisation not only including design but considerable manufacturing resources as well. Samples of all the machines in use were seen and the story of their development was explained. Great use is made of instrumentation in this work and a whole department in charge of an electronic engineer is maintained. A tremendous amount of research has gone into such things as power saws and the Russians have produced their own, the Droughba with a 94 c.c. engine and an all-up weight of 27 lb. (See Plate 10.) The policy seems to be to go for simplicity and such things as hydraulic transmission were said by the Russians to be of interest to them but not being introduced. They volunteered that they knew all about the Hamblin system. This has of course been widely publicised but it is clear that the Russians do keep track of what is happening outside their own country. I formed the opinion that in spite of the vastness of this research institute the field being covered is probably not much greater than is being covered in Britain. With us, however, the main part of the work is split up between a number of centres, notably, the National Institute of Agricultural Engineering and the Forest Products Research Laboratory, with a contribution by the Forestry Commission.

The final official visit in Moscow was to the All-Union Industrial and Agricultural Exhibition which is a permanent installation open throughout the summer months in a park a few miles outside Moscow. Every aspect of the Russian economy is represented but the greater part of our time was spent in the forestry and agricultural sections. A lot of machinery was on view but I saw nothing that was really original. The Russians are obviously moving towards larger and larger agricultural tractors, having one of 140 h.p. already in use and one of 225 h.p. on view in prototype form.

On the night of September the 18th we all entrained in a special train for a four day visit to the forests. As we were to live in the train for four nights we took a more than normal interest in the coaches and everything else connected with the railway. No criticism could be made of the coaches which were comfortable and clean.

An excellent dining car was provided and the fare, including supplies of vodka, was good. The only difficulty that we had to contend with was ten people trying to shave in each of the only two wash basins in each coach. This apparently small problem caused a long delay in the planned early start each morning. Unfortunately all the movement by train was done at night so we saw little of the country through which we passed.

The first call was at the logging camp at Oleninsky where we did a 17 mile road journey over a very wet forest road by coach to reach the felling site. As this was an experimental site all the latest machinery and equipment was on view. Clear felling is always practised and this of course makes mechanization very much easier. The usual plan is to select a large block for felling and then move on to another block, leaving a considerable belt of standing trees to look after regeneration.

As Oleninsky was served with a good earth road, a "top landing" was established on the roadside where the logs were collected and loaded on to road vehicles. Full tree logging was practised, and this means literal full tree logging in that the trees are brought out with the crown still on, as far as the top landing. Felling is done with the Droughba one-man saw and it is interesting to note that we saw virtually no hand saws or axes during the whole tour. Extraction from stump to top landing is done entirely by tractor drag and for this role the Russians have developed special forestry tractors. The main feature is that the load is picked up and carried with the butts resting on the top of the tractor, thus achieving the very desirable object of getting the point of loading reasonably well forward on the tractor. This helps enormously in keeping the front end of the tractor down and distributing the load over the length of track on the ground. A loaded tractor is seen in Plate 12. The tractor in general use is the T.D.T. 40 (40 h.p.) but a new model is now coming out—the T.D.T. 60 (60 h.p.). The T.D.T. 40 carries 4½ tons and the T.D.T. 60 carries 6 tons (Plate 12).

The extraction team is three men—tractor driver—feller with power saw and choker man. Clear felling allows the Russians to make far greater use of chokers than we do and we saw during this tour how much chokers help the assembly of logs. The technique used is for the choker man to put a choker on the butt of each tree that he wants to collect. He then runs the tractor winch rope through the ring on the end of each choker and, as soon as the winch hauls in, all the logs are collected together. They are then hauled up the tail ramp on to the top of the tractor where they are secured for travel. If the tractor stalls on the journey the load is easily jettisoned and picked up again when the tractor has extricated itself. Distance travelled with the load to the roadside is usually up to 1,200 yards but distances up to five miles are sometimes undertaken.

Experimental machines seen at Oleninsky were:—

(a) A tractor which was loaded as the tree was felled. See Plate 11. This was a tractor with a superstructure on top to carry the load. The tractor would stand in front of a tree to be felled with the winch rope fastened to the trunk. The feller would then cut the tree so that it fell towards the tractor with the driver hauling in on the winch. With reasonable luck the tree would fall into place on the superstructure and would be secured before the tractor moved on to the next tree. Usually this happened as desired but we did see the wind take charge once, putting the tree askew on the tractor. It took a long time to recover from this predicament and, as always happens when a demonstration has gone wrong, everyone connected with it got cross with everyone else. I know that the Russians have had this machine for over 18 months and, as it is still experimental, it is evidently not regarded as a complete success.

(b) A 4-wheel-drive tractor on large-diameter large-section tyres. The unusual feature was that tyre pressures could be varied by the driver on the move. The idea was to use low pressures off the road and then raise the pressure as soon as the road was reached. It was not demonstrated and I have great doubts on the life of tyres running at low pressures over tree stumps. Much the same thing is being done by Straussler at fixed pressures in this country but little progress is being made owing to the very high tyre costs.

Loading onto road vehicles at the top landing was done by mobile cranes and an overhead ropeway of normal pattern. Road transport to the lower landing was provided by standard articulated vehicles carrying 14 tons of logs in the length.

The lower landing was alongside the railway siding and the vehicle unloading was done with a simple system of winch ropes onto a platform, where the logs were cut to standard lengths for onward movement by rail. It was noticeable that wherever possible the Russians use electric one-man power saws in preference to petrol. They said that they found them lighter and more reliable. Lower landings are usually provided with electric power as they are semi-static installations.

The next stop was at Krestetsky, one of the larger logging camps and also one of the newest with some experimental machines and ideas. It differed from Oleninsky in that no forest road was available and the ground was too wet for the operation of tractors. A narrow gauge railway ran from the camp and lower landing up to the felling areas, a distance of some 15 miles. Again the practice being followed was to clear-fell blocks about 1,000 yards square and then leave this cut-over area surrounded by standing trees. Branch lines were temporarily laid, on each of these areas, so that the haul from stump to railway was never more than 500 yards. The species were aspen, spruce and birch. As the ground was too wet for tractors all log movement was by winch. The general plan was to establish one of the big L4 or L5 (50 h.p.) winches close to the railway and use a 40ft. mast to provide a high lead. These winches have five drums for the following roles :—

1 Main line haul,

1 Haul back line,

2 Dragging load into line with rail car,

1 Loading onto car.

They are either diesel or electric driven. There are various layouts for this winching operation but all use the high lead system. As ranges up to 500 yards are used the high lead effect on the longer hauls is largely lost, and loads have to be reduced far below the four tons that can be hauled from positions within 100 yards of the mast.

As at Oleninsky, full tree logging was practised and the whole tree was sent on the railway down to the lower landing.

Far more conversion was done at the lower landing at Krestetsky than at Oleninsky. The crowns were cut off and chopped up for fuel for the power station. The logs were then cut up with electric one-man power saws and put onto separate conveyors to go to building timber, pulpwood or firewood. For firewood, a powerful conveyor drives the yard-length logs hard against two knives splitting the log vertically and horizontally.

Output figures for the camp as a whole were given as 2 cu. metres (60 hoppus feet) per man per day, taking into account all the non-productive bodies such as transport driver, cooks, etc. The production of the felling teams of winchman, chokerman and feller was given as 7-8 cu. metres (about 230 hoppus feet) per man per day. From what was said it appeared that these were target figures.

During our stay in both Oleninsky and Krestetsky we were invited to visit the forest villages where we were entertained by most friendly people and saw something of the life led by these isolated communities. (Plate 9.)

The accommodation and other buildings provided can be described as adequate but no more, since housing is on a basis of something under 100 sq. ft. per head and whole families live in two-roomed apartments. The houses are warm and the owners take a considerable pride in keeping them clean and tending a few flowers in very simple gardens. There is no piped water supply and no water-borne sanitation in these villages. Roads are not made up and a wet day means a sea of mud. Gumboots are the standard footwear. The school and club play an important part in village life in this very education-conscious country.

All the workers and their families seemed to be perfectly happy, but it is indeed an austere and isolated life.

The field tour ended at Leningrad where we visited the various forestry institutes in that city. At the Central Research Institute for Timber Floating it was learned that 50 per cent of the forest output uses flotation for part of its journey to the consumer. Large tanks are used for investigation, on models, of the effects of river depth, bends, speed, etc. Distances travelled by timber rafts may be anything up to 2,000 miles, largely on the Volga at speeds of 50-70 miles per day.

A very interesting conveyor was seen collecting logs from the water, measuring them and then distributing them by sizes. A new type of launch driven by water jet provided light entertainment for any delegates who wanted to go for a sail.

Another visit was to the institute where the whole of the planning for forest exploitation is carried out. Air photography is used to draw up the plan and timetable, arrange suitable transport and fix sites for the forest villages and landings. Standard designs are maintained here for all buildings and every kind of equipment. Costs are kept and can be quoted for every phase of any particular project. When it is realised that there are a thousand or more logging camps in the Soviet Union the importance of this co-ordinating centre is appreciated.

Whilst in Leningrad visits were paid to the art galleries of the Winter Palace (Ermitage Museum) and Peter Palace some miles outside Leningrad which was occupied by the Germans during the war. It was interesting to see that there are still some relics of the German occupation.

From Leningrad most of the delegates returned to Moscow to start their journeys home and so ended three weeks of immense interest and equally immense hospitality. That a generous sharing of information had taken place there can be no doubt, and none of us could have left without a deeper understanding of the way in which all countries are leaning on mechanisation to solve the problems of the forest.

FULL DETAILS OF ILLUSTRATIONS

Plate 9. Forest Workers and their families outside the village store at Krestetsky.

Plate 10. The Russian-designed Droughba Petrol Saw. Note that the saw has handles allowing the operator to stand up whether felling or cross-cutting.

Plate 11. An experimental machine which loads itself as the tree is felled across its back. Note that the feller has cut the trunk to fall towards the tractor, and the tractor driver is hauling-in on a front winch rope.

Plate 12. The T.D.T. 40 Forestry Tractor. Note that the load is carried on a platform on the back of the tractor. When loading, the platform is let down at the back, forming both a ramp up which the load is hauled, and also an anchor.

IN THE FORESTS OF THE CAUCASUS

By JAMES MACDONALD

Director, Research and Education

The official Commission delegation to Russia, in 1956, was privileged to visit the little-known forests of the Caucasus, on the verge of Asia, and here Mr. James Macdonald records his personal impressions of that remote region.

On the 4th September we breakfasted earlier than usual because we had a long journey before us from Kharkov into the Caucasus. This would take us into Georgia, along the inland edge of the fabulous country of Colchis, whence Jason stole the Golden Fleece. Perhaps we might pass by the shore where he beached the Argo. Then, away behind, but possibly too far east for us to see it, stands the great mountain of Kazbek, where Prometheus was chained after stealing fire from heaven. I decided that when I reached the mountains, I would keep my eyes on the sky in case I might see a vulture, perhaps a descendant of those which gnawed the hero's liver on Kazbek. So I set off with some inward excitement on what promised to be a memorable journey. Near Sochi, the hills came straight down into the sea, and the slope is cut into by small valleys, some of them steep-sided. The result is that the road is rather exciting, especially when taken at the speed favoured by the local drivers.

For the first twenty miles or so, the countryside is most attractive with the forest on the limestone hills running down to the sea, and the valleys taken up with residences each with its garden or shrubbery where hibiscus and oleanders flowered and where cedars and cypresses stood up high above the roofs. At some points, the road is cut out of the hill side, with a steep slope above and an almost sheer drop below into the water. There is much crumbling rock on the hill side, which must come down on the road after every heavy storm; indeed, after we had passed, at one point a small avalanche of stones rushed down on to the roadway. Beyond Adler we left the hills and came down on to the coastal plain. The farms here are small but one or two had fairly large flocks of poultry and I asked what risk there was of damage by foxes. The answer was that they have no foxes in this part of the world, only a jackal, which is not so troublesome. Here we saw the first cattle of the buffalo type with pronounced frontal bosses and swept-back horns. They are used for draught although they are not very large and are quite lightly built. There were also numerous little thin, sharp-snouted pigs running about the roadside. Most of the women who were walking on the roads were carrying parasols, and some of the holiday makers were wearing large floppy white hats.

Gradually, the plain narrowed and we came to a place, on the outskirts of the town of Gagry, where the hills came down again, almost to the beach. Here the party stopped to bathe, and I noted a very nice row of *Phoenix* palms along the shore, not tall, but uniform and all about the same size and height; behind was a pleasure garden with many specimens of *Magnolia grandifolia*, one of which was nearly three feet in diameter. There was also a fine display of oleanders and hibiscus, with one or two acacias. Behind, the hills were covered with forest right up to the top, except for bare white patches where the limestone outcropped. This is mostly hornbeam on the coastal side but one or two oaks and maples could be distinguished. This type of forest goes up to over 2,000 feet. On the beach there is a small bookstall where I found that most of the books were not printed in Russian, but in Georgian, with characters resembling Persian or some script like that. We drove on into Gagry which is a pleasant little town with a wide main street, on each side of which a row of camphor trees, *Cinnamonum camphora*, was planted. They had been nicely pruned and had shapely crowns, giving shade without taking up too much room.

Not far beyond Gagry we left the main road and turned North towards the mountains up the valley of a small river called the Bzyb. Here, we followed a new tourist road, which had recently been constructed, into country which hitherto had been closed except to visitors who were prepared to walk or ride. There are very few roads in the main chain of the Caucasus, and only two, I believe, which actually cross the range. The river is a typical Alpine stream, fast flowing and with the blue-green limestone water which one sees in the Alps and in the Tyrol. The valley is narrow and the road climbed steadily through the broad-leaved forest with *Clematis* everywhere and odd bushes of *Staphylea* and *Philadelphus coronarius*. After a few miles, we came on an igneous intrusion, a basalt, I think and it was curious to see how the *Clematis* disappeared. Apart from that, we were on limestone all the way for the rest of the time. We passed various small fields of tobacco and patches of vegetables, artichokes, tomatoes, etc. and there were numerous beehives. Our guide told us that Georgian honey is poisonous to all but natives of the country and warned us against eating it. He could not tell me what it is the bees pick up but he said it wasn't arsenic.

The valley wound constantly and gave us a succession of most charming views: the forest remained much the same except that beech was becoming more prominent and evergreen shrubs, such as box and cherry laurel, began to appear. We stopped first at a little pool of water under a cliff, the Blue Lake, which is a favourite haunt of tourists. Little charabancs of tourists kept stopping, and local people, sitting by the roadside, were selling apples and corncobs to the visitors. From this point, looking up the valley, we had our first view of the coniferous forest about a mile away.

As we moved upwards into the mountains, the valley became narrower and deeper and we ran, in one or two places, through deep canyons with limestone cliffs rising for several hundred feet, on either side. In the bottom, by the stream, alders and box trees were growing, festooned with great hanging tufts of the moss *Neckera crispa*, reminiscent of some of moister woodlands in south-western Ireland. These bottom lands must have a peculiar micro-climate as they are moist and cold and short of light and sunshine. The coniferous forest we found to be composed of *Abies nordmanniana*, mixed, at first, with beech but later almost pure, save for occasional beech and maple trees. Here and there, on the hillsides were patches of Scots pine, standing out blue-grey among the dark-green firs, but I was surprised to find no spruce which I had expected to occur in mixture with the *Abies*, as it does in Switzerland and the Jura. We eventually saw, at nearly 3,000 feet, our first *Picea orientalis* by the roadside, but there were few of them. At just over 3,000 feet, we came to the Ritza lake, a pleasant alpine sheet of water, with pleasure boats on it and with a big hotel on the shore. It is not a large lake, but it is in a beautiful setting, with forest all round it, above which the bare limestone mountains rise to about 12,000 feet. Going up the road to an elevation of nearly 5,000 feet, we had a very good impression of an old untouched forest, full of tall old trees dying back at the top and others beginning to decay. The strange thing about it was the absence of young trees, which one would have expected to find, but the reason for this is the heavy grazing to which these forests have been subjected.

On the way up we had glimpses of some of the plants for which the Caucasus is celebrated, a wonderful yellow patch of *Telekia speciosa* in full flower, a clump of *Heracleum mantegazzanianum* by a stream. *Valeriana alliarifolia* and *Aconitum orientale* by the roadside. What a pity it was that we had no time to go beyond the forest to the Alpine meadows, where there is a most wonderful flora, and where *Telekia* grows about 6 or 7 feet in height. Also by the roadside we saw one or two small patches of the fire-weed, *Chamaenerion angustifolium*, which is spreading along the road as the traffic increases. It would be a disaster if this plant got loose and crowded out the rich native flora of the region. I saw later, again by the roadside, some plants of *Erigeron canadense*, a plague in my own garden at home, and a most determined invader.

These forests are classed as protective, and clear felling and exploitation are not allowed. But the Forest Service are carrying out what they call 'sanitary' fellings, clearing patches of old growth, hoping for natural regeneration, although they may have to plant. We looked at one of these clearings, three or four acres, in extent, where the logs of silver fir had been collected in the centre of the space. Many of them were very badly decayed and the butts might just as well have been left where they fell; this decay in these old stands must almost equal the increment, if it does not exceed it. The logs are extracted by tractor or with horses or, sometimes, bullocks. No work is done between January and May, when much of this country must be under snow; when May comes, work starts in earnest. The 'sanitary' fellings remove about 40 cubic metres per hectare or 450 cubic feet per acre approximately, which on a five year cycle represents roughly 90 cubic feet per acre per annum. With the severe and widespread decay, this must be more than the nett increment, but they have no option here but to cut and regenerate. The alternative is the slow disappearance of the forest. There are numerous seedlings of silver fir appearing round the edges of the cut and there should be another good crop next year, for there are heavy crops of cones.

The forest here is mainly of *Abies nordmanniana*, but there are some very good beech, as well as trees like sycamore and rowan. The beech continues, with the fir, right to the upper limit of the forest, which is generally found at just under 6,000 feet, though some fir and beech are found as high as 7,000 feet. In the higher ranges, these species are accompanied by *Betula pubescens*, *Sorbus aucuparia*, *Sorbus aria* and *Acer trautvetteri*, while at the heads of the mountain streams, *Alnus barbata* also occurs. In these places, also, there occur *Rhododendron flavum*, *R. ponticum* and *Arctostaphylos uva-ursi*. At those elevations, the trees are short and stunted. We did not see the high lying forest edge, unfortunately, but I had this information from one of the local officers. I have mentioned some of the plants already, but one has no real conception of the wealth of the flora until one goes into the forest and begins to look around. Under the trees by the edge of the clearing, here are some of the plants I noted in a twenty minutes' stroll. *Polygonum carneum*, *Symphytum asperatum*, *Scutellaria galericulata*, *Impatiens noli-tangere*, *Rubus caesius*, *Paris incompleta*, *Polygonatum multiflorum*, *Mulgedium tataricum*, *Asperula odorata*, *Sanicula europoea*, *Oxalis ocetosella*, *Aconitum orientale*, *Senecio stenocephalus*, *Campanula lactiflora*, a *Geum*, a *Saxifraga*, *Lysimachia punctata*, *Helleborus caucasicus* and *Geranium gracile*. With a little more time and with closer observation, the list could have been greatly lengthened. It was, indeed, a wonderful experience to be able even to have a glimpse of a flora of such richness.

I asked whether it would be possible to see a specimen of *Acer trautvetteri*, which we had been growing in the nursery at Alice Holt. I was told that there were some, not far away, up the valley, and it was arranged that I should go in the jeep, with J. Q. Williamson to take photographs. We set off along the road at a cracking pace and, after about three miles, we saw the trees on the other side of the stream. To get to them we turned off the road, dropped over an almost vertical bank, at the foot of which was the river, with a wooden bridge set at right angles to our line of descent. The bridge was old and had no hand rails, but it had a sizeable gap in the middle about half way over. Our driver, by the most remarkable exhibition of trick driving I have ever participated in, got across almost without changing speed. On the other side, we found ourselves among the herdsmen and their families and their cattle, up for the summer's grazing in the mountains. The cattle were a mixed lot, mostly dun coloured and some of them with more than a suspicion of a hump. Bulls and cows of all ages were running together, about two bulls to every five cows as near as I could determine. The herdsmen and their families were living among their cattle in the ancient manner, having built for themselves shacks made out of boards of freshly felled silver fir and roofed with rough shingles. Very few of these shacks had windows and the occupants took their meals outside where they set up rough tables. The *Acers* were most interesting trees, growing in groups near the river but, further up, as we could see in the distance, interspersed with the silver firs, in the forest. About 50 feet tall, they were not very straight, but they seemed vigorous, though quite old. Below them, on either side of the stream, there were some fine trees of *Alnus barbata*. All this relic of the antique way of life existed not much more than a hundred yards from the new road, along which loads of tourists from the cities were passing backwards and forwards all day long, and we wondered how long the old customs would survive this daily contact with the world outside.

When we reached the main road again, our driver insisted on taking us up to the Avathar mineral spring at the end of the road. There we found quite a company of people. Some of the locals were busy filling bottles at the well, for sale to visitors, and some mountain herdsmen, mostly old men, and most picturesque, were resting on a bench. One or two of these, dark lean fellows, with tight trousers, looked very tough indeed. Another one, with slightly more benevolence in his aspect, made me think of another herdsman, Amos of Tekoa. And then there was a party of students, up for an outing, and singing songs under a tree. It was warm and sunny but the air was fresh, for we were at about 5,300 feet.

We lunched in the hotel on the shore of the Ritza Lake. It was a very jolly meal, the main dish being *schlaske*, a piece of mutton cut from the back of a sheep, roasted on a skewer and very nicely flavoured with herbs. The cuts have to be carefully selected and someone said that they had to kill five sheep to make our lunch. We had two rather nice wines, a red and a white, both I think local, though they may have been Crimean. My neighbours at lunch told me that grazing, in the forests here, is a very serious problem, for they are very heavily over-stocked with cattle. We had seen evidence enough of this during the morning and, looking from the dining room window, across the lake, to the mountain on the further side, we could see that the forest came to an end, on the heights, in a firm line; there was no gradual tapering off; it stopped suddenly like a plantation. They told us that this was the result of very heavy stocking of cattle on the high alpine meadows in the summer; the small stunted forest growth, which naturally occurs at the tree limit, had been destroyed by browsing and everything had been eaten which was not too tall for the cattle to reach. Apparently, the herdsmen of the Caucasus have not been collectivised and they still own their cattle and this is the source of difficulty. The forest authorities would like to fix a limit of one beast per hectare, a heavy enough stocking for forests like these, but they are not sure of success for these Georgian hillmen are formidable customers, not to be offended lightly.

Near the hotel, we inspected an unusual stand of pine, *Pinus hamata*, according to the Soviet authorities, but only a strain of *P. sylvestris* to us. As we could see, coming up the valley, it occurs on dry shoulders in pure crop and it is restricted to these sites by the *Abies nordmanniana*, which overwhelms it on the better ground and which cannot itself survive on the dry sites. This is one of those examples, showing how a tree grows in a certain type of site, not because it likes it, or is particularly well suited to it, but because it has no option and no chance to escape from it. This kind of occurrence makes nonsense of the view put forward by certain enthusiasts that because a tree is found growing naturally on a site, that site must be specially adapted to the tree and the tree adapted to it. The tree may tolerate the site but, given the chance, it might well do much better in another. Here the pine is the prisoner of the fir. The pine crop, when we got near it, impressed us more than it had from a distance. The trees are tall, about 80 feet or so, and, although the age must be considerable, the early growth must have been fairly fast. The stems are straight, with reddish grey bark in large, long flakes passing, higher up the tree, into the typical thin light red bark of the Scots pine. The crowns are rather thin and it looks as though the branches do not carry more than two years' needles, although we could not test this, for the cattle had removed everything within reach. The soil is mainly a scree of small limestone rubble but we had no time to look at it properly. The vegetation is an extremely varied mixture of species, some most discordant. Among the woody and shrubby growth, we noted *Quercus petraea*, *Rhamnus frangula*, *Sorbus aria*, *Sorbus velutina*, *Rhus cotinus*, *Ruscus hypophyllus* and among the herbs *Campanula alliantrifolia*, *Cotoneaster australis*, *Arctostaphylos uva-ursi*, *Melampyrum sylvaticun*, *Hedera colchica*, *Solidago virga-aurea*, *Goodyerne repens*, and *Silea trilobium*. There are a few yellowish seedlings of silver fir on the ground, but no pine, as far as we could see.

Going down from the hills was more impressive than coming up because we realised then how high we had climbed, and, with the sun dropping low, we had the most interesting shadow effects which showed up the forest types and made the valleys and gorges look deeper. In one of the deep gorges we persuaded our guide to stop and give us the chance of looking at the vegetation. It was not the best of the gorges for this purpose, but, nevertheless, it gave us some impression of what type of forest could be expected in them. It was well below the coniferous forest, in the zone of the beech-hornbeam forest. The gorge was not one of the deepest, although it was narrow, and we stopped by the roadside, with the river behind, and a cliff of limestone in front of us. The cliff was not very high, no more than 100 feet, and from its upper edge the mountain sloped away backwards, carrying the broadleaved forest. These gorges are characterised by lower temperatures than the surrounding country, as was quite obvious when we came out of the cars; the light intensity is less, and the humidity of the air is high. One feature of these sites is the presence of an understorey of yew and shrubs with shiny evergreen leaves. In this particular place, there were one or two beech trees 50 or 60 feet high and a number of yews, not quite as tall, but obviously of some age. Along with these were small trees of box. In the lower layers of vegetation there were *Staphylea colchica*, *Ilex aquifolium*, *Hedera colchica*, *Vinca major*, *Polygonatum* and roadside plants like *Lapsana* and *Geranium robertianum*. Mosses were frequent everywhere, on the soil and on the trunks and branches of the trees. On the banks of the stream, *Alnus barbata* was growing with grasses underneath and clumps of *Struthiopteris*.

The light was fading when we came out of the mountains on to the Colchian plain once more, and we all thought we would turn north, along the coast, to return direct to Sochi but, in fact, we turned south. Just before we moved in this direction, we passed under an electric cable running away towards the south-east. This, we were told, is the direct telegraph cable between Moscow and India. As we travelled south across the coastal plain we passed more plantations of *Eucalyptus viminalis* and then came to an area planted with *Citrus* fruits. Each orchard of oranges or lemons was completely surrounded by a high hedge, sometimes of bamboo, sometimes of cypress, to protect the crops from the winds from the sea. Along the road, there were numerous villagers out for their evening walk, the little pigs were picking up what they could by the road-side, dogs of the Collie type were running about, sometimes chasing the pigs, sometimes paying attention to the cars. Vines and fig trees (*Ficus carica*) grow by the cottage doors and we saw one small field of cotton. Finally we came to an old village of some size, grown around a very large, walled monastery, and a place of great antiquity. The name, as far as I could make out is Pithys, because our guide told us that it was founded by Greek colonists in the seventh century B.C. and that they gave it their own name for pine because of the pine forests on the shore. The monastery dates from 551 A.D. and the place remained largely Greek until the Turks seized it about the year 1600. It has thus had a colourful history.

At the edge of the village, on the shore, we came to a solitary stand of pine, the object of our journey, and it was a thousand pities that we arrived to see it as the light was failing fast. The pine is *Pinus pithyousa* Steven, named after the village. The Soviet people are very sure that this pine is an independent species, growing only as a relic in a few small patches on the coast of the Black Sea; other authorities, however, take the view that it is a form or variety of *Pinus halepensis* while some describe it as a form of *Pinus brutia* which, in turn, is regarded by others, as a variety also of the Aleppo pine. It was most interesting to see this crop of this unusual pine. The trees are very tall, with open, slightly flattened crowns and, in general appearance, they do not differ very greatly, as far as we could determine, from the maritime pine. The small wood stands on a flat sandy beach, open on all four sides to the winds, but there was no sign of exposure effects, even along the seaward edge. One sees the same thing round the Mediterranean coasts. The soils is a coarse sea sand. There was just enough light to distinguish most of the plants in the undergrowth, which consisted mainly of a dense shrubby layer. Among them are *Ruscus ponticus*, *Pyracantha coccinea*, *Carpinus caucasica*, *Smilax effusa*, *Paliurus spina-christi* and a few more. There was no time to look at the herbaceous plants, but in one place bracken was well developed. On the shore, at the edge of the pine wood, there are several sea-side shacks, the kind of thing one finds in all countries. Each one had its own kitchen midden inside the wood, heaps of household refuse, which will be a joy to archaeologists centuries hence.

September 5th

It was bright sunshine and warm as I rose about seven o'clock and stood on the verandah looking out over the Black Sea. The water was still and deep blue, with mist in the distance, wiping out the line of the horizon, and there was no cloud in the sky. After breakfast, it was becoming warmer as we set out, in cars, for the Dendrarium, or Botanic Garden *cum* Arboretum, at the other end of the town. This Dendrarium is one of the main responsibilities of the Experimental Station of the sub-tropical Black Sea region, which has its headquarters here. It was established in the eighteen-nineties, and it is laid out with an eye to scenic effects, some of which are extraordinarily well contrived; it has an imposing entrance with pillars, etc. set in mass of bedded-out *Cannas* and other flowers. The Dendrarium, which together with gardens and nurseries, covers about 100 acres, provides trees and shrubs for planting in Sochi and its neighbourhood, and this function is regarded of some importance, for the Director claims that the transformation of Sochi into a garden city is largely due to the services provided by the Dendrarium over the last thirty or forty years. It also plays a part in the cultural activities of the district and visitors are taken round in conducted parties as well as entering unattended; during the last three years, the Dendrarium has been visited by 920,000 people, 32 per cent of whom came in organised parties. There are 18 qualified guides on the staff and they seem to be kept fully employed.

In the Dendrarium itself, there are 800 species of trees and shrubs, with varieties, growing in the open air, while altogether in the nurseries, gardens, houses, etc., the total list adds up to 1,700. Of these, 45 per cent are Asian, 24 per cent American, 23 per cent European, 5 per cent Australian and 2 per cent African. The climate, along this narrow coastal fringe, is suitable for the cultivation of sub-tropical plants, as the mean annual temperature is 57°F, and the annual rainfall 56 inches, and the Russians have, naturally, great success with many things which we in Britain cannot grow in the open at all. I was surprised, however, to find that they have a relatively poor representation of Australian and New Zealand plants and I noticed, particularly, that they had no tree ferns, which is curious, because *Dicksonia*, for example, grows out of doors, here and there, with us and does quite well. They have one specimen of *Eucalyptus*, *E. cinerea* in the Dendrarium, and they have a small trial ground for this genus nearby, but the small proportion of trees and shrubs from the Antipodes is puzzling.

Palms and cypresses are the scenic feature of the Dendrarium and the general effect is the same as in the more sheltered places on the Mediterranean litoral. Among the palms are some very fine tall specimens of *Washingtonia*, a magnificent tree of *Phoenix canariense*, *Trachycarpus fortunei* and *Chemaerops humilis*. *Cycas revoluta* and *Yucca gloriosa*, of course were there in quantity. The tall columnar cypresses are rather a feature of the place and there are some very fine *Cupressus sempervirens*, and also some which they said were *lusitanica*, although I have never seen *C. lusitanica* in this excessively spire-shaped form before. They all seemed to be flourishing very well indeed.

Among the pines, the chief interest to us was in those which we can't grow ourselves, and, for the first time I saw a really good, though not large, specimen of *Pinus echinata*. *P. canariensis* is about 40 feet high and they have two good specimens of *P. palustris*, which we can scarcely get past the nursery stage. *P. radiata* and *P. muricata* are both well-furnished and vigorous, the latter being about 60 feet in height, but badly forked. Of the other conifers, only the cedars looked really happy, *Cedrus deodara* and *C. atlantica* doing well; there is an interesting fastigiate form of the latter. *Ginkgo*, as one might expect, is growing nicely, for it loves warmth.

They have a large number of oaks, most of them not very good, but a fine specimen of *Quercus iberica* (a form of sessile) is an exception. This tree is almost 14 feet in girth at breast height. Among other trees of interest were a very fine specimen of *Lagerstroemia indica*, the best specimen I have ever seen of *Maclura aurantiaca*, the Osage Orange, which is about 30 feet in height and bearing fruit, *Acacia dealbata* which is frequently planted in Sochi in gardens and *Ligustrum lucidum*, 25 feet high. There was a good show of plants of economic or of possibly economic importance—*Quercus suber*, *Sapium subiferum* (a source of wax), *Cinnamonum camphora*, various *Citrus* plants, and a specimen of *Coffea arabica*. I was surprised to see the coffee plant looking so well out of doors, even at Sochi, and enquired whether it was a variety into which they had succeeded in breeding hardiness. My guide grinned and said that they had to take this plant indoors every winter.

Among climbing plants, there was a fine show of *Tecoma grandiflora*, and an even better display of *Pueraria thunbergiana* which flourishes exceedingly at Sochi. Less exotic, *Prunus lusitanica*, the Portugal laurel, does badly and regularly dies back on account of drought. Of the bamboos, there were good specimens of *Phyllostachys edulis* and *Bambusa quadrangularis*. After going round the Dendrarium we looked at a nice little collection of cacti and succulents, and walked past the collection of 212 species of *Eucalyptus*, which the Botanical Institution of the Academy of Sciences planted on 5 acres in 1950.

The Director told us something about the work of his station, which was founded in 1944 and has, in addition to the establishment at Sochi, an experimental area of about 100,000 acres, mainly to the north of that town. They deal broadly with forest management, and park and garden management, and they carry out, at the same time, research into plant physiology and soils. They are paying much attention to the cultivation of cork oak and are investigating methods of protection against the acorn gall-fly (*Callyrhitis*), while they are working with latex-producing plants such as *Eucommia* and *Euonymus japonicus*. They are also working on diseases of the chestnut, which is dying off from Ink Disease (*Phytopthora*). *Endothia* has not yet reached them, but they seem rather worried about it. I told them of our experience in the West, but the disease with them seems to be much more severe. It is curious how the chestnut is suffering in widely separated regions of the world. They have a large programme of work on the introduction of exotics and native species into their forests in order to enrich them; among the trees which are being used in this way, in addition to other mentioned, are walnut, pecan, *Coyra olivaeformis*, hazel, cypresses, *Pinus pinea*, *Pinus pithyousa*, *Cedrus atlantica*, *C. deodara* and *Sequoia sempervirens*.

We were each presented with a box made of local yew wood and I was given a walking stick, made of yew, with an olivewood handle and banded with walnut, hornbeam and the yellow *Maclura*. From the Dendrarium, we drove back through the town, and uphill towards a view-point on a hill above Sochi to which they have recently built a road. We climbed, I should say, more than 2,000 feet out of the sub-tropical coastal strip into the region of broadleaved forest. As we started to climb there were pomegranates growing by the roadside, the lovely red flowers intermingling with unripe fruits on the branches, while there were one or two plantations of *Diospyros kaki*, grown for the persimmon fruit. But, quite suddenly, there was a change and we seemed to have passed into a different climatic zone, as the forest began. At the top of the hill we found ourselves on a ridge with the land sloping down quite steeply to the south and to the north.

This forest is dominated by beech (*Fagus orientalis*) and hornbeam (*Carpinus caucasica*) but it contains a very rich mixture of other broadleaved species.

since 1945 proprietors have shown much greater interest in replanting felled woodland, and the work is proceeding even faster than anticipated. The 1956 rate of planting by private owners was 27,000 acres a year. However, the resources of private individuals now seldom extend beyond the re-planting of existing woods; few of them attempt any large expansion of the woodland area over bare ground.

Regional Trends in Species

Because so much of our woodland has been planted, and also because the same species were so widely used, it is not possible to define regional forest types in Britain. The distribution of tree species was investigated in the Forestry Commission Census of 1947, which showed that broadleaved trees predominated in England but conifers led elsewhere. Oak was then the principal tree over most of England, except for the Chiltern Hills North-west of London, where beech is more important; Scots pine was the principal tree in Scotland, and particularly so in the North-east. Even in the woods planted by the Forestry Commission, a considerable choice of species has been possible in many districts, resulting in regional trends rather than distinct types.

A major trend that has become evident in the distribution of conifers is that Norway and Sitka spruces tend to be favoured in the north and west of Britain, where conditions are generally cool and moist; whereas the Scots and Corsican pines are preferred in the south and east where the climate is generally warmer and drier. The general picture is shown in the map which comprises Figure 1.

Development of Urban Demands for Timber

A feature of the Industrial Revolution, which changed Britain's economy during the nineteenth century, was a great increase in the demand for timber and forest products of all kinds. This demand arose mainly in the growing industrial towns and seaports, and it was found easiest to meet it by imports. There were several reasons for this: the main call was for softwoods, and at that time Britain's mature coniferous woods were very limited in extent and could not supply the quantities needed; second, very large quantities of softwood were available from North America and Northern Europe, at prices which proved cheap in relation to the sums received for British exports of coal and manufactured goods; third, transport was also cheap since timber provided a return cargo for ships engaged in the export trade. Hence it came about that the main industries concerned with timber and wood pulp were concentrated around the seaports, rather than in the forests. In 1914, about 95 per cent of the country's timber needs were being met by imports.

Allied with this process was a growing concentration of the population in big towns and cities remote from the forests, but well served by water transport. Consequently the timber grown on private estates tended to be used locally for agricultural work, where little transport was needed and it could best compete with cheap imports.

The Present Work of the Forestry Commission

Establishment of the Forestry Commission

Prior to 1885 the Government took little interest in forestry; it was generally believed that the unaided work of private owners, together with the plentiful imports, could meet all foreseeable needs. The only national forests consisted of small remnants of the mediaeval royal hunting grounds, such as the New Forest and the Dean Forest, which had a combined area of 118,000 acres; but

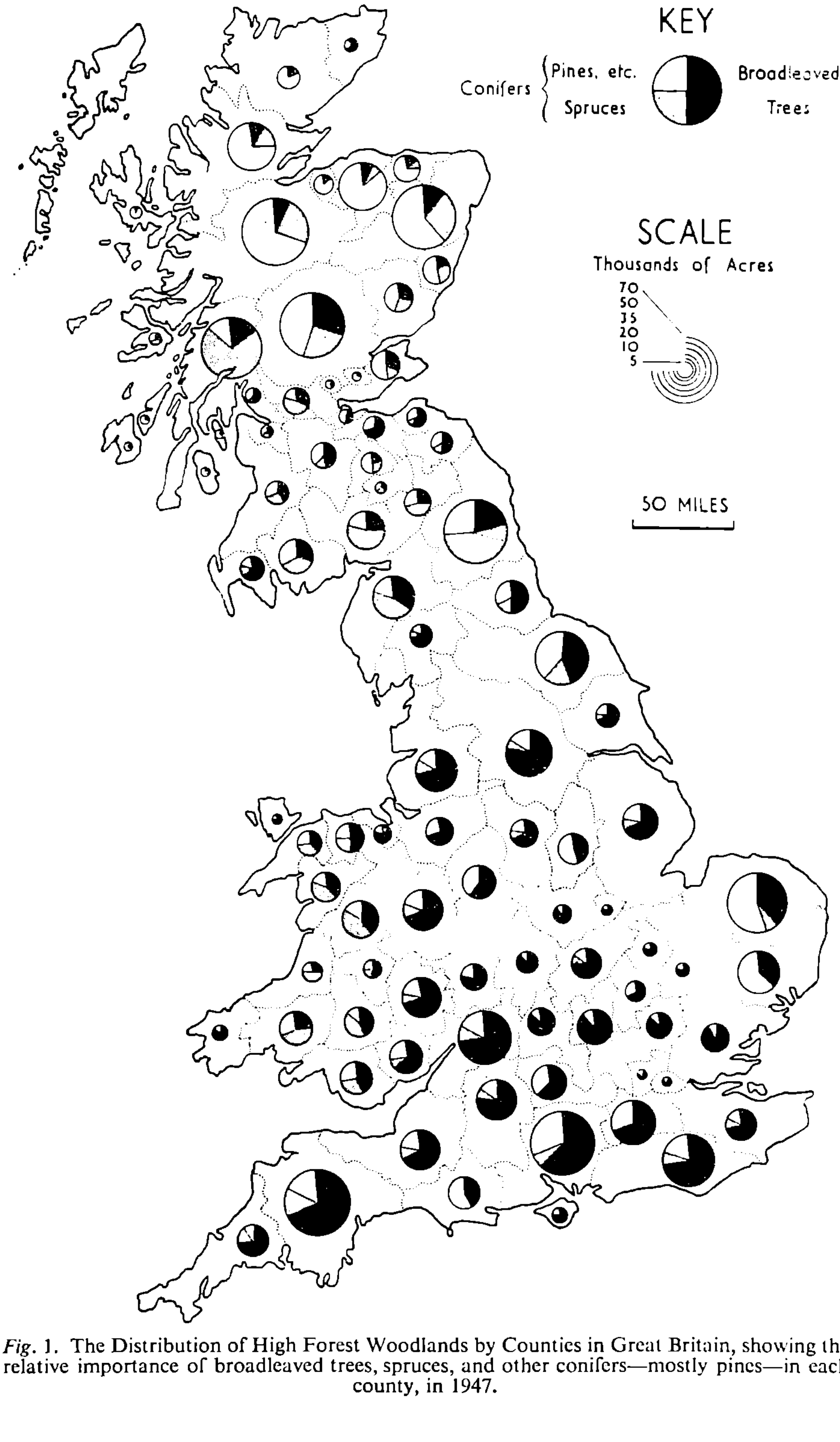

Fig. 1. The Distribution of High Forest Woodlands by Counties in Great Britain, showing the relative importance of broadleaved trees, spruces, and other conifers—mostly pines—in each county, in 1947.

of this only some 60,000 acres was under tree crops. From 1885 to 1919, various efforts were made to encourage the growing of timber, and eventually the Forestry Act of 1919 established the Forestry Commission as the Government Authority responsible for such work. The immediate cause for this action was the need to remedy the country's economic and strategic dependence on overseas sources of timber.

This Commission, as constituted under the 1919 Act and subsequent legislation, consists of ten members appointed by the Queen for a set term of years. The Commission is responsible to the two Government Ministers concerned with agricultural affairs, namely the Minister of Agriculture, Fisheries, and Food, and the Secretary of State for Scotland. The Ministers act jointly in matters of general policy, but the Minister of Agriculture has a special concern for England and Wales, and the Secretary of State a like concern for Scotland.

The Commission is required to make an annual report to Parliament. Funds for its operations are provided in part by the Treasury, and in part from sales of timber and other receipts from its estates. The principal duties entrusted to the Commission are the promotion of forestry and the maintenance of an adequate reserve of growing timber within Great Britain, and it has wide legal powers to pursue these objectives. Its staff are recruited, and operate, under the same conditions as members of the Civil Service.

The present basis of action was outlined in a formal report entitled *Post-War Forest Policy*, which was presented to Parliament in 1943, when the second World War was again making evident the need for home supplies of wood. Briefly the Policy provides for a fifty-year programme, during which time there will be built up a forest estate—partly in private ownership and partly under national ownership—covering 5 million acres (2 million hectares) equivalent to 10 per cent of the country's land surface. When fully established, this will yield about 400 million cubic feet of timber each year, in true measure under bark. So far as can be estimated, this output will be equivalent, on a sustained yield basis, to about one-third of the amount of the country's consumption in 1938. A larger contribution to the country's needs could, of course, be provided during a short emergency, but only by over-cutting the growing stock.

It should be noted that it is not proposed to make the country independent of overseas timber supplies, which will continue to provide a major part of all timber and timber products used. But the present extreme dependence, which involves a heavy drain on foreign exchange and is a strategic liability, will be greatly reduced.

The prosecution of the present fifty-year plan is an extension of the Commission's work which began immediately on its formation in 1919, and has already resulted in the creation of a national forest estate covering, in 1956, 1,062,000 acres. Further details of this achievement are discussed in a following section.

Statistics of Forest Land

The Forestry Commission now (1956) holds 2,177,000 acres of land, and of this 1,062,000 acres is under tree crops. Of the remainder 315,000 acres is held for planting up in the near future; while 800,000 acres consists of land unsuitable for afforestation, mainly the mountain tops in Scotland and Wales, which has had to be taken over with the better ground; such land is used for rough grazing and also, in the National Forest Parks, for recreation. Each year a further 50,000 to 60,000 acres are planted with trees, and this area would be increased if more land could be secured.

Woodlands under private ownership cover approximately 2,750,000 acres but this figure includes many very small and scattered areas. This figure will probably diminish somewhat, as some owners will wish to offer woodland to the Forestry Commission rather than to manage it themselves. It is estimated that by the end of the century the private owners will retain some 2,000,000 acres of efficiently managed and productive forest, excluding very small woods and shelterbelts.

The national objective during the next forty years is 5,000,000 acres of efficient timber-producing forest. Assuming that 2,000,000 acres remain in private ownership, the Commission's share will thus be 3,000,000 acres. It has already acquired 1,400,000 acres of plantable land, but there remains something like 1,600,000 acres that must be obtained from moors and hillsides for planting up.

Forestry Commission Activities

Under its central headquarters in London, the Forestry Commission organises its work on a territorial basis, with a Director of Forestry for England, also in London, one for Scotland in Edinburgh, and one for Wales at Aberystwyth. A Director of Research and Education, stationed at the London headquarters, controls operations in those fields throughout Great Britain. Each country is divided into smaller charges, known as Conservancies, comprising a group of about eight counties or parts of counties; over Great Britain as a whole there are eleven Conservancies and two smaller units, for the New and the Dean Forests respectively. Each Director or Conservator is a senior forest officer with a complement of office and field staff.

In each of the three countries a National Forestry Committee assists the Director and the Commission in the framing of policy, while each Conservancy has a Regional Advisory Committee representative of local interests, particularly as regards the private estates. A special Committee advises on research.

The activities of the Commission are organised on three main lines:

(1) Formation and Management of National Forests.

(2) Encouragement of forestry on private estates.

(3) Research and Education.

For convenience, these activities are reviewed separately below, but in practice one forest officer commonly deals with both national forests and private estates in his own district. He is thus fully familiar with local conditions, and can advise woodland owners on the basis of his own recent experience. Specialist officers are, of course, more closely concerned with one particular activity.

Direct Action in National Forests

Since 1919, some 500 national forests have been set up by the Commission. The land for these is acquired from private ownership either by purchase or by lease for a long term of years. Such land comes from two main sources—former woodland which owners are unable or unwilling to manage themselves, and mountains or moorlands of low value for farming. Further land is steadily being acquired at the current rate of 50,000 acres each year. This is less than half the desirable rate, but as all land is acquired by negotiation with willing sellers, and not by compulsion, it can only be taken up as it comes on to the market. Owing to the large number of private landowners, suitable land is often available only in small blocks, which can only gradually be built up into a forest of reasonable extent.

The Commission raises nearly all the trees it uses in its own forest nurseries. The current rate of planting in the Commission's own forests is some 50,000 to 60,000 acres a year. This involves the raising and planting of about 120 million young trees. The work of afforestation or replanting is done by direct labour. This labour force, which numbers over 13,000 persons, is supervised by resident Foresters. Each group of forests is controlled by a District Forest Officer. To ensure a sufficient number of labourers, particularly in the Northern and Western regions where population is sparse, the Commission has found it necessary to build houses on a large scale.

These sometimes form small groups of cottages or smallholdings, and sometimes larger "forest villages". The planning and management of these housing schemes, together with the management of property other than forests, is entrusted to specially trained Estate Officers. Altogether there are 4,500 houses for forest workers, and about 100 more are built each year.

To make possible the transport of forest produce from the woods, it has been found essential to extend the existing network of roads and tracks, particularly in the hilly northern and western districts. These now extend to 3,500 miles, and a further 450 miles, or so, is added each year. By using machinery such as bulldozers and graders, it has been found possible to build gravel roads of a sufficiently high standard very cheaply. This work is supervised by professional engineers.

At present little mature timber is harvested from the Commission's forests, since most crops are under forty years of age. The bulk of the produce takes the form of thinnings from young coniferous woods. The marking of such thinnings is always undertaken by the Commission's staff, but subsequently the trees selected for removal may be sold, as they stand, to timber merchants, who fell, remove, and market them. Alternatively, the felling and transport may be carried out by the Commission's workmen, and the resulting material be sold as poles at the roadside, or further prepared and delivered to the purchaser's factory or yard. The method of sale adopted depends mainly on local conditions and the prices offered; but it is considered advisable to do enough direct marketing to keep in touch with prevailing costs and prices.

Plans for planting and the ancillary work, thinning, road making, and fire protection, are in force at all forests, and these are gradually being developed into comprehensive Working Plans covering all aspects of management.

Main Forest Regions

Land for afforestation has been acquired wherever it has become available, and consequently there are one or more forests in nearly every county throughout Great Britain. But the larger forests, or forest groups, are naturally placed in certain regions where ample suitable land, too poor for sustained agriculture, is to be found. In the North of England, there is a large forest region around Kielder, on the Scottish Border, and another called Allerston on the Yorkshire Moors near Scarborough. In Eastern England there is a large forest called Sherwood in Nottinghamshire, and another called Thetford Chase in Norfolk and Suffolk. The New Forest in Hampshire is the largest in the South, and the Dean Forest in Gloucestershire the largest in the West. In South Wales there is a big forest called Coed Morgannwg in Glamorgan; while North Wales has a group of extensive new woodlands in its main valleys.

In Scotland, the greatest concentration of new forests lies in the Highlands along the Great Glen that runs from Inverness to Fort William. Farther East, there is a string of new woods between Inverness and Aberdeen, along the foothills of the Grampian Mountains. West of Glasgow, the county of Argyll has a large concentration of Commission forests; while in the South-western region called Galloway there is a big forest group around Glentrool.

Certain of these larger forest regions have been declared National Forest Parks, with the object of encouraging the public to use the tracks through the woods to the hills that lie beyond, and to enjoy some of the most magnificent scenery in the country. Camping sites have been opened and guide books published. There are eight of these parks and, together with the New Forest, they provide 500,000 acres of land for public recreation.

Assistance to Woodland Owners

Woodlands in private ownership form parts of very numerous estates, whose individual holdings vary from over 10,000 acres to as little as 5 acres. All owners are being encouraged to manage their woods in the most efficient way, by the aid of free technical advice from the Forestry Commission, and by schemes for planned management and financial assistance.

Estates having any considerable extent of woodland, usually from 100 acres upwards though there is no strict limit of size, are asked to prepare simple working plans which are revised at five-yearly intervals. The management of the woodlands in accordance with the agreed plan is supervised by a Commission Forest Officer, who visits the estate at least once a year; but ownership of the woods, and their ordinary management, rests entirely with the owners. If the owner signs a legal covenant, binding himself to follow this "Plan of Operations", the woods are regarded as "Dedicated" to timber production, and he receives a grant for planting or replanting each area, and a further grant for managing his woodlands. If the owner merely agrees to follow the "Plan of Operations" without legally binding himself, he receives a smaller planting grant but no grants for management. These "Dedication" and "Approved Woodlands" schemes, introduced in 1947, have been adopted by an increasing number of people, and 1,360 woodland owners, holding between them 600,000 acres, have already agreed to manage their woodlands under working plans.

For the smaller properties, simple Planting Grants are made available, the only condition being that the work must be thoroughly done and the resulting plantations maintained for at least five years. Other grants, available to all estates, are available to meet part of the cost of clearing scrub prior to planting, for planting poplars, and for the early thinnings of young plantations, which while silviculturally desirable are not always remunerative.

The rates of grant paid are reviewed from time to time to keep them in line with current costs. At present the simple Planting Grant is £17 10*s*. per acre, which represents about one-third of the average cost. Woodland owners may also claim certain concessions in national taxation.

In order to conserve the country's limited reserves of standing timber, a system of felling licences has been introduced. Small exemptions are made to allow of minor fellings for such purposes as farm repairs, but in general no substantial quantity of timber may be cut without a licence. The total quantity permitted each year is regulated by a "quota" method. In general, licences are freely obtainable for felling mature woods, or for thinning, but not for the clear felling of young plantations. An important feature of the system is that the owner may be, and in practice usually is, required to replant felled woodland.

Research

The Commission's research activities are based on the Alice Holt Research Station, situated close to Farnham in Surrey, some 40 miles south-west of London; there is also a branch office in Edinburgh that deals with field work in

Scotland and northern England. The experiments and field trials are dispersed over a large number of forests and nurseries, because the wide differences in topography, soil and climate that occur in Britain make it essential to sample a large range of conditions. The main subject of research is silviculture, but there are also sections concerned with genetics, pathology, entomology, the development of machinery, and the utilisation of forest produce, while a further section covers mensuration of tree crops, studies of growth and yield, census or stocktaking of woodlands, economics and working plans. All these sections are aided by a central library and documentation bureau, a photographic section, and a statistician. The Commission also operates a small branch for Forest Work Studies in the field.

The general scope of the Commission's direct research and investigation lies with the immediate practical problems of the forester. Where more fundamental research is needed, it is the practice to enlist the help of specialists attached to the universities, and to make them appropriate financial grants.

The financial provision for all forms of research amounts to about 3 per cent of the Commission's total expenditure. Thirty graduate forest officers are employed full time on research work.

The principal fields of research up till now have been the raising of trees in nurseries, and their planting and establishment in the forests. This is in line with the very large programme of afforestation by artificial methods that is being pursued in Britain. The improved methods that have been developed as a result of such investigations have already amply repaid the effort and expense involved. For example, plants suitable for use in the forest are now regularly raised in two years, instead of requiring three or four years in the nursery as previously; and this means a big saving in cost and also in nursery area. The introduction of various methods of soil preparation by ploughing has led to much more rapid rates of growth in young plantations on very varied types of ground; land considered doubtful for afforestation only ten years ago can now be planted up with confidence.

As the new forests get taller, the emphasis of research is shifting towards problems of management, and the utilisation of their increasing output of thinnings. But planting trials are still in progress to discover, for example, whether afforestation can be carried out on still poorer soils or more exposed sites in the north and west. Provenance studies, and the formation of seed orchards for the large scale production of seed of known high quality parentage, are other fields in which investigations are being actively carried on.

The results of research are made known by means of an Annual Report on Forest Research, by bulletins and shorter papers issued at irregular intervals, and by contributions to scientific journals.

Education

Four Universities—Oxford, Edinburgh, Aberdeen, and Bangor—offer courses in forestry, and forest Officers must obtain a degree at one of them. The Commission undertakes the training of men for posts as Foresters in its own woods or on private estates. There are four training schools—one in England, two in Scotland, and one in Wales, and the course of practical and classroom instruction, which is given free of charge to selected men, lasts two years.

The number of graduate Forest Officers, Estate Officers, and Engineers employed is 425, and the number of trained supervisory Foresters is 1,265. The labourers engaged in the forests number over 13,000, while 2,100 people are employed in all grades of office administration.

The Commission also organises an apprenticeship scheme for boys who wish to become forest workers, and short courses of a few weeks' duration for adult forest workers and woodmen. Other courses, lasting only one week, are arranged for woodland owners, estate agents, and others professionally engaged in forestry. Most of these, together with refresher courses for the Commission's own staff, are held at at residential centre called Northerwood House in the New Forest.

Finance

The current (1956) level of annual expenditure by the Commission is around £11,500,000. Of this some £9,000,000 is derived from the national treasury, £2,300,000 from the sale of timber and other forest produce, and £200,000 from rents of land, royalties for minerals, and other miscellaneous sources. During the present phase of developing large areas of young woodlands, expenditure is naturally far in excess of receipts, but this situation will be remedied as more woods approach maturity and give higher yields of timber. Expenditure on the establishment and maintenance of Commission forests is about £10,400,000 annually. The balance consists of £750,000 expended as grants and other forms of assistance to private woodland owners, £250,000 spent on research, and £100,000 on the education of foresters.

The net state investment in home forestry is now about £9 million per year, whereas the annual cost of timber and forest produce imported from abroad amounts to some £362 million (1955 Figure).

Other Agencies concerned with Forestry

There are several other official bodies or national institutions that are concerned with forestry; all of them work in co-operation, to varying degrees, with the Forestry Commission. The two Departments concerned with farming, that is the Ministry of Agriculture, Fisheries, and Food in England and Wales, and the Department of Agriculture for Scotland, encourage the planting of shelterbelts to protect farm lands, and give grants towards the cost. The Ministry of Housing and Local Government and the Department of Health for Scotland deal with the scenic aspect of trees, more particularly in the towns, and make legal orders for the preservation of trees or woods of exceptional natural beauty. The Nature Conservancy maintains woodland nature reserves, and promotes the study of the biological sciences. Research into the properties and uses of timber is undertaken by the Forest Products Research Laboratory at Princes Risborough in Buckinghamshire, about 40 miles north-west of London, which comes under the Department of Scientific and Industrial Research.

The Forestry Universities not only train forest officers but also carry out research. There are two Royal Forestry Societies, one for Scotland and another for England and Wales, which organise meetings and visits to woodlands, and publish journals; their membership includes woodland owners, land agents, timber merchants, and professional foresters of all grades. There is also a more strictly professional Society of Foresters of Great Britain, which issues the journal "Forestry". In several districts there are also Co-operative Forestry Societies which are essentially commercial in character; they provide their members, who are usually the owners of fairly small areas of woodland, with professional assistance in planting, management, and marketing timber.

The Principal Trees Grown

A major change is in progress in the composition of Britain's forests, involving a swing from the native broadleaved trees, principally oak and beech, towards coniferous trees, all but one of which have been introduced from abroad. This trend is shown in a general way by the table that appears below; for various reasons this cannot be taken as an exact comparison; but it shows the prevailing trend.

Species	*Percentage of High Forest occupied in* 1947	*Percentage of Forestry Commission planting in* 1956
Oak	24	3
Beech	9	4
Ash	5	—
Birch	3	0.5
Sycamore	3	0.5
Elm	1	—
Sweet Chestnut	1	—
All other Broadleaved trees	1	1
	47	9
Scots pine	20	19
Sitka spruce	9	24
Norway spruce	8	8
European larch	8	2
Japanese larch	3	12
Corsican pine	2	4
Douglas fir	2	3
Lodgepole pine	—	13
Western hemlock	—	2
Western red cedar	—	1
Hybrid larch	—	0.5
Serbian spruce	—	0.5
Lawson cypress	—	0.5
Grand silver fir	—	0.5
All other conifers	1	1
Total Conifers	53	91
Grand Total, All Trees	100	100

This table compares the percentage area of high forest plantations under each kind of tree in 1947 (the last date for which complete figures are available), with the percentage of each tree used currently (1956) by the Forestry Commission. At present, the Commission's work covers 70 per cent of all planting done, and it is known that planting on private estates follows similar trends. Hence the left-hand column indicates the past composition of the woodlands, and the right-hand column the likely future composition, if current practice continues. The most remarkable change is the reduction in the proportion of broadleaved trees, with oak falling most markedly. Several conifers show large increases in the proportion planted, particularly Sitka spruce, Japanese larch and Lodgepole pine. Reasons for these changes are discussed later.

Obviously there must be good reasons for such a remarkable alteration in the character of a country's forests, and these are, of course, basically economic. The current demand for timber and forest products, such as wood pulp, in Britain, is for 90 per cent softwood and 10 per cent hardwood. Further, while softwood of any grade is acceptable for one purpose or another, the markets for hardwoods require large logs of high quality, whereas smaller or inferior material is difficult to dispose of at a reasonable price. Then the rate of volume production of the conifers, on nearly any site, is commonly greater than that of the broadleaved trees, and the extra price obtained for high quality broadleaved timber seldom compensates for this shortcoming in growth rate. Finally, much of the land available for afforestation, especially among the northern and western hills, is incapable of growing broadleaved trees to a marketable size, whereas it will produce conifers of reasonable dimensions. Consequently, both the Forestry Commission, which exists to meet the needs of industry, and the private owners who have to consider even more closely their likely financial returns, are both concentrating on the planting of conifers. Broadleaved trees are only used in places where past experience suggests a future crop of rapid growth and high quality; such situations are far more frequent in the Midlands, the South, and the East of England, than elsewhere.

Since Britain has only one native timber-producing conifer, the Scots pine, which is a relatively low volume producer and unsuited to certain conditions of soil and exposure, recourse has been had to several kinds of introduced coniferous trees. The number tried experimentally reaches 100, but as a result of trial and error, only about 14 are now grown on a commercial scale.

Scots pine (*Pinus sylvestris* L.)

This native tree retains its well-merited place in our forests because it has a fairly wide tolerance of soil and site. It also gives better results than any other tree on many of the less fertile moors, characterised by a growth of pure heather, *Calluna vulgaris*, over subsoils of sand or gravel, in the low rainfall areas on the eastern side of the country. Its main drawback is its moderate rate of growth, and this often causes other faster-growing conifers to be preferred. But its timber is widely known and well-liked, and thinnings of all sizes are marketable; timber of this species is imported in great quantities from Northern Europe under the trade name of "redwood", and hence all users are familiar with it. Scots pine is planted all over Britain, but the principal pinewoods lie in North-East Scotland and in Eastern England. In 1947, woods of Scots pine covered 360,000 acres; the Commission now plants about 10,000 acres of it annually, and it is widely used on private estates.

Corsican Pine (*Pinus nigra* var. *calabrica* Schneid.)

Although this Mediterranean tree might appear to be well outside its climatic range in Britain, it thrives amid the warm, dry conditions that are found along the eastern side. In lowlands with a low rainfall and a warm summer it grows rapidly, producing substantially more timber per acre than the native Scots pine. It has proved particularly useful for afforesting coastal sand dunes, since it withstands both drought and salt winds. On the other hand, it has failed when planted under the high rainfall and cool moist conditions of the north-western hills. There is some evidence that this species may also be successful on the heavy soils of England which used to grow rather indifferent oak.

Lodgepole pine (*Pinus contorta* Douglas)

This tree has recently come into prominence following extensive trials by the Research Branch; in 1947, there were only 3,260 acres of it in the country, whereas today some 8,000 acres are planted annually. The reason for this is the surprising tolerance of the coastal strains (though not the others) to severe exposure and high rainfall on infertile peaty soils in the north and west, where no other tree will thrive. Although it is regarded primarily as a pioneer, there is already some evidence that it will produce timber comparable to Scots pine, with at least as fast a rate of growth.

Other pines (*Pinus* species)

The Austrian pine, *Pinus nigra* var. *austriaca* Asch. and Graeb. always shows poor form in Britain, and is used only for shelterbelts, not for timber. Monterey pine, *P. radiata*, and maritime pine, *P. pinaster*, are hardy only in the south, but are used in Devon and Cornwall. No five-needled pine is grown commercially, since the species best suited to growth in Britain all suffer from blister rust (*Cronartium ribicola*), aphis (*Adelges strobi*), or both these pests together. Efforts are being made to find a resistant strain of *Pinus strobus*.

Norway spruce (*Picea abies* Karsten)

The common European spruce has been widely planted on private estates since the eighteenth century, and is still much used there and in Commission forests. It grows well on moist grassy sites and on old woodlands in most parts of the country. In the south and east it is unsatisfactory, however, on all but the dampest of ground where rainfall is less than 30 inches a year. It does not thrive on acid heaths with a vegetation of pure heather (*Calluna vulgaris*) nor on very acid peats, and it cannot stand severe exposure, particularly to the salt winds found on the west coast. Elsewhere, it proves a rapid producer of a useful timber, which is also imported in quantity from Northern Europe as "whitewood" and hence is familiar to users everywhere. Thinnings have proved very suitable for paper pulp and chipboard, amongst other uses. Young trees and the tops of older ones are sold each winter as decorative "Christmas trees". In 1947, Norway spruce plantations covered 133,000 acres; current planting by the Commission is at the rate of 5,500 acres a year, and much is also used on private estates. It is now a species commonly used in mixture with oak.

Sitka spruce (*Picea sitchensis* Carr.)

This western North American spruce is used to an even greater extent than the Norway spruce, because of three virtues: it is much more resistant to exposure at high elevations, or near the sea; it tolerates considerably more acid peats or heathy vegetation; and it produces timber at a rather more rapid rate. Like the Norway spruce, it is unhappy during the warm dry summers in the south-east, but is entirely at home under the high rainfall and moist, cool conditions of the north-west. Another failing is a susceptibility to damage by late spring frosts in valley bottoms; hence Norway spruce is used there instead. Rapid height growth is common, many trees only 30 years old exceed 100 feet. The timber closely resembles that of Norway spruce, and is used for much the same purposes. Sitka spruce plantations covered 167,000 acres in 1947; the Commission plants about 16,500 acres annually, but little is used on private estates.

Other Spruces (*Picea* species)

The Serbian spruce (*Picea omorika* Pancic) shows promise on difficult peaty ground, but planting is restricted by limited seed supply. Several other species have been tried, but none adopted generally.

European larch (*Larix decidua* Miller)

The common European larch has been very widely planted on private estates since the eighteenth century, but the experience of the Forestry Commission has been that it is only a success on selected fertile and well-watered sites, away from severe exposure. Extensive provenance experiments have shown that strains from high mountain regions are unsuited to the British climate; trees of wrong provenance suffer from canker and other diseases causing die-back; plants raised from seed gathered at lower elevations in Europe, or in Scotland, prove much hardier. Larch timber is valued for its naturally durable heartwood, and thinnings are widely used for fencing and estate repairs. Large logs furnish planks for the wooden fishing boats that are still built in Scotland. European larch plantations covered 133,000 acres in 1947; the Commission currently plants 1,500 acres annually, and private owners probably use as much.

Japanese larch (*Larix leptolepis* Gord.)

Since the beginning of the present century this larch has been planted on an increasing scale, because it appears better suited to a wider range of British conditions than the European species. Its rate of growth, especially in youth, is considerably greater, an increase in height of 3 feet a year being quite usual. It stands more exposure and tolerates less fertile soils than does the European species. Japanese larch has proved very useful for planting on hillsides covered with bracken fern (*Pteridium aquilinum*); it is also a good tree for suppressing unwanted regrowth of cleared broadleaved coppice. At first, on the basis of tests carried out too early on young, very fast grown samples, its timber was adjudged poorer than that of European larch; more recent tests made on normal samples suggest that it is nearly as strong, and therefore likely to find the same markets. There were only 55,000 acres of Japanese larch in Britain in 1947; but the Commission now plants 8,000 acres annually, and it is much used on private estates.

Hybrid larch (*Larix eurolepis* Henry)

British foresters take a justified pride in this remarkable tree, a natural hybrid between European and Japanese larches which was discovered at Dunkeld in Scotland about 1904. The first and probably the second cross are even hardier and more tolerant of difficult soil conditions than the Japanese larch, and grow even faster. At present planting is limited by the shortage of seed, but seed orchards have been formed to ensure ample future supplies of first-generation hybrid seed; the two parent species have been planted together to ensure a high probability of cross-fertilization.

Douglas fir (*Pseudotsuga taxifolia* Britton)

This Western North American conifer has been planted on a moderate scale for over 100 years, but experience has shown that it only does well on selected ground. It thrives best on fertile slopes, preferably on former woodland. A drawback is its susceptibility to windthrow, on all but the firmest of ground. As against this, its rate of timber production is rapid, and the resulting timber, which is imported in quantity from British Columbia, has a high reputation in the timber trade. Only Douglas fir of coastal provenance (sometimes called "green Douglas") grows well as a timber tree in Britain; trees of inland provenances (such as the "blue Douglas") prove unsatisfactory. Douglas fir is particularly useful for planting amid thickets of *Rhododendron ponticum*; since its dense shade suppresses regrowth. Douglas fir is being increasingly used in mixture with beech.

Silver firs (*Abies* species)

The common European silver fir, *Abies alba* Miller, was grown successfully in Britain until about 1900, after which date the insect *Adelges nüsslini* became so serious that further planting was not worth while. It is remarkable that this pest, which is a minor one in Europe, should be so serious in Britain.

Two silver firs from Western North America, namely the grand fir, *Abies grandis* Lindley, and the noble fir, *A. nobilis* Lindley, are used on a small scale mainly for re-planting former woodland, and for under-planting. *A. nobilis* will stand considerable exposure, and does well on good soils at high levels. Both produce timber similar to Norway spruce wood, at rapid rates on suitable sites.

Other Conifers

The western hemlock, *Tsuga heterophylla* Sarg. from British Columbia, is being planted on a growing scale because it is easy to establish on former woodland sites, is suitable for under-planting, has only modest soil requirements and produces timber rapidly. It shows promise too on peat-covered land, and may be useful in mixture with Sitka spruce, as in its native country. The eastern hemlock, *T. canadensis*, is not considered worth planting.

Western red cedar, *Thuja plicata* D. Don, is grown on a small scale on the more fertile ground; its exceptionally light and very durable timber is useful for fencing and ladder poles. Unfortunately it suffers at the nursery stage from a serious fungus, *Keithia thujina*, and no sure method of control has yet been devised.

Lawson cypress, *Chamaecyparis lawsoniana* Parl., is used on a small scale only; its great drawback is the tendency of the main stem to divide or fork.

Both *Thuja* and Lawson cypress are being used increasingly in mixture with oak.

Oaks (*Quercus* species)

The two native oaks, the pedunculate (*Quercus robur* L.) and the sessile (*Q. petraea* Lieb.), form the main element in the older planted and natural woods of Britain; indeed it has been estimated that one tree in every three is still an oak. Nevertheless really good big mature timber is far from plentiful, and there is too much small or crooked material of low value. It is apparent that oak can only prove profitable if grown as high quality timber on really good sites. Consequently planting is now done only on a small scale. The durable timber is used for fencing, furniture, and to some extent in building and engineering. The red oak, *Quercus borealis* Michx.f., from North America, which has less strong but still useful general purpose timber, is being planted on a small scale because of its good growth rate on soils of moderate fertility.

In 1947, oakwoods covered 431,500 acres of high forest; but current Commission planting only amounts to 1,700 acres a year, and this rate is likely to fall; private owners no longer plant oak on any extensive scale. Oak is now rarely planted pure.

Beech (*Fagus sylvatica* L.)

The native beech is most abundant on chalk and limestone hills in the south and east, but has also been planted far to the north, even in Northern Scotland, where it thrives on well chosen ground. It is still being widely planted because it is the only timber-producing tree that is fully at home on the shallow rendzina soils found on the chalk and limestone. Nowadays conifers are commonly used in mixture with it. The timber enjoys a good demand, mainly for furniture making, but also for making many other small, strong wooden objects. Beechwoods in 1947 covered 162,000 acres; current Commission planting amounts to 2,000 acres a year, and much is also used on private estates.

Ash (*Fraxinus excelsior* L.)

Ash trees of exceptional quality are found over limited areas of fertile soil, mainly on the limestone formations, and their timber commands a good price for making furniture, sports goods, tool handles, and the framework of vehicles. The planting of ash is now restricted to such places, as small and slow-grown timber is of little value. Ashwoods occupied 85,000 acres in 1947; but current planting is on a very small scale.

Sycamore (*Acer pseudoplatanus* L.)

This is the only introduced hardwood of much consequence in British woodlands. It produces timber of good size and quality generally only on fertile soils derived from limestone, and its present planting is restricted accordingly. Much of the best sycamore comes from the Yorkshire dales; it is used for furniture and for wooden rollers in the textile trade.

Birch (*Betula* species)

Two native birches, the white birch (*Betula pubescens* Ehrh.) and the silver birch (*B. pendula* Roth.) occur plentifully as self-sown seedlings in neglected felled woodlands, and as scrub on hillsides. Unfortunately, birches in Britain seldom reach a size at which they would be useful for plywood or furniture; their small and crooked stems are only suitable for firewood and turnery, and bring low prices. Hence birch is rarely planted. Natural growth, however, forms useful cover for establishing more valuable species.

Poplars

Several sorts of hybrid poplar (*Populus* spp.) are grown on fertile well-watered ground amid farmlands, mainly in the South and East of England. Their timber is in demand for making matches and baskets, and planting is encouraged by special grants.

Other Broadleaved Timber Trees

Willows, *Salix* species, are grown locally along river-sides for craft uses; in particular, the bats used in the national game of cricket are always cut from a special strain of willow. Alder, *Alnus glutinosa* Gaertn. also grows along streamsides, and is used for the manufacture of wooden soles for shoes called "clogs". The English field elm, *Ulmus procera* Salis. springs up naturally in hedgerows, and its timber is used by country carpenters, especially for coffins; the wych or Scots elm, *U. glabra* Huds. is occasionally grown in woodlands.

Coppice Trees

In the South and Midlands of England there are extensive coppices of hazel, *Corylus avellana* L., which formerly provided material for hand-made fencing, called hurdles. Owing to changes in farming practice, the demand for hurdles is now small, and most hazel coppices are gradually being converted to high forest of conifer and hardwood.

In the south-east of England, many coppices consist of sweet chestnut, *Castanea sativa* Miller, which yields stouter and more durable poles suitable for making fencing or training hops. The demand for these products is still good, and chestnut coppices on the best sites are therefore well maintained and profitable. The sweet chestnut is of little importance as a timber tree in Britain. So far the chestnut blight, *Endothia parasitica*, has not reached Britain.

Silviculture

The prevailing concern in British silviculture is the establishment of large areas of coniferous crops, partly on fresh ground and partly on former woodland, by purely artificial methods; of necessity these crops are even-aged, though many soon become uneven-sized. Other forms of silviculture, such as those involving natural regeneration and uneven-aged crops, are the subject of much interest and study, but they involve only a small proportion of the area dealt with each year. As examples of natural regeneration, oak has been successfully treated in the New Forest and the Forest of Dean, and beech is commonly regenerated naturally in the Chiltern Hills north-west of London; Scots pine regenerates readily in the South of England, but unfortunately more slowly and less certainly in Northern Scotland. On some private estates and a few Commission forests, particularly in Scotland, the Swiss *Méthode du Contrôle* is being applied to groups of woodlands suitable for selection management. These operations follow conventional lines developed on the Continent; whereas the artificial regeneration methods are perhaps of greater interest because of their large scale, their degree of mechanisation, and the introduction of new ideas and methods.

Seed Supplies

Seed of only a few species, notably oak, beech, Scots pine and European larch, is generally available in sufficient quantity from home sources; because of the emphasis on exotic conifers, much of the seed used must be imported. Seed orchards are, however, being established in order to ensure home supplies of seed of selected strains of the main trees grown. In practice, the Forestry Commission imports nearly all the seed used for both its own and private estate planting; great care is taken to ensure that only suitable provenances are obtained.

Nurseries

The Commission's nurseries cover altogether 2,100 acres and a considerable further area is worked by commercial nurserymen to supply private estates. Owing to the risk of introducing fresh pests and diseases, quarantine regulations forbid the import of nearly all conifers, except as seed, from abroad. Hence nearly all planting stocks used are raised in Britain; the annual output from Commission nurseries averages 120 million transplants; current stocks run at 250 million seedlings and 180 million transplants. Most of the work is concentrated in large nurseries, usually one or two in each Conservancy, and at these the Forester in charge devotes all his time to nursery work. The aim everywhere is to raise large, sturdy, transplants, cheaply, in as short a time as possible. For many species, one year in the seedbed and one year in the transplant bed suffices; others need two years in the seedbeds but plants older than four years are seldom used. Very little forest planting is done with seedlings; extensive trials have shown such plants to be too unreliable in the forest.

Heathland Nurseries and Seedbed Methods

Since 1945, the trend has been to raise seedlings in what are called "heathland nurseries", because they are deliberately established on poor sandy soil amid the heaths. Although such ground is poor in nutrients, it is quite free from the common weeds found on arable land, and it can be easily and cheaply cultivated with tractor-drawn implements. It is usual to add an organic manure to bring the soil into the right condition; the standard material is spent hops, a by-product of the beer-brewing industry which is available cheaply in sufficient quantities in most parts of the country. Spent hops are completely weed-free, whereas farmyard manure always brings with it a quantity of weed seeds. A heavy initial dressing of spent hops is needed for new nurseries, about 20 tons to the acre.

The spent hops alone do not provide enough nutrients for optimum growth. Therefore inorganic fertilisers containing nitrogen, potassium, and phosphorus are added in forms and quantities which are prescribed by the Research Branch. The resulting seedlings are large, sturdy, and well rooted; for example, Scots pine seedlings one year old are often 6 inches high, and fit for transplanting.

Both broadcast and drill sowing methods are used; the latter method is sometimes mechanised. Coarse sand or grit is always used to cover seed; fine sand or earth is found to cake and to lessen the yield. Lath screens are often used to shield seedbeds from frost, or occasionally in the south, from strong sun. Irrigation is seldom found necessary.

Transplanting

The need to transplant about 180 million seedlings annually, in the Commission's nurseries, has led to a concentration on mechanical methods. American machines on the cabbage-planter principle are used, however, only on a very small scale, since they will only operate economically on a large expanse of flat sandy-soil, which is seldom available in Britain. The basis of transplanting therefore remains the wooden board, familiar on the Continent, into which the seedlings are inserted by hand, usually by women or boys. The preparation of the soil, the opening up of the trench, and the subsequent earthing up of the roots are done by tractor-drawn implements. The most successful arrangement of these is known as the "Ledmore Lining-Out (i.e. Transplanting) Plough", designed by Forester Rose at Ledmore Nursery in Scotland. It performs all three operations efficiently and cheaply, yet is small enough to be drawn by the "Ferguson" wheeled tractor commonly used in nurseries. The lifting of transplants when large enough for the forest is also mechanised, using a sledge-like implement drawn by a tractor.

Weed Control by Oil Sprays

Where weeds are troublesome, either in seedbeds or transplant lines, their control is made easier and cheaper by spraying small quantities of selected oils with the aid of compressed air. A form of tractor fuel has been found very effective for spraying seedbeds, after sowing but before tree seedlings appear; to some extent it acts selectively, killing weed seedlings but doing little or no damage to conifers.

Ground Preparation on Afforestation Areas

Probably the most remarkable feature of current British forest practice is the attention paid to thorough ground preparation by mechanised ploughing and subsoiling on all suitable new afforestation areas. Former woodland still holding stout stumps, steep slopes, or rocky ground, cannot readily be ploughed, but elsewhere some form of cultivation is the rule. The expense of this work is considered to be well repaid by the better and more even growth of the young plantations, the lower weeding costs, and the reduced risk of damage by fire during the first few years. Complete ploughing is not found satisfactory or worth while; the ploughing of strips about 5 feet apart is considered best; depths of 9 inches to 1½ feet are used. This technique originated in trials of the Belgian method of draining combined with planting on turfs, in the 1930's. For many years hand drainage and turf planting was followed with good results on peaty land. From 1935 onwards various ploughs, drawn by tractors, were developed to produce both drains and turfs mechanically, at lower cost than hand work.

Ploughing as now carried out falls into three main classes:

(a) On peaty soils, to provide drains and turfs.

(b) On heaths with podsols to cultivate the soil, to break the "hard pan" layer below ground, and to suppress heather.

(c) On grassland, to provide shallow cultivation and to suppress vegetation.

Different types of plough and tractor are employed for each kind of ground.

The usual planting distance for conifers is 5 feet; somewhat close spacings are used for broadleaved trees. On mineral soils planting by the notch method is the rule. On peat soils, planting is done in turfs or mounds, and for this work the Belgian semi-circular spade is favoured at several forests. Elsewhere a straight-bladed notching spade, or a mattock, is the usual tool. High rates of planting are achieved, with satisfactory results. It is usual for one man to plant 500 to 1,000 trees per day. Ploughing enables small trees to be planted successfully; transplants from 6 to 12 inches are favoured for bare ground. Larger transplants from 12 to 24 inches are used in former woodland.

Drainage is mechanised where possible, the most useful tool on peaty ground being a single-furrow, tractor-drawn plough; but hand work is always needed to complete the network of drains.

Fencing is nearly always required around plantations in Britain. In most districts rabbits are still present, and wire netting fences are essential to keep them out. At present their numbers have been reduced by the myxomatosis disease, but it is feared that they will again increase. Deer, particularly red deer. *Cervus elephas*, cause damage in the Scottish Highlands, where it is often necessary to erect fences 6 feet high. Roe deer (*Capreolus capreolus*) are also troublesome locally.

Replanting of Former Woodland

This follows conventional lines except in one important particular. Where any light cover, for example of birch or hazel, exists on the ground, it is usual to preserve it, thinning it out if required, and to plant the fresh crop beneath it. This preservation of overhead cover is found to give better early growth than that obtained by a complete clearance of the ground prior to replanting. Another advantage is the sparser weed growth that results, and consequently the cheapening of early maintenance.

Tending Young Plantations

Little weeding is needed on ploughed ground, as vegetation around the young trees is suppressed and does not return for two or three years. Elsewhere, one or two weedings each year are often needed to safeguard the young trees;

the bracken fern, *Pteridium aquilinum*, and the bramble shrubs, *Rubus* species, are particularly troublesome weeds in many areas. Plantations on former woodland are often invaded by unwanted birch trees, and by climbers such as honeysuckle, *Lonicera periclymenum*, which must be cut out at a later stage.

A common practice in Britain, though one that is seldom followed elsewhere, is the "brashing", or pruning away of side branches from young conifers up to a height of 6 feet. A limited amount of pruning of selected stems, to a height of eighteen to twenty feet, is carried out.

Fire risk in young plantations is high, since even in high rainfall areas a dry spell in spring coincides with the presence of dry and inflammable vegetation. The lay-out of roads, rides, and compartments at all forests is planned with fire risk in mind. Water supplies are organised and fire towers are built at the larger forests. The main reliance in fire fighting is placed on specially equipped lorries, manned by trained teams of forest workers. These lorries carry a water supply of about 400 gallons, together with mechanical pumps deliberately designed to supply this slowly through small hose pipes. They can reach most parts of the forests, and are used for the first attack, applying water more to aid beating by hand, than to extinguish the fire directly. This first prompt attack often controls the fire, at least until the public fire brigades, with more powerful pumps and bigger hoses, can be brought into action. A good system of communication by telephone and short-wave radio ("walkie-talkie") is organised for fire-fighting control in the larger areas. There is close co-operation with the local public fire services.

No exceptional measures are usually taken to protect tree crops from insect pests or fungal diseases. The spraying of insecticides from the air has, however, been used with good effect on a few isolated epidemics of the pine looper moth (*Bupalus piniarius*).

Thinning

Crops of conifers are usually ready for their first thinning between 15 and 20 years after planting. The intensity of thinning is a question to which much thought is directed, but practice varies according to species and the views held by various foresters. Most thinnings, however, may be classed as "low thinnings", though "crown thinnings" are coming increasingly into favour. Markets for poles and small trees removed as thinnings are adequate, but it is found difficult to carry out the earlier thinnings at an economic cost. For many years to come thinnings will form the major source of produce from Commission forests; they are estimated to account for half the total yield of an average plantation, since their aggregate volume equals that of the final crop.

Rate of Timber Production

The rate of growth of coniferous tree crops in Britain is often high by the standards of Northern Europe or North America. Careful measurements have been made for nearly 40 years by the Commission's Research Branch which maintains a large number of sample plots, and yield tables have been published. These records show that on good sites in the high rainfall areas of the north and west, certain introduced conifers such as Sitka spruce and Douglas fir may show a mean annual increment of 200 or even 300 hoppus feet per acre per annum over the first fifty years. Such rapid growth is not of course found for all species nor in all districts, but a relatively slow growing tree like the Scots pine commonly produces 100 hoppus feet per acre per annum. Little precise information is so far available on the rates of growth of broadleaved trees, but they appear to resemble those found on the Continent.

It has often been suggested that the high rates of growth shown by certain conifers will be associated with timber of lower quality than normal. This important matter is currently under investigation by the Forest Products Research Laboratory. The research results obtained so far suggest that the fast grown material is not seriously inferior in strength to more slowly grown wood.

Although changed economic conditions have raised the relative price of imported timber, transport from the outlying districts where many new forests are situated remains an adverse factor for the British forester.

Timber Consumption and Marketing

The current yearly rate of consumption of timber and other forest products (principally wood pulp and paper) in Great Britain is of the order of 1,200 million true cubic feet calculated as round timber, by under-bark measure; this is equivalent to 24 cubic feet per head for the 50 million people.

At present, home woodlands contribute only about 100 million true cubic feet to this total, or about 8.5 per cent. The volume of standing timber in the country is estimated at 4,400 million true cubic feet, which is a little less than 4 years' normal consumption. The quantity of timber harvested is deliberately kept below the annual increment, which after allowing for natural losses, is estimated at 132 million true cubic feet. Because harvesting is being kept below increment, a reserve of timber is slowly being built up.

The marketing of the produce from British woodlands has therefore to be fitted into its appropriate place beside the larger volume of timber imports. This is not an easy task, for timber users have become accustomed to overseas sources of supply, and the importers' specifications and grades of material, and do not immediately change to home sources, even when comparable material becomes available at competitive prices.

Little difficulty is found in selling large logs of high quality oak, ash, beech, and sycamore. These have long been handled by old-established sawmills in the country towns, which have appropriate equipment to deal with them. The problems lie rather with the marketing of small-sized coniferous thinnings and the poorer hardwood material. Over the past ten years the Forestry Commission has been actively developing markets for such produce, and recently several timber-using industries, new to this country, have been set up, though only on a small scale.

Two major old-established outlets for small trees are those for farm fencing and pit props for the mines. Throughout Great Britain generally, a high proportion of timber used for agricultural purposes is drawn from home woodlands. Most of the pit props are still imported, but in Scotland virtually all those used are now coming from Scottish forests.

The more recently developed outlets include the following:

(a) *Small Sawmill Timber.* An entirely new sawmill on the Swedish Ari pattern, with seasoning plant, has been opened at Strachur, in the Cowal District of Scotland, to handle thinnings from the Argyll National Forest Park. Another specially designed mill operates at Queensferry in North Wales.

(b) *Chipboard.* A new factory has been opened at Annan, in the South of Scotland, to utilise thinnings from forests on or near the border between England and Scotland.

(c) *Fibreboard.* A hardboard factory in London takes large quantities of thinnings from forests in eastern England.

Another factory has been opened at Queensferry in North Wales to produce insulation board.

(d) *Paper Pulp.* Two existing paper factories now take substantial quantities of coniferous wood. One at Sittingbourne in Kent draws upon East and South-East England; another at Ellesmere Port in Cheshire takes material from Northern England and North Wales.

A new factory has been built in Monmouthshire to make paper from hardwood material unsuited for sawing; it has been sited near large sources of supply in Southern England and South Wales.

(e) *Wood Wool.* Factories to make this substance, used mainly for packing, have been established in England, Scotland and Wales.

All these establishments are operated by commercial firms, who have in all cases consulted the Forestry Commission regarding the availability of continual supplies of raw material, before establishing their plant. A feature of most arrangements is that the owners of private estates are able to supply material to the new factories on terms comparable to those agreed with the Commission.

Social Implications of Forestry

I have left to the end a brief note on the value of forestry in providing employment in districts where other activities are failing to provide a sufficient livelihood for the people. This has recently received attention in Britain because of the growing depopulation of certain rural districts, notably in the uplands of Central Wales and the North-Western Highlands and Islands of Scotland. The Commission has undertaken to extend its activities in some of these districts, and to carry out, if necessary, planting schemes that do not promise any high economic return. It is estimated that initially one forest worker is needed to every 100 acres of woodland, whereas ten times that area is needed to sustain one shepherd under rough grazing. Obviously, all new planting in such regions has to be sited so as to cause the least possible disturbance to existing farming practices; but past experience has been that the advent of plantations, which use only the poorer ground and provide badly needed shelter, does not diminish the agricultural output of such regions.

The broad approach that the Forestry Commission is making to this problem is not always to try to acquire land in very large blocks or to plant up whole farms, but rather to acquire the relatively less valuable parts of farms, even though the extent of individual blocks may be quite small. In other words we are trying to arrange that forestry is developed alongside, and in conjunction with, agriculture. The hill lands are undoubtedly producing far less than they could, but the improvement will be made not by a change of use to forestry as an independent venture, but rather by improving and perhaps altering the methods of farming at the same time that new forests are established. A combined operation, in fact, is needed, designed to create or restore a balance between forestry and agriculture.

Until 40 years ago Great Britain in effect had no forest policy, and though a comparatively small number of the larger private woodland estates managed their woods efficiently, and some with considerable enterprise, the State took a very small part in forestry. It is only since 1919 that the State has played an active role both in establishing its own forests and encouraging the proper management of private woods. In the short period since the 1914-18 war—short, that is, in terms of forestry—Great Britain has gone far in making forestry take its proper place in the life and economy of the country. In doing this she has drawn heavily on the experience and wisdom of the countries of Europe who have much longer history and tradition of forestry than she has.

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FORESTRY IN AYRSHIRE

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Ayr is a maritime county, the broad estuary of the Clyde washing its western shores, while its landward boundary is a semi-circular sweep from the Firth of Clyde near Gourock through the Renfrew Heights, the Eaglesham Hills and the Southern Uplands to Loch Ryan, near the south-west corner of Scotland. The County in feudal days was divided into the three districts, which are still popularly recognised, of Cunninghame in the north, Kyle in the centre and Carrick in the south. With an area of over 700,000 acres, Ayrshire ranks seventh in size in Scotland, and is Scotland's largest shire south of the Highlands.

The essentials of the county's relief are fairly simple. A succession of hills and plateaux lie along the landward margin, rarely dropping below 1,000 feet, and in the Carrick region culminating in the 2,764 feet Merrick, which lies just across the county boundary in Kirkcudbrightshire. Occupying the heart of the county, and rising from a flat, true coastal plain through undulating country to about 800 feet, is the Ayrshire Plain. The geological structure generally corresponds with the broad features of relief and outline; the marginal hills consist of volcanic rocks of the oldest Carboniferous formations (the Calciferous Sandstone), the sandstones and volcanic rocks of the Old Red Sandstone, and the hard metamorphosed rocks of the Ordovician and Silurian systems. These outcrops dip, or are faulted, down towards the plain which is developed on the less resistant sediments (mainly shales and sandstones) of the later Carboniferous formations and the Permian. Soils are very varied over much of the country, ranging from heavy sands to moderate or heavy loams, with the heaviest loams and clay soils found only in restricted localities. But, of more importance to the forester, is the fact that on the higher lands peat is always present to some extent; often organic matter is so abundant that peat mosses form, giving great thicknesses of black organic matter virtually free of mineral substances.

Ayrshire is especially subject to oceanic influences as regards climate, and consequently experiences constant rainfall, mild winters and cool, cloudy summers, but there is considerable climatic variation with elevation and exposure. Rainfall ranges from less than 35 inches along parts of the coastal belt to over 80 inches on the highest hills: the minimum rain period is during the spring (March-June). On the hilly part of Carrick and Kyle districts, prolonged frosty spells, often with snow, usually occur between January and March, and in these areas, too, late spring and early autumn night frosts are often troublesome to tree growth, particularly those areas on the lower slopes or in the valleys.

There is no doubt that at one time Ayrshire was an extremely well wooded county, and place names testify to the former existence of considerable tracts of woodlands. Foster, in his book *Ayrshire* states "Names in - *wood* are still common in every parish, while there is a sprinkling of names in *den* (a deep wooded valley) and *hirst* (a thick wood). These last prove not only that trees had grown in these situations but also that woods were in existence after the Saxon language began to prevail over the original tongue, probably about the thirteenth or fourteenth century". These natural woodlands suffered depredations over the centuries, until by the middle of the eighteenth century Ayrshire was generally a bare county, with the exception of plantations which had been laid down on certain estates. However, together with the great agricultural improvements that occurred in the last decades of the eighteenth century, and particularly in the first half of the nineteenth century, much planting was undertaken, and by 1850 the county was fairly well wooded. While the primary motive of the earlier plantings would seem to have been the provision of timber for posterity, the importation of timber in the nineteenth century somewhat altered the position, and plantings were then done also to enhance parks and estates, and to provide shelter for farmland and stock.

The Statistical Accounts, viz. the *Statistical Account of Scotland*, 1791-99, and the *New Statistical Account of Scotland*, 1845, (hereafter referred to as First and Second Accounts) give much useful information on woodlands in Ayrshire at those times. For the Parish of Colmonell, the First Account records that "it is believed in former times, there was a continued wood from Knockdolian Hill to the Kirk of Barr, an extent of 10 miles"; and dealing with Kirkoswald the same Account states "There is little or no natural wood in the parish but the want of this is happily supplied by the plantations made by the Earl of Cassillis and Sir Adam Fergusson. The former has, within a few years, planted upon his estate and especially in his policy, 560 acres. Sir Adam Fergusson has planted 240 acres, all of which are in a most thriving condition". The Second Account tells us that in the Parish of Dailly, "Arboriculture has also greatly advanced of late years. Planting has been carried to a considerable extent on the estates of Bargany, Kilkerran, Dalquharran and Drumburle. On that of Bargany alone no less than 666½ acres have been planted in the last thirty years" and that in the whole parish "it is computed that 2,500 acres are under wood, natural or planted. The trees planted are generally oak, ash, plane and elm with such proportion of Scotch larch and spruce firs as fills the ground for an early crop".

The history of plantings on private estates in the county can well be illustrated by taking an example such as Kilkerran estate, which lies in the valley of the Water of Girvan in South Ayrshire. The first of the Kilkerran planters was Sir John Fergusson, 1st baronet, and it is recorded that he was given a "tack" for three 19 years "of that bit on which the firs behind the stable were planted in 1706 . . . I began in the spring 1711 to sow for nurseries . . . and spring 1715 began the hill planting and soon made great progress in it". Planting was carried on by succeeding generations, and a plan prepared in 1761 of Kilkerran policies and parks shows many planted areas which correspond to those under timber today, while in 1794 the First Account records that plantings on Kilkerran estate in Dailly parish "and within the contiguous borders of Kirkoswald and Maybole cover about 400 Scots acres", (i.e. over 508 English acres).

Blairquhan estate, also in South Ayrshire, and situated near the little village of Straiton, has today approximately 750 acres of woodland, but in 1787 the area of woodland was only 75 acres; the first increase in acreage was due to Sir David Hunter Blair, one of the improving lairds of the early nineteenth century, and since then, for generation after generation, successive owners have taken an active interest in the woods, which have thus benefited by continuity of management.

Plantings by private owners through the last few centuries have therefore led to woodland being widespread over most of the county: today this woodland comprises very nearly the whole of the productive timber in the county. Much of this area is accounted for by hardwood, or mixed hardwood and conifer, policy woodland, and very often land has been taken which would otherwise have been utilised as farmland. But it is also true that much land under timber was such that, if left unwooded, it could only have been utilised for rough pasture and sheep grazing, while in some cases woodlands have been planted on the poorest of hill land. Shelterbelts are very numerous in most parts of the county, except the north; these belts are sometimes ill-planned and are more or less haphazard over the landscape, but, on many of the former large estates, they were systematically planned and form a regular pattern; sometimes on relatively high, windswept areas fields may be entirely surrounded by shelterbelts.

Little natural wood now remains in the county; the remnants consist of hardwood species, nearly always of very poor form and quality and virtually useless, and generally in inaccessible places which is, of course, the reason for their survival. Its situation is invariably in deep glens, such as Glen App, and the valley of the Stinchar in the south, and in the gorges of the rivers Doon and Ayr.

These small remnants of natural woodland, together with plantations made by private owners, formed the sole woodland in the county until the mid nineteen-thirties, when the Forestry Commission began to acquire land for planting. Since then great development has taken place, both in Commission forests and privately owned woodland; more will be said further on about the latter, but it is appropriate at this stage to say something of the Commission's work in Ayrshire. It should be noted that hereafter this article only deals with forests and woodlands in the south and central parts (Carrick and Kyle districts) of Ayrshire, as only these areas lie within South Scotland Conservancy; the north part of the county, viz. that area north of the River Irvine (Cunninghame district) falls within West Scotland Conservancy.

In 1935, Changue Forest of 2,190 acres was acquired; Changue is situated near the small village of Barr, in the heart of the Carrick district. Planting commenced in 1936, and continued through the war until planting was completed in 1957. This was the only pre-war acquisition in Ayrshire, but in 1945 over 48,000 acres were acquired in the parishes of Barr and Straiton, and this block became Carrick Forest. Marching with Changue on its west boundary, Carrick Forest stretches northwards almost to the village of Straiton, then east to Loch Doon, while its southern boundary is along the Ayrshire-Kirkcudbrightshire boundary, across which lies Glentrool Forest. Planting commenced on Carrick in 1947, and is still continuing. Carrick and Changue, together with Glentrool and other forests in Kirkcudbrightshire, form the Glentrool National Forest Park, extending to approximately 130,000 acres. In 1949, Kilgrammie Forest, of 568 acres, was acquired, lying in the fertile valley of the Water of Girvan; planting commenced in 1950, and has recently been completed. In the past few years, small extensions to Changue and Kilgrammie Forests have been acquired, but the most recent large acquisition is that of Arecleoch Forest of 3,105 acres, in 1956. It lies just north of the Ayrshire-Wigtownshire boundary, and planting was started here in 1958.

While all the forests lie in the Carrick district, and indeed Carrick and Changue are adjacent, conditions are often markedly dissimilar, dependent upon geology, soil, elevation, rainfall, etc. Generally, the best soils are found on Changue and Kilgrammie Forests, and limited sections of Carrick. Poor land on Changue is restricted to small localities, the bulk of the ground consisting of shallow *Molinia* peats and good mineral soils. Kilgrammie Forest was formerly felled woodland, and the soils are consequently rich and fertile, often ideally suited to the growth of hardwoods. Carrick Forest has a large proportion of land over 1,000 feet, and much land over the 2,000 feet contour, and while there is much good plantable land on the better *Molinia* and *Calluna* peats, and mineral soils, there are vast areas of the poorest quality peats; the greater portion of Carrick is scheduled to remain as sheep grazing. At all the forests exposure has to be carefully considered, as none of them lies far inland from the sea; while in the more sheltered situations trees have been planted and are thriving at 1,250 and 1,300 feet, the relative exposure experienced at a particular elevation is often a limiting factor. The climate generally is well suited to conifer growth, particularly spruces, as rainfall is abundant; spells of hard frost, sometimes with snow, often occur in the early months of the year and may make the ground unworkable.

The plantations made pre-war on Changue, and immediately following the war on Changue and Carrick, were all on hand-prepared ground. This conformed with the system of turf planting which had been very extensively used since 1928 in all forests in south-west Scotland, drains being cut at about twenty feet intervals, the turves cut from the drains spread at five feet apart, and the plants notched through the turves. While this was perfectly satisfactory for the better areas, it was not so suitable for poorer peats where vegetation may contain *Calluna* and *Scirpus* as well as *Molinia;* moreover, these hand operations were expensive. With the development of machinery, ploughing became more used, and since 1948 the bulk of the plantations made have been on ploughed ground; in the late forties and early fifties, due to shortage of equipment, the common practice was to plough drains at distances of 17 or 21 feet apart, and spread the turves by hand between the ploughed drains. But since then every attempt has been made to plough as much as possible, thereby eliminating the need for hand labour and making possible a better planting site for every plant. The plough most used is the Cuthbertson single furrow, combined with the Cuthbertson double mouldboard plough on the better *Molinia* peats.

Ploughing has also enabled the afforestation of much land which would have otherwise been considered unplantable, the majority of the Carrick areas planted in the last five years being of this category. These areas are generally characterized by heather, often accompanied by *Scirpus*, over a tough, poor type peat. The peat may be deep on the boggy areas, but these areas are often broken up by knolls and hummocks, small and large, of morainic material, over which there may be only a very shallow depth of peat. This latter type area has been best treated with ploughs of the tine type, and in the past few years the Clark tine has been most successful, working on the most difficult boulder-strewn areas and producing as good a planting medium as one could expect on land of this type.

The only type of hand preparation that is now used to any extent is "stepping". This is only done on steep slopes where there is good natural drainage and good quality soil, commonly where rivers have eroded impressive valleys often hundreds of feet deep, as the River Stinchar has done on parts of Carrick. Stepping consists of cutting a triangle along two sides, each of 12-15 inches, and hinging the turf over on the third side; the tree, generally a larch, is then notched through the turf.

Most of the area planted consists of Sitka spruce, which is undoubtedly the best species for general use in south-west Scotland. On the more sheltered areas, Norway spruce has been used wherever possible, but on Carrick in particular, sites for Norway are very limited. Japanese larch has been used fairly extensively, and has been found a very useful species whether planted pure on the more "normal" type of larch ground, or planted in mixture with Sitka spruce on the shallow peats overlying glacial deposits. Scots pine has proved extremely disappointing, and is now seldom planted except perhaps in very small quantities on the steepest of rocky slopes along the sides of small burns. Lodgepole pine is now used to a great extent, particularly on Carrick, as the areas being planted now or to be planted in the future, nearly always bear heather, sometimes very luxuriant, which often tends to increase after ploughing and draining has been done; the pine is only planted pure on the very worst areas, and is generally in a mixture of varying proportions with Sitka spruce comparable with the nature of the ground. On all the poorer areas the plants are treated with phosphate after planting. The noble silver fir has been used more in recent years, and shows great promise, particularly so on Carrick where there is often good mineral soil at the tops of hills at elevations from 1,000-1,250 feet; on this type of site, Sitka spruce also does well except that it is frequently affected by spring droughts which turn the tops of the lower hills quite brown. Lodgepole pine has also been planted in mixture with Sitka spruce on these sites, and would otherwise thrive except that it usually suffers severe blasting and consequent leaf-cast from cold, freezing winds which often occur in the late winter. Hybrid larch is a tree which would be used in greater quantity if it were available, for on the steep valley slopes Japanese larch can seldom be planted above 800 feet, owing to exposure, although the soil may still be sufficiently good for a larch crop; hybrid larch would also mix well with Sitka spruce on the soils derived from glacial material, where again it may be too exposed for Japanese larch.

This then has been the pattern of planting on the hill forests of Carrick and Changue; Kilgrammie Forest, however, is very different. This area, formerly felled woodland, has soils ranging from medium and heavy brown loams to fairly heavy yellowish-brown clay loams, and is well suited to the production of first class timber. Accordingly, the better areas in the forest were earmarked for hardwoods, and a large area of the forest will eventually bear a hardwood crop. The first planting was in 1950, and the system then was to plant alternating strips of hardwoods and conifer nurses. Since 1952 the practice has been to plant groups of hardwoods in a conifer matrix; oak has been the hardwood species most used, and on this system groups, each of 12 oak, are planted approximately 30 feet apart with Japanese larch in between; a ring of Norway spruce is sometimes put round the oak group, and when the spruce reach Christmas tree size they can be removed. This method of planting has proved successful so far, and generally the young oak are thriving. Beech, sycamore and ash have been planted, although the latter are not very successful. Of recent years late spring frosts, occurring in the middle of June, have been very damaging to both conifers and hardwoods: the effect of the frosts is intensified by the fact that much of the forest has a southerly aspect.

Changue, Kilgrammie and Arecleoch forests have each their own Forester; for convenience of working, Carrick forest is divided into four sections, viz. Balloch, Starr, Tairlaw and Tarfessock, and in many ways each of the sections is treated as an individual forest unit. Within the last few years Tarfessock has been worked and managed as part of Glentrool forest, as it lies adjacent to Glentrool and some distance away from the other Carrick sections. The areas under plantations on the various units at the end of 1957 are given below, together with total areas and approximate areas remaining to plant.

Forest	*Total Area*	*Under Plantations*	*Remaining to Plant*
Arecleoch	3,105	Nil	2,800
Carrick:			
Balloch	8,964	2,195	1,200
Starr	11,662	1,158	1,050
Tairlaw	11,979	3,192	400
Tarfessock (now included with Glentrool)	13,853	2,161	1,700
Changue	2,389	1,740	Nil
Kilgrammie	570	564	Nil

As regards the future of state forests in Ayrshire, it can be seen that, with the exception of Arecleoch, the work of planting has passed its peak and that another decade will see planting completed except for any new acquisitions of land. Due to the large post-war planting programme, it is inevitable that at some units there will be an interval between the completion of planting and the commencement of thinning; maintenance work and road construction will occupy a good deal of this time, and at present a fairly large road programme is tackled each year, as many of the earlier plantations were laid down without roads. Changue is the only forest yielding produce, and the earlier plantations are now at the second thinning stage. In the years to come thinnings from the forests in South Ayrshire will yield a very large volume of timber.

Not only in Commission areas, but in private woodlands too there has been much good work since the war. Many of the estates lost much timber as a result of wartime fellings, and most of them proceeded quickly with the work of rehabilitation, much planting being done. The estate of Cassillis and Culzean achieved 416.5 acres planted during the five years 1950-54 inclusive, a not inconsiderable programme as all this was done on felled and devastated woodland sites.

While this was undoubtedly the biggest programme achieved on any Ayrshire estate during that time, most other estates were also planting much land. The Dedication Scheme was generally well received, and to date in that part of Ayrshire included within South Scotland Conservancy there are twelve dedicated estates with a total area of 4,992 acres. Estates under the Approved Woodlands Scheme number six, with a total area of 1,865 acres. Other privately owned woodlands total 8,000 acres approximately, out of which 5,200 acres are "Small Woods" subjects; of the balance of 2,800 acres, 1,600 acres are woodlands which are in good order while 1,200 acres are classed as being inefficiently managed—approximately 8 per cent of the total area of privately owned timber. Earlier in this account, when dealing with the history of forestry in Ayrshire, it was seen that past generations of owners had a keen interest in their woodlands and forestry in general, and it is apparent that this interest is just as alive today, and probably even more so than before, because of increased knowledge and technical skill.

Much of the timber on private estates in Ayrshire today can compare well with any in the country. Of the hardwoods, oak in particular grows well, reaching a fine size and making high quality timber, and there is much valuable oak on many estates. Sycamore would probably rate as the second most valuable hardwood, and not only does it produce good timber, but is extremely useful for shelter; at present sycamore from estates in the Girvan valley is being exported to Germany where it is to be utilised for veneers. There is much beech and ash in the county, but the former is only of prime quality in certain restricted localities, while the latter is generally poor—if ash is to be grown in Ayrshire then a short rotation to produce small and medium size timber is probably the only way.

All the conifers grow well on private estates. Both the spruces, Norway and Sitka, have been planted more in recent years, and make good crops. All the larches do well; there is little in the way of pure European larch stands, but much good European larch exists in mixed woods; there are some very fine stands of Polish larch on Blairquhan Estate. Scots pine generally does well, and many estates have magnificent Scots pine of large size and good quality—every effort is being made to collect seed from this good type of tree, to ensure that future crops of Scots pine will be of the same high quality. The lack of success experienced with Scots pine in many of the Commission plantations can very often be attributed to faulty provenance. Corsican pine is used extensively along the coastal belt, and grows well. Douglas fir and silver firs grow to large size, although often rather coarse, while western hemlock, western red cedar and other conifers also do well. In short, most conifer species will be found thriving on nearly all private estates.

In conclusion, it can be seen that Ayrshire is a county where forestry is playing an ever-increasing role; the private woodlands owner is tending and ameliorating his woodlands, while the Forestry Commission is establishing forests on the moorland areas where trees have not grown for many centuries. The visitor cannot but be impressed by the Ayrshire landscape, with its aspect of neatness and efficiency created by the well-kept hedges, the sharp outline of the shelterbelts, the tidy farms each with its group of trees, and the dark greens of the forests contrasting with the browns and purples of the surrounding hills. Ayrshire is a great Scottish dairying county, and it may be that, in future years, it will be equally well known for its trees and timber.

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NOTES ON WHITTINGEHAME

Recently the Commission acquired a twenty-acre seed orchard, and an interesting small arboretum, on the famous estate of Whittingehame, a few miles south-east of Haddington in East Lothian. The following extracts from The Seven Ages of an East Lothian Parish—Being the Story of Whittingehame, *written by Marshal B. Lang in* 1929, *have been contributed by District Officer R. Faulkner, of the Research Branch.*

Whittingehame Castle

Whittingehame Castle is a building of the late fifteenth or early sixteenth century. The Castle stands on the bank of a wooded ravine through which flows the Whittingehame Water, or the River Papana, as it is sometimes, but not agreeably called. On the south-east side the ravine forms a strong natural defence, while from the north it is easily approached. There are three storeys in the Castle beneath the wall head, which is surmounted by a battlemented walk right round the roof. The staircase is rectangular on the lower flight, and circular above, reminding one of the staircase in the Palace of Holyroodhouse, Edinburgh. On the lintel of the main doorway facing the north there is still to be seen a stone shield parted by a broad band, on the right (dexter) of which is the cinquefoil (the five-leaved clover) beneath two stars; on the left (sinister), a boar's head beneath two stars. These are the arms of the Douglas family, the cinquefoil showing maternal descent from Borthwick.

A Famous Old Yew Tree

It has long been the local tradition that the murder of Darnley was plotted under the yew tree on the east side of the Castle or Tower of Whittingehame. This tree, probably at least seven or eight hundred years old, is one of the most remarkable of its kind in any country. According to measurements taken in 1925, it is 147 yards in circumference, its branches spreading out in a lateral direction, the lower branches being turned downward and resting on the soil, thereby completely obscuring the central trunk which measures 11 feet in girth. That the tree has been thriving in recent years is made clear by the fact that when its circle of branches was measured in 1891 it was found to make a circumference of only 104 yards. The sepulchral-looking enclosure within the tree, capable of holding fifty to sixty people, is eminently suggestive of sinister deeds, but as a matter of relief we know that it has not seldom been slept under by the younger and plot-innocent inhabitants of the modern mansion. The tree is now entered by a single narrow aperture, lately made easier of approach by an iron support to the branches. Addressing the East Lothian Antiquarian and Field Naturalists' Society within this enclosure in September 1925, the Earl of Balfour said that "since the murder of Darnley, Queen Mary's husband, was plotted in the courtyard of Whittingehame Tower, the story has arisen, which might or might not be true, that this yew tree in the courtyard, or close to the courtyard, was the real scene of this political murder. The story must be taken for what it is worth, but, at all events, they might say it had more historical plausibility about it than many legends."

Arboriculture of the Parish

We are indebted to Mr. William Fyfe, Forester at Whittingehame, for the following notes upon the Arboriculture of the estate. The area of woodlands on Whittingehame Estate, including Garvald and Hailes outside the Parish, is, roughly speaking, about 625 acres. The species of trees grown consist of mixed plantations, principally hardwoods. Oak, beech, elm, ash, birch, chestnut, and alder do exceptionally well, as the soil, consisting of deep red clay loam over sandstone, is very suitable for hardwoods. Two tulip trees, more common in the south of England, have been grown with considerable success. Conifers, such as the larch, Scotch pine, and silver fir, make very rapid growth and give a quick return, but begin to deteriorate after forty years. Several handsome araucarias adorn the upper walk of the extensive flower garden.

Many species of ornamental conifers abound in the Policy grounds and gardens, and are much admired by those interested in arboriculture and sylviculture. Among such occur the Cedar of Lebanon, *Cedrus atlantica*, *Cedrus deodara*, Wellingtonia (*Sequoia Gigantea*), *Sequoia Sempervirensis*, *Thuja Lobbii*, *Thuja Albertiana*, Douglas Fir, *Picea Excelsa*, *Picea Orientalis*, *Picea Polita*, *Picea Pungens Glauca*, *Picea Nobilis*, *Picea Grandis*, and *Picea Lasiocarpa*. The age of these trees ranges from forty years upwards. One of the most remarkable trees, growing on the north side of the gardens, and about 360 feet above sea-level, is the *Eucalyptus Gunnii* (Whittingehamensis variety), believed to be the largest of its kind in the country. It is grown from seed collected in 1852 by the late Marquis of Salisbury, uncle of the present proprietor. The young tree was frosted over in 1860, but a year later a sapling sprang from the root, which became the existing tree. The height of the tree is 75 feet, and its circumference, at 4 feet from the ground, is 12 feet. This tree is especially resistant to cold, and is a prolific seed-bearer. Many young trees from it abound and flourish in the policies. Another variety of the Eucalyptus tree (*Eucalyptus vernicosa*) has been successfully reared. It has a green leaf, and is not so pleasing in appearance.

Reference has been made to the famous Whittingehame yew tree, believed to be an English yew, and considered by some to be as old as one thousand years. It shows no sign of deterioration, and is still slowly extending the reach of its branches. It is probably the finest specimen of the yew in the kingdom.

An average of 20 acres each year is planted on the estate, mostly with larch, Scotch pine, and *Thuja lobii*, all grown in the home nurseries from seed. A few small plantations of hardwoods are also being planted annually.

A visit to the gardens and grounds of Whittingehame policies will well reward those who are interested in flowering shrubs, among which may be mentioned the *Desfontaine Spinosa* (Scarlet and yellow), *Garrya Eliptica*, several kinds of Viburnum, Japanese Cherries, Flowering Crabs, varieties of Acers, and most remarkable of all, the *Eucryphia Pinnatifolia*. It is, however, the natural beauty of the grounds that will always make the strongest appeal to the visitor.

(*Note:* The scientific names cited above are not always those accepted today. *Ed.*).

Families connected with Whittingehame

1040 - 1340	Gospatricks—Earls of Merse or March, and Dunbar.
1340 - 1661	Douglas.
1661 - 1695	Setons originally from Saltoun, Winton and Winchburgh.
1695 - 1817	Hays of Drumbue in Peebles.
1817 -	Balfour. Lord Balfour Prime Minister 1902-5. Derivation Bal-orr (R. Orr in Markinch, Fife) origin traced back to King Duncan (1034-40) and in female line to King Robert II (or III?).

CRARAE FOREST GARDEN

By E. A. CROFTS

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It is not intended that this short article should be more than a brief description of Crarae Forest Garden. Two recent assessments are included to give an interesting indication of growth in some species of conifers.

The garden is situated on the west shore of Loch Fyne in Argyll, about one mile north of the village of Minard, and ten miles south of Inveraray. It is close to the main road, and the once-daily 'bus from Glasgow to Campbeltown passes close by.

The district has an average yearly rainfall of about seventy-six inches. The Garden comprises about thirty-two acres and is mainly concentrated on both sides of the horizontal leg, running west to east, of an L-shaped glen and sheltered by the hill to the west of the vertical leg of the L. There are some species plots on the eastern side of the vertical, north-south leg. The garden has a generally eastern aspect and is within an elevation range of 130 feet to 240 feet above sea level. Underlying geological formation comprises metamorphosed igneous rocks, marked on geological maps as "epidiorite, horneblende-schists, etc." The climate is generally mild with little variation between winter and summer temperatures, the January mean being 39 degrees and the July mean 59 degrees.

The garden, planted by Sir George Campbell, was started in 1933 and was presented to the Forestry Commission in 1955. Up to the present, 108 species plots have been planted, of which 100 remain. They are generally small and somewhat crowded together, but they give an interesting indication as to how a wide variety of coniferous—and some broadleaved, species grow in this part of Scotland.

An assessment in March, 1956 gave the following information. These crops are of healthy appearance and of good form, etc.

1956 ASSESSMENT

Species	Age (Years)	Mean Top Height (Feet)	Mean B.H. Girth (True) (Inches)	Remarks
Abies delavayi/forrestii	20	28	19	Trees identified as delavayi up to 28″ b.h. girth and of very good form
„ procera	21	26	13½	
„ lowiana	21	39	18	
„ grandis	22	39	18½	
„ magnifica	23	23	15	
„ amabilis	23	38	15	very good form
Pinus contorta	22	35	15	
„ banksiana	23	31	16½	
Larix decidua				Canker and dieback but also some good formed healthy trees in all plots.
(a) West Alps	20	23	14	
(b) Swiss Alps	20	26	15	
(c) Tyrol	20	28	16	
Larix leptolepis	25	41	22½	
Picea abies	21	28	13	
„ sitchensis	21	39	15	
Sequoia sempervirens	21	32	18½	
„ wellingtonia	21	31	20	very small branches
Cupressus macrocarpa	21	46	20½	attacked by Honey Fungus
„ funebris	23	31	20½	suffering from windblast
Cryptomeria japonica	21	41	24	
Cedrus deodara	21	27	13½	
Chamaecyparis lawsoniana	21	28	20	
Tsuga heterophylla	23	47	18	very good form
Nothofagus obliqua	20	26	13½	
Eucalyptus urnigera	20	36	13	very good form
„ „	20	43	17	

1957 ASSESSMENT

The following species were recently assessed, January 1957, and columns five (5) to eight (8) show an attempt to describe briefly the appearance of the crop and to permit comparison.

1, 2 or 3 in column 5 describes either good, fair or bad stem form.
1, 2 or 3 ,, ,, 6 ,, ,, narrow, medium or broad crowns.
1, 2 or 3 ,, ,, 7 ,, ,, horizontal, moderate or upswept branches.
1, 2 or 3 ,, ,, 8 ,, ,, good, fair or bad health of crop.

(Note: Stocking of plot may have been affected by grazing before a deer fence was erected.)

Species	Age (Yrs.)	Mean Height (Ft.)	Mean Girth (In.)	Stem Form	Crown Diam.	Branch Angling	Health	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
Abies:								
cilicica	9	7.9	—	1	2	2	1	
lasiocarpa var. arizonica	12	4.7	—	1	2	2	1	
lasiocarpa	14	13.0	—	1	3	2	2	gaps in crop
balsamea	18	13.5	—	1	2	2	2	some defoliation
fraseri	18	20.0	13	1	2	2	1	
nephrolepis	18	7.8	—	2	2	2	2	some defoliation
veitchii	18	21.5	—	1	3	2	1	
homolepis (?)	20	10.4	—	1	1	2	1	
cephalonica	20	7.1	—	2	3	2	2	some defoliation
concolor	20	18.0	13	2	2	2	3	dieback
firma	20	10.4	—	2	2	2	2	subject to windblow
holophylla	20	13.6	—	1	2	2	1	
pinsapo	20	13.0	—	2	3	3	2	gaps in crop
spectabilis	20	5.7	—	3	2	2	2	very poorly stocked
sachalinensis	21	21.0	16	1	3	2	2	gaps in crop: under Japanese larch
Picea:								
sitchensis	10	14.2	—	1	3	2	1	
glauca	17	10.5	—	2	2	2	2	on dense *Calluna*
orientalis	17	7.4	—	1	3	2	1	
,,	17	3.9	—	1	2	2	2	on dense *Calluna*
bicolor	18	5.3	—	3	3	2	3	gaps in crop
koyamai	18	14.0	—	1	1	1	1	
schrenkiana	18	4.1	—	1	2	2	2	gaps in crop
spinulosa	18	8.3	—	2	3	2	2	gaps in crop
mariana	19	21.0	13	1	2	1	1	
glehnii	20	17.0	—	1	1	1	1	
hurstii	20	20.0	—	1	2	2	1	
,,	20	9.8	—	1	2	2	2	on dense *Calluna*
obovata	20	17.0	—	1	2	1	1	
Pinus:								
pinaster	5	3.6	—	3	2	2	3	very poorly stocked
cembra	12	6.6	—	1	1	2	2	disease present
nigra var. calabrica	18	7.1	—	2	3	2	2	poorly stocked
strobus	18	11.6	—	1	2	2	1	
wallichiana	18	12.0	—	2	3	3	2	gaps in crop
massoniana	20	16.0	—	3	3	2	3	poorly stocked and diseased

Species	Age (Yrs.)	Mean Height (Ft.)	Mean Girth (In.)	Stem Form	Crown Diam.	Branch Angling	Health	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
Pinus—*cont.*								
peuce	20	17.0	14.1	1	2	2	1	very good crop
radiata	20	21.0	28	2	3	2	2	poorly stocked
rigida	20	9.9	—	3	3	3	2	poorly stocked
sinensis	20	14.5	—	3	3	3	3	poorly stocked and diseased
tabulaeformis	20	15.0	—	3	3	3	3	poorly stocked and diseased
thunbergii	20	11.2	—	3	3	2	2	poorly stocked
lambertiana	22	11.0	—	2	2	2	3	poorly stocked and diseased
Tsuga:								
caroliniana	12	2.4	—	3	3	3	2	dieback
diversifolia	18	5.2	—	3	3	3	1	
sieboldii	18	8.8	—	3	3	3	1	
Cupressus:								
torulosa	22	20.0	16	1	2	2	1	
Sciadopitys:								
verticillata	8	3.4	—	2	3	2	1	

There are many other species in the forest garden, either growing slowly but happily or suffering from attack. There are also many fine individual specimen trees and a few poor ones. All are of great interest and we must be indebted to the founder of the Forest Garden for the formation of such an attractive and useful "show ground".

THE TREE AND GARDEN BOOKS AT GRAVETYE MANOR

By THE EARL OF MORTON, M.A., F.L.S.

This article is reproduced from Volume LXXII, Part 4, *of the* Journal of the Royal Horticultural Society, *by kind permission of that society's Secretary, and the author. As many readers will know, Gravetye Forest, situated near East Grinstead in Sussex, was bequeathed to the Commission by William Robinson, the great authority on gardening, in* 1934.

There has been for many years in the Lindley Library an elegant volume in limp vellum printed on hand-made paper and lettered without in gold *Gravetye Manor* and subtitled within *or Twenty Years Work around an old Manor House*. In his preface to this book, published in 1911, its author WILLIAM ROBINSON wrote "the books I kept included building and many works not of general interest, and what is given here concerns garden design and planting and landscape only". The value of this work has now been much enhanced by the generous gift of the Forestry Commission to the Library of the two MS. volumes of "The books I kept", each entitled "Tree and Garden Book, Gravetye Manor".

Recently I read of the great DUKE OF WELLINGTON saying of his published despatches, "They are valuable as a professional book, more so than Caesar's Commentaries because Caesar wrote afterwards, for effect. These are a collection of the instruments written at the time". (*Conversations with the Duke of Wellington*, edited by the 7th Duke of Wellington. Published by the St. Nicolas Press, Cambridge, 1956). Such a relationship seems to exist between the MS. books and ROBINSON'S highly finished volume of 1911.

The title page of the first "Tree and Garden Book" announces that it was "Commenced by Wm. Robinson, August 1885". On the last page is pasted a newspaper cutting annotated in his hand. "Advert" (the contemporary abbreviation surprises) "in Times which led me to see and buy Gravetye in 1885". The book appears to have been originally intended as a kind of "fair copy" record of work in progress. The first fourteen pages are inscribed in an ornamental script. Thereafter this is succeeded by different hand-writings equally legible, if less decorative. One presumes other amanuenses have been employed. Frequently ROBINSON'S own robust, unpleasing and often illegible handwriting comes hurtling across the page.

Gradually the character of the volumes changes. Records of work done are interrupted by discourses on various aspects of gardening and forestry and it has to be admitted that there is less about gardening than readers of this JOURNAL would wish.

ROBINSON was deeply interested in everything that concerned his estate and in improving his house as well as his property. He also for many years farmed extensively. An interesting point in connection with his career emerges here.

So eminently successful in much that he touched he also had some startling failures and disappointments. He abandoned farming owing to prolonged financial loss. He records building work which turns out unsatisfactorily even though undertaken at great expense and under the supervision of skilled architects. The plumbing system in the house, though equally expensively installed under the care of an "architect of the highest repute", got out of order and had to be renewed at great cost.

Not that cost appears to have been any great object. In 1886 he constructed a sunk fence to "secure freedom of view from the South of the house towards the lower lake and beyond" at a cost of about £325. The new upper drive to the house was "finished May 11, 1889 after very heavy labour for horses and men for 8 months, felling trees, filling hollows, removing many thousands loads of earth to get a good line and easy grade, closing old and useless roads so as to make the approach simple as well as beautiful and easy". In 1890 "an ugly stiff and straight cottage which was once the farm-house of the principal holding in Mill Place demolished as ugly from every point of view . . . Orchard taken away near the same and all thrown in to make one airy field. Effect on the rocks and the Scotch firs on them much better."

Extensive and continuous estate works are recorded in these books and much forestry work was also carried on. There are some very interesting experiments in seeding plantations, both of oak and various conifers. In the autumn of 1893 and spring of 1894 attempts were made to form an oak plantation from acorns. A later note, however, states, "all mostly failed owing to biting down of seedlings by rabbits". In 1902: Cedars of Lebanon, "Planted very small trees 4″-6″ high and between them here and there on 20th May the seeds direct of both the Cedar of Lebanon and Atlantica."

Many large-scale massed ornamental plantings were undertaken. In 1887: "Many handsome hollies, gold and silver and fine green kinds planted in December this year. They were got to shut out view of new kitchen garden from pleasure ground. To save 20 years or more very finely grown specimens were sought. They were brought all the way from Knaphill by road in our own and the nurseryman's wagons which met and exchanged horses at Ockley. . . These plants had been frequently moved and came with good balls, 2-4 feet across, the plants 6-12 feet high." A note in the 1911 volume states that many of the hollies did badly and many died: transplanting specimen hollies is usually a mistake.

Some completely new information comes to light in correspondence in July 1898 between ROBINSON and MR. F. WARNER BURT, then of Nigg, Ross-shire, whose grandfather, a MR. TURNER, had owned Gravetye from 1840-1860, when he had known it. He sent some interesting information about the house, and plans of it, drawn from memory as he remembered it, also two photographs of the house which ROBINSON seems to have assumed were taken in 1848, presumably because MR. BURT had in 1898 written of Gravetye as he had remembered it fifty years before. I can find no evidence for this date, but MR. BURT states that a man named MELVILLE, formerly of East Grinstead, took the photographs and that he had bought them from him about 1865, that is to say about twenty years before ROBINSON purchased the property. An interesting fact recorded by MR. BURT is that Gravetye, before his grandfather bought it for £2,000, had been for many years unoccupied except by harvest labourers, etc. Until some date between 1840 and 1860 the house appears to have remained unaltered, since it was built in the Tudor period.

ROBINSON made many gardens for other people and special interest attaches to any information about his own garden. He declared that his first consideration was the flowers he wished to grow. The favourite of these were tea roses, outdoor carnations, "Tufted pansies" and "Starworts" as he called them.

Of tea roses, in 1888 ROBINSON was able to claim after two years from planting that seventy sorts, in groups from six to twenty, had proved their hardiness through two severe winters, and in a poor summer and a fine one their beauty and long flowering period. He from time to time mentions tea roses in these records but does not say as time went on if, or to what degree, he kept his collection up to date.

His first attempt at hardy carnations at Gravetye was not a success. In 1886 he writes, "Formed a large collection of hardy border kinds, mostly 'self-coloured', over 500 plants coming from Pierrefitte in France. Not many of all these plants survived the winter: rabbits and frost had most!" Here it may be mentioned that during the many years covered by these books ROBINSON battled with "these pests", as he so rightly called them. However, having carefully fenced them, in the autumn of 1887 he set out about 2,000 carnations from good layers. They proved themselves satisfactory in every way. None was lost from the cold.

"Tufted Pansies" were, in fact, violas, so called, he says, to distinguish them from the alpine species which bear the same generic name. He used them for underplanting his roses and for mass planting where important blocks of colour were required. This somehow did not qualify in his view as "bedding out".

His culture of "Starworts" seems to have been a great contribution to horticulture. ROBINSON grew them in empty spaces between newly planted shrubs and found the "result was charming". These "Starworts or Michaelmas Daisies were a lovely sight here in 1887 and 1888", he writes in the latter year. In 1889 he wrote in the "Tree and Garden Book" an account of the "kinds which represent well the beauty of the Starworts as at present known. There are many more names and many more kinds may come but they will hardly surpass the above mentioned in beauty and vigour." ROBINSON did not see the late MR. ERNEST BALLARD'S Michaelmas daisies. He makes no reference to the R. H. S. Aster Conference of 1891.

On October 14, 1890, AUGUSTUS HARE wrote in a letter: "It was a pleasure to drive over to the picturesque old manor house of Gravetye which belongs to Mr. W. Robinson who wrote 'The English Flower Garden', but except for the thickets of Michaelmas Daisies I was disappointed in his flowers for he only attempts those which belong to the naturally existing soil." (Augustus Hare, *The Story of My Life*, Vol. VI, p. 227).

This last clause is curious, for there is ample evidence that frequently beds were excavated to considerable depths and filled with made-up soil. For example, in 1893, finding that certain beds in the flower garden were unsatisfactory, "we ripped up nearly all of them and digging out clay and rock from the bottom of them made each bed 2 feet deep below the level of the grass, filling in with good loam, sand and manure as the best preparation for tea roses and carnations". The great border round the garden was similarly treated at the same time.

In 1893 also, ROBINSON planted a large collection of new finely coloured water-lilies raised by MARLIAC and VILMORIN. He greatly admired these plants and enquired of MARLIAC how he had originated them. A lengthy reply is given but does not appear to reveal his secret methods which, according to MRS. FRANCES PERRY, "to all intents and purposes have passed away with him". Two years later "four different landscape painters", ROBINSON writes, "painted our lily pool in the summer and autumn in 1895, Mark Fisher, Alfred Parsons, H. A. Olivier and H. G. Moon". One wonders what CLAUDE MONET, who was painting at this time, would have made of the lily pools of Gravetye.

Planting of one kind or another was constantly taking place, but the seasons 1893-4 and 1895-6 seem to have been peak periods. It is impossible to enumerate all the subjects planted, but in 1893-4 in the MS. book they cover approximately four-and-a-half large foolscap pages. In this season they appear mainly to have been trees and shrubs. Sometimes only single specimens were acquired, but groups and hedges were planted of hollies, willows, almonds, cedars and pines, including a group of *Pinus leucodermis* "sent me by the Emperor of Austria's head gardener at Vienna, Mr. Kropatsch". One stupefying item is 4,000 kalmias and alpine rhododendrons.

The planting in the season 1895-6 was largely "in gardens and pleasure grounds". The list of things planted covers nearly three large foolscap pages and contains such items as "5,000 chionodoxas in garden near house", "1,500 dogstooth violets", "1,200 iris, English and Spanish among gooseberries", "6,000 tulips in tulip garden", "1,000 Red Roses on own roots in new orchard", "3,000 sweet-brier, fences and other places", "Hollies, Rhododendrons other things planted in Bamboo garden not included here", "2,000 forest and fence plants". "This season in garden, pleasure grounds and forest planted 50,000 in all." W. R., June 1896, is the note at the foot of this list.

"Planted in January 1897 nearly 100,000 narcissus . . . " I quote ROBINSON'S own words: in the spring following about 80,000 narcissus.

ROBINSON was always keen to grow things in as natural a way as possible and in November 1886 planted small groups of the moccasin flower (*Cypripedium reginae*) in bog moss in an old pit. These were a gift from MR. ELLIOTT of Philadelphia. A note in ROBINSON'S hand: "never could trace the plants in 1888". Six months earlier 400 autumn-flowering cyclamen were planted about the property, but ROBINSON again had to note in March 1888 that, "They did not seem to take to the soil". This year, too, about 7,000 snowdrops were planted, some hundreds of *Endymion hispanicus* and winter aconite. After the last is a note in ROBINSON's hand (probably of a much later date) "never did any good, not liking soil". The above bulbs appear to have been planted about October 22. Could this late date account for the failure of the aconites?

At this time also ROBINSON was attempting to naturalize plants by seeding. Blue lupin was sown by the banks of streamlets and in copses, the "Welsh poppy about the farm stables and bailiff's cottage also a pinch at the lake dam," the white columbine "at stoneheap of the dam of the lower lake", and water-forget-me-not was scattered about "the fringes of lakes and streams". In 1894 ROBINSON attempted to establish in the hedgerows, from seed, stout herbaceous plants such as anchusa, everlasting peas, ferula, lupins, heracleums, delphiniums, columbines, aconites, and others. I cannot find any record of the success or otherwise of these experiments.

In the summer of 1891 ROBINSON invited H. G. MOON and W. E. NORTON to "stay for the season and study the beauty of the place from the landscape-painter's point of view entirely, which they accordingly did. They worked at the pictures all the winter . . ." The pictures were exhibited in London in November 1892. The exhibition was entitled "A Story of the Year round an old Country House". ROBINSON wrote an introduction to the catalogue which is pasted into the first MS. book. *The Times* described the exhibition as a "charming little collection" and the artists "clear-eyed observers of nature" each of whom "paints with the brush of a thoroughly trained artist". A cutting among others from periodicals not identified, but pasted into the book, refers to ROBINSON's introduction as suggesting that the artists were handicapped by an unfortunate season. "We should have said they were handicapped by looking at nature through Corot's eyes." This sentence is underlined and alongside is written "Rubbish W. R.".

ROBINSON gives a list of his collection of pictures as at 1895. This consisted almost entirely of landscapes and flower paintings and contained many views of Gravetye by his great friend the floral painter, H. G. MOON. Contemporary academicians were also represented. On the other hand there were three pictures by CAZIN and eight flower pieces by FANTIN-LATOUR, and one or two other works all regarded as distinctly "modern" at that time. He certainly had two COROTS and a VAN HUYSUM, "Various Flowers", hung on the stairs.

In these notes I have selected what has seemed to me most likely to be of interest to gardeners. But there is much else of great interest. The importance of these books is that they illustrate ROBINSON's mind in action and they are therefore a most valuable accession to the Lindley Library.

TALLEST AND LARGEST SPECIMENS OF COMMON TREES RECORDED SINCE 1947

The following list has been compiled by A. F. Mitchell, District Officer, Research Branch. If any of our readers can find other trees to equal or beat these records, they should advise Mr. Mitchell at Alice Holt.

	Ht./Girth at breast height	*Date*	*Situation*
Abies alba	180′×20′ 6″	1955	Kilbryde, Inveraray, Argyll.
	147′×23′ 0″	1956	Ardkinglas, Argyll.
Abies concolor	131′× 9′ 5½″	1956	Benmore, Argyll.
	128′×11′ 3″	1956	Benmore, Argyll.
Abies grandis	168′×12′ 2″	1956	Leighton Hall, Welshpool.
	116′×17′ 10″	1955	Inveraray, Argyll.
Abies lowiana	145′×14′ 4″	1955	Durris Ho., Kincardine.
	120′×16′ 3″	1956	Linton Park, Kent.
Abies magnifica	116′×10′ 3″	1955	Blair Atholl, Perth.
	98′×12′ 10″	1955	Blair Atholl, Perth.
Abies nordmanniana	120′× 7′ 8″	1953	Vivod Llangollen.
	118′×13′ 2″	1954	Taymouth Cas., Perth.
Abies pinsapo	98′× 6′ 0″	1951	Panshanger, Herts.
	87′×13′ 9″	1950	Scotney Cas., Kent.
Abies procera	148′×11′ 0″	1952	Duncraig Cas., W. Ross.
	122′×14′ 8″	1955	Taymouth Cas., Perth.
Abies veitchii	81′	(1944?)	Nymans, Sussex.
	60′× 7′ 1″	1955	Dunkeld, Perth.
Araucaria araucana	{ 84′×12′ 2″	1955	Bicton, Devon.
	{ 84′× 9′ 2″	1954	Monreith, Wigtown.
Cedrus atlantica	119′×19′ 1″	1954	Eastnor Cas., Hereford.
Cedrus glauca	126′×13′ 2″	1952	Pampisford, Cambs.
	89′×14′ 0″	1954	Eastnor Cas., Hereford.
Cedrus deodara	118′×13′ 7″	1953	Redleaf, Kent.
	95′×17′ 0″	1955	Bicton, Devon.
Cedrus libani	ca 140′×13′ 9″	1955	Foxley, Hereford.
	66′×34′ 9″	1954	Cedar Park, Cheshunt.
Chamaecyparis lawsoniana....	102′×11′ 9″	1954	Inveraray, Argyll.
	×13′ 2″	1949	Stourhead, Wilts.
Chamaecyparis lawsoniana erecta viridis	81′	1951	Scotney Cas., Kent.
intertexta	69′× 6′ 7″	1956	Haslemere, Surrey.
Chamaecyparis nootkatensis	{ 93′× 6′ 9″	1956	Linton Park, Kent.
	{ 93′× 8′ 2″	1954	Dupplin Cas., Perth.
	73′× 9′ 1″	1954	Moncrieffe, Perth.
Chamaecyparis obtusa	63′× 4′ 5″	1956	Westonbirt, Glos.
Cryptomeria japonica	{ 111′×10′ 0″	1955	Bicton, Devon.
	{ 111′× 8′ 7″	1955	Foxley, Hereford.
	{ 111′× 6′ 9″	1954	Leaton Knolls, Salop.
	{ 111′×10′ 3″	1953	Redleaf, Kent.
	98′×13′ 1″	1955	Northerwood Ho., Hants.
X Cupressocyparis leylandii	67′× 6′ 4″	1955	Inveraray, Argyll.
Cupressus macrocarpa	126′× 6′ 9″	1952	Pampisford, Cambs.
	×20′ 4″	1949	Montacute, Somerset.
Ginkgo biloba	90′× 7′ 7″	1956	Linton Park, Kent.
	70′×12′ 8″	1956	Kew, R. B. G. ,Surrey.
Larix decidua	145′× 8′ 10″	1955	Parkhatch, Dunsfold, Surrey.
	102′×18′ 3″	1953	Monzie, Perth.
Larix eurolepis	97′× 3′ 7″	1955	Blair Atholl, Perth.
	78′× 7′ 2″	1954	Blair Atholl, Perth.
Larix leptolepis	105′× 8′ 2″	1954	Blair Atholl, Perth.
	98′× 8′ 6″	1955	Dunkeld, Perth.
Larix occidentalis	70′× 3′ 11½″	1956	Kew, R. B. G., Surrey.
	64′× 4′ 5″	1956	Kew, R. B. G., Surrey.
Libocedrus decurrens	105′×11′ 4″	1951	Stourhead, Wilts.
Picea abies	156′×14′ 2″	1952	Studley Royal, Yorks (dying back)
	147′×10′ 7″	1952	Studley Royal, Yorks.

	Ht./Girth at breast height	*Date*	*Situation*
Picea jezoensis	90′× 9′ 10″	1956	Benmore, Argyll.
Picea omorika	80′× 5′ 4″	1954	Murthly Cas., Perth.
Picea orientalis	c120′×9′ 5″	1951	Stourhead, Wilts.
Picea sitchensis	160′×15′ 2″	1954	Murthly Cas., Perth.
	160′×12′ 6″	1956	Inveraray, Argyll.
	119′×25′ 0″	1956	Filleigh Est., Devon.
Picea smithiana	115′×10′ 5″	1950	Redleaf, Kent.
	104′×11′ 6″	1955	Taymouth Cas., Perth.
	88′×11′ 6″	1955	Gordon Cas., Moray.
Pinus contorta	102′×12′ 4″	1949	Monk Hopton, Bridgnorth.
Pinus griffithii	105′× 6′ 7″	195	Pampisford, Cambs.
	100′×10′ 9″	1950	Warwick Cas.
Pinus jeffreyi	99′× 7′ 2″	1955	Westonbirt, Glos.
	97′×10′ 9″	1956	Dropmore, Bucks.
Pinus nigra calabrica	135′×10′ 4″	1950	Stanage Park, Radnor.
	121′×13′ 8″	1956	Dropmore, Bucks.
Pinus pinaster	100′× 7′ 7″	1955	Bolderwood, Hants.
	80′×10′ 8″	1955	Exbury, Hants.
Pinus ponderosa	125′×10′ 7″	1950	Scotney Cas., Kent.
	101′×11′ 10″	1955	Stratfield Saye, Hants.
Pinus radiata	138′×11′ 11″	1955	Cuffnells, Lyndhurst, Hants.
	108′×17′ 9″	1955	Northerwood House, Lyndhurst, Hants.
Pinus strobus	126′× 7′ 11″	1953	Puck Pits, Hants.
	102′×16′ 5″	1955	Stratfield Saye, Hants.
Pinus sylvestris	120′×10′ 0″	1952	Necton Park, Norfolk.
	70′×18′ 0″	1953	Spye Park, Wilts.
Pseudotsuga taxifolia	181′×13′ 4″	1956	Powis Cas., Montgomeryshire.
	110′×20′ 0″	1956	Dunkeld, Perth.
Sequoia gigantea	165′×24′ 0″	1955	Fonthill Abbey, Wilts. (dying back).
	151′×22′ 8″	1955	Glenlee, Kirkcudbright.
	105′×28′ 6″	1950	Crichel Ho., Wimborne, Dorset.
Sequoia sempervirens	140′×18′ 2″	1951	Stourhead, Wilts.
	100′×20′ 9″	1955	Taymouth Cas., Perth.
Taxodium distichum	115-120′	(1955?)	Longford Cas., Wilts.
	95′×16′ 8″	1947	Burwood Park, Surrey.
Taxus baccata	92′	1955	Cowdray Park, Sussex.
	×34′ 7″	1948	Ulcombe, Kent.
Thuja plicata	129′×17′ 6″	1955	Bicton, Devon.
Thujopsis dolabrata	57′× 3′ 2½″	1957	Benenden School, Kent.
Tsuga canadensis	114′× 8′ 2″	1954	Hardwicke, Suffolk.
	90′×16′ 4″	1952	Studley Royal, Yorks.
Tsuga heterophylla	146′×10′ 6″	1956	Benmore, Argyll.
	120′×13′ 8″	1955	Kinloch Ho., Angus.
Tsuga mertensiana	88′× 6′ 11″	1955	Murthly Cas., Perth.
	83′× 9′ 7″	1955	Murthly Cas., Perth.
Acer campestre	86′	1953	Cobham Hall, Kent.
	70′×12′ 8″	1950	Pampisford, Cambs.
Acer platanoides	81′× 9′ 2″	1950	Pampisford, Cambs.
Acer pseudoplatanus	117′×31′ 10″	1955	Newburgh, Coxwold, Yorks. (coppice stem).
	117′×19′ 2″	1953	Cobham Hall, Kent.
Aesculus hippocastanum	107′×16′ 0″	1954	Stanstead Bury, Herts.
	96′×20′ 10″	1950	Hatfield Forest, Essex.
Alnus glutinosa	70′×11′ 10″	1953	Fairlawne, Tonbridge, Kent.
Betula pendula	102′× 7′ 5″	1956	Woburn, Beds.
	58′×11′ 7″	1956	Worlingham Hall, Suffolk.
Carpinus betulus	105′× 7′ 3″	1954	Durdans, Epsom.
	65′×30′ 9″	1949	Easton Lodge, Dunmow, Essex. (Pollard).
Castanea sativa	114′×12′ 11″	1954	Cowdray Park, Sussex.
	×39′ 6″	1953	Canford, Dorset.
Fagus sylvatica	142′× 8′ 9″	1954	Yester House, E. Lothian.
	95′×25′ 3″	1956	Conon House, Dingwall, Ross.
Fagus sylvatica v. purpurea	100′×21′ 9″	1956	Linton Park, Kent.

	Ht./Girth at breast height	*Date*	*Situation*
Fraxinus excelsior	148′×10′ 6″	1956	Duncombe Park, Yorks.
	90′×19′ 6″	1952	Holywell Hall, Stamford, Lincs.
Juglans nigra	105′×14′ 0″	1952	Hatfield Forest, Essex.
	90′×16′ 3″	1951	Syon Ho., Middlesex.
Juglans regia	77′×10′ 8″	1955	Salterton, Middle Woodford, Wilts.
	60′×21′ 6″	1955	Pilton Churchyard, Northants.
Liquidambar styraciflua	90′× 8′ 5″	1951	Syon Ho., Middlesex.
Liriodendron tulipifera	110′×22′ 2″	1953	Killerton, Devon.
Nothofagus obliqua....	79′× 5′ 4″	1951	Kew, R. B. G. Surrey.
	75′× 7′ 4″	1955	Grayswood Hill, Haslemere, Surrey.
Nothofagus procera	74′× 5′ 11″	1955	Muncaster Cas., Cumberland (planted 1923).
Platanus acerifolia	123′×18′ 3″	1952	Richmond, Surrey.
	123′×18′ 3″	1952	Montpellier Row, Twickenham.
	125′×13′ 9″	1954	Albury Park, Surrey.
	114′×26′ 4½″	1950	Bishops Palace, Ely.
Platanus orientalis	108′×17′ 5″	1956	Petersham Lodge, Surrey.
	66′×22′ 10″	1956	Hawstead Old Place, Suffolk.
Populus canescens	110′×11′ 5″	1950	Saling Grove, Essex.
	100′×17′ 4″	1951	Castle Hedingham, Essex.
Populus eugenii	126′×10′ 1″	1956	Kew, R. B. G., Surrey.
Populus nigra	140′×20′ 2″	1953	Fairlawne, Kent.
	×26′ 9″	1949	Shalford, Surrey.
Populus nigra v. italica	108′× 7′ 5″	1954	Golders Hill Park, London.
	×14′ 8″	1949	Upper Edgbold, Salop.
Prunus avium	102′× 8′ 4″	1956	Woburn, Beds.
	70′×10′ 8″	1952	Lexden Manor, Colchester, Essex.
Quercus borealis	102′×12′ 3″	1950	Revesby Abbey, Lincs.
	74′×13′ 2″	1953	Fairlawne, Kent.
Quercus cerris	105′×15′ 0″	1954	Arnos Park, London, N.
	×22′ 0″	1956	Mamhead Park, Exeter.
Quercus ilex	70′×21′ 0″	1952	Chiswick Ho., London (at 0′)
Quercus lucombeana	115′× 9′ 11″	1953	Necton Park, Norfolk.
	72′×21′ 9″	1956	Worlingham Hall, Suffolk.
Quercus pedunculata	128′×14′ 10″	1954	Marchmount, E. Lothian
	64′×25′ 4″	1953	Nedging Hall, Suffolk.
(Pollard)	×43′ 0″	1940	Manton, Cheshire*
Quercus petraea	105′×24′ 0″	1952	The Champion, Powis, Montgomery.*
Robinia pseudacacia	90′× 9′ 5″	1955	Kew, R. B. G., Surrey.
	81′×14′ 9″	1956	Dinton Cas., Bucks.
Salix alba	81′×11′ 3″	1955	Grovelands Park, London, N.
Tilia cordata	105′×15′ 7″	1950	Thurlow Park, Suffolk.
Tilia vulgaris....	152′×11′ 2″	1956	Duncombe Park, Yorks.
	90′×37′ 10″	1953	Cobham Hall, Kent.
Ulmus carpinifolia	141′×21′ 8″	1956	Easton Lodge, Dunmow, Essex.
	90′×24′ 0″	1953	Great Waltham, Essex.
Ulmus glabra	138′×15′ 5″	1952	Earl Soham, Cambs.
	×25′ 0″	1949	Monks Eleigh, Suffolk.
Ulmus procera	141′×17′ 3″	1951	Syon Ho., Middlesex.
	×25′ 6″	1952	Kelston, Somerset.
Zelkova carpinifolia	123′× 9′ 3″	1951	Syon Ho., Middlesex.
	94′×21′ 3½″	1956	Worlingham Hall, Suffolk.

* Pre 1947 measurements but known still to be standing and largest.

NEWBOROUGH FOREST*, ANGLESEY

By G. D. HOLMES
District Officer, Research Branch

		acres
Areas (1956):	Plantations	1,227
	Land to be Planted	660
	Agricultural Land and Forest Workers' Holdings	4
	Unplantable and Other	636
	Nurseries	20
	Total:	2,547

Supervision and Labour. 2 Foresters, 1 Ganger, 40 Forest Workers.

Planting Programme. 50 acres per annum.

The forest consists of six acquisitions, the first and largest one of 2,104 acres was completed in 1940. With the exception of a small outlying block, the whole area consists of blown sand merging into marsh at the eastern end of the forest. A ridge of rock runs right through the dunes and out into the sea where it forms the promontory of Llanddwyn Island. The sand is of a calcareous nature and this is shown in the vegetation by the presence of such calcicoles as *Sedum acre*, and by the scarcity of *Calluna*. On the moving dunes, little else but marram grass (*Psamma arenaria*) is present, with dwarf willow (*Salix repens*) in the winter lakes. Many flowering plants occur on the areas of less mobile sand.

The climate is much milder than that of the mainland, although spring frosts can occur. The average annual rainfall is 39 inches. The area is fully exposed to the prevailing south-west wind from the sea, and the western part o the forest north of the rock ridge consists of fully mobile dunes quite unprotected by a littoral dune. South of the rock ridge, the dunes are lower and less mobile and there is a low natural littoral dune. The unplantable area is salt marsh and seashore.

Planting started in 1947 at the north-east end, where conditions were easiest. Owing to Air Ministry requisition of a large section of the mobile dunes on the north-west edge, no littoral protection could be undertaken until recently. One of the main problems is fixation of the sand prior to planting; thatching the sand surface with conifer branches has been done in parts of the area. There is no local source of branch material and the high cost of its importation from Gwydyr has necessitated confining the thatch as far as possible to the west-facing slopes of mobile dunes (about 12 lorry loads of branch material are required to thatch one acre). This is now combined with spreading of roadside trimmings containing seeding grass and weeds, and with marram (*Psamma arenaria*) planting. In 1954-55, it was decided to interplant all the younger plantations and new plantations with inferior or surplus pines which can be cut later to provide thatching material on the spot. No suitable shrubs have so far been found for stabilising the sand or for growing to provide thatching material.

During the last few years, a twenty foot high littoral dune has been artificially created by means of a palisade along the west shore to protect and ease fixation of the dunes further inland.

* Now part of Môn Forest.

Corsican pine has proved the most successful species for planting the dry sandy area. Scots pine will not stand up to the sea winds and has been used for interplanting to produce thatching material. Lodgepole pine is vigorous on the moister sites and is planted generally in the winter lakes where these can be drained. Unfortunately, much of the lodgepole pine planted so far is of an unsuitable inland race. Sitka spruce is successful in marshy areas and white spruce, *Picea glauca*, has proved very promising. Sowings of maritime pine, *Pinus pinaster*, and Monterey pine, *Pinus radiata*, have proved unsuccessful in small trial areas.

There are two nurseries in the forest and although their productivity is not very high, they have proved very useful as the climate and soil permit work to continue when all other nurseries in North Wales are held up by wet weather, frost or snow. The forest is of considerable biological interest and an area south of the forest has recently been declared a National Nature Reserve.

Compartment 10. Early Plantations

Here are some of the earliest plantings in the forest. These consist mainly of Corsican pine planted 1948 and 1949 with Sitka spruce planted on plough ridges in low-lying wet ground. Failures were replaced in 1949 by lodgepole pine.

A small area of *Pinus pinaster* and grey alder (*Alnus incana*), is found here, the latter having been planted for production of thatching material. A considerable area of unplantable salt marsh extends along the edge of the Malltraeth Estuary.

The Littoral Dune. The formation of this dune was commenced in 1951 to protect the interior from sand-laden winds. In the lee of this protection, the interior sandy wastes can be successfully fixed. The dune has been built up by the palisade or wattle fence method up to its present height of 20 feet. The rapidity of growth of the dune has been due to the abundant supply of blown sand carried by the prevailing on-shore wind from the long sandy foreshore. During 1954 and 1955, the dune was planted with marram grass with a view to fixing it against blow-outs and general wind damage. It is thought the sand will continue to build up with the aid of the marram. The grass has been planted at increased density towards the crest of the dune in order to preserve the desired shape of the dune by increasing deposition of sand towards the crest. The present palisade of branch material will be retained until the marram has established itself.

Very high tides commonly reach the base of the littoral dune, but the gentle upward slope of the base probably prevents any erosion damage. In fact, the dune is tending gradually to steepen the slope of the whole foreshore by the build-up of sand.

Sand Fixation. Where marram-planting is unlikely to succeed, the sand is fixed by thatching with branches from conifer plantations and other suitable material. This is usually fixed to the ground by wiring where necessary, and may also be supplemented by applications of roadside clippings which provide grass and weed seeds.

Large exposures of sand are fixed by planting marram grass. The use of young vigorous growth is essential, and commonly old marram areas are burned off to obtain young regrowth suitable for dividing and transplanting. Planting can be carried out during the 'rain' months, avoiding June, July and August. The newly planted grass usually loses its colour, but recovery is good and planting losses are not high. Planting at a spacing of about 20 inches seems most suitable, and with this, it is estimated that it will require 3 to 5 years for the grass to fix the sand sufficiently to permit afforestation. At present, about 50 acres per annum are being planted with marram grass in this way.

A trial area sprayed with bitumen emulsion as a method of sand fixation has been laid out. The area was sprayed at a variety of application rates in March, 1955, after planting and direct sowing with a selection of species including Corsican pine, *Pinus radiata*, *Pinus mugo*. Certain plots were also sown with marram grass seed prior to spraying, with a view to providing more lasting fixation. The bitumen crust provided good temporary fixation and seed germination and early growth was good. However, all plants became brown and scorched at the end of the growing season and it seems that the complete absence of above-ground protection against exposure on these plots was the main factor responsible. This is supported by the fact that the only really healthy plants growing in bitumen-covered plots occur in the sheltered lee of plots thatched with branchwood.

ADVICE ON CHOICE AND TREATMENT OF FOREST TREE SEED

In response to requests by woodland owners and forest tree nurserymen, the Forestry Commissioners have issued the following notes, prepared by their Research Branch staff, on the choice of origin and nursery treatment of seed of various conifer species.

1. Choice of Origin of Imported Seed.

The question of provenance of seed is dealt with fully in Forestry Commission Bulletin No. 30, *Exotic Forest Trees in Great Britain*, and the notes given below are necessarily brief. In case of doubt reference should be made to the Bulletin or to Chief Research Officer, Forestry Commission, Alice Holt Lodge, Farnham, Surrey.

Conifers

Species	**Notes**
Grand silver fir *Abies grandis*	The usual seed sources are Vancouver Island, British Columbia, and the northern foothills of the Cascade Mountains in the state of Washington. These appear to be suitable. Sources east of the Cascade Mountains should be avoided.
Noble silver fir *Abies nobilis*	Most of the seed imported to date has come from the Cascade Mountains of Washington, but provenance questions have been little studied.
Lawson cypress *Chamaecyparis lawsoniana*	Abundant seed is available from home sources.
European larch *Larix decidua*	It is of the first importance to avoid seed from European high alpine environments. As a second choice to seed from good Scottish sources, Sudeten and Polish larch may be imported. It is, however, necessary to be sure

Species	Notes
European Larch—*cont.* *Larix decidua*	that the true indigenous Sudeten material is obtained and not seed from plantations of Alpine origin in that region. Polish larch is often referred to as " . . . var. *polonica*" or even "*Larix polonica*"; the true Polish larch is found only in the Lysa Gora region.
Japanese larch *Larix leptolepis*	The range of the tree in Japan is restricted, and provenance differences do not appear important. Seed from the natural forest about Nagano may perhaps be preferred to collections from Hokkaido, where the tree occurs in plantations.
Norway spruce *Picea abies* (*excelsa*)	While no disasters from ill-chosen seed sources need be expected, the indications from experimental plantations are that the best results will be obtained from seed of south-eastern European origin, followed by German and Alpine origins. Scandinavian origins (more particularly the northernmost) are unsuitable for use in Britain.
Sitka spruce *Picea sitchensis*	The generally accepted source of seed is the Queen Charlotte Islands in British Columbia. Faster growing spruce may be obtained from more southerly sources, coastal Washington or even Oregon, but this is accompanied by materially increased hazard of spring frost damage in the nursery and in young plantations.
Lodgepole pine *Pinus contorta* (also "var. *murrayana*" and "var. *latifolia*"—varietal names occasionally applied to the tree in the more continental parts of its range).	This common name is applied to the whole species for convenience. The tree has a great range and plantations from different seed sources may be very distinct in behaviour. Seed sources from the coastal regions of Washington, Oregon, and British Columbia, seem the best suited to the British climate. The Washington coast is a well tried seed source, providing vigorous, though somewhat coarse pine, highly tolerant of exposure. In general, lodgepole pine from the "interior", and more particularly that from extremely continental climates in Alberta, Montana and Idaho, appears unsuited for cultivation in Great Britain.
Corsican pine *Pinus nigra* var. *calabrica*	Seed is usually obtained from Corsica itself.
Douglas fir *Pseudotsuga taxifolia*	Three regional divisions of the natural range of this species are usually recognised, namely the Green or Coastal Douglas fir; the Grey or Intermediate; and the Blue or Colorado Douglas fir. For British conditions only the

Species	Notes
Douglas fir—*cont.* *Pseudotsuga taxifolia*	first mentioned is of any value, the other two being subject to a serious needle disease. Coastal or Green Douglas itself covers a wide range west of the Cascade Mountains of Oregon and Washington and also in British Columbia, and there is as yet no certainty as to the best seed source inside this range. However, it is considered that the Washington coast and the northern foothills of the Cascade Mountains in Washington are safe and reliable sources.
Western red cedar *Thuja plicata*	Seed is available from home sources but failing that, coastal Washington and the Queen Charlotte Islands have both proved satisfactory sources.
Western hemlock *Tsuga heterophylla*	Experience does not suggest that seed origin is a highly critical factor with this species; satisfactory results have been achieved with seed from the Queen Charlotte Islands and coastal Washington.

Broadleaved Species

Since the native broadleaved species are usually raised from home collected seeds, regular sources of supply in Europe have not been organised. Beech, however, has been frequently introduced from Europe, and provided it can be obtained from one or other of the (many) fine stands in the countries concerned, it may be imported with confidence from France, Belgium, Holland, Denmark or Germany. The quality of the stand is probably more important than the region.

2. Stratification of Seed.

(a) General

For certain species stratification of seed in moist sand in an open pit for a period previous to sowing, stimulates germination and increases the production of usable seedlings. Important species, the seeds of which are normally stratified prior to sowing, are given below with a note on recommended stratification periods.

Species	Period of Stratification	Notes
Lodgepole pine	6 weeks	The degree of dormancy is variable and the benefits from stratification will vary from one seed lot to another.
Douglas fir	6 - 8 weeks	Autumn or winter sowing is often used as an alternative to stratification.
Common Silver fir	,, ,, ,,	
Grand fir	,, ,, ,,	
Noble fir	,, ,, ,,	
Nothofagus species	4 - 6 weeks	

Seed should be stratified at a date which will permit sowing in the early spring at the end of the stratification period.

The open pit method of stratification is also recommended for storage of seeds which commonly remain dormant for one year, notably ash, lime and *Pinus peuce*. Seeds of many species, including European larch, Japanese larch, Scots pine, Corsican pine, Norway spruce, Sitka spruce, Lawson cypress, *Thuja*, and *Tsuga*, normally do not show any appreciable response to seed stratification.

(b) Method of Stratification

The method employed is to prepare a pit 2ft. in depth and to line the sides and ends with $\frac{3}{8}$in. mouse-proof netting, suitably supported with stakes, and constructed to take a cover of the same mesh netting on a frame to keep out vermin. The bottom 6in. of the pit should be filled with gravel to ensure efficient drainage. A little sand should be sprinkled over the top of the gravel, and on this a piece of the small-mesh wire-netting is placed. The netting serves to separate the seed mixture from the gravel below, without interfering with the drainage.

It will be found convenient, when several smallish lots of seed are to be dealt with, to construct a long narrow pit, say about 2ft. wide and to use boards of the same width to partition the pit off into compartments. The seed is weighed out and mixed with an equal or rather larger bulk of clean sand, sufficient sand being used to ensure that the seeds are well separated from each other. The mixture of seed and sand is poured into the given compartment which can be filled to within 12 in. of the surface. A piece of wire-netting is placed on the top of the mixture and clean sand shovelled on until flush with the surface. In the case of very small lots of seed, the seed may be mixed with sand and placed in well-drained flower pots which are then submerged to a depth of 18 in. in the pit and covered over with sand. After the seed has been placed in the stratification pit further attention is unnecessary until it is removed for sowing in the spring.

The following points are considered to be important:—

(1) The pit should be constructed on a well-drained site and not subject to waterlogging at the depth at which the seed is stored.

(2) The seed should be mixed thoroughly with the sand and not laid down in layers.

(3) The pit, or partition of the pit, should be completely filled to ground level with pure sand throughout the period of stratification.

(c) Sowing of stratified seed

Sowing should take place when the seed is plump and on the point of germinating; usually during March or April. It is important that the seed should be sown immediately after removal from the stratification pit and not be allowed to dry out. The stratification medium can be sown together with the seed after thorough mixing. Alternatively, the seed and sand may be separated by sieving prior to sowing. The rate of sowing can be calculated readily, knowing the original weight of seed stratified.

A KEY TO 21 SORTS OF CONIFER SEED

Compiled by the 1951-53 Class of Students at the Parkend Forester Training School.

1	Seed surrounded by non-detachable wing. Fairly uniform red brown colour.	2
	Seed completely free of wing.	6
	Wing bases fused all round edge of seed.	11
	One side of seed covered by remains of wing.	12

2	Roughly circular in outline.	3
	Longer than broad.	5
3	Seed narrow and thin occupying less than $\frac{1}{4}$ of area of the whole. Very light brown flecked bright red, glossy:	*Sequoia gigantea*
	Seed rounded and thicker occupying more than $\frac{1}{4}$ of area.	4
4	Light red brown. Wing occasionally slightly notched at tip of seed only:	*Chamaecyparis lawsoniana*
	Dark red brown. Wing occasionally notched at both ends:	*Cupressus macrocarpa*
5	Seed narrow and thin. Wing thin and papery. Usually notched at both ends:	*Thuja*
	Seed thick and angular, not easily distinguished from wing:	*Cryptomeria*
6	Less than $3\frac{1}{2}$ mm. long.	7
	$3\frac{1}{2}$ - 5 mm. long.	8
	5 - 7 mm. long.	9
	over 7 mm. long.	10
7	Uniformly black: rough surface, rounded:	*Pinus contorta*
	Uniformly light brown, glossy surface. Conspicuously angular, diamond shaped:	*Tsuga*
	Colour variable, light to very dark brown, dull rough: Rounded in outline:	*Picea omorika*
	Colour variable, light to dark brown, slightly polished: Angular in outline, 1 or 2 ribs from broad to narrow end:	*Picea sitchensis*
8	Broadly triangular in outline: sides rounded. Buff, mottled dark brown, darker on one side. Pitted and warty:	*Pinus sylvestris*
	Pointed end more acute: sides angled. Light to dark brown striated. Purplish tinge or bloom:	*Picea abies*
9	Buff mottled dark brown sometimes much darker on one side: smooth:	*Pinus nigra* var. *calabrica*
	Light brown rough one side. Dark brown shiny on the other: pointed both ends, ridged:	*Pseudotsuga taxifolia*
10	Glossy black one side dull brown on the other. Almond shaped:	*Pinus pinaster*
	Dull slate grey on both sides. Sharp pointed. Rough surface, resinous:	*Pinus radiata*
11	8-10 mm. long. Light brown with dark mottling, same colour on both sides. Oval:	*Pinus excelsa*
	6-7 mm. long. Light brown with various shades of mottling. Dark on one side. Pointed:	*Pinus strobus*
	8-10 mm. long. Uniform golden brown. Conspicuous resin pockets:	*Abies nobilis*
	10 mm. long. Uniform pale brown. Sticky with resin:	*Abies grandis*

12 3 mm. broad. Biscuit to buff mottled bright brown one side. Slightly darker colour shiny on the other due to wing adhering. Portion of wing wrapped round point of seed.
Portion of wing projects from broad end: *Larix decidua*

3-4 mm. broad. Ivory to biscuit mottled light brown on one side. Light brown shiny the other. Portions of wing as for *Larix decidua*: *Larix leptolepis*

A REVIEW OF NURSERY RESEARCH: 1952—1956

Prepared by R. FAULKNER and J. R. ALDHOUS,

District Officers,

FOR THE RESEARCH BRANCH PROGRAMME CONFERENCE. JUNE, 1957

Introduction

At the beginning of the period of this review (i.e. October 1951) the post-war expansion of research work into nursery problems had already taken place. One or two subjects had already been investigated as fully as was necessary; but many others were well under way, and most of the work included in this review had its beginnings in the period 1947-1951.

The two investigations which were (almost) complete by the end of 1951 were steam sterilization and compost making. Steam sterilization had been shown to be a very effective means of improving the quality of Sitka spruce seedlings on 'Sitka sick' nurseries; however, the cost of treatment ruled out the use of steam in practice. In Scotland, the last year's work fell within the period of this review.

Compost making was investigated testing many materials singly and in combination, but here the effect of the work of the Nursery Nutrition Committee was felt and the subject lost much of its relevance when the use of compost in forest nurseries was given up in favour of use of raw hops.

The existence of the Nursery Nutrition Committee and its large programme of nursery and forest experiments accounts for some of the differences between the weight of experiments carried out in the north and in the south. In the south, all intensive experiments on nutrition and use of sterilants have been carried out by the N.N.C.—only field extensions and investigations on species other than Sitka spruce have been carried out in the south. In the north, experiments in parallel, though on by no means the same scale, have been carried out by F. C. staff. None of the results of N.N.C. experiments are mentioned in this review.

The table attached gives the number of experiments carried out under headings in the Oxford Decimal Classification.

NURSERY EXPERIMENTS CARRIED OUT IN THE PERIOD 1952-56

O.D.C.	Subject	Silv. (North)	Silv. (South)
232.315.2	Seed Grading	—	2
232.315.3	Seed pre-treatment	7	7
232.322.1	Long term fertility; green cropping	8	11
232.322.2	Sterilization	58	65
232.322.4	Fertilizers and Manures	96	9
232.322.5	Soil Working and tilth	2	4
232.323.3	Date of Sowing	—	8
232.323.5	Covering Media and Depth	11	8
232.323.6	Rolling and Compacting Beds	12	—
232.323.7	Soil Heating	2	—
232.324	Mixtures in Nursery	—	1
232.324.4	Season and date of lining out	5	—
232.325.1	Irrigation	1	10
232.325.24	Weed Control	23	74
232.325.3	Mulching	9	6
232.325.6	Undercutting	27	8
232.327.12	Shading	—	1
232.327.2	Protection against fungi	3	1
232.327.3	Protection against birds	4	1
232.327.4	Protection against insects	4	2
232.324.9 } 232.412.4 }	Storage of Seedlings Handling	5	10
	Miscellaneous	35/312	2/230

In compiling this table, all experiments have been counted once only, having been entered against the most important heading. Obviously, too, not all the experiments are of one year's duration—undercutting experiments for example require two years in the nursery and three in the forest for their completion and thus have taken far more work than for example, date of sowing experiments.

The large number of sterilization experiments in the south were almost all carried out in Conservancy nurseries and much of the work of preparation and maintenance was done by Conservancy staff.

Abies project

Objects

Abies is one of the most difficult species in the nursery, because the seed is often of poor quality and germinates over a very long period, in many cases throughout the whole of the first year in the seedbeds. Also growth is slow so that only the seedlings which germinate first grow large enough to be transplanted at the end of the first season. The objects of experiments on *Abies* have been firstly to endeavour to speed up germination and ensure that all seedlings that are going to come up do so as soon after sowing as possible and secondly to see whether growth can be hastened so that plants are large enough to be lined out at the end of their first year.

Results

Stratification

In the north, *Abies grandis* stratified for ten to fifty days showed no benefits in one nursery, but in a second nursery fifty days' stratification increased yields by 100 per cent.

In the south, stratification both of *A. grandis* and *A. nobilis* for two and three months has brought about more uniform germination and rather higher yields of seedlings.

Sterilization and Fertilizers

In the north, experiments on *Abies grandis* and *Abies procera* have indicated that *Abies grandis* responds to formalin sterilization more than does *Abies procera*, but in both cases the response is not so high as that normally produced on Sitka spruce. The experiments do not suggest that the normal prescriptions for N.P.K. fertilizer should be any different to those for other conifers.

In the south, *Abies grandis* was included in a series of trials of formalin and chloropicrin in Conservancy seedbeds and responded very little in growth to sterilization.

Date of Sowing

In the north, when comparing the date of sowing of *Abies grandis* in October, November, February, March and April, the highest yields of seedlings were obtained from the April sowings. Early autumn sowings produced pre-winter germination and heavy losses through frost damage.

In the south, winter sowings have grown to give more usable seedlings than spring sowings. No autumn sowings have been made.

Covering media

In the north, nursery soil covers were found to produce taller seedlings than grit covers, but fewer seedlings. Depth of cover from $\frac{1}{4}$in.-$\frac{3}{4}$in. did not greatly affect the yield of *Abies grandis* but a $\frac{1}{2}$in. cover appeared to be the most suitable for *Abies procera* and *Abies lowiana.*

In the south, *Abies procera* also germinated and grew best when given a $\frac{1}{2}$in. covering of grit.

Irrigation

In the south, seedlings of both *A. grandis* and *A. procera* were markedly bigger on irrigated plots.

Taking the Abies project as a whole it is likely that one more year's work should be sufficient to obtain information on the variation from year to year of the response to date of sowing and stratification. No further work should be necessary on fertilizers and covering.

Seed grading

Seed of *P. pinaster* and *P. radiata* was graded into large and small seed, and the two lots of seed sown, at the rate of 1,000 viable seeds per square yard, for both species and grades. There were no differences in seedling numbers or heights of *P. radiata* seedlings, but small seed of *P. pinaster* produced slightly fewer seedlings which, though usable, were an inch shorter than seedlings grown from large seed.

Seed Pre-treatment

General

It is desirable to be able to ensure that germination of any given seed is uniform and as rapid as possible. Experiments on pre-treatment carried out in the nursery have generally been the last stage of seed-laboratory investigations, testing in the field the most favourable laboratory treatments.

Lime

Neither acid pre-treatment nor stratification in peat appreciably hastened germination of lime seed. A full year's stratification appears essential.

Prunus avium

Stratification in peat from two to four months, or sowing of seed in the autumn, have given good yields. Stratification for six months is too long and causes excessive pre-germination, while spring sowings of dry seed yield very few seedlings.

Sitka spruce

Moist pre-chilling of seed for 2-4 weeks at 36°F. had little effect on growth and yield of seedlings.

Douglas fir

Stratification at normal temperatures and at 36°F. for eight and six weeks respectively have been shown both to increase yields and height growth of seedlings.

Long-term Fertility Demonstrations

Long-term fertility demonstrations are maintained at Newton, Fleet and Inchnacardoch on agricultural soils, and at Teindland Wareham and Bramshill on heathland soils. At Newton and Fleet nurseries, which are just beginning the second rotation, there have been negligible differences in the seedling crops caused by the various treatments, which consist of combinations of greencrop, hopwaste, artificial manures and soil sterilization. It is expected that any large treatment differences will appear from the third rotation onwards. The early data for the Inchnacardoch long-term fertility demonstration was summarized in Research Branch Paper No. 15 which covered the 1938-1951 period. Since 1951 the treatments have been 'modernised' and include sterilization and modern greencropping mixtures. No outstanding results were obtained from the first rotation under the new scheme.

The demonstrations at Teindland and Bramshill compare seedling growth on beds treated with hopwaste, artificial fertilizers and combinations of the two, and unmanured ground. Both experiments have run for seven years and by now the control plots have become worked out and grow only very poor quality seedlings. At Bramshill there has been no consistent difference between plants raised on organic and inorganic plots, and the two together have seldom produced plants significantly larger than plants raised on either regime singly. At Teindland on the other hand, the "hopwaste alone" plots have been outstandingly the best for Sitka spruce growth during the past three years and the combination of hopwaste and fertilizer second best, with artificial fertilizers poorest, but even so much better than controls. Hopwaste applications consistently reduce the yield of seedlings.

A demonstration of Dr. Rayner's prescription for the long-term maintenance of fertility has been carried out at Wareham. Plant growth has been consistently satisfactory on the plots treated with bracken/hop compost, but where hop compost alone has been used, some discoloration characteristic of potassium deficiency has been observed.

Greencrops versus Compost for Heathland Nurseries

Three experiments were carried out in the north in which greencrops were compared with hopwaste applications as initial organic additions for newly opened heathland nurseries. The results of these experiments have been summarized in Research Branch Paper No. 19, the main conclusion being that greencrops are as good as, or superior to, initial dressings of hopwaste or compost.

Soil Sterilization

Steam

The last steam sterilization experiment was carried out at Fleet nursery in 1952, and consisted of a practical test of the Hood system of steam sterilization The soil underneath the hoods, which covered an area of 50ft. x 3ft. 6in., was treated with steam up to a period of half an hour. The technique was shown to be quite satisfactory and confirmed earlier work at Newton.

Shell DD Fumigant

Several experiments were carried out between 1950 and 1952 with Shell DD Fumigant and these were summarized in the Annual Report for the year ending 1955. The chemical was tested at rates varying from 150 to 600 lb. per acre and injected at a depth of four inches. Soil sealing treatments using water or foot tramping were also tested. From these experiments it was found that Shell DD was not such a satisfactory soil sterilizing agent as formalin.

Chloropicrin

A series of experiments on chloropicrin was started in 1953 and completed by 1955. During this period rates of chloropicrin varying from twenty to seventy gallons per acre were applied at depths of from three to five inches, and over a range of dates from autumn to ten days before sowing. From these experiments it was possible to provide a suitable prescription for sterilizing nursery seedbeds, which is, applications of between thirty and forty gallons of chloropicrin per acre, applied at least thirty-five days before sowing (preferaby in autumn). Comparative trials of imported chloropicrin and chloropicrin manufactured in a pilot plant in Britain were made. The effects of both materials were similar.

Chloropicrin produces responses in seedling growth which are similar to, or better than, those normally obtained with formalin, but as would be expected with a volatile sterilant, results are usually better on sandy loams and usually unsuccessful on the heavier clay type of nurseries.

The residual effects of chloropicrin are similar to those obtained from steam or formalin treatments.

Assistance has been given to Conservancies in user trials of chloropicrin, the majority of which have been quite successful in Scotland. Some successes are also recorded in some of the English nurseries. Scottish work on chloropicrin has been summarized and will be published in the 1957 Research Annual Report.

Shell CBP-55

In 1955 three trials with Shell CBP-55 were carried out in Scotland. These were quite successful and by using Shell CBP-55 either as a drench application emulsified with water or by direct injection into the soil, results better than those obtained from formalin were obtained when the material was used at 90-120 gallons per acre. Shell CBP-55, if produced commercially, should be very much cheaper than chloropicrin, and early estimates of the cost of treating one acre were in the order of £60-£90; chloropicrin costs on the other hand are in the order of £200 per acre.

General

In the course of these sterilization experiments trial plots sown with species other than Sitka spruce, e.g. *Abies grandis*, Japanese larch, Douglas fir, and Scots pine have shown that the first three species respond well to sterilization, but that Scots pine only responds slightly.

Formalin

Interest was revived in the use of formalin when Miss Benzian reported pronounced sterilization effects from spray applications of formalin applied to the nursery soil surface, and this prompted a recent series of experiments in which formalin was applied either as an undiluted surface spray, by drilling into the soil without dilution, and the standard method of applying formalin as a diluted drench. Different concentrations were used and applications made both in autumn and spring were tested. These trials have shown that undiluted surface sprays are seldom successful, but that drilling neat formalin into the soil can often be as effective as diluted drench applications. It is intended to lay down large scale user trials in which the formalin is applied undiluted into drills.

Summary of Sterilization Work

During the period under review chloropicrin has been shown to be an effective sterilising material which can be easily applied to conifer seedbeds. Techniques of application have been worked out and have been put into practice in two Conservancies in Scotland this year.

Shell CBP-55 has also proved to be a suitable sterilizer and if it becomes available in quantity it should provide a much cheaper substitute for chloropicrin.

Drilled formalin has shown great promise and if a technique for injecting it satisfactorily into the soil can be developed, this method may well become a standard feature in responsive nurseries.

Manuring

In the south, work on manuring has been carried out on behalf of Nursery Nutrition Committee, and the collected data is at Rothamsted Research Station. This work has, however, accounted for a very large part of the time and energy of the nursery research foresters in the south. In the north the position is somewhat different, and manuring experiments are designed in liaison with the Macaulay Institute, and the collection and interpretation of data is done by the Silvicultural staff.

Rates of Phosphorus and Potassium manures and Times of Application

Many experiments have been carried out using Sitka spruce, Scots pine, Douglas fir and Japanese larch and Silver fir, in northern nurseries. From these experiments it has been found that rates of application normally prescribed and in use at the present moment are quite satisfactory for maintaining fertility in conifer seedbeds. It has also been shown that it is immaterial whether the fertilizers are applied three months or three weeks before sowing or even on the day of sowing. The prescriptions are 6 cwt. of superphosphate per acre and 2 cwt. of sulphate of potash, i.e. the equivalent of 40 oz. of P_2O_5 and 40 oz. K_2O per 100 square yards.

Rates of Applying Nitrogen Manures at Times of Application

Detailed experiments comparing rates of application of nitrogen ranging from 12.5 oz. N. per 100 square yards to 75 oz. of nitrogen per 100 square yards have been carried out mainly on Sitka spruce, Scots pine, Douglas fir and Japanese larch seedlings. Experiments on time of application of nitrogen showed that there was no benefit to be obtained from applying a third of the material (Nitrochalk) before sowing and two thirds as top dressings in July, as compared with applying the whole of the material (Nitrochalk) in two top dressings in July. Other experiments showed that top dressings in August or late July produced taller seedlings than those receiving nitrogen in June or early July.

During the whole period of experimentation no single instance has occurred, either in Scotland or in England, of late applications of Nitrochalk increasing the frost susceptibility of any species, even though it has been noted that late and heavy applications of Nitrochalk delay the setting of winter buds. Generally speaking the higher the rate of application of nitrogen the taller the plant, and from the evidence it seems that in nurseries where production of usable 1+0 larch or Douglas fir seedlings is uncertain, nitrogen should be applied in order to promote growth and the percentage of usable plants.

Placement of Fertilizers

Several experiments were carried out on the placement of phosphate and potash fertilizers during the period 1949-52, and results showed that Sitka spruce seedlings respond very greatly in height to phosphate manures placed one to two inches below the seed. Placed potash manure did not produce any marked increase in height growth. Since, however, band sowing is complementary to the placement of fertilizers, and the fact that band sowing reduces the yield of seedlings per pound of seed, the benefit in height growth is off-set by a reduction in production. Placed fertilizers may come into their own if a technique of drill sowing, coupled with undercutting and side-cutting, is practised for the production of undercut seedlings for planting in the forest, or if nursery mechanisation results in drill sowing becoming standard practice.

Trials of Urea and Ammonia as Nitrogen Manures

Trials of both urea and ammonia (.880 ammonia solution) were started in 1956 and compared these two materials at varying rates with the standard Nitrochalk applications. Although neither materials were harmful to seedling development, they in no way showed any benefits over Nitrochalk. The true effects of these materials may, however, have been masked by an inclement summer.

Seaweed Manures

A proprietary material 'Neptune's Bounty' was tested in a heathland nursery to see whether it would provide a satisfactory substitute for hopwaste. The material showed no special merits and indeed was harmful in some respects. The project was discontinued.

Particle Size of Flash

The benefits of manuring seedbeds with a slow-acting form of nitrogen manure in the form of plastic wastes, have been previously demonstrated; see Summary Report in the Report on Forest Research for the year ending March, 1954. These experiments did not take into account the particle size of the flash, and a series of experiments were laid down to see whether the particle size played an important part in the speed of breakdown of urea-formaldehyde. Experiments showed that particle sizes ranging from 16 to 100 mesh, were all equally suitable as nitrogen manures.

Nitrogen, Phosphorus and Potassium and pH Demonstrations

Demonstrations are being carried out at four nurseries to illustrate the effect of N.P.K. deficiencies and the effect of pH on conifer seedling growth.

Magnesium Deficiency

Symptoms of magnesium deficiency in the soil have been observed in two Scottish nurseries. These have usually been associated with higher than normal potash levels. Experiments designed to determine suitable means of correcting the deficiencies showed that ground magnesium limestone applied at fairly low rates (14 lb./100 sq. yd.) was more successful than foliar sprays of magnesium sulphate.

Soil working and tilth conditions

General

On heavy soils, it is frequently asked how the physical properties of the soil can be improved. Little work has been done on this subject, the problem of assessing changes in soil texture being one of the difficulties that has to be overcome. Small experiments have been carried out testing certain "soil improvers".

Krilium

This was tested at one nursery in the north in 1951, at a range of rates of application up to 0.12 per cent by weight of soil. All concentrations reduced the speed of germination of both Scots pine and Sitka spruce. At the end of the season it was shown that Krilium did not affect the final yield of Scots pine, but it did affect the yield of Sitka spruce, the highest dose reducing the yield by about 50 per cent. Heights of both species were depressed by Krilium.

When the areas were re-sown, treatments had no effects on the heights or numbers of Scots pine or on the heights of Sitka spruce, but with Sitka spruce the yields were increased up to 20 per cent. It was reported that the Krilium treated soil was much easier worked than untreated soil.

In the south, Krilium was applied in 1952 at St. Asaph nursery at the rate of 8 oz. per sq. yd. At the end of the first year there were no appreciable differences in growth. The treatment was repeated on the same site in 1953 and caused substantial reductions in the number and heights of seedlings of Scots pine, Sitka spruce, Norway spruce, Douglas fir, and Japanese larch. Some improvement in soil texture was noted. The same site was re-sown in 1954 and 1955 without further applications of Krilium. In 1954 only Norway spruce and Scots pine were adversely affected on Krilium plots while in 1955 no differences in growth of crops were apparent.

Charcoal

Charcoal at a rate equivalent to a 2 inch layer, was incorporated into the top 6-7 inches of soil at two nurseries in Wales in 1955. In the first year the yield of Corsican pine and Sitka spruce seedlings was less on plots treated with charcoal while the yield of Japanese larch and birch was unaffected. The height of all species on charcoal plots was less than on untreated plots. In 1956, there was little difference in yield of Corsican pine, Japanese larch, Sitka spruce and oak, while seedlings of oak and Japanese larch were taller on plots which had been given charcoal.

Date of Sowing

Experiments in the south have shown that the earlier in spring sowing is carried out, the bigger the seedlings obtained, but also, the lower the yield. Sowing at the end of March—beginning of April has usually yielded the highest number of usable seedlings at the end of the season.

Grit covering for seedbeds

Several experiments were carried out in the north to test locally obtainable seed covers on behalf of Conservators. Suitable materials have been found as a result of these experiments.

Experiments in the south have shown that the colour of seedbed covering may have some effect on germination, light materials giving slightly greater yields than dark materials.

The particle size and shape also has had a significant effect on yield of Sitka spruce. A covering of rounded particles the size of coarse sand gave the best yield while a covering of flat particles of the same size was not as good. With larger particle sizes the shape of the particle had little effect.

Experiments on thickness of covering have shown that variation in thickness of cover from $\frac{3}{16}$ inch—$\frac{1}{4}$ inch made little difference to the yield of Sitka spruce at the end of the season. One unexpected result was that *Tsuga* gave higher yields when covered with $\frac{3}{16}$ inch and $\frac{1}{4}$ inch cover than it did with $\frac{1}{8}$ inch.

This work will be written up as soon as the results of the current season's experiments are available.

Seedbed Compaction

Experiments in the north comparing four intensities of seedbed compaction, viz., with $12\frac{1}{2}$ inch diameter rollers weighing $1\frac{1}{2}$, $3\frac{1}{2}$ and $4\frac{1}{2}$ cwt., firming the seed into the seedbed surface after sowing, and rolling with a $1\frac{1}{2}$ cwt. roller after covering the seed with grit, were carried out during 1952-5. The experiments showed that rolling the seedbeds either before or after sowing the seed was immaterial and that rolling after applying grit can be harmful. For the initial compaction a roller weighing between 1 and 3 cwt. is the most satisfactory. The project is summarized in the Annual Research Report for the year ending March, 1956.

Season and Date of Lining-out

In Scotland, seedlings of Sitka spruce, Japanese larch and Scots pine, were lined-out over a period ranging from June to March, in order to determine the most satisfactory period for lining-out. Generally speaking plants which are less than 3 inches succeed best of all when lined-out in early spring, but for plants over 3 inches in height July lining-out normally gives extremely good results, providing soil conditions are suitable. Autumn lining-out is seldom satisfactory except for particularly large and vigorous plants. This work is to be summarized for publication during the current year.

Irrigation

Application of $\frac{1}{2}$in. water whenever the soil moisture deficit exceeds $\frac{1}{2}$in. has always increased the proportion of usable seedlings in experiments at Kennington and Kinver. In dry seasons, the increase has been of the order of 60 per cent.

At Widehaugh nursery, several seasons' work failed to produce any significant response. It is of interest to note that if the position of these nurseries is located on a map showing the difference between precipitation and evapotranspiration for the six months April—September, Widehaugh is found in an area where there is a surplus of precipitation of about 8 inches while both Kinver and Kennington fall in areas where there is a deficiency of about 4 inches.

This work will be written up as soon as the results of the current season's experiments are available.

Control of Weeds

Experiments on mineral oil weedkillers commenced in the south two years before the period of this review. A large number of experiments were carried out in 1952 and 1953, testing mineral oils as pre- and post-emergence weedkillers; these experiments were successful and pre-emergence application of mineral oils is now regularly practised in Conservancy nurseries. Further experiments were made in subsequent years on post-emergence use of mineral oils and also their use in transplant lines, and recommendations for the use of white spirit on seedbeds, and vaporising oil and white spirit in transplant lines are now being put into practice by Conservancy nurseries.

Current experiments on mineral oils test new blends of white spirit and Royal Standard paraffin.

In addition to this work, a number of other materials have been tested and the results are given below.

P.C.P. (Pentachlorphenol)—A pre-emergence weedkiller.

Two formulations have been tested; both were found to damage the seedling crop when applied at rates which gave adequate weed control.

I.P.C. (Iso-propyl-phenyl carbamate) C.I.P.C. (Chloro-iso-propyl-phenyl-carbamate)	Both materials have caused some damage to crops when applied at higher rates, but they may find a limited place.

C.M.U. (Chloro-phenyl-dimethylurea). This is a very potent and persistent material which is very well suited for keeping down weeds on paths, etc., but is too persistent to be applied on cropped ground.

T.C.A. (Sodium trichloracetate). This material is a grass killer and can be used, in conjunction with cultivation to eliminate couch grass on fallow land. It can also be used as a substitute for sodium chlorate as a general weed-killer for fallow land but is little cheaper.

C.D.A.A. (alpha-chloro-N, N-diallyl acetamide) C.D.E.C. (2-chloroallyl diethyl dithio carbamate)	Both these materials have shown some promise as pre-sowing weedkillers, but at higher rates of application have damaged crops.
2,4-D (2,4-dichloro phenoxyacetic acid) M.C.P.B. (4-chloro-2-methyl phenoxybutyric acid) 2,4-D.B. (2,4-dichloro phenoxybutyric acid)	All these materials have caused damage to seedling crops and in addition have not controlled grass weeds.

S.E.S. (2,4 dichlorophenoxyethyl sulphate). This material is inactive and so does not affect plant foliage. In the soil however it is broken down to 2,4-D and is said to kill weeds just as they germinate. When tested the material was found to have little effect either on crop or weeds.

Zinc sulphate Ferrous sulphate	Both these materials damaged crops when applied at rates which gave effective control of weeds.

In addition several materials prepared by Shell Chemicals and issued under a code number have been tested. None have been found to be effective—they either damaged the seedling crop or did not kill the weeds.

The first object in current weed control experiments is to find weedkillers suitable for post-emergence use on seedbeds immediately after germination. For most species it is unsafe to use mineral oils for nine weeks after the commencement of germination and during this period, handweeding is the only method of controlling weeds at present available. The second object is to find alternatives to the mineral oils which are cheaper or safer to use. As far as pre-emergence weed control is concerned, the mineral oils are very satisfactory, but with post-emergence and inter-row applications, there is considerably less safety margin and some precision is necessary both in controlling the rate and direction of application of mineral oils if damage to crops is to be avoided.

In the north assistance has been given with several user trials in Conservancy nurseries, and this work has greatly assisted in the early wide scale use of mineral oils in Scotland.

Experiments on T.C.A. have also been carried out, and subsequently large scale trials in Conservancy nurseries have shown this material to be very effective in the control of couch grass.

Mulches

In Scotland trials of hessian and sawdust mulches, $\frac{1}{4}$, $\frac{1}{2}$ and 3 inches deep, were tested in order to find out whether they would improve the speed of germination, height growth and final yield of seedlings. No improvements were obtained except that in isolated cases hessian covers placed directly on the seedbed surface speeded up the rate of germination, but generally had no effect on the ultimate yield or the number of seedlings. Sawdust mulches were invariably harmful.

In the south mulching experiments have been carried out in close collaboration with Dr. Levisohn, plants of such experiments being sent to her for examination of mycorrhizas. Mulches of bracken or heather, applied on fallow ground in early summer, produced small increases in yields and heights of seedlings grown on the sites the following year. Mulches of inert cellulose fibre were less effective, and it is thought that the effect of bracken or heather may have been partially manurial. All mulches cause a small reduction in the time taken to weed seedbeds in the year following application.

Mulches of sawdust, coarsely chopped bracken and fresh hopwaste, produced insignificant differences in heights of transplants, sawdust being the least and fresh hops the most effective.

A mulch of straw had little effect on the growth of Sitka spruce transplants in their first year, when lined out in a nursery with pH about 7.0; in the second year, plants benefited slightly from the mulch.

Undercutting of Seedbeds

Experiments on undercutting have been carried out, both in the north and south, using oak, beech, Corsican pine, Douglas fir, Japanese larch, Sitka spruce and Lodgepole pine. The work was necessarily complicated in the early experiments which aimed at determining the most suitable months and depths for undercutting and the most suitable densities for sowing. In addition, information was also needed on whether a plant would respond to both undercutting and side-cutting of the roots. It appears that undercutting plants growing at low densities (100-200 per sq. yd.) at 3 in.-4in. in the early spring of the second year or at 2in. in August of the first year, does promote the production of a plant akin to a transplant in appearance, and that such plants are better balanced than those undercut at greater depths, or at other seasons, or plants grown at higher densities. In general the pines seem more responsive to undercutting, in as far as development of root fibre is concerned, than do the larches.

Undercutting hardwoods at 4 inches in August the first year, or March the second year, seems to produce a more fibrous rooted plant than transplanting.

Extensions of undercut plants into the forest have been generally rather encouraging in that most of the plants survived; but adverse conditions have not so far been encountered. As a result, the behaviour of 2+0, undercut seedlings and 1+1 transplants have been very similar as far as survival has been concerned. It is expected that this project will be completed within the next two years.

Shading

Most of the work on this subject had been done before the period of this review; the results indicated that shading against summer sun was not necessary.

In one experiment at Tair Onen nursery, shadings against summer heat had very little effect on seedling growth. Maximum temperatures under the shading were one or two degrees lower and minimum temperatures about one degree higher.

Control of Fungi

A number of experiments testing fungicides to control damping off, *Botrytis*, and *Keithia*, have been carried out for the Pathologist. Results have not been particularly encouraging, and not as good as the literature would have us believe.

Control of Insects—Cutworm

In the south, experiments have shown that cutworm can be controlled effectively by applications of Aldrin or Dieldrin in water made in June—July. Neither material damages Sitka spruce seedlings.

In the north, trials of Dieldrex 30 and Aldrex 30 at from 3-9 pints per acre produced no phytotoxic effects on conifer seedlings in this range of concentrations.

Growth Inhibitors

Work is still in progress on the use of maleic hydrazide as a growth inhibitor, and it is still too early to predict whether this material has a future or not. The intention is to find a suitable concentration of maleic hydrazide which will check the growth of 'surplus' seedlings in 1+0 or 2+0 seedbeds, in order to avoid destroying them. Concentrations of 0.2 per cent, 0.15 per cent and 0.1 per cent solutions of maleic hydrazide in water seem quite promising applications. There may be some genetic effect due to chromosome breakage but this has not been investigated. Records are being kept of the places where treated seedlings have been extended into the forest.

Storage and Handling of Plants

General. Losses in the forest and in the nursery following planting have been causing concern. Faulty handling and storage has undoubtedly been one cause of many plant deaths and experiments have been carried out with the object of reducing the risk of faulty handling and of improving on current techniques of storage.

In the north, in experiments over a period of three years in Scottish heathland nurseries, storage in nursery sheughs was found to be more satisfactory than storage in boxes, in sheds or in the forest. Sitka spruce was able to stand storage for longer periods than lodgepole pine and both could be stored longer than larch.

In the south, experiments showed that of various methods of packing for despatch of plants, plants survived in polythene film far better than in any other form of packing (including straw and moss, and paper). Subsequent experiments have shown that plants can remain in polythene safely for long periods provided they are not exposed to sunlight and are not packed with wet foliage. *Abies* and Douglas fir have not stored as well as Sitka spruce, Corsican pine, Lawson cypress, or *Thuja*. Japanese larch stored well until flushing commenced. The colour of foliage of plants flushing in polythene bags was creamy white; if such plants were lined out in moist conditions soon after flushing commenced, they survived; but if they were well flushed and lined out into dry conditions the new foliage withered.

Fungus attacks have occurred generally following death of plants from other causes. It seems that foliage may be killed by excess moisture condensing in the bags and is then invaded by fungi. Plants infected with *Botrytis* have been included in bags of healthy plants; the disease did not spread.

English Conservancies have generally reported favourably on the use of polythene bags in the field.

A polyvinyl latex into which plants could be dipped and which then dries to leave a thin plastic film on the foliage, did not have any great effect on plant survival, nor did emulsions of lanolin nor paraffin when used in a similar manner.

Miscellaneous

In addition to the work described above, a very limited amount of effort has been directed to the question of studying root development in glass sided boxes, mainly with the object of providing an aid to the undercutting investigations.

An experiment in the south showed there to be no significant benefit from growing Sitka spruce and *Tsuga* in intimate mixture compared with their growth in pure blocks of each species. In both Scottish and English nurseries work has been carried out on behalf of the seed laboratory, to determine correlations between seed testing data and nursery seedling production with and without bird protection.

Work has also been carried out in heated frames with the object of raising three or even four crops of usable "first year" Sitka spruce seedlings in one year, using overhead light, electrical soil heating equipment and boxes. Four crops were raised by this method but difficulties arose during the period of hardening off and losses of seedlings from some batches were heavy. This work has been written up and published in the *Empire Forestry Review*.

Summary of Present Position and Probable Trends in Nursery Research Work

In the past a considerable proportion of the total research effort has been concentrated on nursery problems. Most of the immediate practical difficulties have been overcome and satisfactory working techniques have been developed and have entered into general practice. In the last few years, a good deal of the work has been brought near to conclusion and there is now need to review the situation and to cut down the effort on the least profitable lines of work. The field is discussed below under a small number of major subject groups.

1. Seed

(Seed pre-treatment, seed quality, etc.). We have now sufficient knowledge of all but a few minor species to secure satisfactory field germination, though *Abies* spp. still present some difficulties and a little more work on these appears to be required. The Seed Laboratory is now concerned with the more fundamental seed problems, and future work in the nurseries is likely to be concerned with field extensions of laboratory studies, and will be on a limited scale.

2. Nutrition and Maintenance of Fertility

(Including soil sterilisation, acidification, use of fertilisers, minor nutrients, green crops and crop rotations). This is the main field of work of the Nursery Nutrition Sub-Committee, but complementary studies have been carried out in the north. The position arrived at is that all the most pressing practical problems associated with the old, "worked out", high pH established nurseries and with the more recent heathland nurseries have been largely overcome. Satisfactory crops can be produced provided the nursery sites have been properly selected.

Future work will be concentrated on the long term effects of various regimes of management, and long-term experiments have been started for this purpose. Other minor studies may arise,—e.g. trace element or minor element deficiencies or other minor disorders occurring in particular nurseries, and there will always be a certain limited amount of work dealing with such specific problems. New forms of major nutrients may also occasionally require testing. As regards partial sterilisation, we have here a tool that can be used when necessary, but it is still expensive. More work is justified in searching for a cheaper effective sterilant.

A major question is whether we should investigate the desirability or otherwise of extending the Scottish technique of prescribing manurial treatments on the basis of soil analysis, or whether the present omnibus prescriptions derived from the results of the Nursery Nutrition Committee's investigations are adequate.

Studies in Difficult or Unsatisfactory Nursery Soils

The Research Branch is sometimes criticised for not doing more work on the amelioration of heavy soil types. A little work has been done on "soil improvers" (Krilium, charcoal). It is our opinion that attempts to treat such unsuitable nursery soils are uneconomic and that this is, generally an unprofitable line of work. There will of course be a few problems on individual sites that may require examination, especially when starting up a new nursery.

Seedbed and Sowing Techniques

(Including preparation of beds, consolidation sowing methods—drill, band, broadcast, date of sowing, density of sowing, covering media, depth of covering, shading, irrigation). Most of the basic work leading to current nursery practice was done long ago, and the experimentation during the last five years has largely been directed towards refinement of seedbed techniques. Better standards of fertility and production have necessitated a re-assessment of sowing densities, for instance. Most of the experimental results have passed into practice in the better managed nurseries.

No large programme of work is envisaged under this head, though there is a small amount of tidying up of loose ends. The current work on irrigation will probably be concluded within a year or two when recommendations will be made for its practical application in appropriate circumstances. There may be some work on nursery bed techniques arising out of mechanisation developments.

Lining-out and Undercutting

Work on season and date of lining-out is reaching completion and no further general work on lining-out is envisaged. The use of undercutting as a cheaper alternative to lining-out has given encouraging results, and about two years' further work is required to complete this project.

Weed Control

This has been one of the most important and profitable fields of nursery experimentation in the last seven years or so. We have now got a satisfactory, safe cheap treatment for pre-emergent weed control. For post-emergent control, revised recommendations have been issued, but more work is still required. Present work is concerned with screening a range of chemicals (see page 106), not only for post-emergence weed control, but also for control in transplant lines. Suitable safe and effective weedkillers for pre-sowing application as well as for fallow weed control and for paths and nursery surrounds would be useful. More experimentation is called for here.

Storage and Handling of Plants

This subject has received more attention of recent years. Trial of various methods of storage produced nothing better than the old fashioned "heeling in" and no obvious lines of further work on storage suggest themselves. The latest developments in handling of plants is the use of polythene wrappings. The early results are distinctly encouraging and more work on this is required.

Protection

(Fungi, insects, birds, climate). Recent work on control of *Botrytis*, *Keithia* and on early damping off should continue. Effective control of cutworm with "Aldrin" and "Dieldrin" has been achieved, and little further work on this is required. Bird damage in nurseries remains an unsolved problem. Damage, by insolation and by frost, including frost lift, does not appear to call for any appreciable amount of work.

Mechanisation in Nurseries

The development of mechanisation in nurseries is primarily a function of the Machinery Research Officer, but the silvicultural research section has taken an active interest in all stages of the work. This will continue to involve the Silviculturist in a certain amount of work in assessing the results of mechanical methods of sowing, planting, weeding, etc., and may require a certain amount of incidental experimentation.

Difficult species

While satisfactory standards of production have been achieved for most of the important species that we use, there are a number of species (including some of the important hardwoods, and lesser conifers such as *Abies* spp.) for which the results of our nursery work are less predictable. Some work is necessary to improve nursery techniques in such cases.

Application of Research Results

A great many of the research results obtained in the recent past have found their way into nursery practice. Their application, however, is still very uneven, and there are still many cases of errors and omissions in existing practice which could be avoided by the correct applications of existing knowledge. It seems likely that some more attention by the Research Branch to the application of results,—both by demonstration in selected nurseries, and by more frequent visits to the poorer nurseries (with the Directorate Nurseries Officer whenever possible), would pay dividends, and that a greater proportion of the nursery research officers' time should be spent on such advisory and demonstration work.

THE BENEFIT OF LATH COVERS FOR PROTECTION AGAINST FROST

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The use of lath covers for frost protection is a practice tending to fall into disuse in many nurseries. This is mainly on account of the rather large expenditure involved in construction, erection and storage of the covers and the fact that, in many areas, serious frost damage has been rare in recent years.

Many of the older foresters have had to endure "What, still covering?" sallies for the past few years, but with memories of former severe damage have, in most cases, covered frost-tender species religiously. This practice paid dividends in 1957.

Following the very mild winter of 1956-57 which was notable for an almost complete absence of severe frost (readings of around 0°F. on several days each winter are normal at Inchnacardoch), early mild spring conditions induced flushing of all main species before the first week of April. Flushing does not normally begin before mid April. During the period April 8th—May 4th there occurred a series of frosts of between 22° and 25° F. which caused considerable damage to a fairly wide range of unprotected coniferous and broadleaved species in seedbeds. Where a lath cover or adjacent hedge gave overhead or side shelter no damage occurred. The value of lath covers was particularly well demonstrated in the case of Sitka spruce, where covered beds were entirely undamaged, whereas more than 50 per cent of the crop in uncovered beds suffered frost damage. In the last five years at Inchnacardoch only one year has given conditions where lath covers might have been dispensed with.

Gales during the winter had caused some damage to lath covers, and where repairs had not been carried out, even to the extent of a single missing lath, some frosting followed. This emphasises the need for efficient erection and subsequent maintenance. Laths must be well secured to supporting wires, strainers firmly driven home and intermediate posts sufficient to prevent sagging.

Plasterers' laths of 4 ft. × 1 inch × ¼ inch are used for the construction of shelters and a 1 inch spacing between laths is regarded as ideal. The cover is most satisfactory when placed 9 to 12 inches above the bed, and slightly sloped to aid rain run-off and to prevent water dripping on to the seedlings. Adherence to these specifications will prevent damage, but any increase in the height of the cover may result in frost damage along the bed edges, and gaps of more than 1½ inches between laths may also result in damage.

It is essential to cover all seedbeds of a tender species, and no attempt should be made to economise by covering alternate beds. Such a practice has been found to create artificial 'frost hollows' and may increase the amount of damage.

Where spring or early autumn frosts are likely to occur the following species should be covered if losses are to be avoided; Sitka spruce, *Abies* species, *Tsuga heterophylla* and Douglas fir.

At Inchnacardoch, lath covers are erected during the last week of September and lifted in mid-June i.e. the period in which damage from frost can be expected, although in many other less frosty areas a much shorter period is generally necessary. Drip damage and growth-loss have often been regarded as serious disadvantages of lath covers, but experience here has shown that the former does not occur where covers are sloped, and loss of growth, where direct comparison with uncovered beds has been possible, is negligible. In the case of shade-bearing species, the seedlings may even show a growth *increase.*

The above account is based mainly on experience at Inchnacardoch nursery where the growing season is started later and is shorter than for the majority of nurseries, and where two-year seedlings are more commonly raised than first-year ones; but the general principles are applicable where the standard 3ft. 6 inches wide bed is used, and fairly large areas are involved. Where small lots of frost-tender species are involved, it should be possible to select sheltered corners of the nursery which will give adequate protection. Finally, lath covers give little protection against *frost lift*, and where the two problems of frost damage and frost lift occur there should be but one council—don't sow!

A REVIEW OF RESEARCH BRANCH TRIAL PLANTATIONS

Paper prepared by M. V. EDWARDS *and* R. F. WOOD
for the Research Branch Programme Conference, June, 1957

Definition

By the term "Trial plantation" is meant the establishment of a plot up to about 5 acres in size on land classified as unplantable by the Conservancy. Its object is to ascertain the "degree of unplantability", i.e., to find out whether trees can be made to grow at all and if so, whether they will only make a shrubby thicket or will grow sufficiently well to indicate that the site might produce timber. Experiments testing different methods of technique are not classified as trial plantations, but it sometimes happens that experiments of this kind, when they have been closed for their original objects, may be of value as trial plantations, and some of the older experiments of this sort are now so classified. (The term "pilot plot" has been used to describe small trial plantations, but in general "pilot plot" and "trial plantation" are synonymous.)

This kind of work has been of great importance in the north, but in the south there is comparatively little on exactly similar lines. The main reason for this is a simple geographical one, the Commission has not in Wales and the southern two-thirds of England large uniform areas of doubtfully plantable land of one type or the osher, the older trial plantations in England and Wales were established concurrently with or shortly after the commencement of extensive plantation on the types concerned, with the main object of examining the performance of a range of alternative species. There are a few instances of experiments which more closely resemble the Northern Trial Plantations (as defined) and it is also possible that similar work ought to be undertaken (e.g., at high elevations in Wales). To make this paper comprehensive comment on southern conditions and experience is included whenever it appears to be called for, but it should be emphasised that this is primarily a northern project.

Classification

In the case of most of the trial plantations so far planted, the limiting factors can be considered under three main heads, although of course in all instances there is a complex of different conditions. Nevertheless, it is convenient to consider the plots as primarily concerned with: (a) exposure at high elevations, (b) exposure at low elevations, especially near sea-coasts, or (c) limiting soil conditions such as highly acid peat.

Description

The plots are based on what was considered the best technique of ground preparation, manuring, methods of planting, etc., although occasionally alternative methods of establishment in common use may be employed, though not critically compared. Some are on unprepared ground or on early forms of ploughing, but the majority have been ploughed by modern methods, and planted with or without phosphate according to circumstance.

Most of the plots are based on one or two reliable species used as a matrix, into which secondary species have been mixed in various different patterns. The secondary species may be either possible alternatives to the matrix for establishing a first crop or enrichment species to be nursed by the matrix species. Secondary species include inland Lodgepole pine if coastal is used as matrix, and Lodgepole pine if Sitka spruce is the matrix. Hybrid larch (or Japanese larch) *Tsuga*, *Abies nobilis*, *Picea omorika* and in certain cases Norway spruce, Douglas fir, and other *Abies* species have been included. Around the perimeter a strip to give low shelter (mountain pine) has usually been planted.

In the south, the circumstances have not arisen in which we should have wished to follow this approach. For example the trial plantations on the peculiar Western Heath at Croft Pascoe, Cornwall, could not be regarded as logical extensions of our heathland experiments elsewhere. We know too little about the environment, and have found it desirable to ask more questions than the primary one—will the best indicated species with the best indicated treatment make a crop?

Results

In all northern trials it seems to be true that the matrix species are the most successful. The use of other species usually tends to result in gaps in the plots which will delay canopy formation for a considerable time and in extreme cases will, it is suggested, prevent the possibility of obtaining a fully stocked plot. It seems that under the limiting conditions in which these plots are established it would be better to plant only one or two species. In the north, this usually means either Sitka spruce or Lodgepole pine. A perimeter of mountain pine, of both prostrate and erect form, is also probably desirable from the long-term aspect. We have perhaps been too precipitate in introducing the secondary species and we should not worry about them until we have established that a crop of the matrix species grows reasonably well. Under limiting conditions, whether of climate, soil or vegetation, it seems essential to remove competition by vegetation and produce a tree cover before endeavouring to start the secondary species.

The only important modification of these conclusions which is indicated by southern experience is the somewhat obvious one that restriction in choice of species is not so marked where climate is less limiting. To take the rather extreme example of Croft Pascoe again, we may not succeed in getting satisfactory growth, but it is almost certain that well over a dozen species will be very much alive there in ten years' time. One might also mention the favourable soil conditions often found at high elevations in Wales where climate (in the broad sense) is limiting. This also widens the initial choice of species somewhat. Quite generally, we do not in the south so often experience the full combination of limiting factors.

Organisation

Our capacity to lay down trial plantations is limited. All need considerable organisation in arranging for ploughing, transport, planting, etc., because they are usually on distant and often somewhat inaccessible sites. In certain cases we have undertaken the plots on the basis that the Conservancy staff would organise the establishment and that we would help, and record the results, but this division of responsibility leads to them being looked upon as "experiments" and in practice they become our responsibility, nothing being done except under the control of the Research Forester.

Modern trial plantations have usually been ploughed, but the ploughing of a small and rather inaccessible area is not easy to arrange. The Technical Committee considered that such trials should not be limited to ploughed land, but, in practice, hand preparation of the ground in distant areas may be even more difficult to accomplish than ploughing.

Future Plans—New Plots

If these arguments are admitted, then there is no reason why Conservancies should not establish trial plantations and make many more than we are able to do. It would be sufficient if their situation and a brief report of the methods of establishment were reported to the Research Branch. A joint visit by Conservancy and Research Branch after the tenth year from establishment, followed by an assessment if considered desirable, would be adequate, and information of this kind from a large number of plots would be a great deal more useful than detailed information from the few plots at present existing. Successful plots would of course be maintained and their later history recorded.

Where soil is not a limiting factor, the present type of plot with both matrix and secondary species, or shelterbelt plus species plots, would of course continue to be used, but experience shows that when complications are involved, the plot must be a Research Branch responsibility.

Future Plans—Old Plots

There are, of course, many old plots already established both by the Commission and by private owners. Research Branch already has notes of these in some cases, especially in the vicinity of the trial plantations that we have established. It is suggested that a wider survey of such plots would be useful. A map showing their position and the compilation of Experiment Record Forms 1, 2 and 4, plus the experimental punched card, would give us a much better general picture than we have at present, and would be a valuable addition to our knowledge.

Forest	Type and Number of Experiment	Elevation, feet	S = Severe exposure M = Moderate ,,
	(a) **High Elevations**		
Lael	14 P. 54	800- 950	M
Dundonnell (Ross)	1 P. 54	940-1000	M
Achnashellach	6 P. 28	920	S
,,	18 P. 33	800- 900	M
Glen Righ	21-26 P. 30	800- 900	M
South Laggan	7, 9, 10 and 12 P. 28	1300	M
,, ,,	3 and 11 P. 22, 28 and 29	1800	S
Inchnacardoch	21 P. 26	1250	S
,,	25, 25A and 139; P. 27, 29, 53	1100	S
,,	142 P. 54		S
The Queen's Forest	1-9 P. 30	1600	S
Clashindarroch	2 and 3 P. 31	1300	S
,,	9 and 14 P. 31 and 34	1300-1400	S
,,	11 P. 33	1250	S
,,	12 P. 33	1250	S
Fetteresso	5 P. 53	1000	S
Drumtochty	3 and 5 P. 51	1100-1200	S
Glen Doll	1 and 2 P. 52	2000	M and S
Blackcraig	1 P. 35	1200	S
Carrick	1 and 2 P. 54	1200-1400	S
,,	5 P. 55	1400	S
Glentrool	15 P. 55	1400	S
Garraries	1 P. 55	1500-2000	S
Kielder	55 P. 50	1000	M
,,	56 P. 50	1100	S
,,	61 and 62 P. 51	1350	S
,,	67 and 68 P. 52	1450-1500	S
Cleveland	1 P. 52	900	S
Halifax	1-2 P. 51	1000	M
,,	3 P. 51	1025	S
,,	4-6 P. 51-52	1100	M
Hebden Royd	1-3 P. 57	900-1200	M
Hope	1 P. 39	1100-1300	S
,,	5-7-8-9; P. 40 and 41	1100-1300	S
	(b) **Coastal Exposure**		
Shetland	1 P. 52		M
,,	2 P. 53		S
Hoy (Orkney)	1-2 P. 54		S
,, ,,	3-4 P. 54		M
Borgie	1-2 P. 30		S
,,	6 P. 39		S
,,	7 P. 40		S
Strathy	1 P. 49		M
,,	2 P. 50		M
,,	3 P. 51		M
Skiall (Caithness)	1 P. 49		S
,, ,,	2 P. 50		M
,, ,,	3 P. 51		S
,, ,,	5 P. 53		M
Forss (Caithness)	1 P. 50		S
,, ,,	2 P. 51		S
,, ,,	3 P. 51		S
Watten (Caithness)	1 P. 51		S
Reay	1 P. 51		M
,,	2 P. 53		M
Lael	15 P. 55		S
Dundonnell (Ross)	3 P. 56		S

Forest	Type and Number of Experiment	Elevation, feet	S = Severe exposure M = Moderate „
	(c) **Acid Peat or Upland Heath**		
Achnashellach	7 P. 28		S
„	25 P. 38		M
Inchnacardoch	2 P. 22		S
„	75 P. 29		S
„	86 and 91; P. 30 and 31 (Groups)		S
„	93 P. 31		S
„	75 and 95 P. 32		M and S
„	103 P. 33		S
„	120 P. 38 (Groups)		S
„	128 P. 46		M
„	129 P. 46		S
„	135 P. 47		S
Glen Righ	5 P. 27		M
„ „	12 P. 28		M
„ „	32 P. 35		M
Glencoe	1 P. 57		S
Teindland	62 P. 38		M
Benmore	4 P. 36		M
Wauchope	4 P. 53		M
Spadeadam	1 and 2 P. 56		S

Some additional plantations have still to be added to this list in some centres as old experiments on technique are closed and amalgamated.

Trial Plantations in the South

It would merely confuse the issue to add a list of southern experiments here which have some features or objects in common with the Northern Trial Plantations but are in fact materially different in approach. However, it may be useful to mention some of the recent work on difficult sites which provides the closest analogy.

Cornish Heaths

Croft Pascoe. Peculiar site overlying Serpentine, high degree of maritime exposure. Ploughing methods; trials of species; nursing; mixtures; methods of establishment (including direct sowing); fertilizers, etc.

Wilsey Down. Culm measures, high degree of exposure. Species trials have been laid down on sites where the crop has failed completely.

Southern Heaths

Wareham, Purbeck, Haldon. Sites with advanced podsolisation, extremely low phosphate content, and (locally) physical difficulties.

On one site at Wareham (Hyde Heath Bog), at present rated unplantable, a "pilot plot" in the accepted sense has been laid down. Elsewhere in the group a considerable amount of work has been done in recent years, part on new ground, part on the sites of failed plantations. Experiments have included methods of ploughing, trials of species, fertilizers, and control of *Calluna*.

Central Wales

Taliesin. Mineral soils at fairly high elevations, overlying shaly rocks. Tending to revert to *Calluna/Ulex gallii/Vaccinium* associations on the cessation of grazing. Experiments have included the usual range of treatments—methods of ploughing, trials of species, fertilizers, etc. Work has been done at both moderate and high elevations.

TRIALS OF A DISC PLOUGH ON UPLAND HEATHS

By G. G. STEWART

District Officer, Research Branch

The investigations of root development on upland heaths carried out by C. W. Yeatman in 1952 and 1953, led him to suggest that a ground preparation method of complete surface cultivation would be better than the usual heathland technique of single mouldboard ploughing giving a ridge and furrow (see Forestry Commission Bulletin No. 21). Yeatman presented two main reasons why spaced furrow ploughing was not satisfactory; first, the main roots were confined to the cultivated furrow and ridge and thus not able to make the fullest use of the site; secondly, the orientation of the roots in only one direction increased the likelihood of windblow. He advocated that complete ploughing of medium depth (8-10 inches) would overcome these disadvantages.

Complete ploughing can be carried out on many heathland soils with some of the ordinary single mouldboard ploughs, but the operation is slow, expensive and often not very effective in giving the necessary degree of surface cultivation; if the heather vegetation is tall and dense, burning beforehand is essential. An alternative method of complete surface cultivation is by using disc ploughs, and in 1953 trials of two such ploughs—the Newlands 3 disc plough and a modified Sunshine plough with 4 discs, both ploughs tractor mounted—were made at Devilla Forest, Fife, and of the latter at Hallyburton Forest, Perthshire. Neither of these implements gave satisfactory cultivation. It was believed that they were too light—they each weighed about half a ton—and that a much heavier trailed disc plough might give the necessary cultivation, not only over the surface, but also sufficiently deeply to satisfy the rooting needs of the trees downwards. Yeatman knew that heavy disc ploughs were widely used in Australia and in August 1954 a Majestic disc plough was brought over from that country.

Description

The Majestic plough is of the "stump-jump" pattern, that is, the discs are spring loaded so that they can ride over stumps or other obstacles in their path without upsetting the carriage. It is a very large implement 12 feet long by 10 feet wide, and carries eight discs each 26 inches in diameter. The total weight is 3 tons 1 cwt. and the machine is extremely robust.

Trials

The plough was used at four forests—Allerston and Cleveland, Yorkshire, Hallyburton, and Speymouth in Moray—in 1954 and 1955. All the sites were upland heaths of varying types and in all about 50 acres were covered, part in combination with standard single furrow ploughing practices. Details of these trials are given below.

DISC PLOUGH TRIALS

Forest (Section)	Compt. No.	Area (acres)	Date of ploughing	Depth of ploughing (ins.)	Tractor used	Species	Year of planting	Notes
Allerston (Harwood Dale)	71	8	November, 1954	6-8	TD 9 (Narrow tracks)	P.C., J.L., S.S.	P.56	Boulder strewn heather moor with 3-6" peat over yellow stony clay loam. The perimeter of the compt. was ploughed round and round. The vegetation and peat layer were not buried over more than 40% of the area. Later, 7 of the 8 acres were ploughed by RLR.
Allerston (Harwood Dale)	Experimental Enclosure Expt. 41 Extn. F.Y.55	2	November, 1954	5-8	TD 9 (Narrow tracks)	S.P., C.P., J.L., 2 rows of plants were planted on each ploughed band.	P.55	Ground and vegetation similar to Compt. 71. 1 acre was ploughed completely; 1 acre was ploughed in bands 5 feet wide leaving 5 feet uncultivated between each band. The vegetation—heather—and peat were 15 to 20% buried. A comparison with various other ploughs, including RLR and Tine will be possible in the adjacent ploughing Experiment 41 P.54.
Cleveland (Hutton)	19	1	November, 1954	7-9	TD 18	J.L., S.S.	P.56	Convex summit of a felled S.P. wood. Vegetation mainly grass with some gorse and bracken; many hard stumps. Area "chewed" rather than ploughed. Stumps caused discs to miss patches.
Cleveland (Hutton)	22 Expt. 2 P.56	1	February, 1955	6-8	TD 18	S.P., P.C., J.L., S.S.	P.56	Vegetation mainly 3-4 inch tall heather with some grass. Pan touched occasionally by discs. Rather a rough job with small patches missed owing to discs hitting stones.
Cleveland (Kildale)	6, 7	7	January, 1955	8-10	TD 18	S.P., P.C., J.L., S.S.	P.55	Vegetation mainly grass with patches of heather. A more pronounced pan than in Compt. 19. Old woodland area with hard stumps.
Speymouth	319	24	July, 1955	7-8	TD 18 (D 4 was tried but failed to pull the plough)	S.P. (with scattered birch groups)	P.56	Vegetation heather/deer grass (recently burned). Some hummocks but no stumps or boulders. Raw humus layer and part of gleyed former A horizon were turned over. B horizon and pan were rarely broken into. On steeper slopes there was a gravelly 'pavement' a few inches down and this was not broken up. Most of the area was reploughed by Tine (without mouldboard).
Hallyburton (Strelitz Wood)	59 Expt. 5 P.56	9	October, 1955	3-5	TD 18	S.P.	P.56	Vegetation short heather (burned within 3 to 5 years). 2 in. peat over 3-6 in. sandy clay (no pan). A few large boulders but generally not stony. Various combinations of discing and Tine ploughing were made, including the reploughing of an area disced by a Sunshine plough in 1953. The depth of Tine ploughing was 12-16 inches.

Note: P.C.=Lodgepole pine; S.P.=Scots pine; J.L.=Japanese larch; C.P.=Corsican pine; S.S.=Sitka spruce.

Ploughing Performance

The discs cut a swathe of a little over five feet in one run, that is eight to eight and a half inches per disc. Under the conditions encountered, the depth of cultivation was about six to eight inches and on only one site was a depth of as much as ten inches achieved. The stump-jump action worked well and the individual discs rose over stumps and boulders, the whole plough lifting only when the obstacles were close together or very large. The turnout of soil was not what is expected from a normal single mouldboard plough but was no worse than is usual with disc ploughs. Rough heather was a difficulty and seriously reduced the turnover of the top soil. No breakages occurred despite the hard use the plough received; it is interesting to note that in similar conditions at two of the sites, the RLR plough usually suffered breakages costing 15/- per acre to repair and that the Tine plough had difficulty in working.

Ploughing Techniques

The plough is a formidable machine by reason of its size and weight, and its proper adjustment is not easy, but is of great importance. Turning the plough is difficult, and the best method of working was found to be round and round in an anticlockwise direction. When turned to the left like this, a turning radius of eight yards is possible, as the discs roll on their edges but do not cut into the ground. By beginning at the perimeter of a compartment it is possible to cover the whole area, apart from the very corners and a small area in the middle. The tool is obviously best suited to large scale operations. The speed of ploughing is of importance and at a fairly fast speed the turnover is greatly improved; a speed of about three miles per hour was found to be suitable.

Tractors

A powerful tractor is needed and a TD 18 was found the best. A TD 9 managed successfully at two sites but probably only because of a slightly less compacted soil; a D 4 could not pull the plough. A large machine like a TD 18 was able to operate at a good speed and this increased the quality of the plough's work.

Results of Trials

There is no reason to doubt that the Majestic is an efficient tool for complete cultivation and would work well on fairly loose soils even if they are full of boulders or covered with stumps (as it does in Australia, apparently most successfully). In practically every trial made, the soils were too compact to allow the discs to penetrate deeply. The most difficult site was at Speymouth where there was a hard "pavement" of gravel a few inches below the surface, which the discs could not penetrate. In general, the leached layer was not fully disturbed and the pan, where there was one, was not broken; thus the primary necessity for root penetration was not obtained. This often had the effect of leaving the area wet on the surface; rupture of the deeper compact layers would enable vertical drainage to take place; if these layers are not broken, ordinary surface drains may be necessary.

The actual cultivation of the surface layers was satisfactory on the whole, but the discs could not deal effectively with tall growing heather and needed a fairly clean surface if the soil was to be turned up effectively. The looseness of the surface layers has led observers to question their suitability for planting, but this lack of consolidation may mean merely a longer delay before planting than is the general custom. Another objection has been that the loose top soil will be invaded rapidly by new vegetation. However, with the Sunshine ploughing at Hallyburton, which was not considered a success at the time, the soil weathered to a surprising degree in two years, and the regrowth of vegetation has not been as strong as expected. Consequently, it may be that loose but complete disturbance of the whole surface is a better way of eradicating vegetation than is commonly thought. The rough and untidy result given by the plough has been a criticism, because of the difficulty of finding suitable planting spots; usually it was found easiest to plant in the hollows between the disc slices.

Summary of Disadvantages and Advantages

The main disadvantages appear to be the following:

1 Lack of depth of cultivation—a very serious fault.

2 Difficulty of planting because of lack of surface consolidation and because there is no definite furrow to follow. (This is a difficulty of establishment only.)

3 Expected rapid regrowth of vegetation. (This remains a matter of opinion and may not take place.)

4 Difficulty of manoeuvre and transport—another important point.

5 Need for a powerful tractor.

The main advantages are as follows:

1 Complete cultivation can be expected to give the crop a more balanced and efficient root system.

2 The plough can overcome the difficulties of boulders and stumps without breakages.

3 The plough covers the ground very quickly. (This may offset the high cost of the heavy tractor.)

Conclusions

The Majestic disc plough has given fairly good surface cultivation of the compacted soils on which it has been tried but it has not given the depth of cultivation wanted; and depth of ploughing usually has been considered to be the point of first consideration. If this is not obtained, then other matters are of secondary importance, and it is the failure of the Majestic plough to go deeply into compact heathland soils which has condemned it in the eyes of most of those who have seen its work. Consequently, the problem originally posed of how to combine the advantages of both depth and complete surface cultivation has not been solved by the Majestic Plough. However, there is no reason to doubt that more satisfactory results would be obtained on soils less compact than the rather extreme types on which the plough was tested. Unfortunately, large areas of ground suitable for the Majestic plough are rarely available for forestry and the use of so large a machine in small enclosures is impracticable.

Acknowledgments.

This article has been made up from the reports of many who have worked with the Majestic plough, in particular, those of M. V. Edwards, J. W. L. Zehetmayr and J. Weatherell.

SOME PRINCIPLES OF COMBUSTION AND THEIR SIGNIFICANCE IN FOREST FIRE BEHAVIOUR

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Combustion chemistry

Although a large fire is essentially a physical or meteorological phenomenon, combustion itself is a chemical chain reaction process, which takes place at high temperatures. In all forest fires, large or small, materials such as leaves, grass, and wood combine with oxygen in the air to form combustion products plus large quantities of heat. Heat, as we shall see, is the most important combustion product in fire behaviour.

There are three rather definite phases of combustion, although they overlap somewhat and all exist simultaneously in a moving fire. First comes the preheating phase in which fuels ahead of the fire are heated, dried, partially distilled, and ignited. In the second phase, the distillation of gaseous substances continues but is now accompanied by their burning or "oxidation." Ignition might be regarded as the link between the first, or preheating, phase and the second, or gaseous, combustion phase. Ignition may also be regarded as the beginning of that part of the combustion process in which heat is given off. The flames seen over a forest fire or in a fireplace are the burning of distilled gases; combustion products are principally invisible water vapor and carbon dioxide. If combustion is not complete, some of the distilled substances will condense without being burned and remain suspended as very small droplets of liquid or solid over the fire. These condensed substances are the familiar smoke that accompanies most fires. Under certain conditions some of the water vapor may also condense and give the smoke a whitish appearance.

In the third or final phase the charcoal left from the second phase is burned and leaves a small amount of residual ash, which is not a combustion product. If combustion is complete and if the charcoal is mostly carbon, the primary combustion product in this phase will be carbon dioxide because the initial water is driven off in the first two phases. Some carbon monoxide is formed as an intermediate product which in turn burns as a gas to form carbon dioxide. The small blue flames appearing over the coals in a fireplace are carbon monoxide burning. However, if combustion is not complete, small amounts of carbon monoxide remain. In this phase the fuel is burned as a solid, with oxidation taking place on the surface of the charcoal.

Note.—The composition of charcoal varies, depending on the conditions under which it is formed. If the distillation temperature is low, 400 to 500° F., the charcoal will contain considerable tar coke. However, in the rapid heating and resultant high temperatures existing in a forest fire, the deposits of secondary products in the charcoal are probably low.

Even though the three combustion phases tend to overlap, they can be plainly seen in a moving fire. First is the zone in which leaves and grass blades curl and scorch as they are preheated by the oncoming flames. Next is the flame zone of burning gases. Following the flames is the third but less conspicuous zone of burning charcoal. Unless fuels dry to a considerable depth (that is, unless the Built-up Index is high), this last zone may be almost absent. If this happens the burned-over area will appear black instead of gray, which means that much of the remaining charcoal, as well as some of the underlying fuel, has not completely burned. With the exception of such years as 1947, 1952, and 1955, a blackened burned-over area has been more common than a grey ash-covered area in the Eastern and Southern States.

Heat of Combustion

The heat of combustion is heat that makes combustion a chain reaction. Heat supplied to unburned fuel raises its temperature to the point where the fuel, or the gases distilled from the fuel, can react with the oxygen in the atmosphere and in so doing give off more heat. This in turn raises the temperature of adjacent fuel, and thus the chainlike nature of combustion becomes established.

The heat energy released by burning forest fuels is high and does not vary widely between different types of fuels. The tabulation below gives the heats of combustion for a number of substances. These materials and heats were selected from tables in Kent's *Mechanical Engineers Handbook*, 12th edition. Their average is probably a good approximation for forest fuels. Fuels do not ordinarily burn with maximum efficiency, so the actual amount of heat released per pound of fuel in a forest fire will be somewhat less than shown in the tabulation. For a small fire burning in dry fuels with very little smoke, the combustion efficiency might be as high as 80 per cent. Large fires burning with dense smoke would be less efficient. Combustion efficiency probably drops somewhat with increasing moisture content.

Substance	*Heat of combustion per pound, dry British thermal units*
Wood (oak)	8,316
Wood (beech)	8,591
Wood (pine)	9,153
Wood (poplar)	7,834
Pine sawdust	9,347
Spruce sawdust	8,449
Wood shavings	8,248
Pecan shells	8,893
Hemlock bark	8,753
Pitch	15,120
Average (excluding pitch)	8,620

Heats of combustion are given in British thermal units per pound of dry fuel. A B.t.u. is the quantity of heat needed to raise the temperature of 1 pound of water 1° F. For example, the above tabulation shows with the help of a little arithmetic that the burning of 1 pound of an average woody fuel gives off enough heat to raise the temperature of 100 pounds of water about 86° F. To raise the temperature of 100 pounds of water (about 12 gallons) from a temperature of 62° F. to the boiling temperature of 212° F. would require about 1.7 pounds of an average woody fuel if it burned with maximum efficiency. About 1 pound of pitch would accomplish the same result.

The rate of heat release in a forest fire can be visualized by comparing it with a familiar rate, such as that required for house heating. For example, consider a hot, rapidly spreading fire burning with a 20-chain front and with a forward rate of spread of 50 chains per hour. If the fire burns 6 tons of fuel per acre, in 1 hour's time enough fuel would be consumed to heat 30 houses for a year if each house yearly required the equivalent of 10 cords of wood weighing approximately 2 tons per cord. Occasionally there is a fire in the Eastern States with a rate of spread exceeding 5,000 acres per hour. If it burns in a dense, continuous stand of conifers, which might have 12 tons or more of available fuel per acre, such a fire could consume enough fuel in an hour to heat 3,000 houses for a year.

Heat transfer

There are three primary ways in which heat travels or is transferred from one location to another. These are conduction, convection, and radiation. Although dependent on convection, there is a fourth or secondary means of heat transfer in forest fires, which might be described as "mass transport". This is the carrying of embers and firebrands ahead of the fire by convective currents and results in the familiar phenomenon of "spotting".

As a heat-transfer mechanism, conduction is of much greater importance in solids than in liquids and gases. It is the only way heat can be transferred within opaque solids. By means of conduction, heat passes through the bottom of a teakettle or up the handle of a spoon in a cup of hot coffee.

Convection is the transfer of heat by the movement of a gas or liquid. For example, heat is transferred from a hot air furnace into the interior of a house by convection, although the air picks up heat from the furnace by conduction.

Radiation is the type of energy one feels when sitting across the room from a stove or fireplace. It travels in straight lines like light, and it travels with the speed of light.

Most of the preheating of fuels ahead of a flame front is done by radiation. For a fire that occupies a small area and can be thought of as a "point" (such as a small bonfire or a spot fire), the intensity of radiation drops as the square of the distance from the fire increases. For example, only one-fourth as much radiation would be received at 10 feet as at 5 feet from the fire. However, when a fire becomes larger, the radiation intensity does not drop off so rapidly. For a long line of fire, the radiation intensity drops as the distance from the fire increases; that is, one-half as much radiation would be received at 10 feet as at 5 feet. For an extended wall of flame, radiation intensity drops off even more slowly. This tendency for radiation to maintain its intensity in front of a large fire is an important factor in the rapid growth of a fire's energy output.

Convection, with some help from radiation, is the principal means of heat transfer from a ground fire to the crowns of a conifer stand. Hot gases rising upwards dry out the crown canopy above and raise its temperature to the kindling point. Although convection initiates crowning, both convection and radiation preheat the crown canopy ahead of the flames after a crown fire is well established. Convection is also a factor in the preheating of the ground fuels in a surface fire but to a lesser extent than radiation. The effects of both radiation and convection in preheating are considerably increased when a fire spreads upslope, because the flames and hot gases are nearer the fuels. The opposite is true for downslope spread.

Convection and radiation can transfer heat only to the surface of unburned (or burning) fuel. Actually, radiant heat may penetrate a few thousandths of an inch into woody substances and this penetration may be of some significance in the burning of thin fuels, such as grass blades and leaves. However, radiation, like convection, for the most part transfers heat only to the surface of fuel material, and conduction may be considered the only means of heat transfer inside individual pieces of fuel. For this reason conduction is one of the main factors limiting the combustion rate in heavy fuels, such as slash and limbs and logs in blowdown areas. Materials that are poor conductors of heat, such as most forest fuels, ignite more readily than do good conductors, but they burn more slowly. Although the effects of conduction are far less conspicuous than those of radiation and convection, conduction is a very important factor in the combustion process.

Factors Affecting the Combustion Rate

Many factors affect combustion in such complex ways that they are not yet fully understood even for a simple gas or liquid fuel. Solid fuels are even more complex. Even so, there are two rather simple factors that have obvious and definite effects on the combustion rate of woody substances and are of great importance in forest fire suppression. The first of these is the moisture content of the fuel, and the second is fuel size and arrangement.

It is difficult to overestimate the effect of water on the combustion rate and, hence, on fire behavior. Water in a fuel greatly diminishes the preheating rate in the first phase of combustion. Much of the heat is used in raising the temperature of the water and evaporating it from the fuel. The large quantities of resulting water vapor dilute the oxygen in the air and thus interfere with the second or gaseous combustion phase. If the initial fuel moisture is high enough, water vapor may make the mixture so "lean" that the gases will not burn. This dilution of the oxygen in the air also affects the third or carbon-burning phase of combustion. Although data are lacking, it is probable that moisture reduces considerably the heat yield or combustion efficiency. This heat loss would be in addition to that resulting from the water-heating and evaporation requirements.

The effect of size and arrangement of fuel on combustion can be illustrated by the following example. Consider a large pile of dry logs all about 8 inches in diameter. Although somewhat difficult to start, the log pile will burn with a hot fire that may last for 2 or 3 hours. The three primary heat-transfer mechanisms are all at work. Radiation and convection heat the surfaces of the logs, but only conduction can transfer heat inside the individual logs. Since conduction is the slowest of the three heat-transfer mechanisms, it limits the combustion rate in this case. Consider now a similar pile of logs that have been split across their diameters twice, or quartered. Assume that the logs are piled in an overall volume somewhat greater than the first pile, so there will be ample ventilation. This log pile will burn considerably faster than the first one because the combustion rate is less dependent on conduction. The surface area was more than doubled by the splitting, so that convection and radiation are correspondingly increased in the preheating effects. The burning surface is also increased by the same amount.

Assume that the splitting action is continued indefinitely until the logs are in an excelsior state and occupy a volume 30 or 40 times as great as in their original form. Convective and radiative heat transfer will be increased tremendously in the spaces throughout the whole fuel volume, and the combustion rate might be increased to a point where the fuel could be consumed in a few minutes instead of hours.

The effect of fuel arrangement can be visualized if a volume of fuel resembling wood wool, such as that just described, is compressed until it occupies a volume only 4 or 5 times that of the original volume of logs. The total burning surface and radiative conditions remain the same as before compression, but both convective heat exchange and oxygen supply are greatly reduced. There will be a corresponding decrease in fire intensity.

Fuel size and fuel arrangement have their greatest effect on the lower intensity fires and in the initial stages of the buildup of a major fire. When a fire reaches conflagration proportions, the effect on fire behavior of factors such as ignition probability and quantity of firebrand material available for spotting may be greater than the effect of fuel size and arrangement. This point will be discussed in the section on applications to fire behaviour.

The Fire Triangle

The principles of combustion may be summarized in an effective way by means of the fire triangle. This triangle neatly ties together not only the principles of combustion but illustrates their application as well. The three sides of the triangle are FUEL, OXYGEN, and HEAT. In the absence of any one of these three sides, combustion cannot take place. The fire triangle represents the basic link in the chain reaction of combustion. Removing any one or more sides of the triangle breaks or destroys the chain. Weakening any one or more sides weakens the chain and diminishes fire intensity correspondingly. The purpose of all fire suppression efforts is to remove or weaken directly or indirectly one or more sides of the fire triangle. Conversely, all conditions that increase fire intensity operate in such a way as to greatly increase or strengthen the sides of the triangle and, hence, the chain reaction of combustion. In a blowup fire the chain becomes so strong that it cannot be broken by the efforts of man. This means that when blowup conditions exist, the only opportunity to break the chain is by early strong initial attack.

Application to Fire Behaviour

It is more difficult to apply our knowledge of ignition and combustion to the behavior of very high-intensity fires, sometimes referred to as conflagrations or "blowups", than to the behavior of the more frequent low-intensity fires. The ordinary fire behaves for the most part as one would expect from the principles of combustion. In a conflagration or blowup, however, the sides of the fire triangle are greatly strengthened by factors that are absent, or nearly so, in small fires. Although these factors work through the basic combustion principles, they so greatly modify the expected effects of the basic processes that a high-intensity erratic fire cannot be considered as a large-scale model of a low-intensity fire. This is best illustrated by considering the spatial structure of the two types of fires. The height of the significant vertical structure of a low-intensity fire can usually be expressed in tens of feet. This distance is usually small compared to the surface dimensions of the burning area, so that in a physical sense the fire is "thin" or 2-dimensional as far as volume structure is concerned. On the other hand, the significant vertical structure of a well-developed conflagration may extend thousands of feet into the air, and this dimension may at times exceed the surface dimensions of the burning area.

The height that smoke rises above, or in the neighborhood of, a fire is not always a true indicator of the height of the active convection column above a fire. Smoke from a small fire may reach a height of 1,000 feet or more, but active convection may reach only a few percent of this height.

Note.—Although it is too involved to discuss in a paper on combustion, the height of the convection zone depends on the rate of heat output of the fire, the wind speed, the vertical wind shear, and the stability of the atmosphere.

It is the 3-dimensional structure of a large fire that causes it to take on storm characteristics which, in turn, produce behavior phenomena that one could not expect by scaling upwards the behavior of a low-intensity fire. However, this does not mean that scale-model fires, including small fires in the laboratory under controlled conditions, would not be useful in preliminary convection column studies. Probably experimental work on convection column properties should be started first on small scale fires. Such work might give essential fundamental information on the relation between the variables controlling the convection process.

Certain properties of the atmosphere, such as the vertical wind profile and to a lesser extent the vertical temperature profile, appear to be the controlling factors in extreme fire behavior if an extensive area of plentiful dry fuel exists. A discussion of the atmospheric factors is outside the scope of this paper, but it may be well to examine in some detail those phases of the combustion process that permit the atmospheric factors to exert their maximum effect.

Fire behavior is an energy phenomenon and its relation to the combustion process can be understood by the use of four basic fuel factors relating to energy. These are (1) combustion period, (2) critical burn-out time, (3) available fuel energy, and (4) total fuel energy. This last factor is constant, or nearly so, for any given quantity of fuel per acre. The first three are variables which, even for any homogeneous component in a given fuel type, depend on factors such as fuel moisture content and fire intensity. A fifth fuel factor, the quantity of fire-brand material available for spotting, is more or less independent of the other four and will be treated separately.

The combustion period may be defined as the time required for a fuel to burn up completely, and depends primarily on fuel size, fuel arrangement, fire intensity, and fuel moisture. It may range from a few seconds for thin grass blades to several hours or longer for logs and heavy limbs. Critical burn-out time is defined as the maximum length of time that a fuel can burn and still be able to feed its energy into the base of the forward travelling convection column; its magnitude depends primarily on fire intensity or the rate of a fire's energy output. The available fuel energy is that part of the total fuel energy which is fed into the base of the convection column. For fuels with a combustion period equal to or less than the critical burn-out time, the available fuel energy is equal to the total fuel energy. If the combustion period is longer than the critical burn-out time, then the available fuel energy is less than the total fuel energy. Total fuel energy is determined by the quantity of fuel per acre and the combustion efficiency. If the combustion efficiency is assumed to be constant, the terms "available fuel energy" and "total fuel energy" can be replaced by the terms "available fuel" and "total fuel".

An example will illustrate how fire behavior relates to the four preceding quantities. Consider a fire spreading in an area of plentiful heterogeneous fuel, a considerable part of which is in the form of flammable logs and heavy slash and the rest a mixture of smaller material such as twigs, pine needles, and grass. Assume that the critical burn-out time is about 20 minutes. Those fuel components with a combustion period less than 20 minutes will have an available fuel energy equal to their total fuel energy. However, logs and heavy limbs may require several hours to burn out, so their available energy may be comparatively low; they could still be burning after the fire had moved several miles, so would not be affecting the behaviour of the fire front.

Note.—Heat sources a considerable distance behind the main flame front could possibly have indirect effects on fire behaviour by slightly modifying the structure of the wind field.

From the standpoint of fire behaviour, a crown fire in a dense conifer stand could have more available fuel energy than a fire in an area of heavy logging slash. However, unless large portions of a heterogeneous fuel have very long combustion periods, fuel size and fuel arrangement should not have as much influence on the behaviour of major fires as on smaller fires. In a major fire a larger proportion of the heavier fuels take on the characteristics of flash fuels.

This is a combined result of the shorter combustion periods and longer critical burn-out times for the high-intensity fires. Nevertheless, fuel size and fuel arrangement contribute heavily to the rate of buildup of fire intensity, especially in the early stages, and are therefore an important part of the fire behaviour picture.

Much of the effect of fuel moisture can be interpreted in terms of the four basic fuel factors. Because moisture decreases the combustion rate, it increases the length of the combustion period. This, in turn, means that a smaller fraction of a heterogeneous fuel will have a combustion period less than the critical burn-out time. The available fuel energy and fire intensity will, therefore, drop as fuel moisture increases. For most fires there are some fuel components which do not burn because of their high moisture content; in other words, these components may be regarded as having infinitely long combustion periods.

An increase in fire intensity can greatly reduce the combustion period for those fuel components with the higher moisture contents. For some components the combustion period might be infinite for a low-intensity fire, but perhaps only a few minutes, or even less, for a high-intensity fire. For example, in the high-intensity Brasstown fire on March 30, 1953, in South Carolina, as well as in other large fires in the Southeast in the last few years, green brush often burned leaving blunt pointed stubs. In a similar manner a reduction of the combustion period from infinity to a few seconds for green conifer needles takes place when a fire crowns.

The fifth fuel factor, the quantity of firebrand material available for spotting, becomes increasingly important as fire intensity increases. Equally important is the relation between surface fuel moisture and the probability of ignition from embers or firebrands dropped from the air. This relation has not as yet been determined experimentally, but ignition probability increases rapidly with decreasing fuel moisture—hence with decreasing relative humidity. We know that the ignition probability for most firebrands is essentially zero when fuel moisture is 25 or 30 percent (on an oven-dry weight basis). We also know that not only ignition probability but combustion rate as well is greatest for oven-dry material. In addition, both of these phenomena in the lower moisture content range appear to be considerably affected by a change of fuel moisture content of only a few percent.

The importance of the relation between fuel moisture and ignition probability in the behaviour of large fires can be illustrated by a hypothetical example. Suppose that from the convection column over a large fire, 10,000 embers per square mile per minute are dropping in front of the fire. Suppose that the surface fuel moisture content is such that only 0.1 percent of these firebrands catch and produce spot fires, thus giving only 10 spot fires per square mile. On the other hand, if we assume that the surface fuel moisture is low enough for 5 percent of the embers to catch, then there would be 500 spot fires per square mile. As they burn together, these spot fires would greatly increase the rate of spread and intensity of the main fire. Thus, relative humidity (working through fuel moisture) has a 2-fold effect on rate of spread in certain types of extreme fire behaviour. First is the effect on fuel combustion rate and rate of spread of the ordinary flame front. This effect would be present on small and large fires alike. Second is the effect in accelerating rate of spread and fire intensity by increasing the probability of ignition from falling embers. This latter effect would be present only on fires where spotting was abundant. Ignition probability will also depend on other factors, such as the nature of the surface fuel in which firebrands fall and the fraction of the ground area covered by the fuels.

Fuel characteristics that make plentiful and efficient firebrands are not definitely known. The material would have to be light enough to be carried aloft in updrafts, yet capable of burning for several minutes while being carried forward by the upper winds. Decayed punky material, charcoal, bark, clumps of dry duff, and dry moss are probably efficient firebrands. Leaves and grass are more likely to be inefficient firebrands except over short distances.

The initial phases of the blowup phenomenon are directly related to the combustion process and the basic fuel factors. A decreasing fuel moisture means higher combustion rates and shorter combustion periods. There will, therefore, be an increase in the available fuel energy, or available fuel, accompanied by an increase in fire intensity. The increase in fire intensity lengthens the critical burn-out time, which means a further increase in available fuel. A cycle of reinforcement is thus established which favours growth of fire intensity. As the intensity increases, the atmospheric factors become increasingly important. It is at this stage that spotting and ignition probability may become dominant fire behaviour factors.

By using the basic fuel factors it is possible that a fuel classification method could be developed to classify fuel in terms of expected fire behaviour. It would first require a series of burning experiments to measure some of the factors and their response to variables such as moisture content and fire intensity. However, once this was done, the classification system itself might be comparatively simple. Probably its greatest value would be in estimating the conflagration potential of different fuel and cover types for different combinations of weather conditions.

There is an important difference in the energy conversion process for a low-intensity fire and a high-intensity fire. In the "thin" or 2-dimensional fire, most of the energy remains in the form of heat. At the most, such a fire cannot convert more than a few hundredths of one percent of its heat energy into the kinetic energy of motion of the updraft gases and the kinetic energy of the convection column eddies. On the other hand, a major conflagration may convert 5 percent or more of its heat energy into kinetic energy which appears in the form of strong turbulent updrafts, indrafts, convection column eddies, and whirlwinds which can carry burning material aloft. The efficiency of the energy conversion process, and hence the kinetic energy yield, increases rapidly with increasing fire intensity. This is brought about by the mutual reinforcement action in the basic fuel factors plus favorable atmospheric conditions.

In addition to the difference in the energy conversion processes in the two types of fires, there is an enormous difference in rate of energy yield. For example, there were periods in the Buckhead fire in north Florida in March 1956 when the rate of spread probably exceeded 8,000 acres per hour. The rate of energy release from this fire would compare favourably with the rate of energy release from a summer thunderstorm.

Note.—Although a detailed discussion is outside the scope of this paper, energy conversion processes in a fire can be studied by a thermodynamic procedure in which a large fire, like a thunderstorm, can be treated as a heat engine. The efficiency of a heat engine is measured by the fraction of heat or thermal energy that can be converted into the kinetic energy of motion. A 2-dimensional fire has an efficiency as a heat engine that is very nearly zero or, at the most, only a few hundredths of one per cent. A major high-intensity fire has an efficiency as a heat engine that may reach 5 percent or more.

Summary

Combustion is basically a chemical chain reaction that can be divided into three separate phases: (1) Preheating and distillation, (2) distillation and the burning of volatile fractions, and (3) the burning of the residual charcoal.

For a forest fuel, ignition is the link between phase 1 and phase 2 of the combustion process.

For most forest fuels the heat of combustion is between 8,000 and 9,000 B.t.u.'s per pound on a dry weight basis.

Heat is transferred by conduction, convection, and radiation. A fourth means of heat transfer might be defined as mass transport and is the familiar phenomenon of spotting, which becomes increasingly important on high-intensity fires.

Fuel moisture has more effect on the ignition and combustion process than any other factor.

Low-intensity fires are essentially 2-dimensional phenomena, and major high-intensity fires 3-dimensional. The third dimension of a high-intensity fire permits the conversion of part of its heat energy into the kinetic energy of motion, which changes the relative significance of the various combustion factors and greatly modifies their expected effects. For this reason a high-intensity fire cannot be regarded as a magnified version of a low-intensity fire.

The relation of fire behaviour to the combustion process can be understood by the use of a group of basic fuel factors which are (1) combustion period, (2) critical burn-out time, (3) available fuel energy, (4) total fuel energy, and (5) quantity of material available for spotting. Such a group of factors might be used to classify fuels in terms of expected fire behaviour.

If atmospheric conditions are such that one or more strong convection columns can form, the following appear to be the main combustion factors that determine the intensity and rate of spread of a major fire:

1. The quantity of available fuel energy, or available fuel, per acre. The magnitude of this quantity depends on a reinforcing relationship between the basic fuel factors. In turn, this relationship is regulated primarily by fuel size and arrangement, fuel moisture, and the intensity of the fire itself.

2. Quantity of firebrand material per acre available for spotting.

3. Probability of ignition from firebrands dropping ahead of the main burning area. This probability depends on several factors, the most important of which is the prevailing relative humidity determining the surface fuel moisture.

AN EXPERIMENT TO CONSERVE WATER USED BY A LAND-ROVER FITTED WITH A LANGDON PUMP FOR FIRE FIGHTING

By R. T. WHEELER
Forester, North-East England

This invention was the subject of an award under the Staff Suggestion Scheme.—Ed.

Foresters with vehicles fitted with the Langdon Pump and Water Tank for fire fighting may be interested in an experiment carried out with a view to conserving the limited amount of water available in the Tank.

Past experience of fire fighting in the Rothbury district of Northumberland where scarcity of water can be acute, particularly during periods of high fire danger, has shown that, while the Land-Rover carrying a 30 gallon water tank

Plate 1. Begley: Le Tourneau electric logging arch in Kaingaroa Forest.

Plate 2. Begley: Australia: *Pinus radiata*, 31 years old, with two-year-old regeneration.

Plate 3. Begley: Mechanical sorting and handling of saw logs at Nangwarry.

Plate 4. Begley: *Eucalyptus grandis*, mountain ash, 200 feet high. Little Yarra.

Plate 5. Begley: Log and Timber yard of sawmill at Imbil, Queensland.

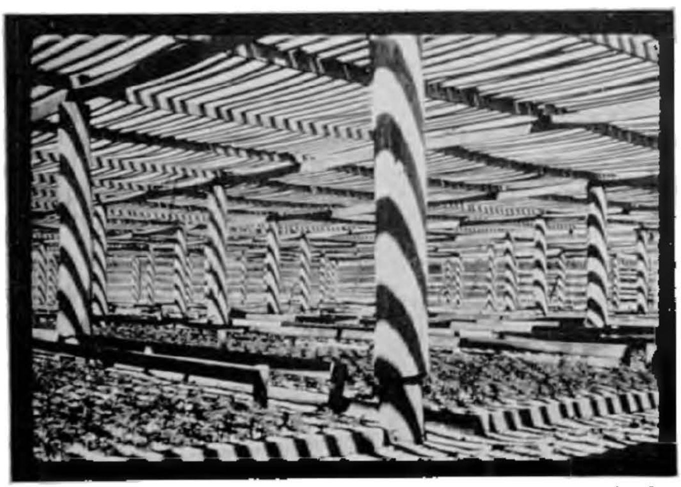

Plate 6. Begley: High shelter in nursery at Little Yabba, Queensland.

Plate 7. Feaver: America: At Watersmeet Nursery, Upper Michigan, Holland transplanting machines run along pipe steerage rails. White spruce seedlings are being lined-out at 4,000 per hour by each operator, and then receive overhead irrigation from the overhead pipe system.

Plate 8. Feaver: America: Engelmann's spruce, attacked by beetle, being salvaged in Montana. This grab type of loader does not damage the clear outer wood. A full truck load contains nearly 2,000 hoppus feet.

Plate 9. Shaw: Russia: Forest workers and their families outside the village store at Krestetsky.

Plate 10. Shaw: The Russian designed Droughba Petrol Saw. Note that the saw has handles allowing the operator to stand up whether felling or cross-cutting.

Plate 11. Shaw: An experimental machine which loads itself as the tree is felled across its back. Note that the feller has cut the trunk to fall towards the tractor, and the tractor driver is hauling-in on a front winch rope.

Plate 12. Shaw: The TDT 40 Forestry Tractor. Note that the load is carried on a platform on the back of the tractor. When loading, the platform is let down at the back, forming both a ramp up which the load is hauled, and also an anchor.

Plate 13. Backhouse: Germany: A fine example of beech regeneration, with old European larch left standing, in a communal forest.

Plate 14. Backhouse: Typical three-storeyed beechwood in Salem Forest, Baden.

Plate 15. Backhouse: Loading big European larch logs with winches in Eberstein Forest.

Plate 16. Goodland: Heavy Timber: Felling a great elm in Hampshire.

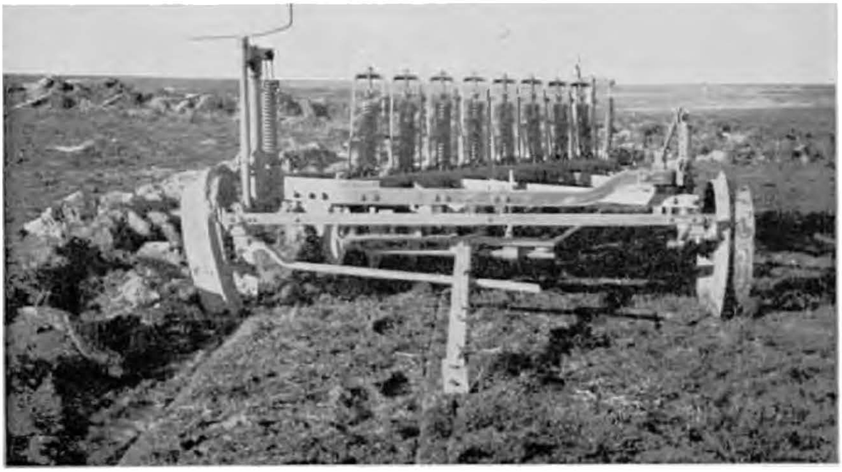

Plate 17. Stewart: Majestic Stump-jump Disc Plough: Front view.

Plate 18. Stewart: Majestic Stump-jump Disc Plough: Rear view showing character of work.

Plate 19. England: Knapsack Sprayer: Details of Supply point connections.

Plate 20. England: Filling the sprayer.

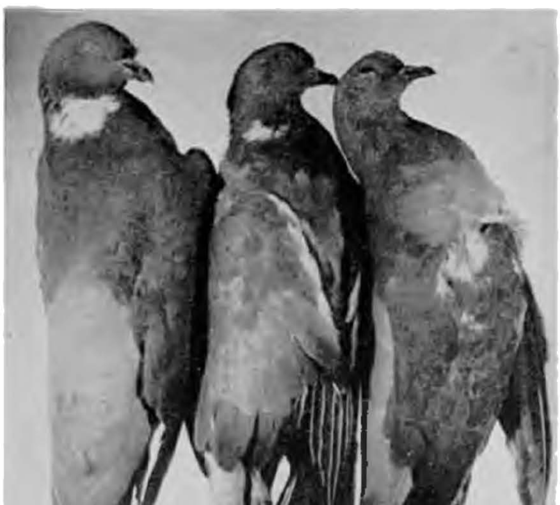

Plate 21. Robertson: Wood Pigeons: A, adult; B, early-hatched young; C, late-hatched young bird.

Plate 22. Blankenburgs: Waterways: A forest road bridge in danger, because the waterway is too small.

Plate 23. Blankenburgs: A flood on a forest road, due to the use of too small a culvert.

Plate 24. Findlay: Scots pine shoots damaged by a hormone weed-killer sprayed on a cornfield nearby, during the preceding summer.

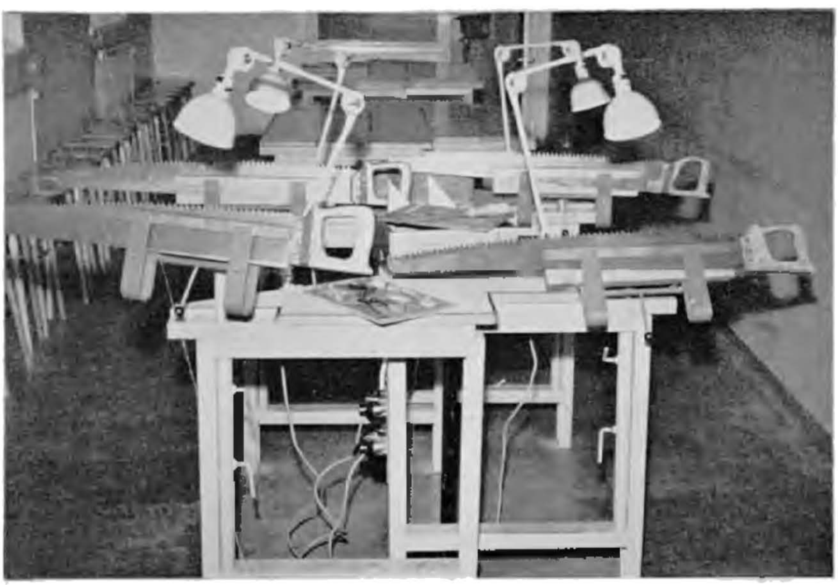

Plate 25. Dickenson: Forest Work in Sweden: Group of four tool-sharpening benches at Kratte Masugn Forestry School.

Plate 26. Fire Danger Sign on the roadside at Wareham Forest Dorset

Plate 27. Worsley: The smoke of a forest fire as seen from Alice Holt look-out tower.

Plate 28. Worsley: Fire brigade going into action at Alice Holt.

Plate 29. A souvenir of the Lynford Hall Forester Training School, closed in 1957. District Officer R. G. Streets instructs a class in meteorology in 1950.

Plate 30. Scholars at the new school in Glen Trool Forest Village.

Plate 31. Brewster: Staple Howe from the east.

Plate 32. Brewster: Staple Howe from the south-west.

Plate 33. Brewster: View of western end of Staple Howe.

Plate 34. Brewster: Excavations in progress on the eastern end of Staple Howe.

Plate 35. Brewster: Section of palisade trench on south-eastern end of Staple Howe.

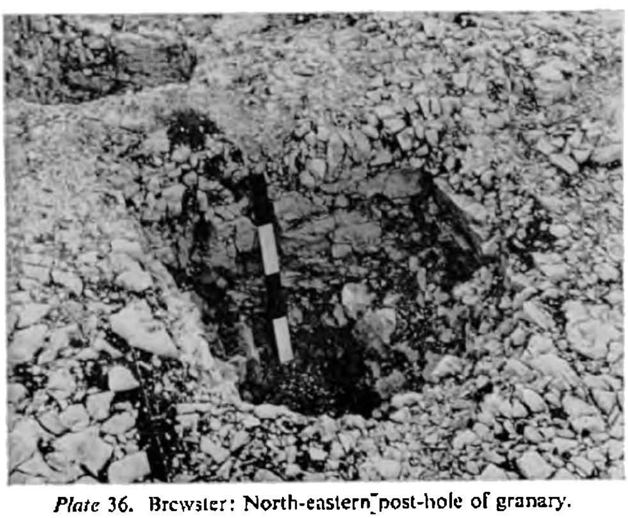

Plate 36. Brewster: North-eastern post-hole of granary.

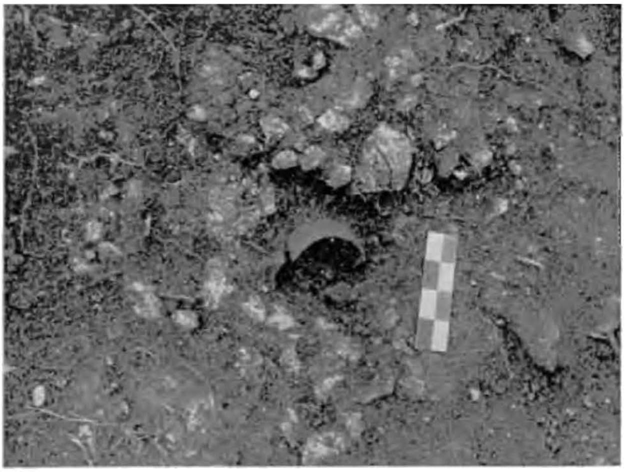

Plate 37. Brewster: Staple Howe: Broken pottery lamp *in situ* on floor of oval hut.

Plate 38. Brewster: Ox skull rammed into palisade as extra packing.

Plate 39. Brewster: Human skull, red deer antler, and ox bones.

could do valuable work attending moorland fires, it was sometimes necessary to lose several valuable minutes, away from the actual scene of the fire, travelling some distance to the nearest stream or static water supply for a tank refill.

It was also found that the volume of water discharged by the Hathaway Pistol Nozzle normally fitted, though excellent under certain conditions, particularly when dealing with fires in very long heather or taller vegetation, was greater than that really needed for short vegetation. The rate of discharge was such that the tank emptied in 6 minutes continuous pumping. It was felt that a much finer spray than is possible with the Hathaway nozzle would be more effective both for damping down the actual flames and conserving water.

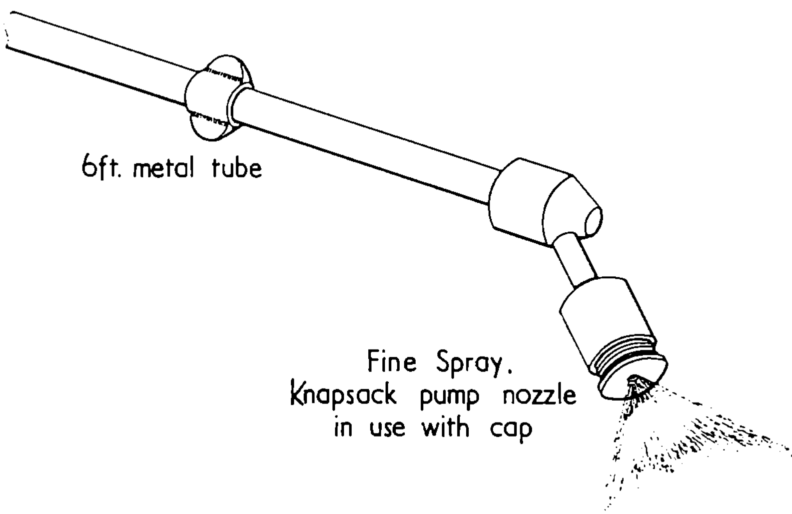

Fig. 2. Fine spray arrangement.

With the aid of the Mobile Mechanist who provided a 6 foot length of $\frac{1}{2}$ inch metal piping suitably threaded at one end to take a Knapsack Pump nozzle (see Fig. 2), experiments to produce a suitable spray were started.

The Hathaway nozzle, which was attached to a plastic delivery hose from the Langdon pump by a small Jubilee clip, was removed and the 6 foot metal tube with the Knapsack pump nozzle attached by the same Jubilee clip to the hose.

At first the spray produced was too fine and immediately blew away as a light mist.

By enlarging the nozzle outlet hole from $\frac{1}{16}$ inch to $\frac{1}{10}$ inch, however, a suitable cone-shaped spray was obtained, giving a solid funnel-shaped wall of water up to 9 inches from the nozzle before breaking up into a fine spray heavy enough to fall to the ground from a height of about 2 feet.

With the engine of the Land-Rover running on the hand throttle, at the same speed as that by which the tank emptied in 6 minutes continuous running when using the Hathaway nozzle, it now took 31 minutes to empty.

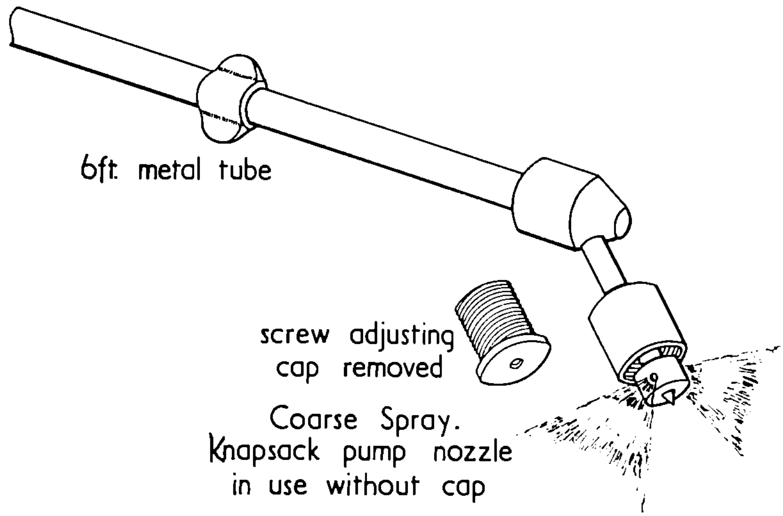

Fig. 3. Coarse spray arrangement.

If a heavier spray was required this could be provided by removing the screw adjusting cap from the outlet end of the nozzle (Figs. 2 and 3) which then gave double the amount of spray, emptying the tank in 16 minutes.

It was necessary, of course, to keep the nozzle close to the actual fire to be effective, but this did not expose the operator to intolerable heat, as he held the nozzle at the end of his reach on the 6ft. metal tube. In fact, should he have found himself dealing with heat greater than he was able to bear, the time would have come to revert to the Hathaway nozzle, which was always carried and easily exchanged in a few seconds by loosening the Jubilee clip with a screwdriver.

It has been suggested that an instantaneous coupling could be fitted to the inlet end of the metal tube, thus dispensing with the Jubilee clip and need for a screwdriver when changing from or to a Hathaway nozzle.

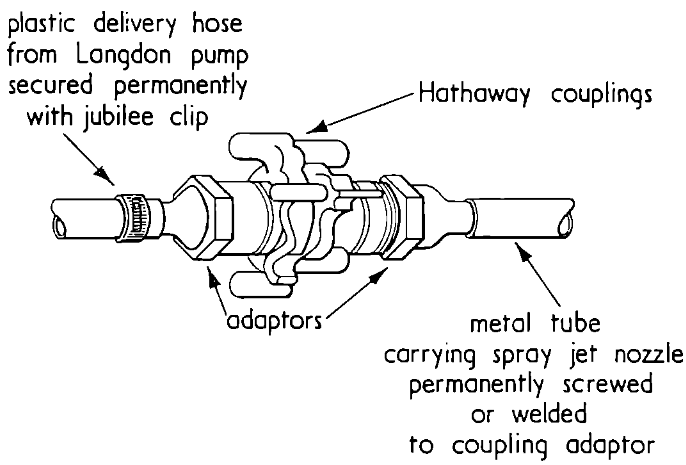

Fig. 4. Coupling arrangement.

This would be a great improvement although necessitating a pair of Hathaway couplings, similar to those already used on normal 60ft. delivery hose, being adapted to fit the ½ inch plastic delivery hose from the Langdon pump on the Land-Rover on one side, and the ½ inch metal tube on the other (see Fig. 4).

Such a coupling would also enable the spray nozzle to be fitted to any length of normal fire hose, instead of the Hathaway pistol nozzle. Similarly, standard fire hose could be coupled to the Land-Rover Langdon pump if required. In the event of the Land-Rover being unable to get close enough to the fire. one or more 60 ft. lengths of hose attached to the pump may save the day.

The occasion may also arise when a boosting pump is required for pumping long distances or over steep hills. With Hathaway coupling attached the Langdon Pump could be used for that purpose.

SUPPLY POINTS FOR KNAPSACK SPRAYERS

By. J. W. ENGLAND

Assistant Forester, South Wales

[See Plates 19 and 20—Ed.]

The development of Fire Equipment for use at Forest Fires is a continuous process, and as part of that process the item of equipment described in this article suggests a further step towards the speedier control of fires.

The expansion of the Forest Road Programme has facilitated the installation of Static Water Supply Tanks, they can be installed more frequently and maintained more economically and easily. Consequently the practice of using water in conjunction with other methods, e.g. beating, is becoming more widespread.

The use of the knapsack sprayer to follow up beating as a normal method of attack means that an adequate supply of water must be immediately available for refilling, as much valuable time is lost when the main jet is interrupted for this purpose. To avoid this without incurring any extra loss of time by undue walking and the necessity to direct the operators, I have made a simple item of equipment which is effective and easy to use. It is also cheap to produce.

It consists of a short length of canvas hose 3 feet long, fitted at one end with a standard bayonet coupling and at the other end with a simple tap of small bore, both secured with Jubilee clips. The equipment can be inserted anywhere along the length of hose between the pump and the delivery nozzle by means of the standard 'Y' coupling (it has therefore, the extra advantage of being readily located). It is essential that a tap of small bore is used as this prevents any undue loss of pressure at the nozzle of the main jet. A ½ inch bore tap fills a Wizard type Knapsack Sprayer in under ten seconds.

A VISION OF F.Y. 85 OR FIRE PROTECTION FANTASY

By. M. R. W. WILLIAMS
District Officer, South Scotland

Outside it was hot and dusty, although the newly opened leaves on the trees proclaimed it to be only early May. Inside the long, low building it was cool and in the large room the light was dim. Seated in the room were four people. two men and two women. Each was anxiously scanning a series of telescreens on which appeared a moving panorama of wooded countryside.

Joe McTaggart, the older man in the room, stared nostalgically at the wooded hills and valleys appearing in front of him. He was remembering how as a young man in the 1950's he had watched these same hills through field-glasses from the top of a high tower. It was certainly much easier now to sit in this darkened room some 20 miles away and see the whole forest spread out in front of him, instead of laboriously climbing over the plough furrows to the top of the hill. However, he missed the clean invigorating air of the mountains, the smell of bog-myrtle and heat baked pine needles.

Suddenly he stiffened, on the third screen in the second row he saw a wisp of smoke curling up from the edge of a ride. Grabbing the controlling knob he stopped the regular movement of the television scanner and adjusted it until the smoke coincided with a vertical line in the middle of the screen. Reading off the bearing at the foot of the screen, he pressed down a switch and spoke to the Controller in the next room. "Smoke on B.3., bearing 056" he said crisply into the microphone. "Rightho, Joe" replied the voice of the Controller "see if you can get a correlation on C.5". McTaggart transferred his attention to the fifth screen in the third row and watched carefully until the same point came into view and then saw the same tell-tale smoke curling up. "Bearing 237 on C.5" he said into the microphone.

In the next room, John Smith, the Fire Controller strode across to a large map on the wall and pulled two cords across until they coincided. Jotting down the Grid Reference on a pad he switched the radio set in front of him to 'transmit'. When it had warmed up he spoke "Fire Control to Bentrool, smoke visible at Grid Reference 325400, north edge of ride between compartments 25 and 26. Please investigate and report". "Bentrool answering, Roger", came the reply.

Walking over to another wall, he put over a switch and adjusted a knob until the whole of the wall carried an enlarged image of the views on telescreens B.3 in the next room. He drew the curtains to make the picture clearer, sat down again and lighted his pipe.

Twenty miles away in the Forest Office at Bentrool, the mounting tension had been broken by the message on the radio. Andrew McIntosh, the Head Forester, turned to his assistant John Bright and said "Take the Skyrover and have a look at some smoke reported between compartments 25 and 26". Hardly pausing to answer, John ran outside to the waiting Skyrover. In a matter of seconds the rotor blade was revolving and the green-painted machine rose gracefully over the office and headed out over the valley towards the reported fire. Soon he saw it and circling low landed on the ride beside the source of trouble. Switching on the electric pump, he jumped out dragging a length of light hose with him and began spraying the fire. However, he could tell that without assistance it would get out of hand and ran back to his machine to report. "Hello Mr. McIntosh" he said into the microphone, "I shall need some assistance. Please send the duty fire crew with beaters and light pumps".

Within five minutes, while John had been keeping the fire at bay as best he could, a heavy Bedford Rotortruck came sweeping in to land beside the Sky-rover. Out jumped 20 men with powerful knapsack sprayers and mechanical beaters. In a matter of minutes the fire was out.

It hardly needed McIntosh's triumphant message on the radio to say that the fire was out to let Smith know that all was well, for he had been watching the whole drama on the wall of his office. He had seen Bright's gallant efforts on his own and the arrival of the fire crew as if he had been there.

The minor excitement over, the firewatchers continued their steady watch over the screens as the mechanical scanners swept slowly over the countryside.

"Time for the midday reading" thought John Smith, looking at his watch. Stepping across to a control panel, he put over a number of switches, each below a dial. He carefully noted in a book the various readings of temperature, humidity, rainfall, etc., from a number of panels, each representing an automatic meteorological station situated from 10 to 30 miles away. Pressing a master switch on this panel sent out a radio-wave which caused a relay in the distant station to trip, thus switching on its transmitter. The information from the instruments at the station was thus automatically relayed and could be read off the dials in this room. Having noted the information from the various stations, Smith then moved over to another instrument and set the dials to the figures noted in his book. He switched on and waited for the machine to warm up. After perhaps half a minute, a high pitched whine could be heard which suddenly stopped with a loud click. A red light came on and the pointer suddenly swung round to the figure 2. "No change" he muttered to himself as he went over to the radio on his desk. Switching it to 'transmit', he spoke "Fire Control calling all units. Fire Hazard for this afternoon will be Grade 11. Take all necessary precautions. Answer by turn, over". Each of the fifteen units then acknowledged the message in turn.

Telling the firewatchers in the next room to keep their eyes skinned, he opened his packet of sandwiches.

VOLE DAMAGE 1956/57

By W. A. CADMAN

Divisional Officer, Directorate for Wales

In Wales, with the exception of pockets mostly on the high ground, rabbits were eliminated by myxomatosis in 1954. This had two important results which have a bearing on the vole population. There was a rapid reduction in the numbers of predators. Many failed to breed during 1955, a year when weather conditions during the spring were also very adverse. Whilst this was going on there was a rapid and marked acceleration in the growth of vegetation, hitherto kept in check by rabbits. The summer and autumn of 1955 were warm and dry, which led to heavy seed bearing of many plant and tree species, mostly in the following year (1956).

All these conditions were favourable for a rapid increase in the vole population. In fact, the increase rapidly reached plague level in 1956 and this was more widespread, throughout Wales, than any previous vole plague within living memory.

Normally, where vole numbers reach plague conditions, a peak is reached during the lean months of the early spring of the following year, and thereafter there is an almost complete disappearance. To some extent this normal pattern was followed towards the end of March 1957, and numbers did fall sharply. But the very mild winter, combined with an exceptionally early spring (when growth of vegetation was a month or six weeks before its normal time) were favourable factors for the survival of voles. There is no doubt that some in most places, and many in some places, did survive, and odd cases of damage have occurred during the summer of 1957.

Distribution

In the past in Wales, within the knowledge of the Forestry Commission, there have been several severe vole plagues. But they have been confined to the hill ground and these plagues have occurred in relatively isolated areas.

The 1956/57 plague was widespread. Plague conditions occurred within every district in Wales. Even in Anglesey voles have been present in plague numbers and serious damage has occurred, in places.

An unusual feature has been the fact that the plague has not been confined to the hill ground, or to *Molinia* areas, as in past instances. Numbers have been excessive in all types of country, including woodlands, pastures, nurseries and gardens at low elevations. Even dense bracken areas have been very seriously affected, which is unusual. In sand-dune areas numbers have been less than elsewhere.

Types of Damage

In nurseries very serious damage has been done to seed beds of Sitka spruce, Japanese larch, European larch and to lines of red oak. In places two year Sitka spruce has been cut off as if by shears.

In the plantations every type of damage has occurred including girdling the root collar, the main stem, the roots (particularly in the case of Norway spruce) and the side branches; gnawing through at ground level (this has occurred to trees 7ft. and 8ft. high) and nibbling the tips of the growing shoots without girdling.

In many cases trees planted during the 1957 season were eaten within twenty-four hours, losses being up to 60 per cent, even in Sitka spruce.

In most cases damage has been confined to plantations under four years old.

Damage to different species was by no means consistent in different areas, but a broad assessment by species is:—

Beech	Most universally attacked of all species. Trees up to six years old and 7ft. high being affected, in places.
Red Oak / Oak	Both very severely damaged with possibly some preference for red oak.
Chestnut / Ash / Sycamore	Odd cases reported, but these are not species which have been much planted.
Lawson cypress	This species was attacked more readily than any other conifer.
Norway spruce	In South Wales attacks on Norway spruce have been rather more widespread than in North Wales, where the incidence of damage has not been so proportionately heavy as in previous vole plagues. (But in South Wales there are fewer "other species" available.)

Thuya, Hemlock	Both seriously attacked, where present in young age-classes.
Japanese larch	Damage to Japanese larch has been more serious in South Wales than in North Wales. Trees up to 6ft. high have been killed. Damage has occurred in eight districts.
Sitka spruce	In many cases Sitka spruce has not been damaged. But where it has been attacked very heavy losses have been inflicted. In most cases damage has been confined to small plants only just planted (and to nursery seedlings).
Douglas fir	Douglas fir has been affected in a few instances, mainly in newly planted areas.
Abies grandis	There has been one case of damage to *Abies grandis* four years old. Probably more would have come to light, if it were a species more widely used.
Abies nobilis	No damage has been reported.
Pines	Without doubt, pines are attacked by voles less than any other conifer. There has been one case where Scots pine five years old and 5ft. high was stripped of bark, even into the branches. Corsican pine, lodgepole pine and maritime pine have all suffered damage, but cases reported have been very few.
	Of the unusual species, *Metasequoia*, *Sequoia* and *Cryptomeria* have been shown to be very susceptible. There has been one case of damage to poplars.

Control Measures

Predators have exercised a certain amount of natural control. Short-eared owls were unusually numerous throughout the winter months. Foxes were feeding mainly on voles during the winter and early spring. As many as eighteen voles were found in a fox's stomach. The result of this easy living was that vixens produced very heavy litters of up to ten cubs. Stoats and weasels appear to be more numerous.

Two main methods were used in Commission forests. Where the voles were concentrated, warfarin was put down in various forms (Ramicide and Rami being frequently used). Some dead voles were found and in some cases the apparent success was considerable: but, it was impossible to assess how much the apparent reduction was due to poison and how much to the natural recession which took place in March.

The other method involved the use of repellants such as animal oil and bitumen emulsion. Here again the apparent success was masked by the natural recession of voles, and the alternative food supply as the vegetation came into growth, abnormally early.

In some areas voles were trapped by sinking old tins and jam jars in the ground.

THE NATURAL AND ARTIFICIAL CONTROL OF VERTEBRATE PESTS OF AGRICULTURE

By DR. I. THOMAS

Ministry of Agriculture, Fisheries and Food

(*A paper read at the British Association Meeting, Sheffield,* 1956)

From palaeolithic times man has left his imprint on nature—he himself is part of the natural scene, indeed, part of the animal kingdom; hence biologists regard the term 'balance of nature' with a certain amount of misgiving. Do we say that nature was balanced before man exerted his influence, or do we say that nature was balanced before, say, rabbits were introduced into Britain?

Many examples of man's interference with nature are quoted by Taylor (1955) in a talk on 'The adverse effects on animal life brought about by man's interference with nature'. It can be argued that the very appearance of the rabbit in this country can be put down to man. The extent to which man has changed the natural scene will be fully appreciated by anyone who has read *Dawn in Andromeda*, by E. C. Large.

In a book on the Balance of Nature, in 1909, George Abbey described vermin as 'wild animals of carnivorous habits, called ground [vermin] and wild birds of a rapacious nature, termed winged [vermin]' and many people would still define this dangerous word in the same way today. The dictionary says, 'mammals and birds injurious to game, crops, e.g. foxes, weasels, rats, mice, voles, owls, etc.' But throughout the length and breadth of the country there are differing shades of opinion as to which animals are beneficial, which harmful and which are vermin. If then we argue that land should be used solely for the production of food, both animal and vegetable, and that the maximum should be got out of every acre irrespective of housing, or factories, or defence, or amenities, or sport—then stoats and weasels immediately become beneficial. At present they are regarded as vermin because they kill ground game and winged game. Jays and magpies are vermin because they take the eggs of game birds, but stoats and weasels are among the chief predators of the rabbit, and stoats may take the eggs of the wood-pigeon. The wood-pigeon may also be kept in check by the jay and magpie, and even the grey squirrel may, on occasions, be beneficial in this respect. For the purpose of my talk, however, I have in some arbitrary way to distinguish between those animals which I believe to be harmful to agriculture and those which are beneficial, and I am going to deal specifically with the two most harmful, namely, the rabbit and the wood-pigeon.

The Rabbit

The rabbit itself is an introduced species—it is believed to have been introduced by the Normans (Thompson & Worden, 1956). Such an event as the introduction of an important new species into a community, is clearly a change in the balance of nature. What has this meant to agriculture? At first wild rabbits were kept in small communities in circumscribed warrens and they were not unreasonably regarded as a useful additional source of food because they did not take the place of animals which were more economic and better converters of herbage. Warrens were usually constructed in coastal areas and along the boundaries of parishes where the activities of the rabbits would not impinge upon agriculture as then practised. In the Middle Ages rabbits were regarded as a delicacy and their value as food was very high.

In the United Kingdom a rough balance-sheet has been drawn up (Thompson & Worden, 1956). On the credit side the rabbit may be said to have been worth about £15 million per annum to the community; this includes the meat value, the fur value and the value of the finished products produced from the fur. The value of the raw material was only a fraction of the total and the income from rabbits actually received by agriculture was probably less than £2 million per annum.

In addition there are on the credit side certain intangible factors the value of which it is difficult to estimate—the pleasure afforded to children by the sight of live bunnies—the sport they afford to many a countryman, the training of gun-dogs and the additional protein which might not otherwise be consumed. Last but not least perhaps I should add that the shooting of rabbits is possibly the townsman's easiest method of satisfying his primeval hunting instinct. Put a townsman in the country and it is surprising how quickly he gets the habit of walking around with a gun—after all, most townsmen are only one or two generations removed from the country. The question is—how much are we as a country prepared to pay for these pleasures? In France members of La Chasse come from town and country and freedom to 'hunt' was one of the rights fought for in the Revolution.

On the debit side the damage to crops has been variously estimated at between £45 million and £60 million per annum. This includes damage to trees—the annual cost of protecting 750,000 acres of State-owned plantations is about £500,000. The damage to cereals carefully calculated as a result of statistically conducted experiments throughout the country was of the order of 5 per cent per annum of the cereal tonnage. The average yield of spring wheat, for instance, from unprotected plots was 15.2 cwt. per acre as compared with 18.2 cwt. per acre from protected plots. The damage to grassland can be estimated only from a few experiments. In West Wales, for instance, in one experiment the increase in weights of lambs on rabbit-damaged plots was 263 lb. compared with an increase of 521 lb. on rabbit-free plots. Similar figures were obtained at Wye where the increase of weight of sheep on rabbit-grazed plots was 64 per cent less than on rabbit-free plots. The total loss of herbage from rabbits is thought to equal the losses to cereals.

To these figures must be added a considerable sum necessary for the repair of ditches and banks, the depreciation of the value of land and the possible role of rabbits in the spread of certain important diseases of domestic animals.

How did this situation arise?

Rabbits eventually spread from the warrens into cultivated and well-cared-for land. At first, however, they were kept in check because the land was mostly in the hands of small or large estate owners and it was usually well keepered. Rabbits were snared, ferreted and netted; hares were usually present in some numbers and winged game was well looked after. Subsequently, when rail transport became cheap and the demand for rabbit skins and carcases increased, the trapping of rabbits became a remunerative occupation, and particularly during the First World War open trapping with the steel gin trap led to much increased catches. When such trapping started on farms in Carmarthenshire, for instance, foxes, weasels, stoats, cats and dogs were usually caught in some numbers, in addition to rabbits. Buckley (in Kirkman, 1934) has, for instance, cited the case of a farm in Pembrokeshire of about 250 acres, where on the first trapping only 250 rabbits were caught, but there were in addition twelve foxes, between thirty and forty weasels and stoats as well as cats and dogs. In subsequent years, 5,000 rabbits were caught annually on this farm, the hedges and fences became dilapidated and the farm became more or less a ranch. Where previously the rent of the farm was £1 an acre, following the increase of rabbits it could not be let at 5*s*. an acre. On another farm of about eight acres, in the first round the trapper caught twenty-one cats. During the First World War trapping thus became an industry in West Wales to the detriment of farming and other field sports in the area. This has been attributed by Buckley to the use of the steel gin trap, and striking confirmation of this view has been obtained in a few preliminary experiments we have done on the open trapping problem. In one experiment, using a gin and a humane trap in the open, we caught thirty-seven rabbits; but in addition to a few birds we also caught three grey squirrels, three cats and one pole-cat. There was in addition evidence that the traps had caught but failed to hold two foxes, one badger and a few domestic animals, to say nothing of one farmer!

It is possible that the killing of a comparatively small number of predators would allow the rabbit population to build up to numbers which would become out of hand; the result would soon be the disastrous condition known as rabbit-farming. Quite apart from this aspect of trapping, other considerations tend to favour the build-up of the rabbit population. For instance, trapping is done only to take off the 'cream' of the 'crop', with sufficient residue being left for breeding up quickly in subsequent years and, what is more, it has been shown that by intensive snaring following gin trapping in the open, many more does are caught than bucks. In areas where rabbit-farming was practised, individual farmers attempted to stand out against these measures, but usually they had to succumb to pressure from all around them because of the very large numbers of rabbits moving in from neighbouring farms. Matthews (1952) in his book on British Mammals also makes the point that the great increase in the trapping of rabbits has been responsible for the decrease in predators. Of stoats, he states that in south-west Wales, they have been locally, but probably only temporarily, completely exterminated. The destruction of carnivores, he says, 'dates from about the middle of the last century or a little before, and its onset coincides with the introduction of the steel trap or gin. Whatever may be said about trapping animals, it cannot be denied that this is a cruel device that has been responsible for the death of great numbers of the predators as well as of the prey'.

It is difficult to tell whether myxomatosis comes under the heading of natural or artificial control. It was anticipated that as a result of the calamitous decline in the rabbit population due to myxomatosis, foxes would become hungry and would attack domestic animals on an increasing scale. It is known, for instance, that over a period of years the numbers of foxes killed in Wales by Fox Destruction Societies may be measured in thousands. The figures are: 1949, 7,739; 1950, 8,321; 1951, 7,072; 1952, 6,463; 1953, 5,105; 1954, 6,307; 1955, 8,004.

It was also known from some work done by Southern & Watson (1941) that in an area where rabbits were numerous, some 50 per cent of the diet of foxes consisted of rabbits. One would have thought then that if rabbits were taken away foxes would be adversely affected. It was natural, therefore, to step up work on the control of the fox, and this was done. In 1955, 8,004 foxes were destroyed by Fox Destruction Societies in Wales, but this figure is lower than 8,321 foxes destroyed in 1950. I think the reason why we have not had large numbers of hungry foxes and serious depredations on domestic animals is the fact that the fox is a most omnivorous animal, and I think when rabbits are available it will feed on rabbits, when rabbits are not available it can still fend for itself. For instance, in some preliminary work we have done on the fox diet, there had been a considerable increase in the numbers of the short-tailed vole and the brown rat eaten, and the amount of vegetable matter had also increased. Indeed some vegetable matter was found in 57 per cent of the stomachs examined.

The effect of increased growth of wild herbage has been studied in detail by Dr. A. S. Thomas of the Nature Conservancy. But an incidental effect of this increased herbage will probably be a large increase in the population of voles (*Microtus* species). Up to 1956 this had not occurred, but I think it is very likely that if the rabbit population is maintained say at about a quarter of what it was before, we shall then have periodic increases of the vole population with a flare-up of damage to young forest trees.

This history of virus diseases such as myxomatosis generally follows a set pattern. The virus itself becomes attenuated, and the host builds up its resistance. We all imagine that this will also happen in the case of myxomatosis and there is evidence that it is taking place in Australia.

What are the remaining factors that tend to check the rabbit population? A natural population regulation factor of some importance was discovered by Brambell& Mills (1947, 1948), who found in Caernarvonshire that in the early part of the season some 60 per cent of all the litters conceived were resorbed. But it is likely that this factor becomes economically significant only when the numbers of rabbits are quite beyond those which can be tolerated by good farming.

Of the diseases of the rabbit, liver-fluke is probably one of the most important, not altogether because of its effect on the rabbit but because it parasitises domestic animals, including sheep and cattle. Only occasionally does the rabbit population itself suffer and then only in wet habitats where the intermediate host, the mud snail *Limnaea truncatula*, is able to exist in sufficient numbers to be a reservoir. Both nematodes and cestodes also occur in the rabbit and, here again, these parasites are of significance because the rabbit is an alternative host. This is especially true of the larval stages of *Taenia pisiformis* and *T. serialis*.

Other diseases just worthy of mention are coccidiosis, which probably exercises some degree of control, necrosis of the liver, rabbit syphilis, toxoplasmosis and tularaemia.

There remains for me to mention a few artificial methods of control. Rabbit-proof fences can be of value only in confining rabbits to small limited areas or keeping them out of small areas—on a large scale they break down because of the impossibility of supervising adequately every yard of fence as frequently as necessary. This has been proved up to the hilt in Australia where the enormous barrier fences failed to check the advance of the rabbit.

Then there is shooting and ferreting, which are both useful adjuncts to other methods, and repellents, which at best are palliatives. Gassing is perhaps the most efficient method for use in Great Britain but it needs to be done with great care and thoroughness. Best of all is good farming and avoidance of the temptation to combine farming with game preservation to the extent that the latter becomes as important as farming itself.

The Wood-Pigeon

Where rabbits have been seriously reduced, wood-pigeons are now perhaps the farmers' greatest vertebrate pest. But as with rabbits it is probably true to say that man has created just those conditions which have allowed pigeons to flourish and multiply. In the course of hundreds of years and intense cultivation, man has not only changed the character of the countryside but in some instances he has produced in profusion the food required by certain animal and bird species. In the case of the pigeon he has recently increased the breeding habitat preferred by the species. Forest and woodlands have been planted on a large scale and although the pigeon does not favour building nests deep in forests, it relishes the conditions produced along the periphery. Man has planted—and this within comparatively recent years—enormous acreages of the foodstuffs preferred by pigeons, that is, brassicas and—perhaps in a more restricted area—peas. In the Eastern Counties peas have become a most important and lucrative crop for the farmer. The gross returns from some pea crops may be as much as £140 per acre. A farmer is therefore prepared to pay quite large sums of money to ensure that such a crop is harvested and naturally he brings all the pressure he can to bear on the scientist who is working on the control of such a pest. The farmer is usually prepared to co-operate fully and enthusiastically with the research worker, but he is usually a bit worried about what his neighbours will think if there is only just a small possibility of game birds being accidentally killed in the process of trying to find measures for combating the pigeon pest.

The annual mortality of adults of most birds is very high and varies from 30 to 60 per cent, and that of eggs and young is higher, being in the region of 70 per cent in the wood-pigeon. Any control measure, therefore, which has as its aim the killing of eggs or young, is likely to leave little impression unless it is very efficient and, to a lesser extent, the same applies to the killing of adults. For instance, in the year ending December 31, 1955, over 2½ million wood-pigeons were said to be killed by shooting, and in the first quarter of 1956 it is estimated that as many as 445,000 pigeons were killed in England and Wales. Admittedly these are estimates, but even if half this number were killed, it is, indeed, very large. In this quarter the expenditure on cartridges alone was probably over £28,000 and the subsidy on these is about 50 per cent. In a few years, therefore, it is easy to see that wood-pigeons have cost the country large sums of money. It is not yet possible to assess the damage with accuracy but sampling experiments are now being made.

Other methods of dealing with the pigeon are by scaring and by the use of narcotics; nearly all birds learn so quickly that any method of scaring has to be very frequently changed in order to stand any chance of being successful even very locally for short periods. As to the use of narcotics I can only say that we are at the stage where we know we will have to learn far more about the habits of the pigeon before this method is likely to be successful.

Of the diseases of pigeons the most common are pseudotuberculosis, caused by a *Pasteurella*, pigeon pox, coccidiosis and avian tuberculosis (Mc-Diarmid, 1948). Although locally a number of pigeons may be killed by one or more of these causes, I do not think any of them is likely to become an important factor in the control of the species.

Here then the choice before us is: (1) to revert to the old balance whereby there were fewer breeding sites; (2) to disperse far more widely the crops which are attractive to the species; (3) to control the bird by artificial means. I suppose this is a case of Hobson's choice, but it is certain that any artificial means that are devised will have to be drastic and large numbers of birds will have to be killed if farmers are to see the benefit in reduced losses to crops. With insects, for instance, it is possible to control a pest on one particular field. Even with rabbits it is possible to control a pest on one particular estate, but with pigeons the whole of the pigeon population of the country probably has to be affected before a beneficial result is obtained.

The theme of my talk seems to have been that man has himself induced, or at least created, the conditions for changes in the balance of nature. As Taylor put it, 'There can be no doubt that the arrival of man was one of the worst calamities that ever happened to all the creatures of this lovely earth'. It is, therefore, up to man to look ahead and to foresee and avoid the consequences of some of his actions instead of wasting his substance in vain attempts to remedy dangerous situations of his own creating.

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THE WOOD-PIGEON PROBLEM

By DAVID ROBERTSON

The North of Scotland College of Agriculture, Aberdeen

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One of the most interesting and controversial problems connected with the wood-pigeon is the huge winter flocks which many believe are reinforced by migrants or 'foreigners' from abroad.

In order to get some up-to-date information on the winter movement of wood-pigeons in the north-east of Scotland, I enlisted the help of Mr. F. S. A. Oliver, Conservator, East Conservancy, Forestry Commission. His area stretches from Moray to Fife and comprises a total of 125,000 acres of woodland, of which 40,000 acres are spruce at a suitable age and density for wood-pigeons breeding. It is divided into 54 forests each with a forester and a trapper.

Frequently the blame for excessive numbers of wood-pigeons is laid at the door of the Forestry Commission so that a questionnaire to their foresters could hardly fail to arouse interest. Such, in fact, was the case for out of a total of 54 questionnaires dispatched on 29th November, 1955, all were completed and returned within a month. In addition, three replies were received from a forester in Fife who had handed copies of his questionnaire to the members of a shooting syndicate. I am greatly indebted to Mr. Oliver and his staff for the information they have put at my disposal.

The first question addressed to the foresters was: "*Do you consider the wood-pigeon to be on the increase or decrease?*" Fifty-three per cent. said they were on the increase, nine per cent. on the decrease and 36 per cent. no difference. Slightly more than half are therefore of the opinion that the wood-pigeon is on the increase.

The second question was: "*When do you notice large flocks of wood-pigeons?*" Eighty-two per cent. said late November-beginning of December; 18 per cent. said in late November and also again in the spring. There appears to be general agreement, therefore, on when large flocks are seen. The spring increase is an interesting observation and I intend to discuss it later.

The third question to which an answer was invited was: "*Do you believe that your area suffers from an influx of 'foreign' wood-pigeons and if so when does the influx occur?*" Forty-three per cent. said there was an influx of 'foreigners', 44 per cent. said no influx and 13 per cent. were not prepared to express an opinion. All of the 43 per cent. who stated there was an influx of 'foreigners' stated that it took place in November-December.

The fourth question was: "*The so-called 'foreign' wood-pigeon is said to be smaller, darker in colour and without the distinct 'bloom' of a home-bred pigeon. Do you believe this to be the case?*" Forty-three per cent. answered this question in the affirmative, 20 per cent. said there was no difference and 37 per cent. did not know and were not prepared to pass an opinion.

Two foresters and one shooting tenant of a forest sent in specimens of 'foreign' wood-pigeons. In the first case the bird was a young wood-pigeon; in the second case two birds were sent, one a young wood-pigeon and the other a stock dove; in the third case two birds were sent, both young wood-pigeons.

In the past, I have had several 'foreign' wood-pigeons sent to me, all of which had the typical feathering of a young wood-pigeon, namely, absence of white neck marks, dark slate grey and brown-tipped wing feathers. It should be noted that a young wood-pigeon, especially if it is late hatched, may take a year to develop the typical plumage of an adult bird. This question of the identity of the 'foreign' wood-pigeon is a leading one, because there are many sportsmen who insist that they know the difference between a home-bred and a 'foreign' wood-pigeon. The fact is, however, that there is none, as both are the same species and are identical in plumage. The explanation for the smaller and darker birds in the winter flocks would appear to be the presence of young birds.

A severe winter, when the birds find the only available food in the form of kale, Brussels sprouts and turnip tops, can also produce a darker bird. The sudden loss in body weight and of 'bloom' in the feathers gives a smaller and darker bird with a different look from the well-fed summer bird. Adult birds, however, still retain the white patch on the neck.

Flocking

A word about flocking. Flocking is a natural habit of the bird and in the north-east of Scotland begins about the last week of October. No doubt stormy weather and the colder conditions have much to do with this, but the birds' congregation at a source of food might also be a factor of importance. For instance, birds this autumn were observed to flock in large numbers as soon as the beechmast was ripe, comparatively few having been seen on the stubbles.

The presence of abundant food in lowland areas will draw the birds in from the colder and less favourable upland regions and, in a matter of days, a flock of several hundreds of wood-pigeons may suddenly appear where only a few were previously seen. These flocks generally move from north to south in search of food, and it is not unlikely that along the east coast of Scotland many will move into England if conditions are favourable.

The movement south in winter appears to be followed by a movement north in spring. In north-east Scotland this occurs about the first week of March, and it is interesting to note that a considerable proportion of the birds are young. For instance, on 2nd March, 1956, I shot 42 wood-pigeons coming to roost, of which 13 were young birds. Prior to 24th February birds were scarce, but, by the end of February-beginning of March, they were in very large flocks.

Three of the birds shot from this flock (plate 21) show the plumage of two young birds, B and C, contrasted with an adult bird, A. Bird C is obviously a late-hatched bird, having no white spot on the neck and pronounced buff-tipped secondary wing feathers. Bird B, although showing the commencement of the white spot on the neck, still has the *secondaries* tipped with a fawn-coloured edge. Birds B and C show all the characteristics of the so-called 'foreign' wood-pigeon, being smaller, darker and without the distinct white patch on the neck, but the fact remains that they are simply young wood-pigeons which have not yet attained adult plumage.

Control by Shooting

In concluding this article I should like to give my own opinion on the best methods of keeping the numbers of wood-pigeons in check. My experience covers a period of 35 years, during which time most of my shooting has been directed against the wood-pigeon, chiefly because it is the finest sporting bird in Britain.

In the first place, I should like to stress that I am not in favour of any method of baiting the birds with a narcotic, which renders them incapable of flight so that they can be knocked on the head. Nor do I favour a virus or any disease-producing organism. Such drastic measures are unwarranted.

The answer to the wood-pigeon problem is, in my opinion, shooting by those who understand and are prepared to undertake the job. Shooting over decoys on the birds' feeding ground is the most effective method. With the advent of the modern seed drill fewer wood-pigeons are being killed at sowing time but, during harvest, on lodged grain or in the stook, some phenomenal bags can be obtained.

The most favoured cereal is wheat, followed by barley and then oats. Peas are also greatly favoured but the acreage grown in Scotland is comparatively small. It is true to say that wheat, whether lodged or in the stook, will draw wood-pigeons for miles and excessive numbers in any district can be greatly reduced by a single gun. In one day I have many times exceeded a total of a hundred, but this figure is poor compared with that of Mr. Hampton of Wolverhampton, who shoots wood-pigeons as a hobby. His bag for one day on August Bank Holiday 1955 was 470, a record for Great Britain. To quote his own words, "that bag came in the middle of a glorious week when everything seemed to go right and in eight consecutive days I killed 1,006 wood-pigeons".

I mention this incident because it does show that an experienced shot amongst the pigeons at the right place and at the right time will have much more effect than a dozen doubtful shots banging away at birds coming to roost.

WINTER ROOSTING OF STARLINGS AT HALVANA, WILSEY DOWN FOREST

By J. KELLIE
District Officer, South West England

General

The influx of foreign birds is said to make the starling the most numerous bird in Britain during the winter months. These migrants which so conspicuously augment the native population come largely from Scandinavia, Holland, and those countries which border the Baltic Sea. Outside the large cities, where the mass flocking of starlings in winter has attracted so much publicity in recent years, their typical roosting grounds include:

thicket woodland, especially conifers
scrub thicket—frequently laurel and rhododendron
reed-beds and osier beds.

Shelter and warmth are obviously the most important considerations in the selection of a roost and the most favoured woodland sites are those where young conifers, especially Sitka spruce, have completely joined thicket, so that there is a minimum of air movement within the stand.

It is apparent that there has been a considerable increase in the starling population at large during the last ten to twelve years, and their winter roosting activities in woodland have consequently become much more conspicuous. This increase in population has been particularly in evidence in Cornwall and, in the Halvana Block of Wilsey Down Forest there has been a recurring infestation each winter for the past six years, on such a scale that the bird has become a serious pest.

The Halvana Block

This block of plantations, mainly pure Sitka spruce extending to some 500 acres, is situated toward the east side of Bodmin Moor about ten miles north-east of the town of Bodmin. The bulk of the area lies between elevations of 800 and 1,000 feet where the terrain is no more than gently undulating. The edges of the block are fully exposed but effective shelter is quickly built up and adequate protection is available, so far as roosting birds are concerned, only a few yards in from the edges. Most of the crops are in the thicket stage, P32 and P42, so that a wide choice of roosting sites is available.

History of Infestations at Halvana

Starlings first appeared on a large scale at Halvana in October, 1951 and they roosted there throughout that winter. The brief history of the infestations is as follows:—

Winter 1951/52. The area selected covered about 6 acres in C15, SS.P32 at an elevation of about 800 feet. Although part of the crop had been brashed about a year before the starlings arrived, certain groups of trees which were emerging from check remained unbrashed, so that there was adequate shelter and warmth for the birds.

Winter 1952/53. The birds returned to roughly the same area in C15, but there was a slight overspill into Cs.16 and 17 where the crops were also Sitka spruce, in the advanced thicket stage. The area, affected extended to some 8 to 10 acres.

Winter 1953/54. The roosting area was changed to C27, SS.P38 at an elevation of 960 feet. The crop was in the advanced thicket stage and unbrashed except for inspection racks at intervals of one chain. The area affected was 15 to 16 acres.

Winter 1954/55. The birds returned to much the same area of C27 but there was also some overspill into Cs.28, 29 and 30 and in all, 20 to 25 acres of plantation were affected.

Winter 1955/56. The roosting site was moved entirely into Cs.29 and 30, around SS.P40 where the average elevation was 1,000 feet. The crops were again in the thicket stage: in places inspection racks had been brashed at one chain intervals. The area affected was again in the region of 20 to 25 acres.

Winter 1956/57. A new roosting ground was again selected in C20, SS.P39, at an elevation of 950 feet. The crop was in the advanced thicket stage. Inspection rackways only had been brashed in certain sections of the crop.

Period of Infestation

The birds start flocking during October and the population gradually builds up to a peak by mid-November. Dispersal is more rapid and usually occurs in early March. Starlings may therefore, occupy their winter roost for a period of from eighteen to twenty-four weeks.

During the roosting period, the birds return from their feeding grounds immediately before sunset, and remain until the first light of morning, so that they may spend twelve to fourteen hours each day on the roosting area.

Extent of Infestation

It is evident from the history of events that there was a large increase in the number of starlings roosting at Halvana from the time of the first infestation, in the winter of 1951/52, until the winter of 1954/55. This increase was presumably related both to the general population trend and to the abandonment of less favourable roosting sites in the neighbourhood for Halvana. Not only did the earlier infestation affect a much smaller acreage than now, but the concentration of birds on the roosting area was also much less, so that while relatively little damage resulted to the 6 acres of C15, which were affected in the first two years, the damage, which has extended to some 20 acres or more annually in the last three years, is of a serious nature. The indications are that the number of birds roosting at Halvana during the last three winters has been fairly static, so it is possible that the population peak, from the biological standpoint, has been reached. However, there are no signs that a reduction in numbers is likely to take place in the near future, and while the population of starlings remains at its present level this bird will probably continue to be a serious pest of young plantations in Cornwall. While the problem of starlings roosting in plantations is not a new one, the present infestation at Halvana has perhaps assumed more serious proportions than any other on record.

Estimate of Number of Birds

Any attempt to give an estimate of the numbers of birds involved must be somewhat speculative, but there is no doubt that the birds which have roosted at Halvana over the last three years can be numbered in hundreds of thousands. If only 25 birds roost on each tree, assuming 1,200 trees per acre are available for roosting, then the total number of birds roosting on 20 acres would be 600,000. On the other hand if as well may be the case 250 birds roost on each tree (400 trees per acre available) then there will be 2,000,000 on 20 acres. Working on the assumption that starlings will fly up to thirty miles to their feeding grounds—the figure generally quoted by ornithologists—a population of 2,000,000 gives a density of 2,850 birds per square mile. This figure appears very high, but it is probable that the birds fly an even greater distance than thirty miles to their feeding grounds.

The Damage Caused

The main damage to the tree results from the heavy coating of excrement which is deposited all over its branches and leaves: the leaves in particular are badly affected and they frequently discolour and fall. In cases where defoliation is severe, the tree rarely recovers and death is fairly rapid.

Actual mechanical breakage due to the weight of birds is negligible.

It is not yet known whether the accumulation of the excrement on the forest floor gives rise to any toxic or harmful effects as far as the trees are concerned, but it seems there must certainly be a strong concentration of nitrogen in the surface layers.

It is proposed to have soil samples made before the end of the 1956-7 winter.

(a) to examine soil currently affected,
and (b) to examine the residual effect, if any, from infestations of previous years.

The damage which resulted in the first two winters i.e. 1951/52 and 1952/53, in Cs.15, 16 and 17 was not of a serious nature. Some individual trees and small groups were killed, but the crops have now had a first thinning and the effects are barely visible. On the other hand, the effects in C27 where a very large concentration of birds roosted during 1953/54 and 1954/55 were severe, and the crop has been virtually destroyed over an area of some 20 acres. In the worst areas well over 90 per cent of the crop was destroyed. The height of the trees killed varied from 15 to 25 feet as a general rule, but trees up to 30 feet in height have been killed. The effects of course, are particularly severe when a large concentration of birds uses the same roost in two successive winters, as happened in C27. In subsequent winters, with the exception of certain areas in C29 and 30, the birds have changed their roost each year so that, although the damage resulting is still of a serious nature, it has been less severe than in C27. Nevertheless a large number of trees have been killed in Cs.29 and 30 and others are still dying there. It is anticipated, however, that even on the worst affected areas, sufficient trees will survive to form a crop.

The current year's (1956-7) roosting ground in C20 is carrying a heavy concentration of birds, and the trees are heavily coated with droppings. There will obviously be a proportion of trees killed, but if the birds can be made to change their roost next winter (it must be assumed they will return) the damage again should not reach the proportions it did in C27.

Other Effects

During the day, the first indication of a near-by starling roost is the objectionable, all-pervading smell from the great accumulations of droppings, and once starlings have been roosting in an area for a few months, the trees and ground become so coated in excrement, and the smell can be so nauseating, as to make work in the area virtually impossible.

Starlings also deposit a large number of weed seeds onto the forest floor, and on areas where they have roosted such plants as chickweed, groundsel, docks, nettles and elder grow in profusion.

Examples of other Starling Roosts in Cornwall and Devon

Other roosting sites which have been or are being used include:
In Cornwall:

(a) Bamboo thicket at Lanivet, near Bodmin.

(b) Thicket woodland, laurel and rhododendron, etc., at Carnanton Estate, near Newquay.

(c) Thicket Sitka spruce at Roughtor Farm, on the north side of Bodmin Moor. (Certain birds shot here in 1946 had been ringed in Norway.)

(d) Thicket Sitka spruce at Grogley, Bodmin Forest,

and in Devon:

(e) Thicket Sitka spruce at Halwill Forest.

(f) Reed-beds at Slapton Leigh, South Devon.

It is of interest to note that while the two sites quoted from Devon are still in use, all the Cornish ones have been deserted.

Ornithologists seem to agree that, as a general rule, starlings do not roost at elevations above 600 feet and most of the sites listed above are at low elevations. All the roosting sites at Halvana, however, have been well above this elevation, varying from 800 to 1,000 feet. While the incidence of strong winds on Bodmin moor is admittedly high, the relatively milder climate of Cornwall in other respects is apparently an influence in so far as the selection of this area is concerned.

Efforts to Evict the Birds

Starlings seem to be resourceful and tenacious in every way, and once they have selected their winter roost they are notoriously difficult to evict. In dealing with a light infestation in a small wood it may be possible to drive them away by concerted shooting and noise over a period of about a fortnight although, even on a small scale, such efforts have often been unavailing. It has also been claimed that sulphur burning has been used successfully to evict starlings from an eight acre plantation and also from scrub thickets.

The problem assumes new proportions when an infestation on the scale of that at Halvana has to be dealt with. There, with such a large choice of suitable roosting sites available over a wide area, eviction would in all probability simply mean a movement of the bird flock from one compartment to another. It is evident, therefore, that nothing less than a drastic reduction in the number of birds is likely to relieve the problem at Halvana. Failing that, or until such time as it can be achieved, the object must be to force the birds to move their roosting quarters at least annually so as to keep damage within manageable proportions. So far, however, attempt to move the birds from their selected roosting quarters, using the more conventional methods, has met with little success. Methods which have been given a trial include:

(a) **Shooting**

The normal routine has been to shoot up the successive flocks of birds as they come into roost in the evening and later, once the birds had settled, to drive through the roost with the guns. This had a marked unsettling effect on the birds while the shooting and drive were in progress, but the only result was to drive the birds temporarily to neighbouring compartments and they usually returned to their regular roost as soon as the noise had stopped. When this shooting was kept up on successive evenings the birds became very wary on returning to their roost: the flocks usually flew in higher and alighted in adjoining compartments, from which they flew to their regular roost just before daylight failed completely.

It can be readily seen that shooting as a control measure would be prohibitive in cost. If, for example, an average of four birds were killed with every shot it would cost in the region of £13,000 for cartridges alone to eliminate 2,000,000 birds.

(b) **Noise and Lights**

Noise, by way of fireworks, blank ammunition, rattles, whistles, etc., and lights have usually been used in conjunction with shooting and have achieved similar results.

Once starlings have settled in their roost the effect of noisy shooting etc., is surprisingly local, and one difficulty when dealing with a mass congregation of birds extending to some 20 acres is to assemble a large enough party to unsettle the majority of the birds at one time.

(c) **Smoke and Sulphur Burning**

The use of smoke has not been tested, as efforts to obtain smoke canisters of the type used by the army were not successful.

Sulphur burning was given a trial at the beginning of the current winter's infestation but it was in no way an exhaustive trial and the fact that it met with no success cannot be regarded as a conclusive result. The trial was restricted by unsuitable weather, and as a decision was then made to brash as much of the crop as possible in order to allow more air movement in the roosting area, conditions were rendered rather unsuitable for further sulphur burning.

It was evident that while this might be an effective method of dealing with a smaller infestation, it is not a simple matter to achieve the necessary concentration of sulphur dioxide over an area approaching 20 acres.

The technique employed was to distribute five-gallon oil drums through the area, roughly at intervals of a chain: they were filled with twigs and coal dust and the fires were lit during the afternoon. A large handful of sulphur was placed on top of each fire when the birds began to arrive.

As they came in, the birds spotted the smoke from the fires immediately, and they alighted first of all in the trees adjoining the regular roosting ground. They made their way back to the roost gradually, however, as darkness fell, and the sulphur dioxide appeared to have little effect on them.

In order to achieve a sufficient concentration of sulphur dioxide very still, dry conditions are most essential, while it would appear the fires should be placed no more than half a chain apart.

(d) **Brashing**

Brashing, as a means of moving the birds from their regular roost, was not tested until the present winter. (The theory is that the additional air movement in the stand following brashing will make the roost colder and less acceptable to the birds.)

C20 is on the east edge of Halvana Block and it was felt that if the forest edge was opened up, and as much of the crop brashed as possible, an appreciable movement of cold air within the stand might be achieved. A decision was therefore made to brash where possible, and in all eight acres, most of which were in the centre of the roosting area, were completed: the remainder of the crop was too small to brash. This operation however, has no visible effects on the birds so far, and it can only be hoped now that the brashing will induce the birds to go elsewhere next winter.

Control

Although the starling was black-listed by the Protection of Birds Act 1954, it is evident that farmers and countrymen at large have shown little interest in taking control measures against it. The bird is frequently seen feeding in fields behind live-stock and for that reason it is a suspected carrier of foot and mouth disease, but so far as Cornwall is concerned, the bird has apparently emerged as a much more serious threat to our young plantations than to live-stock. It may therefore be that the forester will have to give a lead in the initiation of control measures against the starling unless some effective biological control brings a downward trend in the population.

MECHANICAL ENGINEERING IN FORESTRY OPERATIONS

By Major-General H. P. W. HUTSON
Chief Engineer

Ploughing

Most of the afforestation in this country is on land where it would be uneconomic to raise livestock or grow farm crops. Moorland, heath and poor downland are typically the sites used for planting. They are commonly hilly, often boggy and not infrequently strewn with rocks. Their rugged nature calls for more robust implements than are commonly used in agriculture. Drainage and ploughing for planting are the usual forms of ground preparation in forestry, but on some sites there may be the additional preliminary task of clearing the existing vegetational covering.

Ploughing can assist tree growth in the following ways:

(1) By improving drainage.

(2) By checking weed growth by burying the existing vegetational covering under the up-turned turfs: and

(3) By improving rooting; this is either by cultivating the soil and breaking through the hard pan, or by providing a favourable planting place in the furrow (on dry sites) or on or near the ridge (in wet situations).

Decisions as to which of these objectives is required have of course to be made on silvicultural grounds, as also such questions as the acceptable thickness of the turf for effective weed suppression, or to give satisfactory planting positions, and the depth of cultivation desired. Once these points are decided, it is the engineer's job to produce the requisite equipment.

He has to do this broadly speaking for four categories of soil condition, each sufficiently particular to call for special features in the design of implements which are to operate successfully:

(1) Wet sites, commonly peat, where drainage is the most important need, but where it is also necessary to provide turfs in which to plant the young trees.

(2) Hard heavy lands where the surface peat layer has to be broken up to improve the drainage and then the hard pan or compact layer lower down broken through;

(3) Light soil heather lands, down and gorse lands where freedom from competing vegetation is the first requirement, but where it is also advisable to keep the ploughing shallow so as to expose the minimum amount of soil to wind erosion:

(4) Certain types of old woodlands where the ploughing has to be done amongst stumps.

The first attempt at mechanical ploughing seems to have been in 1928 and 1929 on the heather moorlands at Allerston, Yorkshire. Wheeled tractors and light agricultural ploughs were used. They were not very successful in achieving the principal objective, which was to break the hard pan and mix and aerate the packed soil from below. But in the following years, when the experiments were continued with heavier equipment—a Crawler Caterpillar 20 and several different ploughs—the practicability of mechanical ploughing for forestry was established. It was however clear that the ploughs, which had all been agricultural types, would need considerable development.

The first plough for mechanical use to be produced specifically for forestry was probably the R.L.R., built some twenty years ago by a Yorkshire engineering firm. The R.L.R. is still one of the best ploughs in really rank heather, but it has been very costly to maintain, and silvicultural opinion has come to believe that in many sites the upheaval made by its deep ploughing does not give any better cultivation effects than could be achieved by deep sub-soiling with a tine, at much less strain to the equipment. This has led to what is now called the Clark-Ross plough, which was started by modifying a Ripper Tine to make it turn over a shallow screef along the sub-soil cut, and fitting it to the beam of a Cuthbertson hill drainage plough. As a next step, the Cuthbertson plough carriage, which had been designed for work on soft ground and suffered considerable damage from the boulders and stumps met with on moorlands, was replaced by a specially designed carriage. Tine ploughing is equivalent to shallow ploughing with sub-soiling, and is preferred to deep ploughing in low rainfall areas where water conservation is important, and where the upturned turf would not form a good planting site. Tine ploughing gives good vertical drainage and, especially if it is done along the contour, reduces run-off and erosion.

The dual requirement—drainage and turf for planting—mentioned for wet sites is being met by two ploughs, namely the Cuthbertson single mouldboard (Type F) and the Cuthbertson double mouldboard (Type P). Both are modifications of a machine of the same name designed for cutting hill drains. The Type F plough is primarily a drainage tool, cutting a furrow 24 inches wide at the top, 15 inches deep, and 10 inches wide at the bottom. The turf ridge can be planted, or else the turf can be cut into single pieces which are then spread by hand. This hand spreading is costly, but the Type F plough is not a good machine for ploughing at the close spacing needed for planting. This is better done by the Type P plough which has a centre disc which splits the furrow slice into two sections; the double mouldboard then lifts these and spreads them on either side at 5 foot centres. Normally this plough is set to cut a furrow 6 to 9 inches deep, which would be too shallow for a permanent drain.

On the light soil heath and downlands, shallow single furrow ploughing for planting in the furrow bottom has often proved adequate, and has been done satisfactorily with agricultural type machines. Recently the silviculturists have asked for better suppression of the vegetation, combined with ridge side planting. This has led to the development of a light double mouldboard plough with an adjustable sub-soiler. This machine ploughs a shallow furrow, throwing a half slice to either side, with a subsoil path along the centre of the furrow.

Where old woodland has to be cultivated, there is need for a plough which will ride over old stumps and not miss too much ground in doing so. If the cultivation does not have to be deep, a plough such as the Newlands mounted disc, which was designed for surface cultivation in a standing crop, will give a satisfactory performance. For deeper cultivation, and work in heavy ground, a wholly suitable machine has still to be found. Whether it will be worth special development will depend upon the amount of work there would be for a plough of this sort.

Tractors

Although most of our ploughing can be done with standard makes of tractor, either wheeled tractors on the drier sites or crawlers of 40-50 horse power on the rougher wetter areas, the going in many of the "crawler areas" is too soft for the narrow width tracks which are generally fitted. It has been found necessary therefore to use tracks wider than the normal in order to keep the ground pressure low. In some cases it has been possible to increase the soft-going performance of the wheeled tractors by an addition of half-track conversion and large diameter front wheels, the aim being a tractor approaching the crawler in performance, but with lower operating costs.

For ploughing on really boggy land, tractor ground pressures have to be kept down to 2 lb. per square foot and under. This has been done by fitting special track blades 30 inches wide to the County tractor and, as an additional modification where the machine is to be used for cross drainage over land already ploughed, by increasing the length of the track on the ground. The Cuthbertson Buffalo is another tractor which performs excellently in boggy conditions.

Clearance

In clearance work, the other main form of ground preparation, the engineer does not find the requirements so clear-cut as in ploughing. The acreages involved in a particular area are usually small and the clearance required is commonly not the complete removal we see when woodland is turned over to farm land but is selective, leaving belts or individual trees to grow on with the new crop. Such conditions are against the economical use of the heavier equipment which the clearance of any substantial woodland growth requires.

It has been established that where the cover is dense and the stems to be removed reach 1½ inches in diameter, crawler tractors of 100 horse power or thereabouts have to be used. The actual clearance can be done by equipments such as heavy discs, large rotovators or a heavy chain, which are pulled, the last name requiring two tractors (one at each end); or else by front-end equipment. The latter include the ordinary bull-dozer blade, the grubber blade which has protruding tines, and a 'V' blade, shaped in plan as its name implies and having a cutting edge on the bottom, so that its action is chiselling or planing rather than rooting. Except with the discs and rotovators, there is always the problem of disposing of the uprooted material. It would take a very long time in our climate to rot down, and there are many reasons why it should not be left in windrows. More often than not therefore it has to be burnt, and this may be a tedious process. It can be said however that with one or other of the equipments obtainable now, almost any type of vegetation—coppice, scrub, thorn, rhododendron, gorse, or broom—including trees up to about 8 inches diameter—can be cleared, though not always at an economic price.

Nursery Work

In Britain the mechanisation of nursery work has been limited hitherto to the actual cultivation of the ground, and has employed processes and machinery common to agriculture. Overseas, especially in the United States, it has proceeded further, embracing nearly the whole range of nursery operations and employing specialist equipment. The conditions which make possible this greater degree of mechanisation are not commonly found in Britain. Our existing nurseries, which were laid out before mechanisation was thought of, were intended in the main for local requirements and are consequently small in area. Only a small proportion exceed fifty acres and not one reaches 100. They have been managed very much on individual lines and show little uniformity either in bed dimensions or in general layout. Moreover many of the sites are uneven and stony. Before mechanisation can make much progress, therefore, major changes are necessary, in particular a redistribution of nursery work into fewer but larger units on sites sufficiently level and free from stones to permit the effective operation of the machines. Adequate size is important to obtain the volume of work to justify the new equipment and to allow the beds to be of such length—probably about 100 yards—that time is not unduly wasted on turns. Since plants from these larger nurseries would be distributed over wide areas, more elaborate arrangements than at present would be wanted for packaging and despatch; these operations too give scope for mechanisation.

Equipments for further advances in mechanisation are already available or are being developed. We have the tractor-mounted Ledmore seed-sower designed to sow six drills at six-inch spacing along a three foot seed bed and the Forestry Commission self-propelled inter-row cultivator whose five sets of rotating blades will cover the spaces between six rows of plants at a working speed of 100 yards in five minutes. For lining-out, there are the Ledmore lining-out plough and the Holland transplanter. The former is designed to fill and level one lining-out trench, and to cut and prepare the next simultaneously. It does not do away with the filling and placing of lining-out boards, but its costs are proving considerably less than those of the work done entirely by hand. The Holland transplanter is available either as a self-steering tractor carrying a tool bar, on which two planting units are mounted, or with a greater number of units drawn as a battery by a single tractor.

Undoubtedly there is room for further development work on nursery equipment. It has been suggested for instance that lining-out boards could be replaced by some form of paper strip container which could be fed into the ground and left there. This possibility has still to be examined. There are also the various practices connected with the storing, packaging and handling of seedlings: none of these have as yet been considered for mechanisation, but will have to be if the size of the nursery units is materially increased.

Planting

The prospects for the mechanical planting out of young trees in the forest are not so bright. In the United States mechanical planting is used widely, but the process requires extensive level areas of light almost stone-free soil, and such conditions do not occur commonly in Britain. On our heavier soils it would be difficult to achieve the proper firming of the plants, and on heather and old woodland sites the mechanical trenchers would not operate successfully. The best possibilities for a mechanical planting machine such as the Pilling or the American Lowther, would be on fully-ploughed land and possibly on grassland, and it is doubtful whether the available acreages of this type of land would be large enough for the work to be economical. However, the last word on the matter has still to be said, and it is conceivable that the development of a means for effectively clearing heather cover might open up other areas where mechanical planting would be practicable.

Tending of Woods

During the period of fifteen years or so when the young trees are growing, and before thinning starts, weed growths have to be kept down, drains cleared and protection provided against fire and disease. Unwanted growths along rides and roadsides have to be dealt with, and such matters as brashing and pruning call for attention. Most of these operations are susceptible to mechanisation although, where the machines are of the one-man type, there may not be much economy in the change. The most difficult, technically, is the cleaning of drains through plantations. Roots, often rocks, and lack of space between trees, have made it difficult to develop a satisfactory machine, and the work is still commonly done more cheaply by hand. It is hoped that this particular problem will be made a diminishing one, by keeping the trees in future plantations sufficiently back from main drainage channels.

For the clearance of vegetation there are a variety of machines on the market. Some, like the Four Seasons Scrub Cutter, are hand-propelled, and can be used for weeding between young plants. Others, which are mounted upon, or are towed by, tractors and will deal with bracken, brambles, heather, gorse and other small woody-stemmed growths, are suitable for keeping ride and roadsides free of tall vegetation. Most of these machines chop up the vegetation so that it can be left as a mulch, and there is no disposal problem. The larger types such as the Wilder Rainthorpe Chopper and the Roadless Brush Cutter, will deal with stems up to 1½ inches diameter: they do their clearing by means of hinged revolving tines or knives, which swing or fold back on striking an obstacle and recover their position after it has been passed. The Wolseley Swipe, a much smaller machine, operating with three flailing chains attached to a disc on a vertically mounted shaft, was originally designed for the destruction of potato haulms, but has proved successful on brambles and other vegetation, and can deal with stems up to half an inch in diameter.

For grass cutting on verges and the like, there are various makes of grass cutter such as the Allen Auto-scythe and the Hayter Grass-cutter which are effective. How advantageous any of these machines will be, depends to a great extent upon the cost of their maintenance and upon the number of passes needed to reduce the vegetation satisfactorily.

Fire Protection

Effective fire protection is as much a matter of organisation as of equipment. There has to be an efficient system of look-outs and patrols, backed by adequate arrangements for prompt action to deal with any outbreaks, the whole linked by a reliable intercommunication system. Once the general pattern of the fire protection set-up has been settled, the engineer should have no great difficulty in finding suitable equipment and, where necessary, adapting it to meet particular requirements. The basis of all successful fire fighting is speed of coming into action, and this must be provided for by an adequate system of roads in the first instance, and secondly by the mobility of the fire fighting vehicles and of their equipments. Forest fire plans will of course take into account the assistance which the county fire fighting services would render, but our concern now is only with the resources to be provided for the forest.

There are, broadly speaking, four lines or aspects of fire fighting, each of which calls for mechanical equipment:—

(a) First aid, i.e. means of getting to and dealing with a fire in its earliest stages, whilst it is still small and so can be suppressed with relatively simple and small-scale resources;

(b) Fighting by the forest staff with the forest equipment;

(c) Mobile reserve located to serve several forests; and

(d) Special reserve for cases where it is necessary to hold, on wheels, a considerable supply of water.

The basis of first aid is the equipment of those vehicles, normally Landrovers, which are commonly used by the forester or others of their staff for patrolling, with small simply operated pumps and water tanks. A pump giving about four gallons a minute, and a tank of twenty gallons capacity, are considered adequate. The Hathaway Langdon pump, driven off the fan belt of the vehicle, and the Allman pump operated from the power take-off, have both proved satisfactory. The former is started up from the dashboard, and is controlled by a pistol action nozzle, the user being able to walk round his vehicle and direct the water as he wishes.

For the next phase—fire fighting by the forest staff—a larger pump able to deliver some ten gallons a minute against a ninety foot head is wanted. This requirement is being met by the Hathaway Mark II pump, one of which at least is held by every forest and would be sent out to the site of the fire in any vehicle available. Arrangements for water would vary with the circumstances, but might be from natural sources, from specially made static tanks, or be held ready in a tank for sending out in lorry or trailer.

The mobile reserve, sometimes called the mobile dam unit, is a specially equipped four-wheel drive lorry carrying a dual purpose pump such as the Hathaway 6060, capable of delivering ten gallons a minute against 120 foot head when fire fighting, or 2,000 gallons per hour at low pressure when replenishing its water supply; a tank of about 400 gallon capacity; a supply of hose (two 60-foot reels), fire beaters, and pack pumps.

The special reserve requirement is met by tank wagons of 1,000 or 2,000 gallons capacity according to circumstances.

Logging

Logging is mainly a transportation problem. One part of it, the haul of the produce away from the forest, has been mechanised for many years, but the rest of the movement, from stump to roadside, and also important elements of the main haul itself such as bundling and loading, are lagging behind in mechanisation. The tendency moreover, with such mechanical methods as have been introduced, has been to concentrate on individual steps in the logging, and to forget that these need to be integrated into a single extraction system working as a whole.

The objective in logging is to get the produce from the forest to the mill or other destination at an economical cost. The process comprises four main steps or stages:—

(a) Felling, which includes topping and limbing;

(b) Drag from stump to point where the main haul begins;

(c) Loading on to the main haul transport; and

(d) Main haul from the forest.

These four steps, together with other operations such as peeling and propping which may be done in the forest, should form one extraction system which, to be fully efficient, should be operated as such with each step working at full capacity under optimum conditions for output, and with all the separate operations in balance so that the flow through the system is steady. In practice unfortunately there always seem to be conflicting factors upsetting this picture of perfection. Not always will the same agency be responsible over the whole system, and more often than not, rather than having the equipment best suited to the job, it is a case of making the best use of what happens to be to hand. These however are practical difficulties which the engineer should know how to meet, with as little departure as possible from the basic transportation principles.

Most dominant of all the elements determining logging efficiency, and therefore costs, is the forest road network. Whilst the movement of produce by road can be reckoned in pence per ton-mile, that from the stump to the roadside has, with the means we now possess, to be figured in pounds. Except in the case of the extraction of parkland timber, there must always be some initial movement to reach a motorable road. Under the conditions which persist in Great Britain, and with a silvicultural practice which will mean that nearly half the total crop is harvested in a series of periodic thinnings, it does not pay to have the drag from the stump much longer than 150 yards. It follows that where the roads can be fed from both sides their spacing should be about 300 yards apart, which gives a density of one mile of road per eighty acres of forest. The provision of roads on this scale is a major operation, especially so in view of the progressively increasing capacity of logging vehicles. Road construction has to be highly mechanised, not only to keep the expenditure on the network economic, but also to reduce the call on the available labour supply. The responsibility is a civil, not a mechanical, engineering one, but cannot be omitted from any consideration of logging, for it has of course its mechanical implications.

In Britain, where the forest roads are typically being built by tipping a layer of gravel, stone or other available material on to a shaped formation, virtually the whole of the work, with the exception of building bridges and culverts, can be mechanised. Further, with this type of construction, the subsequent maintenance, apart from the clearance of water channels, can be a mechanical process too, done by a drag or by a powered grader.

Given the network of forest roads motorable by the same vehicles which carry the timber on the national road system, and suitably connected to the latter, the full mechanisation of the main haul becomes practicable.

The weakest link in our extraction system, and the one which would most repay attention, is the drag from the stump. No method universally preferable to the traditional horse-drag has as yet been found. But, both horses and horsemen are much less plentiful than they were, and in many areas are practically unobtainable. The tractor is the obvious alternative to the horse, just as it has been for ploughing, and there are standard tractors available which, suitably equipped, perform very satisfactorily, except with the earliest thinnings when the trees are too close together for the machines to manoeuvre. This limitation is not a serious one, since these small thinnings can be man-handled. However both in the matter of accessory fittings, and in techniques of operation, there is much to be done with tractor-drag before the method is as efficient as it should be.

We do not know, for instance, what is the optimum load and how it can be best picked up and put down. These are the first questions of tractor drag which ought to be studied. Most of the small tractors suitable for logging have the power to transport loads considerably in excess of the amount a horse commonly drags. It has to be determined how much, if any, of this additional power it will pay to use. Over the short distances which the tractor will be operating on, the terminal times, i.e. for picking up and for discharging the load, will have a determining influence on the amount which can be carried economically. These terminal times, in their turn, will depend upon the equipments and the techniques used with the tractor. And these again cannot be considered in isolation, since the unloading at the end of the drag should be done in such a fashion as to facilitate the next step, which is the loading on to the main haul transport.

Although a start has been made with the design of tractor-mounted grabs, which the driver can attach without leaving his seat, the problem of tractor drag remains today one which has still to be tackled seriously. Primarily the matter is one of securing a quick turn-round. There may be no gain at all in raising the load-to-power ratio. Perhaps a smaller tractor ought to be looked for, although adequate performance across drainage ditches may be difficult to achieve.

The question of the unit or units in which the produce is handled is another problem of importance. With so much of the timber coming out as relatively small-sized thinnings and being left, at the end of the drag from the stump, distributed alongside the forest roads, the lifts for loading on to the main haul vehicles tend to be light. This favours the use of truck-mounted loading equipments such as the Hiab hydraulic hoist, rather than the employment of a higher capacity crane which under the circumstances would not only spend too high a proportion of its time travelling between heaps of produce, or else would want these concentrated or bundled to form reasonable lifts.

Now even the light truck-mounted hoists, when fitted to a fleet of transport vehicles, may mean a considerable expenditure; and where the trips per day are few, and the off-loading is done by the consignee as is common practice, the usage of the hoist will be very low. This shows the importance, here, in the main haul, just as much as in the initial drag, of assessing the optimum load; but in this case it means also choosing vehicles of the proper capacity in relation to the length of the trip.

Where the timber is being moved in the length, and the loading is being done by truck-mounted hoist, it is a simple matter for the operator to pick up from the roadside pile one or more pieces at a time, as he thinks fit. No question of bundling arises. So long as the lengths have been reasonably laid in position, the hoist operator can load efficiently. Where however the produce is in short lengths, such as pitwood and pulpwood, some form of bundling will be needed; this must be done with reference not only to the lift desired but also to the dimensions necessary to obtain good packing in the lorry. The whole question of bundling—where it should be done, at the stump or at the roadside, the size of the bundle, how it should be secured and how picked up—is still in its infancy. If a "former" is used which is left behind in the forest, then there is no bundle to pick up at the unloading end; if the bundle with its securing rings or other means of fastening is left on until the load reaches its destination, there are problems connected with its quick release and return to the forest; unless the fastenings are regarded as expendable, when means of cutting them must be provided which will come into action as the bundle is lowered on to the stockpile. None of these bundling problems can be considered without taking into account the design of the transport vehicles.

Felling

Felling, which we have left almost to the end although it is the first step in logging, is still mostly done with the bow-saw or the axe. Power saws have not shown much economic advantage with trees whose butt diameter is less than twelve inches, although woodsmen are to be met who use them because they find that whilst their earnings may be no higher, their work is rendered less arduous—'one hour sweat instead of three'.

For trees of diameters exceeding twelve inches, and for cross cutting, power saws are becoming increasingly popular.

The lightest British-made power saw weighs about 34 pounds, and this weight is the real factor against its wider use. Could it be made 9 or 10 pounds lighter—and there is a possibility of this—then the range of the power saw would be extended. Its more general adoption will call for a fresh study of felling techniques, especially where thinnings are concerned. Instead of the fellers working singly or in pairs, as most of them do now, a more profitable procedure might be to have one man operating the power saw in a team, with two or more others who do the limbing and topping as well as positioning for the drag. It may be found that the strain of using a mechanical saw will put a limit to the time one man can work continuously with it. If this is so there would have to be an interchange of tasks within the team.

Peeling

There now remains only peeling to discuss. Its successful mechanisation depends more than anything else upon the volume of the throughput. So long as the peeling is done in small packets by the roadside in the forest, the peeling machine is unlikely to give material savings in cost over hand peeling. But there is an advantage with the cutter type mechanical peeler, in that it can make what would otherwise be an unmarketable prop a saleable one. The large peeling machine, from which material reductions in peeling costs could be expected, would have to operate in some fixed centre, with an assured regular flow of timber for barking. Almost certainly this would imply a depot set-up with cross-cutting and other processes carried out as well, and some system of mechanical handling. Opportunities for the concentration of a sufficient volume of work to justify the capital expenditure involved in such an installation seem more likely to arise as part of the milling business, than in the logging which we are discussing.

WATERWAYS FOR CULVERTS IN BORDER FOREST AREAS

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Although in constructing forest roads many thousands of culverts must be built in Great Britain every year, it has not been established quite satisfactorily how to co-relate the sizes of the culverts with the varying sizes of streams.

If the waterway of the culvert should be too small, during high water the road may become flooded, causing considerable damage to the road and, in some cases, to the culvert itself. (See Plates 22 and 23.)

On the other hand if, for example, a culvert of 36 inch diameter pipes is built in a stream where one of 24 inch diameter is sufficient, approximately half of the money spent will be wasted.

How then can the waterway appropriate to different streams be estimated?

Sometimes, but only in a very few cases, evidence given by the local inhabitants, or grass or sand deposited by the flood water on the bank and in bushes, provide data to indicate the highest water level in ditches, sikes and rivers. From such traces can be obtained the maximum cross-section of the stream when the water level is at its highest.

Usually this kind of evidence or data cannot be found and the necessary waterway must be calculated by special formulae which are given in various handbooks. Difficulties however still exist, because different formulae give widely different results. Which is the right one?

To illustrate this, I would like to mention some of the formulae which I think are most popular in Great Britain today.

Talbot	$a = C\,\sqrt[4]{A^3}$
Myer	$a = C\,\sqrt{A}$
Fanning	$a = 0.23\,\sqrt[6]{A^5}$
C. B. & Q.	$a = \dfrac{0.46875\,A}{3+0.079\sqrt{A}}$

Where a = necessary waterway for culvert in sq. ft., C in Talbot's formula, according to the terrain, form of the catchment area and any snow accumulating in the area = 0.15 — 1.0

C in Myer's formula, according to the terrain = 1 (flat areas) to 4 (mountainous areas)

A = Catchment area in acres.

Using the appropriate coefficients of C for the Kielder area, the waterway in sq. ft. has been calculated for areas of 25 acres, 250 acres and 2,500 acres. The results are shown below in Table A:

Table A

	25 *acres*	250 *acres*	2,500 *acres*
Talbot	5.6	31.4	176
Myer	10.0	31.6	100
Fanning	3.4	22.9	156
C. B. & Q.	2.8	16.3	62.5

The question regarding estimation of waterways of culverts in the Border Forest districts was raised as a matter of urgency some five years ago, when after the very heavy rainfall on April 21st and 22nd 1952, many culverts on forest roads were flooded over, causing considerable damage to the roads in some places.

To obtain information on extreme floods in the Border area, Assistant Engineer S. Perkins, instructed me to commence some research work in this matter, using the marks of the extreme high water levels left on the banks of the streams. This work has since been sympathetically assisted by Assistant Engineer T. Bassey and Conservancy Engineer G. W. Preston.

Up to the present, some 200 measurements have been taken on more than 130 different streams, and although the research work is still in progress some interesting data can already be obtained.

A Short Description of the Research Area and Research Work

Most of the research has been done on streams in the Kielder and Wark Forests (99 and 33 streams respectively), less in the forests of Redesdale (3 streams) and Harwood (2 streams).

The catchment areas vary greatly regarding the gradients, altitude, soil and vegetation. In some areas the slopes to the streams are more than 1 in 8 (Kielder) but in Wark there are some having slopes of less than 1 in 50. The altitudes vary between nearly 2,000 feet (Kielder) and 700 feet (Wark); the soil varies from rocky areas to clay or sandy clay and deep beds of peat. Also, the vegetation in the different watersheds varies considerably—from a thin covering of heather on rocky and stony ground to vigorously growing grass on rich clay soil. Some, but not many, of the areas are fully covered with established, thick, coniferous forests.

The number and condition of the existing drains differ greatly in each watershed area; from only a few badly kept 'sheep drains' on hill grazing areas to a very well kept extensive drainage system in the newly planted forests.

The yearly rainfall in the area is about 50 inches (the average, near Kielder Castle, for 1945-56 was 48.5 inches). The maximum rainfall for a period of 24 hours was 2.0 inches (actually this was during approximately 13 hours) when one of the highest flood levels in the area was recorded.

There are no figures available for the intensity of rainfall, as the first rain intensity recorder near Kielder Castle has only been installed a year and a half.

Most of the worst flooding in the area has been caused by heavy and prolonged rainfall, but some also by snow melting very quickly, usually in the spring. There is also evidence of flooding in small areas caused by local 'cloud bursts'—rain measured in inches of rainfall, not actually very heavy, but coming down in a very short period.

Altogether, in the period 1952-1956, some six extremely high floods have been observed caused by rainfall, and two floods in spring 1953 and spring 1954 caused by quick snow melting. In addition some 20 measurements have been taken of extremely high water levels using some proof signs left by water on the stream banks. In these latter cases the cause of the flooding could not be established.

In the field work stage, a total of 137 streams ranging from 44 acres to 23,340 acres in the catchment area have been subjected to this research. In 40 streams measurements have been taken, at the same place, of two or more extreme flood levels at various times. Altogether 191 measurements of extreme high flood waterway have been taken.

Method of Research Work

After a case of extremely high flooding, to obtain the maximum waterway of drains, sikes and rivers, a characteristic spot of the stream was chosen. Taking into account the traces of the highest water level during the flooding, the maximum cross-section was established and measured. For large-size streams a level has been used, but in small streams direct measurements have been taken.

In the office stage of the research work, with the help of a 6 inch forest map and other sources of information, the following data have been calculated and obtained for each site of the stream where research has been carried out. In particular the contours shown on the 6 inch map, when intelligently interpreted, provide much invaluable information :

(1) Acreage of catchment area.

(2) The maximum water flow in sq. ft.

(3) The amount of water in sq. ft. per 100 acres in the catchment area.

(4) The average gradient of the stream expressed as percentage.

(5) The average gradient of the slopes to the main stream expressed as percentage.

(6) The average height of the watershed area.
(7) The form (shape) of the watershed area, i.e. length divided by width.
(8) The quality of the drainage of the area (poor, moderate, good or very good).
(9) The amount of established forests in the watershed area (less than ¼ of the area, ¼, ½, ¾ and more than ¾.

The influence of each factor on the highest waterflow was calculated, dividing the obtained waterway figures (sq. ft. per 100 acres) into groups, according to the above characteristics.

Deductions

As is generally known, the controlling factor for the extreme flood waterway is the acreage in the catchment area. However, the amount of water from every 100 acres decreases sharply as the area of the watershed increases.

The figures are shown in Table B below:

Table B

Watershed area	Extreme Waterway in square feet per 100 acres	No. of measurements used as base for calculations
(1) Under 100 acres .... (Average 89 acres)	7.52	13
(2) 100-300 acres .... (Average 209 acres)	5.23	34
(3) 301-950 acres .... (Average 569 acres)	4.17	42
(4) 951-2,925 acres (Average 1,895 acres)	3.05	25
(5) 2,926-10,000 acres (Average 5,310 acres)	2.66	13
(6) Over 10,000 acres .... (Average 22,900 acres)	2.13	2

Terrain of the Catchment Area

In many of the run-off formulae, also in the Talbot and Myer formulae already mentioned, terrain is regarded as a very important factor of influence in extreme flood level. Usually, however, there is little or no explanation in figures regarding what are 'flat', 'hilly' or 'mountainous' areas, and therefore for the same area, very different answers could be obtained according to the formula users.

If the terrain really has a great influence on the flood level, it is interesting to know why.

Gradient of the stream

There is a widespread belief that the extreme flood water in hilly areas is greater than in flat areas, because of the higher gradient of the streams. To test this, all the areas have been divided into six groups, according to the acreage of the catchment area and the average gradient of the stream. The obtained average figures of the extreme flood water in square feet per 100 acres are shown in Table C following.

Table C

Area groups	Gradient of Stream	Flood Waterway in square feet per 100 acres	Average acreage	No. of measurements taken
(1) Small areas	0.7%— 5.7% Av. 3.7%	5.58	181	17
(2) Small areas	6.3%—22% Av. 9.8%	5.68	179	17
(3) Moderately sized	2.1%— 4.4% Av. 3.3%	4.11	520	21
(4) Moderately sized	4.4%—16.8% Av. 7.7%	4.39	522	20
(5) Large areas	1.1%— 3.5% Av. 2.5%	2.96	2,870	20
(6) Large areas	3.5%— 7.7% Av. 4.5%	2.93	2,830	19

The above figures show that there is very little difference between extreme high waterflow from streams of high and low gradient, if other conditions are similar.

The Average Gradient of the Slopes to the Main Stream

Since the gradients of the slopes to the streams are extremely varied in different parts of the streams, and at different distances from the streams, it is not possible to obtain fair figures without solid levelling on the spot. As this was not possible with the time available, to obtain at least approximate figures, a simplified method has been developed, using the contours of a 6 inch map. For calculations of the slopes to the main streams, 43 characteristic streams with 100-1,000 acres in the catchment area have been selected.

The results are shown in Table D below:

Table D

Gradient of Slope to Stream		Av. Waterway in square feet per 100 acres	Av. acreage of catchment area	No. of Streams
(1) *Low*	0.3%—4.3% Av. 3% (Less than 1:30)	4.55	352	16
(2) *Moderate*	4.6%—6.2% Av. 5.5% (Approx. 1:20)	4.54	358	12
(3) *High*	6.3%—18% Av. 10.2% (Approx. 1:10)	4.92	362	15

There is only a very slight (approx. 8 per cent) increase in the waterway of high gradient slopes. For practical calculations also, that can be ignored.

The Average Elevation of the Catchment Area

It can be assumed that in mountainous areas the extreme flood water may be increased for the higher altitudes of the area with different climate (temperature, humidity, rainfall, etc.) to compare with nearby low altitude areas. To check on this point for the Border area and for comparison, useful waterway figures have been divided into two groups:—

Catchment areas with average elevation 660 to 1,000 feet. (36 measurements)

Catchment areas with average elevation 1,010 to 1,505 feet. (49 measurements)

The increase in the high altitude group was only 2½ per cent (4.71 sq. ft. and 4.83 sq. ft. from 100 acres respectively).

The Form of the Catchment Area

There is a firmly established fact which is also indicated in some formulae (including Talbot's) that the extreme flood waterway of long and narrow areas is less than that of areas of the same size but of a more concentrated shape, if other conditions are similar.

The results obtained from the calculations for the Border area are shown in Table E below:—

(*Note*: The form of figure = the length of the area in the direction of the main water stream, divided by the average width of the area. The latter has not been obtained from direct measurements on map, but by dividing the catchment area by the length of the area.

For practical calculations it means that the form figure $= \dfrac{L^2}{a}$ where

L= the length of the area in the direction of the main stream, in miles, and a = the catchment area in square miles.)

Table E

Form of the Catchment area	Waterway in square feet per 100 acres	Av. Area in the Watershed	No. of Streams
(1) Concentrated areas Form figure 0.65 —2.0	4.42	955	32
(2) Not very elongated. Form figure 2.1—3.0	4.23	957	39
(3) In elongated areas. Form figure 3.1—4.0	3.97	957	23
(4) In very elongated areas. Form figure 4.1 and over	3.56	960	12

The Influence of Drains

This influence is generally recognised and pointed out also in various formulae for calculating the extreme maximum waterway, but how great is it in the Border area?

To prove this, all the different areas have been divided into two groups: areas with poor or moderate drainage systems and areas with good or very good drainage.

The results are as shown in Table F following:

Table F

Drainage Group	Square feet per 100 acres	Av. of area in acres	No. of streams on which measurements based
(1) Poor or Moderate drainage....	3.53	1,569	43
(2) Good or very good	3.85	1,555	71

The Influence of the Forest

There are still varying opinions on this matter. Although the previously mentioned formulae and many other 'run-off' formulae do not consider forest as a factor which influences the flood levels, many sylviculturists—especially on the Continent, share a view contrary to that. Also some newly established 'run-off' formulae, similar to those in the State Forests in Latvia, include forest as an important factor in waterway calculations.

Additional research work done in Kielder forest about "waterway capacity" of spruce crowns, and observations on the covering of snow and rate of the melting of the snow in the forest and open spaces can prove, I think, the following conclusions:—

There are, in the Border area, two causes which lead to extreme flooding and in each case the influence of the forest is quite different.

(*a*) Floods caused by heavy and prolonged rainfall or cloudbursts.

(*b*) Floods caused by rapidly melting snow, usually in spring time.

The figures in Table G below refer to (*a*) above.

Table G

Description of area groups	Waterway square feet per 100 acres	Average acreage	No. of Streams
(1) Areas with 100 per cent established forest (Spruce stands)	4.46	540	23
(2) Areas without Forest	5.14	539	39

The figures show that an established spruce forest may decrease the flood waterway in the Border area by some 13 per cent of that in areas without forest, if the flooding is caused by heavy, prolonged rain—this figure appears to be very small but, I think, is easily explained.

Daily rainfall measurements for a year under a very thick and well established Norway Spruce plantation near Kielder Castle, have shown that the 'water capacity' of the tree crowns—the maximum amount of water that can be absorbed by the tree crowns—does not exceed 0.25-0.30 inches of rain. Therefore, even 100 per cent thick coniferous forest cannot absorb more than some 20 per cent of a rainfall heavy enough to cause flooding ($1\frac{1}{2}$ to 2 inches during 24 hour period). The actual difference reaching the soil in forest and open spaces will be less. In an open space a remarkable part of the rainfall will be absorbed by grass and other growth covering the soil, but in thick forests such growth is not usually present, and all the rain falling through the crowns reaches the soil.

Although not enough data has been gathered to produce definite figures regarding the influence of the forest on extreme flooding caused by quick snow melting, some general conclusions can already be drawn.

Such flooding can be caused only in regions where snow can accumulate over a great extent and in deep layers. This occurs in the Border area usually only at altitudes above 1,000 feet. Some observations have clearly shown that when severe flooding has occurred in elevated altitude regions which are of the open moorland type, in similarly situated, but forest-covered areas little or no flooding has occurred. The explanation for this is simple—the accumulation of snow in a thick coniferous forest is very much less than in open country, while the melting rate is much slower due to the snow deposit being shielded from the effect of rain, wind and sun by the trees.

Although only research work can prove it, I am of the opinion that quick snow melting cannot cause extreme flooding in the Border region, in catchment areas covered by established coniferous forest.

Replying to the question of whether prolonged rain or quick melting snow makes the greater contribution towards increasing the water levels, calculations based on 92 floodings caused by rain and 41 by quick snow melting have shown that the flood heights are very nearly the same (actually the latter flood figure was 2 per cent higher).

Practical uses of the Research Material

Using the calculated figures about the influence of the forest, drainage system and form of the catchment area, on the extreme flood level, all the collected data on waterway has been brought to a 'standard' catchment area possessing the following features:

(a) Length of the catchment area—not more than three times the width.

(b) Very good drainage system.

(c) No forest in the catchment area.

The catchment area plotted against the corresponding point of the waterway produces a number of scattered points. Ignoring some extreme maximum points, a curve can be drawn over the points which can be used to find the maximum cross-sectional area of the extreme flood water in *natural stream beds*.

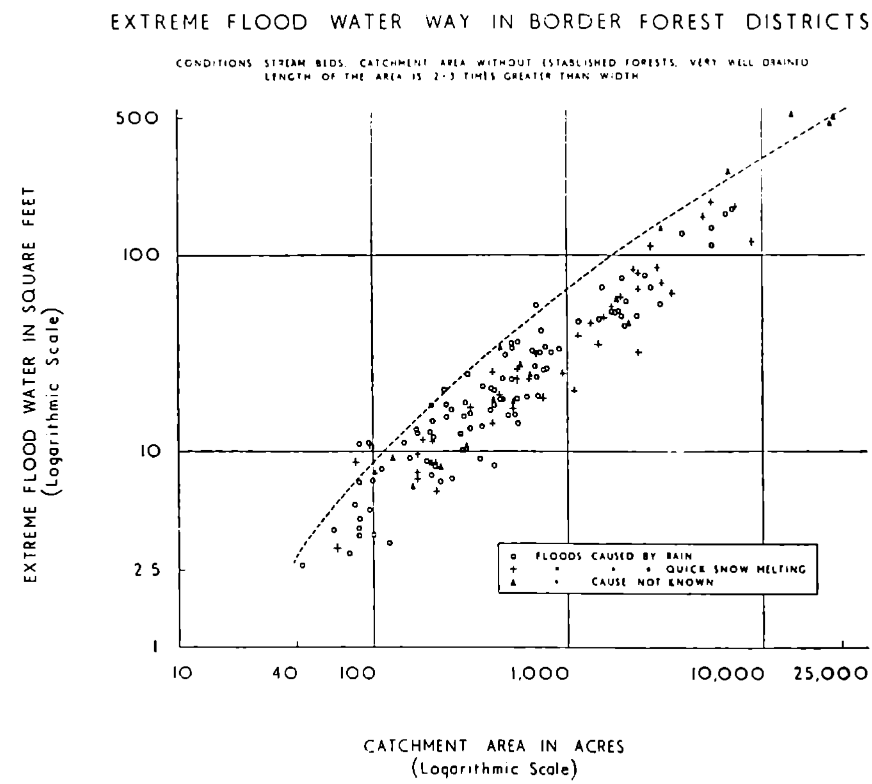

Fig. 5. Relationship between Catchment Area and Extreme Flood Waterway.

Additional simultaneous measurements of the extreme flood waterway in stream beds and in existing culverts on the same stream, have shown that the actual area of the culvert can be safely made 75 to 85 per cent of the particular stream flood waterway. This is due to the flow of water being much faster in the straight and smooth culvert, than in the corresponding section of the stream, where the speed of the water is influenced and slowed down by the uneven bed, bends and other obstructions.

Table H

EXTREME FLOOD WATERWAY IN BORDER FOREST STREAM BEDS AND IN CULVERTS

Form of the catchment area 2.1- 3.0 Very well drained; without forest.

Watershed area acres	Waterway in square feet	
	In natural stream beds	For culverts
40	2.8	2.1
50	3.8	2.8
60	4.8	3.6
75	6.2	4.7
100	8.6	6.5
125	10.8	8.2
150	12.7	9.6
200	16.9	12.8
250	20.7	15.9
300	24.7	19.0
400	31.5	24.6
500	38.5	30.0
600	44.5	35.0
750	53.5	42.5
1,000	66.0	53.5
1,250	78.5	64.5
1,500	91.5	76.0
2,000	109.0	91.5
2,500	128.0	109.0
3,000	144.0	—
4,000	174.0	—
5,000	202.0	—
6,000	225.0	—
7,500	257.0	—
10,000	306.0	—
12,500	354.0	—
15,000	396.0	—
20,000	468.0	—
25,000	509.0	—

The extreme flood figures for stream beds draining various areas drawn from the curve and proposed waterway for culverts are shown above in Table H. It must be remembered that the figures relate to a catchment area with the 'standard' features already mentioned.

If the catchment area is different, the obtained figures must be multiplied by the constant shown below.

(*a*) If the area is poorly drained and there is every likelihood that it will stay so in the distant future = 0.90

(*b*) If the form of the catchment area is between 3.1 and 4.0 = .95

,, ,, ,, ,, 4.1 and more = .85

(*c*) If the established coniferous forest is covering approximately:

$\frac{1}{4}$ of the area = .95

$\frac{1}{2}$ of the area = .90

$\frac{3}{4}$ or more of the area = .85

An example is given below to illustrate the above passage.

What is the necessary waterway for a culvert in the Border Forest area if:—

The acreage of the catchment area is 150 acres; the length of the area is more than four times the width; the area is 100 per cent covered by coniferous forest and the drainage is, and will be moderate?

The 'standard' waterway for 150 acres is 9.6 sq. ft. (Page 167) but for the area in question it will be:—

9.6 × .90 (moderate drainage) × .85 (form figure more than 4) × .85 (forest covering $\frac{3}{4}$ or more of the area).

= 6.2 sq. ft.

A Critical review of the Research Methods and value of results

The very large distribution of points in the diagram casts some doubts on the efficiency and correctness of the measurements, and the general approach of the research method itself. However, the great variations of the maximum flood water flow for two or more similar catchment areas can be explained in several ways:

1. The extreme flood waterway figures have been obtained from not less than eight floods at various times, and it is most probable that all these floods did not reach the same level.

2. For the same amount in cu. ft. of water, the waterway in sq. ft. can be different, since the speed of the water is affected by conditions of the stream bed (obstacles, bends, etc.).

3. Many more factors can have minor influences on the extreme flood level, but have not been, or cannot be, taken into account.

   To mention some:

   (a) Soil consistency.

   (b) Direction of orientation of the catchment area. (Area facing South has a larger evaporation rate than one facing North.)

   (c) Speed and direction of wind during rainfall responsible for the flood.

   (d) State of soil during rainfall or just before it (whether frozen, saturated with water, or dry).

4. The most important factor which causes variations in maximum flood levels for otherwise similar areas is the very unevenly distributed rainfall, even in closely situated areas. The figures given opposite support this statement.

Stream No. and Beat	Waterway in square feet per 100 acres of Watershed	
	Flood of 2.4.52 Rainfall 2 inches in 13 hours	Flood of 16.8.56 Rainfall 1.38 inches in 15 hours
No. 4—Kielder	8.10	2.75
No. 12—Kielder	5.73	2.48
No. 4—Kielder	5.77	2.73
No. 31—Plashetts	2.59	3.06
No. 41—Plashetts	3.29	4.19
No. 26—Plashetts	6.63	10.00

Note: (a) The rainfall figures were obtained from rain gauge reports at Kielder Castle.

(b) The utmost distance between the above watersheds does not exceed five miles and in the period 1952-1956 there were no important changes in the affected areas.

5. Drawing the curve on the graph (page 166) some 5 per cent of all the points, regarded as extreme, have been left above the line. From that we can assume that some 5 per cent of the culverts, if based on the curve, will be liable to overflooding, but such small risk is economically and technically justified for the following reasons:

(a) Experience shows that a slight and brief forest road overflooding does not affect traffic or silvicultural operations, and does not cause any or only very slight damage to the road.

(b) On the whole, the expense saved by making all the remaining (95 per cent) culverts about 20 per cent smaller, will give a great saving against the cost of repairing the damage to the roads and culverts of the 5 per cent that get overflooded.

Conclusions

I. 'Run-off' formulae for extreme flood waterway, which do not reflect local rainfall, temperature, etc. cannot suit equally well for all climatic regions. It will therefore be very useful for practical engineering work if the Forestry Commission, or other Research Institutions, could produce the necessary adjustments for existing 'Run-off' formulae, or develop new formulae suitable for all parts of Great Britain.

II. Although the catchment *area* is the main factor which influences the extreme flood waterway, to achieve data for most economical planning, the form of the catchment, existing drainage system and amount of established forests must be taken into account.

III. The research work on extreme flood waterway in the Border Forest region has been done on a comparatively small and very local scale. Therefore, the figures produced must be regarded as provisional, and can be applied in the Border area only.

IMPRESSIONS OF FOREST WORK IN SWEDEN

A REPORT OF AN INSTRUCTIONAL TOUR

By M. E. S. DICKENSON

District Officer, Education Branch

The Course was arranged for the Forestry Commission by Sandvikens Jernverks Aktiebolag of Sandviken, Sweden, and was attended by six Assistant Foresters under the leadership of myself. Scholarships were awarded to the six Assistant Foresters by the International Labour Office; they had previously received instruction in tool maintenance in Britain and visited factories in Britain manufacturing saws and edge tools, and had spent a period of months instructing in tool maintenance in the field, thus obtaining a general picture of the standards of tool manufacture, maintenance and use, on which they could base comparisons of Swedish standards.

PART I

Sandvikens Jernverks Aktiebolag

Sandvik Iron Works Company

The steel works was founded rather less than a century ago, and by international standards is not very large. The raw materials used comprise iron ore from the Company's own mine, mill waste from the steelworks, and commercial waste bought outside. From them are produced strip and tubular steels, both alloyed and unalloyed, and to differing specifications, by methods general throughout the steel industry. The aim is to produce high grade steels of uniform quality, so that they may be guaranteed within tight specifications.

Within recent years a factory has been set up to manufacture certain finished products from the steel, though the majority of this continues to be sold in an unmanufactured state. The principle finished products are saws, springs, tungsten carbide tipped tools (particularly rock drills), and machine knives.

No-one on the course was qualified to comment critically on the manufacturing processes or methods, but certain impressions stand out when comparing what was seen with similar works in Britain. First, an impression of cleanliness; no pall of smoke hung over the works, and inside, except in the smelting furnace buildings, floors, machines and air were all remarkably free from dirt and dust. This is part of a definite policy, since not only are working conditions improved, but the quality of the products can be adversely affected even by dust. This cleanliness is greatly assisted by the almost complete electrification of the works.

Secondly, we gained an impression of a great deal more automation. The supreme example was a large hot rolling mill for strip steel which was run, on shifts, entirely by seventeen men. At the time of our visit only four were seen, one of whom was eating his lunch. Many of the machine operators sit down at their work in specially designed chairs which give support to their backs, since the chief occupational malady at the works is back-ache. In the saw factory many processes, such as tensioning, sharpening and setting were carried out by machine, giving much greater precision and uniformity than is possible by hand, and this is one of the outstanding points of superiority of Swedish saws—the condition in which they are received by the user.

The third impression was of repeated testing, the manufacture of the article being controlled at each stage. A percentage are tested at every stage and any variation from the permitted tolerances results in a much higher percentage check, and, should this also show variations, the rejection of the whole batch. This control can be maintained after despatch of the finished article, since the manufacturing history of that article can be traced back should any complaint be received.

Finally, it was very obvious that the manufacturers knew what the user wanted, and also what would best do the job. There was continual research to find something that would do the job better, and to educate users to the uses and care of particular products, and continual contact with the users and the conditions under which the products were used.

Saw Manufacture

All saw blades are manufactured from high grade cold rolled strip steel. This steel is hard, to ensure long life and retain an edge well, but not so hard that it is brittle and liable to rupture in normal, careful work. After the blades have been cut from the strip all felling, cross-cut and hand saws are ground, tapering to the back, and in the case of one-man saws, from handle to point. They are ground so that, provided the original saw shape is maintained, all the teeth will be of the same thickness. The tooth-shape is then stamped out and the saw tensioned by rollers, with a final touching up by hand, though the machine operators appear sufficiently skilled to reduce this to a matter of one or two taps with a hammer. There follows machine filing and setting, which ensures that all teeth are sharpened and set to the same degree.

Bow saw blades are not ground, but otherwise undergo the same treatment, and Nos. 21 and 51, in addition, undergo a tip-hardening process. In this the top 1/32nd of an inch of each tooth is subjected to high frequency electrical currents for a short period, which gives the extreme tip of the tooth, which alone is concerned with cutting, the hardness of a good file.

Saw Frames and Handles

The Company manufacture their own bow saw frames from tubular steel. The tube is oval in section and incorporates a tensioning lever which enables a tension of 400 lb. to be put on the blade. This tension is essential if the saw is to work efficiently, particularly with the narrow tip-hardened blades. When the blade is under tension it should not be possible to distort the blade more than 15° in either direction when gripped between the knuckles of the first and second finger. The tensioning lever also enables the tension to be taken off easily, which should be done when the saw is not in use. Two types of frame are manufactured, the No. 8 which is of fixed sizes from 24 to 42 inches, and the No. 25 which is adjustable either for 36 and 42 inch blades, or for 42 and 48 inch blades. Both these frames are tested to a tension of 1,000 lb. so that there is no likelihood of the 400 lb. pressure exerted when a blade is inserted distorting the frame.

One-man saw handles for cross-cut and felling saws, and joiners' saws of all kinds, are supplied either in plastic or laminated wood as required. The advantage of these over the older solid wood handles is that under normal conditions they are unbreakable. The plastic handle is cold to the hand in low temperatures, and at temperatures of about 12°F. and below become brittle and easily broken; the laminated wood handle is superior in these respects, but must be kept varnished to exclude moisture, which would cause distortion.

Uses of Various Types of Sandvik Saws

There are two basic types of dentation in saws, the peg-tooth type and the raker type, and though tooth shape and arrangement may vary in each for different conditions, two basic principles apply:

1 Peg-tooth types are more suitable for hard or frozen wood, and raker types for soft, fast-grown, green wood.

2 Peg-tooth types are more difficult to maintain, and quickly become inefficient if not properly maintained.

From these two principles it may be seen that in the majority of Forestry Commission plantations of fast-grown conifers, and with semi-skilled, or even unskilled labour, the raker type saws are likely to be more efficient than peg-tooth types. Both types of dentation are supplied in each type of saw.

Two-men Cross-cut Saw

This is the most familiar type of saw to British woodsmen, particularly that with a tooth arrangement of four lance cutting teeth to one raker tooth. It is manufactured by Sandviks (No. 915) with a curved tooth line—so that only a few teeth are working at any time, making for smooth and efficient cutting—and hollow back—to reduce friction and permit the driving of wedges behind the saw if necessary. It is supplied in lengths from 4 to 8 feet. This type is most suitable for felling large, unfrozen conifers, though with adjustments to the tooth shape and set it may also be used for large hardwoods. It is considered, in Sweden, to be inefficient to use a two-man saw on trees less than 20 inch diameter at the butt, and this type of saw is rapidly being superseded by the one-man power saw.

It is also supplied with two curved cutting teeth to one raker, and this is considered to be the most efficient cutting instrument. However, it has the serious disadvantage that if one cutting tooth is not working, through fracture or poor maintenance, there is a large gap between cutting teeth at that point, as may be seen from the diagram. (Figure 6.)

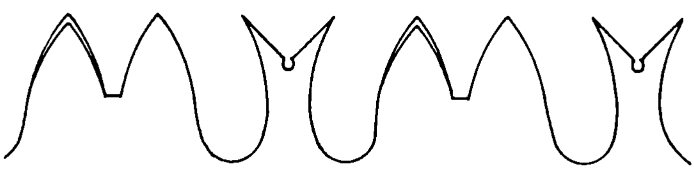

Fig. 6. Raker cross-cut saw with cutting teeth in pairs.

For cross-cutting, the use of a straight-backed saw is preferable since this gives greater rigidity, and there is no occasion for using wedges.

The peg-toothed types of this saw are unlikely to have any general application in Britain, but might well be used by skilled fellers in hardwood areas. It is unlikely, even in North Scotland, that conifers will be as slow grown or as frozen as in the Northern part of Sweden, where this type of saw is found to be the most satisfactory, though it is not greatly used even there, as under these conditions few trees reach a sufficient size to justify a two-man saw.

One-man Felling Saw

This type of saw is in general use in Sweden for felling trees between 9 and 20 inches diameter at the butt, the dimensions with which the Swedes and our

Forestry Commission, are chiefly concerned. It is a type of saw which has never gained favour in Britain, though the reasons for this do not seem to extend beyond ignorance of use-techniques, and conservatism.

Five saws of this type are made by Sandviks: No. 704 has four lance cutting teeth and one raker as with the two-man No. 915, breasted, but with a straight back; it is available in lengths from 39 to 54 inches. Nos. 242, 243, 244 and 245 are all peg-tooth types. The 242 Bredby has the teeth at approximately 86° to the back of the saw, is breasted and 38 inches long, tapering from 5$\frac{1}{8}$ inches in width at the handle to 2$\frac{3}{8}$ inches at the point. The 243 and 244 Tiger saws are similar except that the teeth are at approximately 89° to the back of the saw, for 2/3rds of the length nearer the handle in the 243, but throughout the length in the 244. The 245 King Tiger is similar to the 244, but only 3$\frac{3}{8}$ inches wide at the handle and 2$\frac{1}{8}$ inches at the point, and is not breasted.

The greater angles of the teeth give more bite but are more difficult to use and maintain, and are therefore only suitable for more experienced fellers; the narrow width of the 245 means lower friction and therefore faster cutting, but at the cost of rigidity, and therefore are only suitable for the most experienced fellers. As it is not breasted the use technique of this saw differs from the others.

For present British conditions the 704 raker type would seem to have possibilities, and even the 242 for hardwood thinnings, if prejudice can be overcome.

Bow Saws

These saws are used for cross cutting and for felling trees up to 9 inch butt diameter. They are essentially a one-man saw and even the larger sizes are not intended to be used by two men.

Blades, both ordinary and hard-point, are manufactured with peg-tooth and raker dentations. In the peg-tooth types the gullets are of varying sizes to prevent vibration or 'chatter' when the saw is in use. The raker type have a tooth arrangement of two cutters to one raker—with the much smaller teeth the gap caused by the non-working of a cutter is not so significant. Also breakage is less likely, and bad maintenance is eliminated in the case of hard-point blades.

The arguments in favour of hard-tipped blades are very strong. They are guaranteed to remain sharp at least three times as long as an unhardened blade, so that provided a new hard-point blade costs less than a man's time to carry out two sharpenings of an ordinary blade it is more economic, and there is no doubt that this is so. Secondly it is not easy to sharpen bow saw blades well because of the small size of the teeth—this is particularly so in the case of the peg-tooth type—so that for unskilled men there is no doubt that they would work more efficiently with hard-tip blades and their increased production would justify some additional cost, even if this should exist. Finally there is a saving on the provision of equipment and tools for the sharpening of bow saws.

For efficiency, bow saw blades must be kept at sufficient tension, and the use of poor quality frames, or ones which have become strained in any way, will make them poor tools. Other points that must be observed in using bow saws are, first, that as there is no breast on the blade the saw must be rocked slightly in use so that only a few teeth are biting at one time, and secondly, both hands should be used on the saw, the right hand as close as possible to the blade, supplying the motive power for the saw, and the left just in front of the rear curve of the frame, steadying the saw and providing a slight downward pressure.

Two men using a bow saw are unlikely to produce twice as much as one man using the same saw, and all "non-sawing" time is immediately doubled. With this proviso there is no doubt that bow saws could be used much more in Britain in early thinnings, using No. 21 hard-tipped blades, with advantage.

Pruning Saw

The Sandvik 339 pruning saw, while generally similar to the Grecian type commonly in use in Britain, has two innovations which would seem to be of distinct advantage, particularly when used on a pole for high pruning. There is a "buffer" at the point which prevents the saw coming out of the cut, and at the base there is a chisel edge which, as the saw is pushed up, cuts through the bark and bast, thus preventing tearing when the branch snaps off. However, the socket on this saw seems rather weak for high pruning in plantations.

As despatched from the factory this saw is sharpened for cross-cutting. In practise branches are frequently at an angle other than a right angle to the bole and therefore pruning is not cross-cutting, but is an action intermediate between cross-cutting and ripping, and it would be better if the teeth were sharpened as for the general-purpose hand-saw.

Maintenance of Saws

It is important, when sharpening a saw, to know *why* a tooth is a particular shape; it is then much more likely that the right shape will be obtained. Three actions must be performed by a cross-cut saw, which is the type normally required in forest operations; these three actions are:

(a) To cut the fibres across at two points;

(b) To break or chisel off the fibres from the third side between the two cuts;

(c) To push the sawdust thus formed out of the cut.

The two types of dentation—peg-tooth and raker—perform these actions differently and must be sharpened accordingly.

Raker Type Saws

In these saws the fibres are cut by approximately 1/32nd of an inch at the side of the tip. The cutting is not done by the point and the saw will work even if the teeth are not sharpened to a point, though this will form an extra small breast and result in additional friction. The main breast of the tooth performs no function and should be removed to reduce friction (see Figure 7(a) below).

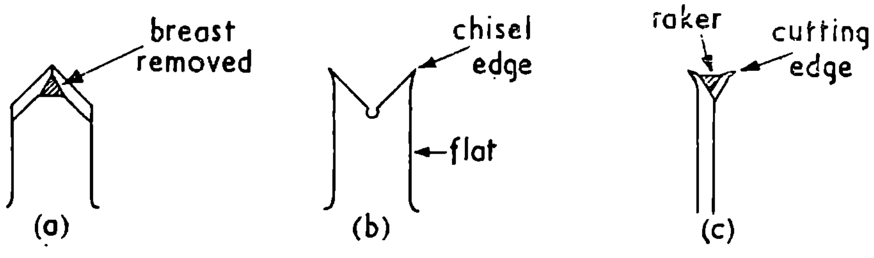

Fig. 7. Sharpening rakers and raker saw cutting teeth.

After the fibres are cut they are chiselled out by the chisel edge of the rakers, and the sawdust is pushed out by the flat side of the raker (Figure 7(b)). The chisel edge may be swaged or not, but must be slightly lower than the cutting teeth. When sighted along the saw it should appear as in Figure 7 (c).

The principles of sharpening this type of saw are well known in Britain.

Peg-Tooth Type Saws

In this type of saw there is only one shape of tooth—which may vary in different saws—and this tooth must therefore perform all three operations. The cutting is done by the edge of the tip as with the lance tooth, the fibre is broken off by the breast of the tooth, which must not be removed, and the sawdust is pushed out by the "flat" below the cutting edge. This means that the tooth must not be sharpened to the base of the gullet, and it is in this that peg-tooth saws are so often incorrectly sharpened, particularly where the teeth are small, as in bow saws. (See Figure 8.)

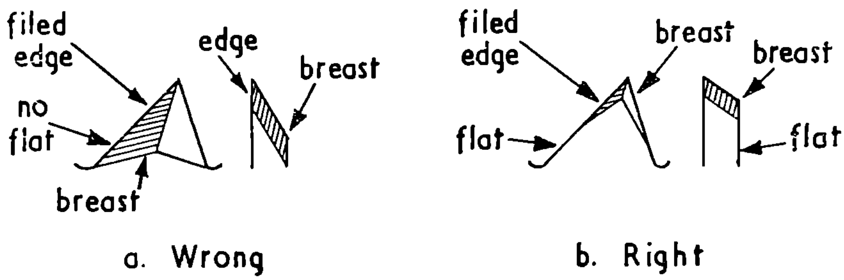

Fig. 8. Sharpening peg teeth.

In cross-cut and felling saws of either type the gullet should not be lowered more than one inch or the tension of the saw will be affected.

Barking Spade

The barking spade manufactured by Sandviks (No. 975) differs from those in common use in Britain in two ways; it has a sharp edge, and a changeable blade. The blade has a long bevel on top and a short bevel below. The actual angle of this lower bevel should be varied to suit the individual user. (See Figure 9.)

The tool incorporates a hook at the side to assist in turning logs and the handle is rather longer than used in Britain. All these points are designed to ease the job of peeling and so increase output, and the tool would seem to justify field trials.

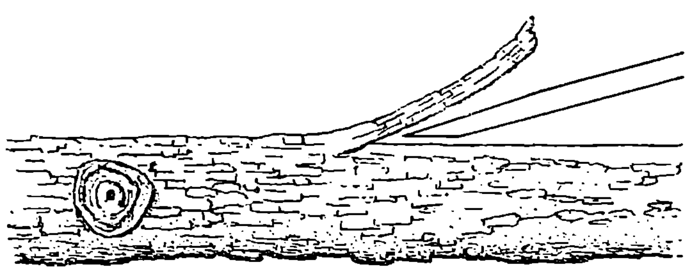

Fig. 9. Barking spade in use.

General Considerations

There can be no question that saw maintenance has been sadly neglected in the Forestry Commission in the past. This is partly the fault of the system by which saws are issued to workers and can be exchanged for another if their condition becomes bad; partly due to the fact that saw maintenance is a job which can be done indoors and is therefore 'saved up' for wet weather; and partly due to the more or less complete absence of reasonable facilities for proper saw maintenance.

In Sweden all woodmen own their own tools; they are the tools of their trade by which they earn their living, and the extent of their earnings is largely dependent on the condition of their tools. They know that time spent on their maintenance is not just a useful job when they cannot be outside; they also know that a saw cannot be sharpened properly without proper equipment and light. Successful sharpening depends on being able to see the reflection of light on filed surfaces and this means that, if the job is to be done indoors, artificial light is almost always necessary. Of the equipment, the first essential is a steady clamp. The Sandvik pattern portable clamp is easily made and enables the saw to be clamped either vertically or at 45°, but would be improved by the addition of a box or shelf for tools required in sharpening. If all maintenance, other than touching up, is to be done at a central building, permanent clamps on fixed benches should be provided. The tools required will vary with the type of saw, but must include files of an appropriate hardness—British files for Swedish saws are of little use—and instruments to ensure precision setting and adjustment of rakers.

It is obviously desirable that all woodmen should learn to sharpen saws properly, at any rate those regularly engaged on sawing, but until this can be achieved it might be necessary for certain capable men to do all the saw maintenance.

PART II

Hults Brucks Aktiebolag

This Company is primarily concerned with the manufacture of paper pulp, with a large pulpmill at Norkopping. They required further forest land to supply raw material for this mill and to obtain this they purchased the axe factory at Aby and the considerable forests which it owned. The manufacture of axes is therefore in the nature of a sideline for this particular Company, though their concern with it has resulted in many improvements.

Manufacture of Axes

The axe heads are hand forged from high grade steel, followed by grinding and annealing. It is, in fact, a similar process to that employed in Britain, and the quality of the steel alone accounts for any difference. It should be noted, however, that in Swedish axes the eye is 'choked', that is, smallest in the middle and not at the end. This, is it claimed, makes the shafting more secure, but it also makes shafting more difficult.

Shafting is at present done by hand, though it is proposed to install machinery for this work. It was surprising to see that the majority of the shafts were of birch. The standard of shafting was not high, the majority of heads being too high above the shoulder, and many of them underhung. The wedges used are of Scots pine, which seems inferior to hardwood.

Axes are produced in weights from 2 lb. to 5½ lb. with shafts from 26 to 36 inches. On the whole the axes have less shoulder than those in Britain.

Use of Axes in Sweden

Woodmen in Sweden use a lighter (2 to 3 lb.), thinner axe on a shorter shaft than is common in Britain, but this difference is largely accounted for by the difference in felling technique. The majority of felling is done in the winter and is done at snow-level. On average this means that trees are felled 12 to 18 inches above ground level, and this practise continues even in summer. Consequently felling is done above any normal buttress and there is no necessity to axe this off. When the saw is some 2/3rds through the stem, a few cuts with an axe, without any effort to cut horizontally. prevent splitting, and if necessary wedges are used to control the fall. The axe therefore, is used almost solely as a snedding tool. Trees are of three species only, Norway spruce, Scots pine and birch, slow grown and seldom exceed 18 inch quarter girth at the butt, in fact quite unlike the fast grown conifers and large hardwoods with which fellers are chiefly concerned in Britain. The wood is harder and less resilient, particularly in winter when it is frozen, hence the smaller shoulder, and being used chiefly for trimming, a light axe is adequate for the job and more easily handled. It is used with both hands held at the end of the shaft, and can be swung to left or right. In the different conditions in Britain an axe of at least 3½ lb. would seem preferable.

Maintenance of Axes

For sharpening axes a grindstone or file and a smooth whetstone are required. The grindstone should be turned towards the axe and kept wet with clean water. Turning away from the axe results in less 'bite' and therefore a longer time to achieve the desired result, and water containing particles of stone will result in scratches in the metal and consequent longer honing. In grindstones with a water tank, the water should be drained off after use or that part of the stone standing in the water will become softer than the rest. There is no reason against filing an axe as long as all the file marks are honed away with the whetstone, and the stone is used to give the final edge—this is just as important where a grindstone is used, though less honing will be necessary to obtain a smooth finish.

The curve of the edge should be the arc of a circle whose centre is the point of balance of the axe head. This will ensure that the point of impact is the centre of the edge, with the full weight of the blow behind it, provided the head is properly hung.

The shafting of axes is fully understood in Britain, even though practise does not always live up to theory.

PART III

Korsnas Aktiebolag

This Company was founded in 1855 with a sawmill on Lake Runn, close to Falun, but at the beginning of this century was moved to the Baltic port of Gävle. In 1910 a sulphite pulp mill was built, to be followed five years later by a sulphate mill. An alcohol plant and a paper mill followed in 1918 and 1925 respectively.

The sawmill, and pulp and paper mills, are on opposite sides of a small bay into which flows the log flume from the Dal River. This flume carries 75 per cent of the timber coming to the mills, with a capacity of 100,000 logs a day.

This timber comes partly from the Company's forests, which extend to 1,050,000 acres of which 825,000 acres are productive, and partly (40%) from purchases. It is worthy of note that the current annual increment of these forests is stated to be only 47 hoppus feet per acre.

The mills use 62 million gallons of water per day which is obtained through a 55 inch pipe line 6 miles long from the Dal River, and power consumption is 25,000 kilowatts.

The figures are given as an indication of the size of the undertaking.

Sawmill

The mill was completely re-built in 1948 and so is one of the more modern mills in Sweden.

The logs are stored in the log pond and drawn out by conveyor into the barking machines. There are three Andersson barking machines, automatically fed and working on similar principles to the Bezner peeler on a larger scale. They remove the bark effectively, though leaving the exterior surface rough. A Hillbrom barker in which smaller logs are tumbled in water is now only used as a reserve. After barking, the logs are sorted and returned to the pond. A further elevator conveyor takes them from the pond to the saw house. At the top of this conveyor they pass under a metal detector, which, if activated, stops all the saws until the log has been removed. In the saw house there are four gang saw units, each comprising four gang saws. Three of these units are in operation at any one time. The sawyer's job is simplified by having overhead wires lighted from above which cast shadows on the benches showing where the saw cuts will be. Everything moves on conveyor belts which, after sawing, take the various size timbers to the primary grading shed, where it is graded by dimensions. The grader, noting the end dimensions of a piece of timber, pulls it out so that the end projects a certain distance over the side of the conveyor belt. Down the side of the belt are a number of trip levers, at different distances from the side. In this way all timbers of the same end dimension trip the same lever and are dropped through the belt into the same wagon below. These wagons take the timber to the drying kiln, where it is seasoned for shipment. From the kilns it is taken to the second grading plant where it is graded by quality and length. By a series of electrical timing devices and contacts the grade and length are stamped on the ends of each piece of timber, and it is sorted into its appropriate grading merely by the grader selecting one of three quality grade levers as the piece of timber passes him. The timber is then stacked in the storage shed. This shed, entirely constructed of wood, can accommodate 10,000 standards of timber, so that all the sawn timber can be stored under cover before loading on ship. The rail track from the storage shed to the covered quay is also covered, so that there is a continuous covered area of nearly half a mile.

Saw mill waste is chipped and used in the sulphate pulp mill at the rate of 33,000 cords a year, and in addition sawdust, bark and other waste unsuitable for chipping supplies 40 per cent of the fuel used in the steam generating plant.

There is a great deal of automation as can be seen from the above notes, but the sawmilling is greatly simplified in that the mill is dealing with timber of two species only, and within a very small range of sizes. When Britain is producing large quantities of small size conifer saw logs, as will be the case in the foreseeable future, mills of this kind will be required to handle them.

Pulp and Paper Mills

The sulphate and paper mills were visited; the operations concerned were too technical for proper comprehension, but there appeared to be no fundamental differences from the same processes in Britain.

Again there were the impressions of cleanliness and automation—such devices as a jet of water, which when broken by a log passing under it broke an electrical circuit, and in this way the logs coming into the plant were counted.

The sulphite mill uses only spruce, the sulphate mill spruce and pine. Between them they consume 235,000 cords of timber a year in addition to the sawmill waste.

Here again the products are loaded directly on to ocean-going ships from storage sheds on the quayside.

This Company is an example of a completely integrated timber-utilising concern where virtually nothing of the log is wasted, but it seems unlikely that British forestry could sustain a concern of this kind for a considerable time, though there is equally no doubt that, with our much greater growth rate, that that time will come.

PART IV

Kratte Masugn Forestry School

The School

The background to forestry education in Sweden is the fact that the majority of the forests are in private hands; practically every farmer owns some woodland since it provides employment, and income, during the winter months, and the vast majority of forest work is done as piecework so that it behoves a woodman to learn his job thoroughly. Kratte Masugn School is owned by the provincial government of Gävleborg, on much the same basis as the county farm institutes in Britain. It provides courses for budding woodsmen, farmers' sons, and anyone likely to be concerned with the management of small areas of woodland. Although it is not a prerequisite to have attended one of these schools to obtain entrance to the State Forester Schools, in practice there is little chance of entry without having done so because competition is so great.

The School provides three courses during a year:

(a) A fifteen week course from September to December for boys of 15 straight from school. Thirty boys attend each course and are selected purely on school record and headmaster's recommendation. It is essentially a practical course dealing with the use and maintenance of tools and mechanical equipment, extraction with horses, mensuration and planting, etc. A State grant of Kr. 500 (about £35) is available for boys attending the course.

(b) A twelve week course from March to June for twenty seventeen-year-old boys which is a follow-up course on the earlier one after the boys have had some experience in the woods. The State grant in this case is Kr. 400 (about £27).

(c) An eight week course from January to March for ten or twelve eighteen- to twenty-year-olds and concerned chiefly with management, carrying a State grant of Kr. 300 (about £20). In addition there are a number of short courses for woodsmen and schoolteachers.

The School is eleven years old, and very modern by British standards. Two students share a bed-study and there are communal dining room, recreation room, library and shower room. There is one general lecture room, equipped with sound film projector, and rooms for instruction in tool maintenance. The latter are very well equipped with work benches as shown in Plate 24, at which four students, all facing the same direction, can work. Overhead strip lighting and individual adjustable lamps ensure adequate light. The teaching technique here is interesting. While the students are practising saw maintenance, the particular operation they are practising is shown continuously on a screen at the end of the room. This is done by having a silent projector at the side of the screen, projecting, through mirrors on to the back of the screen, film loops illustrating the operation. The projector is thus easily accessible to the instructor, and the same operation continues to be shown on the screen until he changes the film loop for the next operation.

Each student is issued with a set of tools which he keeps in a special locker and for which he is responsible while on the course.

Forest Tree Breeding

At the School there is a forest tree breeding station and grafting from plus trees in the province is carried out. Three distinct areas in the province are recognised; the lowland, highland in the south, and highland in the north, and plants for use in each area are raised from seed from plus trees in that area. Tree seed orchards have been formed and are producing seed. The techniques involved appear similar to those used in Britain, and the general principles applied are those given in Professor Lindquist's "Genetics in Swedish Forestry Practice".

Nursery Practice

Also attached to the School is a nursery of some 20 acres, where plants are raised for the expanding planting programme in Sweden. The reasons for this increase in artificial regeneration are that stocking from natural regeneration is inadequate, and that, by planting, the quality of the crop can be improved.

The normal ages of stock used are Norway spruce two-plus-one transplants and Scots pine two-year seedlings. No other species are being used apart from some experimental planting of European larch in attempts to raise the tree line.

The timing of nursery operations is necessarily quite different from British practise because of the severity of the winter. Thus lifting starts as soon as the snow has gone—probably late April except in the south where it is rather earlier—followed by lining-out and sowing as soon as the ground can be prepared.

At the School nursery, although it is on a light soil, only inorganic fertilisers are used, and no sprays are used for weed suppression. The ground is prepared with a tractor-drawn rotary tiller, and sowing is done with a mechanical drill developed by the nursery officer on the lines of an agricultural drill, also tractor drawn.

Plants lifted for lining-out are placed in small boxes of local design and taken direct to the lining-out site. The lining-out is done by several women working individually on the same area. Two side boards are placed 3 metres (9½ feet) apart and parallel. These boards are drilled at 20 cm. (8 inch) intervals. Cross boards, drilled at each end, are placed at intervals so that these holes coincide with the holes in the side boards, and they are then fixed with steel 'pins' about 1 metre (3 feet) long. The ground between two cross boards is one woman's stint. The cross boards are notched at 5 cm. (2 inches). This layout is illustrated in Figure 10 facing.

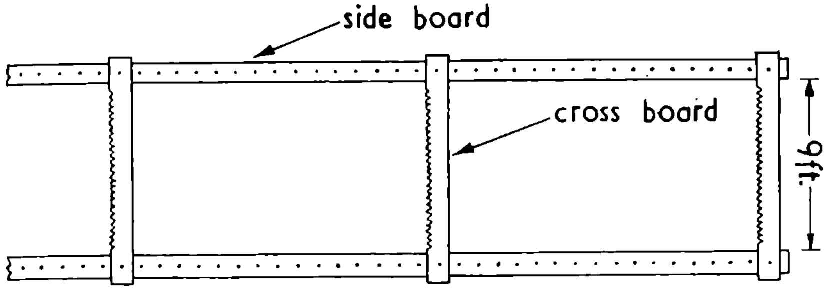

Fig. 10. Layout of Lining-out boards in Sweden.

A trench is cut in the normal manner using the cross board as a guide, and plants placed in the notches and held there with a handful of soil as in normal hand lining-out. When about 20 plants are in position, that part of the trench is filled in and firmed. When the row is finished the board is moved back to the next hole and the process repeated. One row between each woman's stint is left blank as an alley and when the section is finished the right-hand side board is lifted and placed 3 metres (9½ feet) to the left of the left-hand side board, and a new section lined out. In this way long lines of transplants in beds of any desired number of rows are obtained. (See Figures 11 and 12.) The method seems complicated, but the fact remains that each woman lines out 10-12,000 plants a day, and there is very little danger of roots drying out. The spade used for cutting the trench is unusual in that it is heart-shaped and has a swan neck. The shape would not be suitable for use with larger plants where a deeper trench is needed, but the swan neck certainly helps in obtaining a vertical face to the trench.

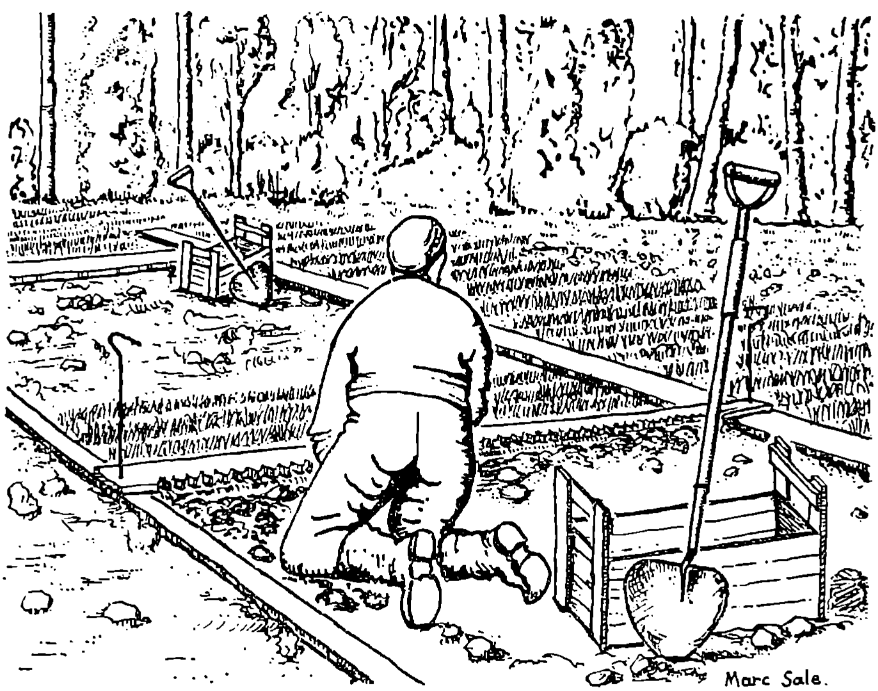

Fig. 11. Lining-out: General view and equipment used.

Even allowing for the shorter growing season, the plants were of poor quality—small and with poor root systems. The size is less important than in Britain since there is not the weed problem on planting sites, but better roots could give better results.

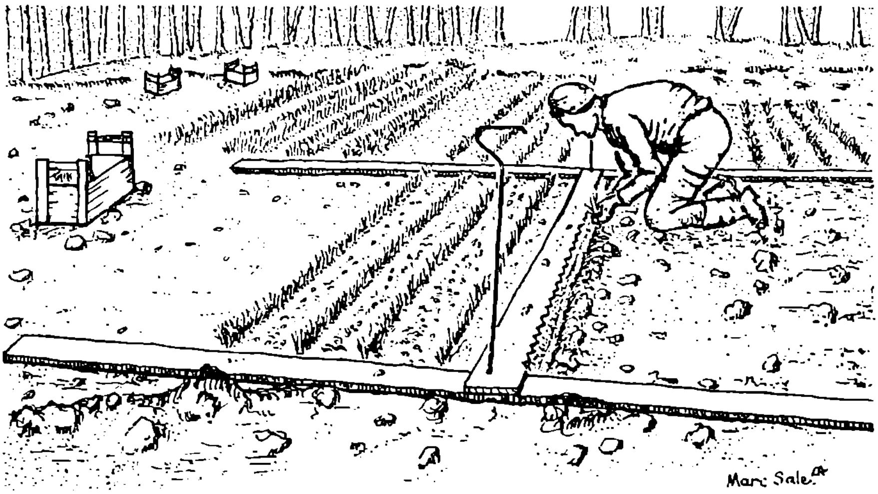

Fig. 12. Lining-out: Details of operation.

Planting Practice

At the School we were given a demonstration of three methods of planting used, the method depending on the depth and type of soil. Great care is taken with the planting so that 400 a day is a good day's work. No doubt the type of plants used necessitates care in planting to ensure survival, but it would appear to be overdone.

In all methods the plants are carried in a wooden "basket" which contains about 200 small plants—half-a-day's work—and which is kept covered. This, of course, has to be put down and picked up at each planting site.

The three methods really only vary with the tool used.

1. **Semi-circular Spade.** This is similar to the same type of tool in Britain, but with a shorter handle. No divot is removed, but a curved notch is made, into which the plant is planted. An elaborate technique has been evolved for this, but the net result appears to be no different from ordinary notch planting as practised in Britain. (See Figure 13.)
2. **Trowel Mattock.** This tool is like a large trowel set at right angles to a pick-shaft type handle. It is used in the same way as a mattock in Britain.
3. **Spike.** This is a round iron spike on the end of a heavy handle similar to that on a cant hook. In shallow stony soils it is driven vertically into the ground, making a circular hole some 3 inches in diameter. When the plant is in position the hole is filled up with soil which the planter carries with him in a bucket. This is a two-man method and must be extremely expensive.

In view of the amount of study that appears to have gone into the correct method of use of these tools, the methods of planting seem to be a long way behind those adopted in Britain.

Fig. 13. Swedish semi-circular spade in use: note carrying box for trees.

PART V

Felling and Extraction

Felling

The method of felling has been discussed already in Part II but certain general points were noted during an afternoon spent at a felling site in the Hults Bruks forests.

It has always been the practice in Sweden when felling an area to leave a few of the best stems per acre standing. This is, of course, in the hope that gaps in the natural regeneration will be filled by seed from these trees. However, this practice has become traditional, and even where the area is to be replanted artificially such trees are still left by the fellers, and they are reluctant to remove them even when instructed to do so. In fact, the leaving of standards for a second rotation to produce some larger prime timber might well be worthwhile as the virgin areas are worked over, where there is no indication of butt rot in the crop.

Both the men concerned with felling and those on extraction, although employees of the Company, are more in the nature of contractors, since they are paid on a piecework basis, and provide all their own tools and equipment. The feller fells, trims out and, in the case of small poles, stacks in "V" tushes, or with larger timber cross cuts it to specified lengths for timber, pulpwood, or pitwood for export. He also peels if this is required.

Extraction

Virtually all extraction to a hard road is by horse, which is most suitable for the rough, trackless terrain. Until recently this, as with the felling, was confined to the winter months. This meant that there was practically no employment for woodsmen during the summer so that forestry was a part-time occupation. The reason for this was that forestry work could be done in winter, whereas little agricultural work was possible, while extraction by sledge was very much easier while snow was on the ground. In recent years development of extraction methods without snow have been studied so that forest work could continue throughout the year.

One of the developments which we saw was a small-wheeled wagon of welded tubular steel construction. The method by which the shafts are connected to the steering mechanism is designed to enable the wagon to travel over rough ground without discomfort to the horse, and to reduce the turning circle. Using this wagon a horse is able to draw loads of over one ton over very rough ground. The horses used are rather bigger animals than normally used in Britain, more like a Percheron.

The use of small wheels, while less suitable on many sites in Britain, assists considerably towards the ease of loading the wagon, and, as always, the emphasis in Sweden is on reducing fatigue to the woodsman.

PART VI

General Conclusions

There can be no doubt that in matters concerned with the utilisation of timber Sweden is considerably in advance of Britain. This is not surprising since the forests have provided a large part of the national income for a very long time.

This is particularly so in the case of the tools used in exploiting the forests. Not only is there a desire to produce tools which are good in themselves, but also tools which will do the job best. This requires experiment on the tools both in the factory and the forest, and a study of the techniques of using each tool. Having produced what is considered the best tool for the job—until an even better one can be developed—the next important stage is seeing that it is kept in the best possible condition for performing its function. While we in Britain must make up our own minds as to which tools are most suitable for our own conditions, on this question of maintenance we can learn directly from Sweden. A good tool, well maintained, must be an economic proposition unless the initial cost is out of proportion to the amount of work to be done.

On establishment work, except in the field of genetics, the boot would seem to be on the other leg. Nursery work and planting methods used in Britain are greatly superior to anything we saw in Sweden.

Work study in foresty is well established, but Swedish woodsmen are as suspicious of new methods as are their British counterparts, and only when they see that bigger earnings are possible are they prepared to change. This is reasonable enough since the criterion of a new method must be its effect on output—both qualitative and quantitative,—but it is difficult to test new methods in the field in these circumstances.

Handling and conversion are both simplified by a small range of both species and sizes,—a uniformity of product—and by the large quantities available, a state of affairs which we shall more nearly approach in the future, though our wider range of conditions will prevent complete achievement.

Finally, it was agreed by all who attended the course, that the Swedish manufacturers, particularly saw manufacturers, study the market very closely so that they can produce a high quality tool suitable for the conditions in which it is to be used, and for the work it is to do. The results of this policy are apparent in the outstanding efficiency of the tools they produce.

NORWEGIAN IDEAS ON FOREST WORKING TECHNIQUES

By C. P. KIRKLAND

Forester, Work Study Section

The following notes were compiled in the course at a visit to the Sonsterrud Training Centre, near Flisa in Norway, during November and December, 1956.

The word "techniques", as used in Norway, covers all training designed to obtain the best use of forest tools, and of the workers' muscles and limbs. It is expected to minimise fatigue, cut down accident rates, and eliminate damage to muscles like strained ligaments, slipped discs, etc. "Techniques", as one of our members, A. Hartley, wrote "is the main theme round which Norwegian Forest Workers' Courses are built" . . . it is concerned with the correct holding of tools, and the correct posture of the body, such positioning being designed to bring into use the best muscles for the job.

The theory of "techniques" seems to have been developed by Dr. Tvet, built up from anatomy, study of circulation, respiration, his experience in supervision of training of athletes, and in studies of workers in action.

Dr. Tvet has a practice in Oslo. He is, I believe, a consultant in a hospital, and I gathered had specialised at one time in diseases of bones. Practical instructors have been trained in his theory, and have been trained in his practices as well. They are full of enthusiasm, as far as the efficacy of his method is concerned, while admitting that it may yet be modified, and may not suit everybody.

The idea is put over largely through a day and a half of lectures by Dr. Tvet. He is an able lecturer, and demonstrator of the awkward use of limbs. Demonstrations of the right way to do the operations met with in felling are given by the practical instructors before commencement of work. They then stay with the men for the entire period of the outside work, advising and if necessary demonstrating. A few individuals are apt at picking up the method, most want at least some individual tuition.

They would like to train young individuals, from 15 years to a maximum of thirty years old. It is considered doubtful if the ways of the normal forest worker can be much changed after the age of thirty.

In addition to the above instruction, demonstration and practice is given by a forest official, trained at a medical school for about 9 months.

Dr. Tvets main theory is that contraction of muscles also contracts blood vessels. As muscles are fed through the blood vessels, and waste removed the same way, reduced circulation leads to tiredness. Muscles should therefore be used in such a way that maximum relaxation is maintained. This is done by avoiding cramped postures, and avoiding taxing too much certain muscles, especially the smaller ones, when bigger muscles can be used with less effort and contraction. The use of bigger muscles, such as legs, thighs, shoulders, and back, will provide an easier and more free-moving action; rhythm is built up and maintained. It is said that each muscle should be used to its full capacity each day, otherwise the fibres nearer the bone lack tone, and extra effort may lead to a "pulled" muscle.

The "standard" of an easy and free movement is that employed in walking correctly. The nearer the posture of the body, and movement of the limbs, in any operation, approximates to the posture of the body, and movement of the limbs in walking, the better will be the method of work. All limbs or muscles not in active use should be relaxed. All the practical instructors, including the motorsaw instructor, are imbued with these ideas. Instead of relying, say, mainly on the biceps to provide power for peeling, the movement should be from the feet upwards. If a man is very powerfully built, they say, alright, for him it may be right to use his muscles that way. But the average forest worker is not of big build.

In addition, it is pointed out that the smaller muscles should be trained first until good aim with the tool has been achieved, after that the bigger ones should be used to provide more power. Movements, though rhythmic and smooth, should be of good acceleration, this gives a better and brighter mental approach, and the worker with this attitude will develop less fatigue.

Exercises for developing quick response of muscles, and for developing abdominal and back muscles, are recommended. It is said that most people do not walk properly, having from early training largely lost mobility of the base of the spine. In commencing work for the day, do not start on too heavy work. Time should be given for loosening the muscles.

Some more precise points of instruction, to illustrate, are given below:

In winter peeling, a change of grip on the handle may be required after the initial contact with the bark.

When peeling, both feet should point in the direction of travel up the tree.

Weight on the rear foot should not be on the side of the foot, but on the ball of the foot.

Knees should always bend in the direction one is facing, as in walking. Many people work in such a position as to make them bend at odd angles. All such positions involve unnecessary strain.

Body should half face direction of walk. Thrust comes from all muscles, using a swivelling of the hips to reinforce thrust.

A good high swing from the shoulders is used, with the leading arm not bent too much.

Method study is taught as the necessity to think where each tool should be placed, so as to be where it is wanted next. Walking should be reduced to a minimum, though when a worker is tired this may be *increased* to a certain extent.

Snedding must not be done with a peeler. The edge of the peeler is not designed for it, requires to be very sharp, and would soon get blunted. (Certainly on the frozen trees we were working on.)

Grips on tools should not be too tight.

Use of their small axe, is in such a way that though the movement commences over the shoulder, the action is rather one of throwing the axe head at the point of contact, holding the wrists at one position, as in serving a tennis ball.

Finally, they were very loathe to lay down any particular laws either as to technique, or method of work. Both, they say, will vary with the individual, after definitely wrong practices have been eliminated.

One of the lecturers on technique had done 4 years' practical forest work, 18 months at a forestry school, and 8 months at a medical school, and is now a forester.

Summary

Judging from the keenness on this subject amongst students, it is a very popular one.

A knowledge of how the body works, and of the position and function of every muscle, is necessary if intelligent methods of working are to be taught.

Especially for clumsy workers, consideration of posture and correctness of defects, brings about a great reduction in wasted energy.

Movement-consciousness also leads on to consciousness of other details, such as positioning of tools.

Training of men should be given as early as possible.

REPORT ON SONSTERRUD FOREST WORKERS COURSE, NORWAY

By C. P. KIRKLAND

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Introduction

The following is a report on a course held at Sonsterrud, near Flisa, Norway.

Flisa is approximately 75 miles north-east of Oslo, and 13 miles from the Swedish border. It is situated in a broad valley, through which runs a tributary of the Goma river, used extensively for floating of timber. Surrounding country consists of low hills, covered with forest. Such forest is mainly of Norway spruce, but some very fine stands of Scots pine occur here and there, and generally there is a tendency to convert the low-lying areas to Scots pine.

The Course lasted from the 15th November to 19th December, 1956. Attendance of foreign students was organised under the auspices of the International Labour Organisation, Geneva. A grant of about £12 per student for expenses on the course, and the cost of the student's passage from Newcastle to Flisa, was met by the I.L.O. Tuition and accommodation at the School were free.

Five members of the Forestry Commission staff attended the course. Arrangements for the course were made at a time when the School had, on its staff, an Instructor who spoke fluent English. However, when we were there, there was no tuition in English, owing to this Instructor having gone to work in Sweden.

A certain amount of literature was brought back. Reports of the Forest Research Station, with short summaries in English, and including some Work Study data, were provided by Professor Samset. Short treatises on Method of Working and on Technique of Felling by Broch, were obtained from the School, together with a small Text Book for Forest Workers.

An effective rubber sheath for protection of the blade of Peeling spades was also brought back.

Conversion of Produce

For both Scots pine and Norway spruce, minimum top diameter is 1 cm. Diameters of 2 cm. or over go for mill timber, if straight enough and if not tapering too much. Minimum length for mill timber is 4 m. and maximum length 12 m., but if the volume of the smaller pieces is over 40 litres minimum length may be 2 m. Smaller stems than the above may be used for firewood. These are usually stacked in the wood, in units of 1 m. high and about 2½m. long.

In the Flisa area, trees are converted when felled, by the feller. Each feller carries with him a graduated stick of some 2½ m. in length. In his hip pocket he carries a pair of calipers. These two items, together with a table of produce sizes and value, enable him to measure and select the most profitable conversion lengths into which to cut his tree.

Peeling of every tree is the practice round Flisa. It is said to be general practice at the moment, except where logs are conveyed away by road or rail. Present trends as regards the peeling are to accept the greater loss of logs by sinking due to flotation down river with the bark on, as the cost of subsequent peeling by machine at the pulp-mills would be very much less than hand peeling. Recovery of sunk stems is considered feasible.

The School

Since its inception in 1946, 2,531 men have been through the school at Sonsterrud, the only one of its kind in Norway. It is now being decided whether to open other similar schools in different regions.

Some anxiety is felt by the school staff about the ages of workers who should benefit most from attendance. The longest course held at the school during the year is the 5-week course we were on; this course had only two or three older forest workers, all the rest appeared to be very recently out of the ordinary educational schools, with perhaps a few months to a year or so of experience in the woods. All had their National Service still before them. A fair proportion of the students would be going on to higher forest occupations than that of a forest worker; some were hoping to become graduates. It is considered very doubtful if the ways of a forest worker can be changed much, if he is over the age of thirty years. Fifteen to thirty years of age was nevertheless stated to be the ages they wanted at the school. The Chief Instructor however was more keen on concentrating on the younger men, and was hoping some apprentice scheme could be started to encourage boys of the 15 to 18 age group to come into forestry and be trained, as workers. There are, at the present, courses of 10 weeks duration, in the summer, devoted to boys of 15 to 18 years.

For forest work a man was said to be at his best at the age of 35; they compare this with the average age of marathon runners, which is said to be 36, whereas the best age for sprinters is 24 years. This interest in athletics in its comparison with forestry is rather typical of their attitude at the moment, in stressing training and the proper use of muscles, possibly because I believe the doctor who has advised on technique has had something to do with the training of athletes.

The number of students on the course was 40, split into permanent groups or classes of eight for instruction purposes.

The School has courses during at least 28 weeks of the year. Two courses are run in summer, two in winter. One of each lasts 5 weeks, the other 4 weeks. In addition, there is the 10 weeks' summer course for younger men, and a 2 weeks course on power saws only. There is also a 4 weeks' course on motor saws and hand tools, but tool maintenance is said to be unpopular, whereas power saw courses are very well attended.

The Course

This Course of 5 weeks is split up as follows:

Lectures	50 hours	21.2%
Hand-Tool Maintenance ...	65 ,,	27.5%
Motor saw Maintenance and use	39 ,,	16.5%
Felling, peeling	58 ,,	24.8%
		90% of total time

The remaining 10 per cent of the time was spent on two excursions (one to a pulp-mill, one to a stand of big Norway spruce), and on three whole-day lectures on technique of felling and peeling. Total number of hours of instruction, lectures and excursions was 236.

Only three complete days are allotted to lectures, but 101 hours of lectures with and without films or slides on various subjects are given between the hours of 4.30 and 6.30 each day. Practical instruction therefore occupied from 8 a.m. to 3 p.m. each day, including Saturday. During this period there was a three-quarter hour break for lunch.

The day's routine at the School started with breakfast at 7.30 a.m., work commenced at 8 a.m. 'Second breakfast' was from 11.15 a.m. to noon. The afternoon session was from noon to 3 p.m. 'Dinner' was at 3 p.m. there was then a break of 1½ hours, followed by supper at 6.30 p.m.

Instructors

Two of the Instructors were mostly on administrative duties. Most of the instruction was given by a staff of five, with permanent accommodation at the School. Two of the five were teaching tool maintenance in the School, one instructed both maintenance and outside use of power saws, and the remaining two instructed in practical work outside, mainly the proper technique of felling, trimming and peeling. No Instructor could speak much English.

All Instructors were extremely good at their jobs. They were very patient, nothing was hurried, and their method of instruction was very good. All were well qualified for their jobs. The instructor on power saws had spent at least one year working at the factory that makes the Jo-Bu power saws used at the school; the tool maintenance instructors had started their instruction before the war, and were trained by Swedish experts, in Oslo, and since then have been on refresher courses. Teachers of techniques of felling, etc. were trained at forestry schools, and then by Dr. Tvet. It was difficult to ascertain precisely how they got their training. They were outstanding men to start with, I think.

First Aid and General Health

Three well-planned and ably executed lectures by a medical orderly demonstrated bandaging of cuts, application of tourniquets, artificial respiration, and methods of transport of the injured. Demonstration was followed by a trial by the students.

Supplementing these lectures, a film was shown emphasising the manner of occurrence of the more common accidents in the forest, and coloured posters are displayed in the class-rooms showing typical danger-fraught incidents.

Prevention of injury was also touched on by Dr. Tvet in his technique lectures, where the proper use of muscles and way of doing work is shown to decrease the incidence of pulled muscles and strained backs. Anything decreasing fatigue will lessen the accident rate.

They quote the following table of accident distribution:

66%	FELLING	Felling	16%
		Trimming	38%
		Peeling	12%
27%	EXTRACTION		
7%	OTHER		

Ten per cent of the workers are said to injure themselves per year. Accidents occur mainly when workers first start work in the mornings, when muscles are not properly loosened up, and just before rest periods when men are becoming tired. Skilled men suffer less accidents than unskilled.

Films and lectures were also given showing improvement in living conditions in workers' quarters that are being implemented now, and an Estate Officer has been appointed to see that accommodation provided by the firms for their workers is up to certain standards. Such improvements are taking the form in the most advanced areas of new and better houses replacing the old cabins, attention to the sanitation and feeding of the workers, and training of some female staff in dietetics. It is said a forest worker should have between 6,000 and 7,000 calories per day.

Tool Maintenance Instruction

Type of Tools

Range of tools used in the forest at this School is small. Sawing during felling operations is done almost exclusively with the Sandvik "Tiger" one-man saw. Bow saws were not used. Broch said they are used quite a lot in other parts, but he doesn't know which is best. He said the bow saw is better for smaller trees, owing to its thin blade, but that the position of the operator when felling with it is not so favorable as the position of the operator felling with the one-man cross cut saw. The Tiger saw is used for trees of 7in. to 20 in. butt diameter. A smaller but similar saw, the "Vedsvan" or firewood saw, is used for smaller trees, and power saws for larger trees. If power saws are not available, a two-man cross cut saw would be used.

In Norway the Tiger saw costs about 44/-. Length of blade is 36 inches. It is very effective in sawing through their slow-grown, mostly frozen softwood. The saw has a straight back, and a curved tooth-line. No pressure is necessary. The Tiger saw is said to be the most popular saw for medium-sized trees, and is asserted to have been proved by the Swedes to be the best saw for this class of tree.

Power saws will be dealt with later, but they are in use in large and increasing numbers, bought often by the workers. Using a power saw, the operator also usually carries a bow saw.

Axes used are of a variety of makes, some Swedish, some Norwegian. They vary in weight from 2½ to 3½ lb. The heavier ones are used mainly on the west coast of Norway, where trees are bigger or more branchy. Length of edge of blade is about 4 inches. Handle length is about 24 inches.

Bark spades were also of a variety of make, including the EIA spade. They are all straight-edged. Weight for hard and frozen wood is about 2½ lb. and for thin and soft bark 1¼ to 2½ lb. Handle length is about 40 inches. Summer felling employs the lighter peeling spades. If bow saws are used, blades in summer have more room for sawdust than winter blades, i.e. the blades with rakers or larger gullets between the teeth, as opposed to the blades used in winter of maximum number of teeth, and no rakers.

Tool maintenance

On this course of 236 working hours, tool maintenance instruction occupies 58 hours, or 24 per cent of the time. Of this time, about one quarter is devoted to axes and peeling spades.

As mentioned earlier, the Tool Maintenance instructor had been a forest worker for many years, and was then trained by Swedish experts at Oslo, with subsequent shorter courses.

Facilities at Sonsterrud were excellent. Saw sharpening was given priority of accommodation, and occupied a large light room of about 50ft. long and 20ft. broad. The whole of one side was window space, and in addition each sharpening space (of which there were eight) had an individual adjustable light. In addition, there was ceiling lighting.

Tools necessary were plentiful. Saw vices were well made, made so that two positions of the saw were possible, i.e. upright and at an angle of about 30 degrees.

Files used were made by Oberg & Co. of Sweden. Cut of files was FINE, except those used for gulletting.

Instruction in saw-sharpening was given in a very unhurried manner. Such a method is the only one possible, where the main requirement is the attainment of facility in handling files, obtained only through practice.

The two days on axe and peeling spade maintenance were spent in shafting an axe, and grinding and sharpening axes and spades. Facilities here, though not nearly so spacious as for saw-sharpening, were adequate. Two joiners' benches, and four powered grindstones, comprised the equipment.

Very great care is taken to turn out a perfectly sharpened edge tool.

For use in the forest, saws were carried backward and forward each day in boxes. At the end of the day, blades were dried with a rag, and then cleaned with cotton waste and a mixture of petrol and oil. All saw blades were maintained bright and polished.

General Tool Maintenance by Forest Workers

Conditions of service in the forests of Norway appear to vary very much. State forests, communal forests, and forests owned by private firms have different arrangements as regards to tools and their maintenance. Generally, workers own their own tools. They always pay for them themselves, even if not personally owned. Some of the big firms hire tools, and also maintain them in their own well-equipped workshops. In some such cases workers may be charged say 3/- to have a saw sharpened, this would compare with an amount of about 5/- if the worker took his saw to the local village 'saw-doctor', which seems to be a system in use in some places.

I got the impression that with the bigger firms it is becoming increasingly common for them to provide sharpening service, and to make a charge to the worker. More than one set of tools is then required per worker, and it was stated that three sets per worker was best.

Techniques

We now come to the subject the Norwegians call 'techniques'. It covers all training designed to obtain the best use of forest tools, and of the workers' muscles and limbs; it is expected to minimise fatigue, cut down accident rates, and eliminate damage to muscles through improper methods of work, and to increase production. 'Techniques' is the main theme round which Norwegian Forest Workers' Courses are built . . . it is concerned with the correct holding of tools, and the correct posture of the body, such positioning being designed to bring into use the best muscles for the job.

The theory seems to have been developed by Dr. Tvet, built up from anatomy, study of circulation of the blood, respiration, his experience of training of athletes and studies of workers in operation. Practical instructors have been trained in his way. They are full of enthusiasm while admitting that it may not be the only way.

Dr. Tvet is himself a very able lecturer and demonstrator of his methods. Demonstration of the right way of doing operations are given by the instructor before commencement of work. He then stays with the men for the entire period of the outside work, advising and if necessary demonstrating again. A few individuals are apt at picking up the method, most want at least some individual tuition.

The theory is that contraction of muscles also contracts blood vessels. As muscles are fed through the blood vessels, and waste removed the same way, reduced circulation leads to tiredness. Muscles should therefore be used in such a way that maximum relaxation is maintained. This is done by avoiding cramped postures, and avoiding taxing muscles too much. Therefore the bigger muscles should be employed, rather than straining smaller ones.

The standard of an easy and free movement is that employed in walking. The nearer the posture of the body and the worker's movements, in any operation, approximate to the posture and movement of walking, the better will be the method of work. All limbs and muscles not in active use should be relaxed. Movements, though rhythmic and smooth, should be of good acceleration, this gives a better and brighter mental approach, and the worker with this attitude will develop less fatigue.

Exercises for developing quick response of muscles, and for developing abdominal and back muscles, are recommended. It is said that most people do not walk correctly, having from early training largely lost mobility of the base of the spine.

In commencing work for the day, do not start on too heavy work. Time should be given for loosening of the muscles.

Method study is taught as the necessity to think where each tool should be placed, so as to be where it is wanted next. Walking should be reduced to a minimum. Grips on tools should not be too tight. The small axe used, is used in such a way that though the movement commences over the shoulder, the action is rather one of throwing the axe head at the point of contact, holding the wrists at one position, as in serving a tennis ball. With the peeling spade, the movement should commence well up with a good swing from the shoulders, the leading arm should be nearly straight, and additional thrust obtained by a swivelling from the hips.

Finally they are very loathe to lay down any particular laws either as to technique, or method of work. Both, they say, will vary with the individual, even after wrong practices have been eliminated.

As far as choice of tools is concerned, the light axe they say is ideal, and they point out that this has not always been the axe used in Norway. In former times, heavier axes were used. As far as saws are concerned, they seem to think the "Tiger" one-man cross cut saw is the best, apart from power saws. They point out that in certain areas of Norway however, the bow saw is the most popular saw for felling, and that in Finland the bow saw is exclusively used. In considering tools, working position of the operator should always be borne in mind. From this point of view the "Tiger" may have some advantage over the bow saw.

Motor saws

The motor saw instructor had spent one year working at the Jo-Bu factory. He was an extremely good instructor, both inside on maintenance, and outside on felling trees.

Thirty-nine hours, or 16% of the time, was allotted to power saws.

The saw most used was the Jo-Bu Junior.

Three and a half hours were taken on stripping, re-assembling and cleaning the "starter-pulley" mechanism. Two and a half hours were taken by the instructor in demonstrating stripping and re-assembling the carburettor. At the end of the day the instructor assembled a saw (in another room) with as many mistakes as possible. Students had to locate and rectify the faults.

Conclusion

In conclusion, I like to put on record how remarkably friendly, and helpful, were both Instructors and students at the School, in trying to satisfy the needs of these five students, who knew none of their language.

I do not think their willing and pleased acceptance of strangers could be surpassed. The Head of the School had put the three Norwegians who spoke the best English into our class. This was an invaluable aid for us.

Summary

Care and maintenance of tools, working in such a way as to use the body's muscular and energy resources in the best way; constant attention to planning of one's work system, so as to have a minimum of non-productive walking time, and so as to find the right tools in the right place at the right time; these were the subjects the Instructors held patiently and constantly before the students.

A great deal of time and professional advice seems to have flowered into their present teaching of tool use, aiming at making work both less fatiguing and more efficient. Such methods, of course, apply to the tools used at the School, and under the conditions met with in Norway. These differ from our tools and forest conditions, mainly in our use of bigger axes, and our more prevalent use of the two-man cross cut saw. Their conditions differ from ours mainly in the greater branchiness and coarseness of our trees, and in the fact that our trees are rarely frozen, whereas much of their felling work is done when the wood is frozen.

A DISCUSSION ON TOOL MAINTENANCE INSTRUCTION COURSES

This record of a meeting held in the Village hall, Ae, nr. Dumfries, on 27th and 28th March, 1957 was compiled by Forester C. P. Kirkland, of the Work Study Section

Present:	W. P. Thomson	West Scotland Conservancy, *Chairman*
	E. R. Lewis	Headquarters
	J. W. L. Zehetmayr	Work Study Section
	C. P. Kirkland	Work Study Section
Instructors:	D. W. Lawson	Scotland, North and East
	D. T. Patterson	England, East and South-east
	D. J. Snellgrove	Dean, New, and England, South-west
	W. J. Stevens	Wales, North and South
	I. Toulmin-Rothe	Scotland, South and West
	A. H. Weir	England, North-east and North-west

Object: To exchange experiences from the tool courses, and to review the equipment necessary for tool maintenance.

1. Report of Tool Instructors

Conditions under which courses held

There was a lack of adequate accommodation for the courses. Accommodation failed in the following:

Light

Protection from cold

To escape the dungeon-like conditions of some accommodation, the course had to be taken outside. This made attention, sharpening, etc. difficult, owing to the cold. For the same reason the open-ended sheds used in many places were hopeless. Holding the courses in the winter added to the difficulties of instructing either without artificial light, or without cover. Inside, it was often too dark to sharpen saws by 2 p.m.

Exceptionally, accommodation was better in Wales, in Northumberland (at Kielder and Kershope artificial light was available), and at Thetford, where on occasions the Brandon Seed Store could be used, which, well-lit and heated, was ideal.

Where the instruction centres had to be changed between courses, two such courses per week was the best number, allowing time for travelling, arranging accommodation, etc.

Interest in courses

Men were keen to learn. The tools displayed aroused enthusiasm, and envy. The simple 'drifts', used for extracting broken shafts from axe heads, were welcomed. With the following exception, ignorance of tool maintenance was complete—in areas visited by the Lightmoor 'saw-doctor' standards were higher, but instruction in re-shafting was necessary.

Co-operation from foresters was satisfactory. In some areas, even the old 'die-hard' foresters welcomed the courses. Elsewhere, courses were occasionally looked on as a waste of time. In such cases the best workers were not 'spared' for the course.

In north and east Scotland, many District Officers attended the courses, in addition to the foresters. If more than a few such people come, they tend to distract the attention of the workers, and separate courses should be run for them. On the other hand, in some areas no District Officers and very few foresters attended.

General condition of tools

Generally, the state of tools was atrocious. No forest in Wales had a raker gauge for adjusting cross-cuts. In the Dean, there was not one saw vice. With the exception of South Wales, there was a general lack of shafts. Equipment for tool maintenance had not been available until recently. For instance, nails were commonly used instead of rivets.

Supply of tools

(a) **Shafts.** The lack of shafts is aggravated by the multiplicity of tools doing the same job. For instance, spades of at least four makes are in use—all doing the same job, but some requiring different shafts. (Spades having split straps are easier to re-shaft than the closed socket type). Shafts are supplied to South Wales from Tintern. In North Wales there are no spare shafts. One aspect of supply of shafts, namely the introduction of short shafts for axes, is being dealt with by Work Study.

(b) **Crosscuts.** Preference for the Sandvik two-man crosscut No. 915 is growing. We know workers who bought their own Sandvik crosscut (price over £4). Dissatisfaction with the state of some of the new Slack, Sellars & Co. crosscuts was expressed by the Tool Instructors. Reduction of the excessive set of these saws has led to breaking teeth. The set has sometimes been nearly five times that required. Such saws commonly have to be sharpened also.

Mr. Lewis said he would arrange strictly comparable tests of 4ft. and/or 4½ ft. raker tooth crosscuts of Sandvik and of Slack, Sellars & Co. Good quality Slack Sellars would be chosen. The test is of quality of the saw, not of its state of readiness for sawing. The two makes are therefore both to be brought to the best state of sharpness and adjustment, prior to testing.

Many of the Commission's saws are too long. For much of the thinning work 4ft. is sufficient.

(c) **Bowsaws.** The Sandvik bowsaw is the best for one-man work. The No. 8 frame is recommended by Work Study. Length used by them is 36 inches.

The correct blade for conifers normally is the Sandvik No. 21 hardpoint raker tooth bowsaw blade. This blade, which has been discarded in the Thetford area, has not been tried in North Wales. Mr. Lewis said he would arrange a supply of these blades to North Wales, who have been supplied with the literature on these blades like everyone else. As regards the Thetford area, Mr. Lewis promised to obtain for trial a few Sandvik No. 704 one-man raker-tooth crosscuts. It is thought that the sandiness of the area is responsible for the short life of hard-point blades. However, blade No. 129 is proving satisfactory.

(d) **Axes.** Weight of axes supplied is often excessive. In Northumberland men issued with 7 lb. axes for thinning, preferred to buy their own lighter axes. In the Thetford area Mr. Patterson would like to see some lighter axes tried. He will be sent one or two 3½ lb. axes with short shafts, when these are received by Work Study.

Ordering of Tools. Some of the useless tools in forest stores are those sent to foresters as substitutes for items demanded. Mr. Lewis pointed out that such substitutes should be returned if unsatisfactory. Such action is rare, the general attitude is that 'they may come in handy'.

Mr. Lewis said that a complement of good tools should be established, covering type and number. This will be a development of the future. The system of ordering tools requires revision. Foresters should estimate a year's requirement, and the Conservancy order quarterly. This would reduce clerical work and assist manufacturers.

Some of the present lack of tool maintenance equipment is, in some areas, due to foresters not ordering items available.

Tool storage. Good storage of tools is rare. Commonly tools are heaped too closely together. Stocks of useless tools are too big, taking up space available. Exceptionally, on one unit (a small one with only 9 men) there was a tool box for each man. On another there was a system of tagging each tool, on removal the tag was handed in to the Office. New units found it difficult to get any storage space.

Without efficient tool maintenance tools deteriorate, storage becomes a dump for broken tools.

We think first class production workers' tools (crosscuts, axes, peelers) should be stored in the Tool Maintenance rooms, when these are available. They will be segregated from accepted down-graded tools (axes and saws used casually or for drain maintenance, etc.).

Writing-off tools. The space that should be allotted to good tools is shared with useless stuff that needs writing-off. Attempts at doing this are commonly frustrated by over-caution. For instance, a forester may want to write off an axe. His District Officer may say 'there's a bit of use in it still'. The axe is kept as a wedge, or for use in cutting drains. But the number of such tools is too great. Mr. Thomson suggested a directive to District Officers might facilitate the process of writing-off. Mr. Lewis said there should be periodic inspection of tools in use for quality, as well as for writing-off.

Surplus stock. Another aspect of the lack of storage for good tools is the surplus stock on forests. At Ae there are about 200 pickaxes left by Roads Branch. These take up space and become progressively more rusty. Much surplus stock exists from the war years. It was suggested that lorries should be used to collect surplus, for sale or disposal. Mr. Lewis pointed out that, from his experience of Ministry of Supply sales, such surplus would be worth nothing, since valuable pieces of equipment (such as the Clinometers he had recently purchased, which are proving so useful) go for almost nothing. It is therefore best to cut our losses and get this old stuff swept away. On the subject of salvage, Mr. Lewis pointed out the danger of perpetuating out-of-date design. In addition, the recipient of reconditioned tools is never keen on receiving them in place of more modern, new, equipment.

New items. Samples of the following three items were taken by Mr. Lewis from Work Study.

(a) A small wedge, brought from Norway, also obtainable in plastic.

(b) An aluminium and fibreboard axe sheath brought from Sweden.

(c) A rubber guard for peeling spades, brought from Norway. These can be obtained from:

Jo-Bu Sales (London) Ltd., 150 Fleet St., London, E.C.4.

2. Tool Maintenance Equipment

Equipment issued to Instructors was reviewed. Decisions were taken as follows:

(a) **Sandvik Raker Adjusting tool or Burki raker adjusting tool**

The Sandvik has these advantages:

Built-in file holder, for stripping saw teeth.

Units are tenths of a millimetre.

Adjustment is continuous from zero upwards.

This tool is described in a useful printed pamphlet on saw sharpening by Sandvik.

It is already in use in some areas.

Some Instructors find that the platform files away more easily than the Burki, but this should not occur as men become experienced.

The Burki System Raker lowering device has these advantages:

It is light, compact, and easy to adjust.

Does not require such a depth of saw above the vice.

The disadvantage that stops the adoption of the Burki is that its smallest adjustment is rather large. Probably too large for all conditions.

The decision was made to allow both to compete. The Burki is not recommended for areas dealing with hardwoods. In addition, it should be made clear that the units on the Sandvik and on the Burki differ, a setting of 3 on the Burki is equivalent to about 5 on the Sandvik.

(b) **Saw Setting Pliers**

The Eclipse No. 77 pliers are not entirely suitable for bowsaws. They will be retained for handsaws. The six Tool Instructors will be sent two different Sandvik Setting pliers for bowsaws each, by Work Study, for trial.

(c) **Saw vice**

Provision of a good pattern of saw vice is essential. Mr. Weir will forward a sample of that used by him, to Work Study. Mr. Thomson promised to obtain a sample of a Swiss saw clamp, to forward to Work Study. When these are received, a final pattern probably based on the satisfactory model now used by Work Study, will be forwarded to Mr. Lewis.

(d) **Pierre Pertuis Set Indicator**

Two of the six Instructors experienced trouble. This was probably due to damp affecting the spring. A number of these indicators have been obtained by Mr. Lewis from Switzerland. It is thought that under less rigorous conditions than those of the Tool Instructors, and if kept relatively free from storage in damp places, the Pierre Pertuis will prove satisfactory. However, each Tool Instructor will be sent a Sandvik Set Indicator, through Work Study, for trial. In addition, Work Study will investigate a new 'Lasso' product, for possible issue for trial.

(e) **Axe drift**

A very useful tool. Patterns vary, A popular pattern obtained by Mr. Patterson will be forwarded to Work Study, for copy. This will later be forwarded to Mr. Lewis, for consideration as to central supply.

(f) **Rivets**

Arrangements for supply of rivets through Elwells have proved satisfactory.

(g) **Axe wedges**

Lack of these is mainly due to foresters' ignorance of their existence, or not thinking they are worth while.

(h) **Files**

The Tool Instructors' dissatisfaction with Austin & Dodson files for certain jobs was not unexpected, in view of experience of preference shown for Swedish files by the workers at Slack, Sellars & Co.

It does not seem to be realised that files are consumable stores, and will not last indefinitely.

Samples of various Oberg files for saw-sharpening are being forwarded to Tool Instructors by Work Study, for use in saw maintenance kits. For less fine work Austin & Dodson files will be retained.

(i) **Slack Sellars No. 133A Saw Set Key**

Mr. Lewis is to be sent a sample of the neatest key in the possession of Work Study, in order that the big variation in batches of the 133A key supplied may be diminished.

(j) **Tool Maintenance room**

Well-lit accommodation is essential and, while a certain amount can be done by improvisation, a possible solution is prefabricated one-, two-, or three-bay units. Work Study is investigating this.

A list of the equipment for a Tool Maintenance room is given below.

RECOMMENDED EQUIPMENT FOR TOOL MAINTENANCE ROOM

Grindstone (preferably power-operated).

Bench.

Engineers' 6″ vice.

Engineers' Breast Drill, with $\frac{1}{2}$″ chuck.

Twist drills for above, $\frac{3}{16}$″, $\frac{1}{4}$″ and $\frac{1}{2}$″.

Cold chisels, $\frac{1}{4}$″ and $\frac{1}{2}$″.

Wood Chisel 1″.

Hacksaw.

Centre punch.

Punch, 5″ x $\frac{1}{4}$″ approx.

Rivets, Elwell. Slashers: 1″ x $\frac{3}{16}$″, 1″ x $\frac{1}{4}$″, $1\frac{3}{4}$″ x $\frac{1}{4}$″, $1\frac{3}{4}$″ x $\frac{3}{16}$″.
Spades: $1\frac{5}{8}$″ x $\frac{1}{4}$″, $1\frac{3}{4}$″ x $\frac{1}{4}$″, $1\frac{7}{8}$″ x $\frac{1}{4}$″.

Wedges, axe. Oak, 4″ x $3\frac{1}{2}$″ x $\frac{3}{8}$″ top and $\frac{1}{16}$″ bottom.

Elwell 4 lb. club hammer No. 4005.

Elwell $1\frac{1}{2}$ lb. Ball-Pein hammer No. 615.

The following items are those concerned with sharpening, and are worked out to give the approximate minimum number per year for 6 men.

Files:	Austin & Dodson	10″ rasp	2
	—do—	10″ flat, bastard	6
	—do—	10″ round, constant diameter, 2nd cut	12
	—do—	8″ millsaw, 2nd cut, 2 round edges	12
	—do—	6″ slim taper	12
Handles:	File handles, Large		12
	Medium		12
Other:	Sandvik No. 118 Setting hammer		2
	—do— 119 Setting anvil		2
	—do— 120, or a Burki Lowering Device		1
	—do— 123 Raker gauge for bowsaw blades		1
	—do— 124 Jointing tool		1
	Eclipse Saw Set pliers No. 77		1
	Slack, Sellars & Co. No. 133A saw set key		1
	Pierre Pertuis Saw Set Indicator....		2
	Axe drift (pattern to be supplied later)		1
	Saw sharpening vice (pattern to be supplied later)		2

In addition, the following Oberg files will be issued for trial to the Tool Instructors, through Work Study. Some or all may then be added to the above list.

8″ Millsaw file, 2—2½ mm. (Extra thin.)

8″ Cross-cut file.

6″ Knife saw file No. 629.

6″ Double saw files of varying patterns.

FOREST WORKER INSTRUCTION

By W. F. STODDART,

Head Forester, North-East England

The success of all plantation work depends on the skill of the forest worker and the way in which forest labour is organised. The best type of truly rural forest worker is in the minority nowadays. Our forest villages are full of the small town and city type of worker who has been attracted to forestry for various reasons such as the open air life, the certainty of obtaining a house, the possibility of a secure job, etc.

This latter type of worker is the one who is least skilled of all in forest operations and requires to be trained in the use of the various forest tools. While it is necessary that a forest worker should be skilled in the use of various tools and be able to carry out a task satisfactorily, his training should not end there.

In my opinion forest workers should have all forest operations explained to them, e.g.:

Scrub clearing. The various methods of treating scrub and the reasons for not completely clearing some forms of scrub growth.

Draining. The benefits derived by the plants as a result of lowering the water table.

Planting. The site requirement for each species, how vegetation assists in the choice of species, care of transplants, the necessity for screefing and cultivation on sites where close vegetation overlies compact mineral soil, (where ploughing has not been done).

Thinning. How a tree grows, the relationship between root and crown development and increase in girth and height growth, and so on.

It should not be difficult for a Forester to explain to his workers, in simple language, the reasons behind all forest operations. The result, I feel sure, would be that forest employees would take an added interest in their work, with a consequent increase in output and efficiency.

SOME NOTES ON TIMBER FELLING

By Major-General H. P. W. HUTSON
Chief Engineer

Direction of Fall. Make up your mind which way the tree is likely to fall naturally. If the tree is fairly straight and is uniform in its branching it can usually be dropped in any direction desired. This is done by proper location of the cuts, by wedging to tip it on the stump and sometimes by pushing against the trunk with a long pole.

Big trees which are leaning considerably or which have heavy branches on one side can seldom be thrown in the opposite direction, but most of them can be thrown 45 degrees or so to either side of the direction in which they would naturally fall. When working on a steep hillside the best way to fell the tree is diagonally up the slope. A tree felled *straight* up a steep slope may bounce as it strikes the ground and its butt kick back over the stump to strike the unsuspecting feller. There is no way of telling what it is going to do. A tree felled straight down a steep slope can be shattered by the fall, particularly if the ground is rough. A tree felled straight across the slope may roll downhill in a dangerous fashion. It is equally bad practice to fell across a gully or over a sharp ridge or let a tree drop across a rock, or stump, or over another log. Obstructions like these may break the stump and waste good timber.

Still another hazard to be considered is the chance of your tree lodging in the branches of another tree. Half a day can be wasted in getting it down. And if the second tree has dead branches these may snap off and catapult through the air with dangerous speed.

Clearing. Having decided the direction in which the tree is to be felled the next step is to clear away any brush or low branches which could interfere with the use of the axe or saw at the base of the tree. See that there is plenty of room to swing the axe.

The Undercut. This is made on the side to which the tree will fall and as low as possible. Its functions are to provide a fulcrum and hinge point on which to tip the tree off the stump in the right direction. The stump should not be more than three inches above the ground and should not be lower than the highest root. Single roots should be cut off so that the stump is not too high.

An inexperienced axeman may have some trouble in getting the chips to fall out properly. The best method is not to let all of the axe edge be buried in the wood. If the heel or the nose of the blade is exposed the chip tends to roll off easily. This can be done by working first the nearside, then the farside and then the centre of the undercut. When the undercut is completed its direction should be checked. The crease or angle at the back should be straight and at right angles to the direction in which the tree is to fall.

The Backcut is made on the opposite side of the tree to the undercut and at the same height or not more than two inches above the bottom of the undercut.

The backcut is usually made with the saw. The cut should be kept parallel with the undercut and should be continued until only an inch or two of holding wood is left. If the tree does not fall then it should be tipped over by driving in one or two wedges behind the saw. Do not saw deeper into the holding wood. This is needed to act as a hinge to guide the tree as it falls.

When a two-man cross-cut saw is used to make the backcut, each sawyer should keep his mate informed how much is left between his cut and the undercut, so that one side will not be cut off too soon.

Leaning Trees. Trees leaning in the direction of fall can be quite dangerous. They are apt to fall prematurely, splintering the stem and thrashing the butt around in unpredictable directions.

Some valuable leaning trees that can be dropped only in the direction of lean can be cut three-quarters through from the leaning side. The saw is then removed and the cut completed from the backcut side. A good general rule is 'the greater the lean the deeper the undercut'.

When a tree leans slightly away from the direction in which it should be dropped, the direction of fall can be changed a little by 'holding the corner'. This is done in the backcut by leaving more wood on the side *opposite* to the one towards which the tree is leaning. This acts as a holdback to twist the tree away from the direction in which it leans.

Wedging, either by itself or in combination with this special backcut, can also be used to alter the direction of fall. One or more felling wedges are driven into the backcut on the landing side. This helps to tip the tree into an upright position from which it can be made to fall in the desired direction.

Small trees can be pushed over in almost any direction by hand.

Lodged Trees. Even the best of fellers sometimes lodge the tree they are cutting in a standing one. Dislodging may be easy and safe; it can also be very difficult. As a general rule hang-ups should be dealt with immediately.

If the tree is lightly lodged, cutting it loose from its stump and prying it off the ground is sometimes enough.

Pushing or twisting it loose is a next step which is frequently successful when only the ends of the branches are caught.

The safest and best way to dislodge a lodged tree is to hitch a tractor or horse to its butt, and so to pull it away from the other trees.

The last resort and perhaps the most dangerous practice of all is to cut the standing tree in which the first one is lodged. It is difficult to judge the stresses involved, or the way in which the two trees will fall, or the time at which they will fall.

Snedding or Trimming. When the tree has been felled and is on the ground the next step is the removal of its side branches. This is usually done with an axe.

A limb should be cut from its lower or outer side, cutting from the base towards the top of the tree.

The stubs or snags of the limb should be left smooth with the bark of the tree. Whenever possible the axeman should cut limbs on the opposite side of the log to himself and swing the axe away from himself.

Cross Cutting. As logging operations become more mechanized, the operation of cutting the tree into log lengths has been tending to shift away from the stump site to the roadside and latterly to the depot or mill. Where the crosscutting is done by hand in the woods, the narrow-bladed two-man cross-cut saw is the usual tool. Two things to avoid in crosscutting are getting the saw blade pinched, and sawing into the ground. In both cases the problem is one of seeing that the log is properly supported.

Measurements. Accuracy of measurement is important in crosscutting. Usually a trimming allowance is specified so that any irregularity in the ends can be evened off by the trim saws at the mill, leaving square-ended boards of the full specified length.

Wedges should be made of untempered steel. A tempered steel wedge is liable to spall or splinter when hit with a tempered sledge-hammer, and the flying fragments can easily put out an eye. Sometimes these wedges are scored across the face or are grooved. This reduces the chances of the wedges flying out of a cut as may happen, especially with frozen timber, due to insufficient friction between the wedge and the wood.

Constant pounding by the sledge-hammer will make the wedge head mushroom shaped and in this state it is very dangerous since small fragments of metal may chip off and fly into the eye. The remedy is to keep these mushroom tops ground or filed away.

Wooden wedges should be made of well-seasoned hardwood, and should be prepared with a saw rather than hewn. The sawn wedge will have a more even taper and a rougher surface which will hold better in the cut.

A wooden wedge, not a metal one, should be used with a chain saw. The danger of driving a metal wedge into the moving chain or of having the latter jump back against the wedge is too great. A large wooden wedge is the right thing to use. It should be from ten to sixteen inches long so that the fingers need never be near the moving chain when the wedge is being driven into the cut. Wooden wedges are best driven with a wooden maul.

Splitting wedges are usually thicker than those used in felling and crosscutting. They should be of soft untempered steel and should be driven with a sledge-hammer of eight to ten pounds. Hit the head of the wedge centrally so as to reduce 'mushrooming'.

HEAVY TIMBER FELLING

By NORMAN L. GOODLAND

Reproduced, by kind permission, from the Country Gentlemen's Estate Magazine, March, 1957

Spare not that tree

Among timbermen, there are those who specialize in the felling of the giants. These specialists are no longer easy to find. This is because, generally speaking, the true art of handling the giants must be acquired from the experience and guidance of men already experts at it. It is no task for the novice. Even timbermen used to handling normal work realize how difficult and dangerous the giants can be, and often refuse to handle them. A long apprenticeship is needed, therefore, before the expert can fully train a man in the safe, efficient, and clean way of taking down heavy timber.

The youths of the countryside, impatient as are most modern young men with long apprenticeships, do not take kindly to it. The task is almost always gruelling in the extreme. Heavy timbermen do their best to choose the weather they work in; consequently they are always working at great speed, lest adverse conditions set in.

However, men on piece-work, which is the normal practice among these men, are at times obliged to carry on working even in adverse conditions. In damp or snowy weather, great dangers face even the experts. Footholds are not so secure. Twigs are weighted down lower and lower by moisture as work proceeds, and most accidents occur through the axe fouling such twigs during swinging. The slightest touch will set the precisely balanced axe off its course—very dangerous indeed when striking near the feet, which sometimes has to be done; and in addition to this, a wet axe-handle is not easy to hold. When a giant is top-heavy with snow, and there is frost in the trunk, the most experienced are relieved to see it lying safely upon the spot required of it, with no great split in the valuable trunk.

As in all the best country crafts, the heavy timberman's tools are simple. He still does his task in what he considers to be the only truly safe, efficient way —by hand. He uses nothing more than axes, saws, wedges, and hammers. He is most particular in his choice of tools. Axes must be perfectly balanced in order that he can have full control over them; they must be able to stand fully to their task. At one time, I was told, 9 lb axes could be obtained, but today, 7 lb axes are the general rule, the "Elwell" being regarded as among the finest in the world. "Diston" saws, generally 8 ft. in length, with teeth in the series: four "cutting" and one "raker," are also a favourite choice. The "rakers" pull out the chips taken off by the cutting teeth, in a surging jet called the "streamer." In certain situations, resort may be had to a winch, but apart from that the heavy timber specialist does not recourse to any form of mechanical aid.

He has sound reasons for his preference for the ancient method of felling by hand. He can cut low to the ground, thus ensuring that there is no loss to himself in the remaining stump. He is not overfond of losing timber in the wide cut required by most motor-saws. Since most motor-saws are unable to cut trees of more than 4 ft. diameter without severe "cutting-in" so that they can be applied, he dispenses with the further loss in timber incurred in that process.

Also, the hand method ensures a more certain control over his tree. The wide cut of the motor saw can make efficient wedging very difficult. The whole art of guiding the fall of a heavy tree lies in the wedging. Certainly, for his own particular work, the heavy timber feller would not countenance those saws with engines *beneath* the blade, for these may force him to start cutting as high as 3 ft. above the ground, and he may also be obliged to make a sloping cut rather than a straight one. In addition, with such an implement he would almost certainly have to fell the tree in its most natural direction of fall—not in the direction most desirable. The motor saw, he thinks, is an admirable implement in its place—for small timber, and for cross-cutting; not for felling the giants.

Perhaps the best way in which to give an account of the work of the heavy timber specialist is to relate the felling of two actual examples.

On Sir George Cooper's Hursley Park Estate in Hampshire, stood an oak, which according to the estate records, had seen at least 500 years, and an elm tree, recorded as 380 years old. They had become dangerous, and two fellers of repute were employed to take them down: Gordon Old of Braishfield, and Harold Neville of Alton.

The oak was 13 ft. in diameter, the first limb 24 ft. from the ground, and at a height of 12 ft. from the ground, the circumference was 20 ft. The estimated weight of the whole tree was 51 tons: the trunk, or "butt" weight, 19 tons.

The elm was a monster 120 ft. high. At 12 ft. from the ground, its circumference was 18 ft.; the estimated weight of the whole tree was 39 tons, and that of the butt, 23 tons.

The oak was a reasonably straightforward task, but the elm was a challenge. Its natural incline was towards farm buildings. It had to be swung in its fall away from these by means of correct placing of the wedges, and it was also decided to leave one "spur" uncut in order to assist this.

In the standing tree, as is well known, the roots can be seen growing outwards, down into the ground. In the timberman's language, these root-heads expanding from the base are called "toes" or "spurs." First of all, they have to be taken off; but as explained, in this case, one spur was left uncut to guide the fall.

Next, a very deep bite into the tree was made, facing the required direction of fall. This is called the "sink." The axe-work in this operation was wonderful to witness, for it combined physical strength, balance, and unerring judgment, thus completing the task in the minimum of time. The two men worked at great speed, striking alternately, and the resultant cut face above the actual sink showed a wonderfully smooth plane.

The sawing was then begun in such a position that if the cut through remained completely level it would stop four to five inches behind the inner margin of the sink, but two inches higher than its lowest level.

All unspoiled trees have a natural balance. In sawing through them, therefore, they do tend to "sit back" on the cut. To prevent this happening, the wedges are inserted into the cut behind the saw as soon as possible. They are also placed so that they incline the tree gently towards the sink; and here the timberman's experience and judgment is utilized to the full.

Too heavy an incline would quite possibly send the tree crashing prematurely. The result would be an enormous split up the middle of the butt—a catastrophe, both to the feller's and the owner's returns, and to the timberman's prestige! A similar though not so serious splitting might occur if an error of judgment was made in the amount of "hold" left unsawn behind the sink.

Having sawn, therefore, to the position described behind the sink, the saw handles were dismantled and the blade withdrawn. All that remained now was to strike in the wedges, and topple the tree.

With an elm, or any other soft wood which tends to fit round the wedges as they are driven in, this is the most laborious part of the task. Both timbermen exhausted themselves driving the wedges into the soggy wood before—as the timbermen say—it began its protesting "grunt." It fell with appalling speed and suddenness; 380 years of life brought to a close, 39 tons guided to the exact spot calculated, the farm buildings safe, the neighbouring trees undamaged.

Such is the more orthodox method of felling the large trees, but in certain situations other methods must be employed.

Some trees grow outwards, towards the light; in that case, no sink is made. The method then is to remove the spurs, and commence the sawing and wedging on the side towards which the tree is leaning. It will stand until a hold of three to five inches is reached on the other side. The saw is then removed, and the axes used on the hold.

Should a tree be of a really awkward shape, and have to be felled in a particular direction, or should it be impossible to judge its natural direction of fall, a winch is employed, usually in conjunction with a tractor. The method is initially the same as in felling a naturally balanced tree; the spurs are cut, the sink made, but during the sawing, in addition to wedging, the winch is used to gradually move the tree in the direction required.

Again, the utmost judgment is needed in order to prevent premature falling and splitting, but a rather larger hold is left before the full force of the winch is brought into play, and the tree toppled.

With the great tree down, the heavy timberman's work is by no means complete. Now, of course, comes the trimming. It is not merely a matter of knocking off the limbs. Striking in the same direction in which they are growing, they have to be planed down level with the trunk, otherwise there are complaints at the mill. Saws are useless here, because they cannot be brought to bear close enough to the trunk. The limbs and saleable timber are then cut into 4 ft. lengths, and sold as cordwood to the merchant, who turns them into logs for domestic use. The residue, or "brushwood," is burned, and if fellers of repute are employed, the whole area left neat and clean.

It may not be generally known that on many private estates the measuring of the timber is traditionally left to the feller. He is usually paid at so much per hoppus foot, over-bark measure.

Previous to the war, there was a brisk trade in oak bark for the tanneries. Bark stripping was done at the end of May, or at the beginning of June, when the sap rises. The best was found on the spurs or toes of the tree. It was stacked on rails to dry out, tied in bundles, and bought by the ton. Today there is still a small demand for such tanbark.

All heavy timbermen are proud of their most notable achievements. At Bambridge Park, cedars, dating from 17-18th centuries, 7 ft. through, were felled by these men, and since they were using an 8 ft. Diston, much cutting-in had to be done so that the saw could be put to use. The trees had to be quartered for transport to London.

At Abingdon Park, the manager of Messrs. Vitak officially timed these two specialists, and after they had set up a beech of 4 feet 3 inches diameter, with spurs removed and sink in place, they were through in 13½ minutes, against the average time of half an hour. They have taken down firs, larches, Douglas firs, birches, of 2 feet 6 inches diameter in about 4 minutes after setting-up.

Conclusion and Recommendations

The exercise of sending three shipments of pit props has been well worth while and now we know what we are up against. As a comparison we have always used the flat railway rate, but this does not give a true picture, particularly in the case of the Bodmin area where the normal rate is in the region of 60/- per ton. On the other hand we have not used as a comparison the road haulage rates to South Wales which are in the neighbourhood of 52/6d. per ton with only loading at the forest entailed. To transport by sea involves far too much handling and is wasteful of our labour force. A fresh line of approach has been taken with the shipping companies in that they contract to pick up the pitwood in the forest and deliver to the colliery in South Wales in lots as low as 5 ton.

That something should be done to revive the coastal traffic is obvious, and there is the added attraction of taking a certain amount of traffic from our far too busy roads.

GRADING OF SAWN BRITISH SOFTWOODS

Leaflet No. 49 of the Forest Products Research Laboratory Princes Risborough. Reproduced by permission.

Foreword

The main purpose of grading of timber is to enable the raw material, which is inherently of widely varying quality, to be classified into groups best suited for the different purposes for which it may be used. Classification according to quality cannot be exact and any practical scheme of grading must allow for some individual judgement and tolerance. On the other hand, whilst grading rules are not in themselves specifications, they may form part of a specification and they should therefore be laid down in terms as exact as possible. Such terms assist a grader to develop a standardized judgement which enables him to grade quickly whilst permitting reference to exact rulings in cases of doubt or dispute. Thus, whilst grading rules may appear to be formidable and detailed on paper, with a little experience they need not be other than simple in operation.

These recommendations for grading British softwoods allow for classification into four main groups based largely on the likely usage, No. I grade being joinery and high class structural work, No. II grade for general structural work and carcassing and Nos. III and IV grades for general purposes where consistent strength properties are not a primary requisite. A sub-division of Grade I permits of the selection of clear material for special uses such as high class joinery, ladder making, etc.

When timber is graded in the green condition and subsequently seasoned, defects such as splitting and distortion may develop which necessitate a certain amount of re-grading. The grading therefore should be related to the seasoning condition at the time of grading, and any specification should include, in addition to the grade, data on the condition of seasoning, preferably in terms of moisture content. Shrinkage, which inevitably occurs during drying, should be recognized and consideration given to changes in dimension across the grain which take place in timber with changes in moisture content. To allow for shrinkage, members should be cut oversize so that the dimensions when the material is seasoned to a moisture content of 20 per cent will not be less than the nominal dimensions.

Sawn material enclosing the pith or heart centre is more prone to degrade by splitting on seasoning than material which excludes the pith. During conversion, therefore, sawing should as far as possible be such as to include a sawcut down the pith, thus avoiding to a large extent boxed heart and subsequent degrade associated with it. It must be realized also that when timber is resawn its grade may be altered, as the permissible sizes of knots are based on their relation to the width or thickness of the member. The grading rules have taken into account most of the characteristics which affect the quality of the timber. There may be occasions when unusual defects arise which have not been catered for but such occasions will be rare and can generally be left to the practical judgement of the grader.

Definitions and Nomenclature

The definitions and terms in this publication are generally in accordance with B.S. 565 "Glossary of Terms Applicable to Timber, Plywood and Joinery", and B.S. 1860 "Structural Softwood: Measurement of Characteristics Affecting Strength". The following definitions shall apply:

(1) **Knots**

(a) *Arris knot.* A knot emerging on an arris (*see* Figs. 14 and 15).

(b) *Edge knot.* A knot on an edge other than an "arris knot" or "splay knot" (*see* Figs. 14 and 16).

(c) *Face knot.* A knot on the face other than a "margin knot", "arris knot" or "splay knot" (*see* Figs. 14 and 16).

(d) *Margin knot.* A knot appearing on the face outside the middle half of the depth of the face near to or breaking through an edge (*see* Fig. 17).

(e) *Knot cluster.* A group of two or more knots such that the wood fibres are deflected round the entire group.

(f) *Splay knot.* A knot cut approximately parallel to its long axis so that the exposed section is definitely elongated (*see* Fig. 18).

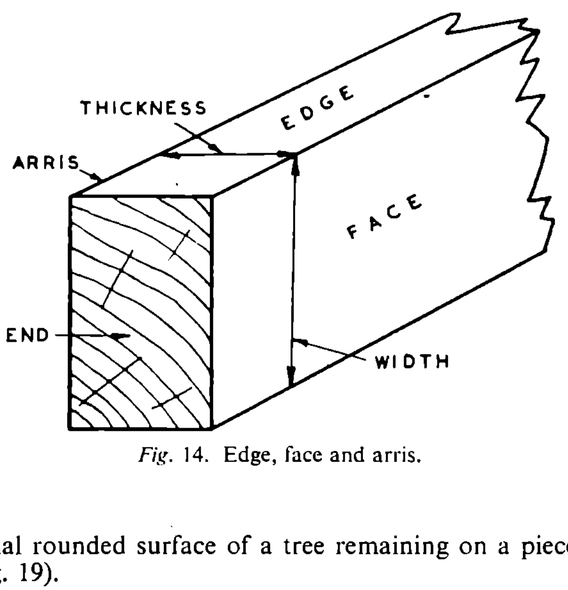

Fig. 14. Edge, face and arris.

(2) **Wane**

The original rounded surface of a tree remaining on a piece of converted timber (*see* Fig. 19).

(3) **Slope of Grain**

This term is used to indicate the inclination of the fibres to the longitudinal axis of the member.

(4) **Rate of Growth**

This is commonly expressed as the average number of growth rings per inch measured radially on the cross-section of the timber (*see* Fig. 20).

(5) **Pitch or Resin Pockets**

A well defined lens-shaped opening which contains resin in the form of a streak between the growth rings.

(6) **Seasoning Defects**

(a) *Checks and splits.* A separation of the fibres along the grain, forming a crack or fissure in the timber.

(b) *Bow.* A curvature of a piece of timber in the plane of its edge. (*See* Fig 21.)

(c) *Spring.* A curvature of a board or plank in the plane of its face. (*See* Fig. 21.)

(d) *Twist.* Spiral distortion. (*See* Fig. 21).

(e) *Cup.* A curvature occurring in the transverse section of a board or plank. (*See* Fig. 21.)

(7) **Blue Stain**

A form of sap-stain producing a bluish discoloration.

Measurement of Defects and Characteristics

(1) **Knots**

(a) *Arris knots.* The size of an arris knot shall be taken as the sum of the width of the knot on the edge, measured between the arris and a line touching the knot parallel to the arris, and one-third of its depth on the face (*see* Fig. 15).

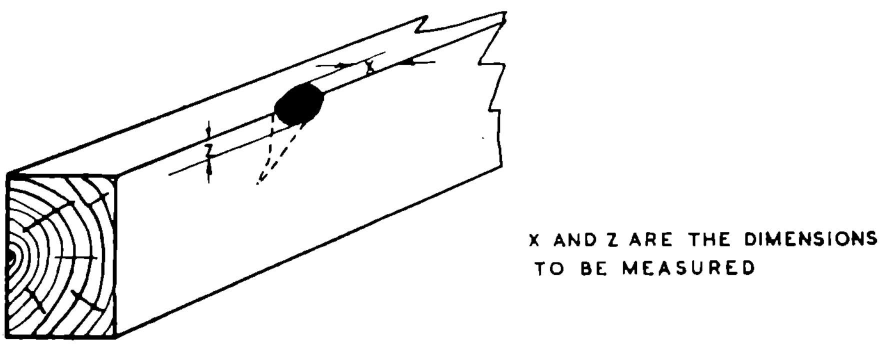

Fig. 15. Arris knot.

(b) *Edge knots.* The size of knots on an edge shall be taken as the width between lines touching the knot and parallel to the arrises of the member (*see* Fig. 16).

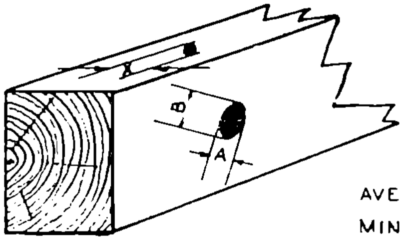

Fig. 16. Edge and face knots.

(c) *Face knots.* The size of each knot within the middle half of the width of the face shall be taken as the average of its largest and smallest diameters (*see* Fig. 16).

(d) *Margin knots.* Where these break into the arris of the piece the size of knot shall be taken as the width between the arris and a line touching the knot parallel to the arris, otherwise they shall be measured in the same way as face knots (*see* Fig. 17).

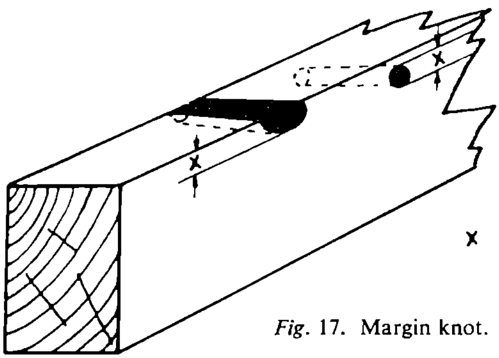

Fig. 17. Margin knot.

(e) *Knot clusters.* Each knot in the cluster shall be measured as in (c) above and the measurement for the knot cluster shall be expressed as the sum of the averages of the diameters of the several knots.

(f) *Splay knots.* Where these extend more than one-fourth the width of the face, the measurement shall be taken on the edge as the width between the arris and a line touching the knot parallel with the arris (*see* Fig. 18).

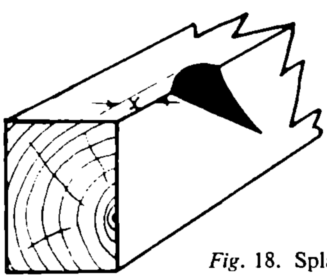

Fig. 18. Splay knot.

(g) *Knot holes* and holes from causes other than knots shall be measured in the same way as knots.

Knots less than $\frac{1}{8}$ in. diameter shall be disregarded.

(2) **Wane**

The amount of wane on any surface shall be the sum of the wanes at the two arrises, and shall be expressed as a fraction of the width of the surface on which it occurs (*see* Fig. 19).

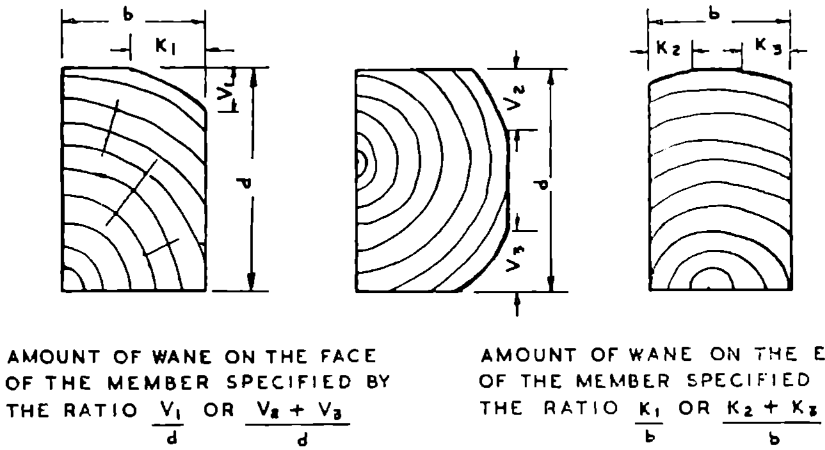

Fig. 19. Extent of wane.

(3) **Slope of Grain**

The slope of grain shall be measured over a distance of not less than twice the width of the member, disregarding slight local deviations. It is measured as the tangent of the angle of the inclination of the fibres to the longitudinal axis of the member.

(4) **Rate of Growth**

Rate of growth shall be measured on both ends of the member, and shall be taken as the average number of growth rings per inch intersected by a straight line 3 in. long, normal to the growth rings, commencing 1 in. from the pith when this is present. When a line 3 in. in length is unobtainable the measurements shall be made on the longest possible line normal to the growth rings and passing through the centre of the member (*see* Fig. 20).

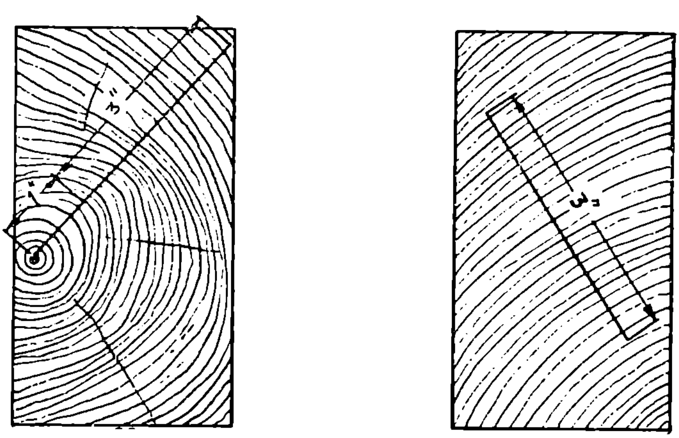

Fig. 20. Measurement of rate of growth.

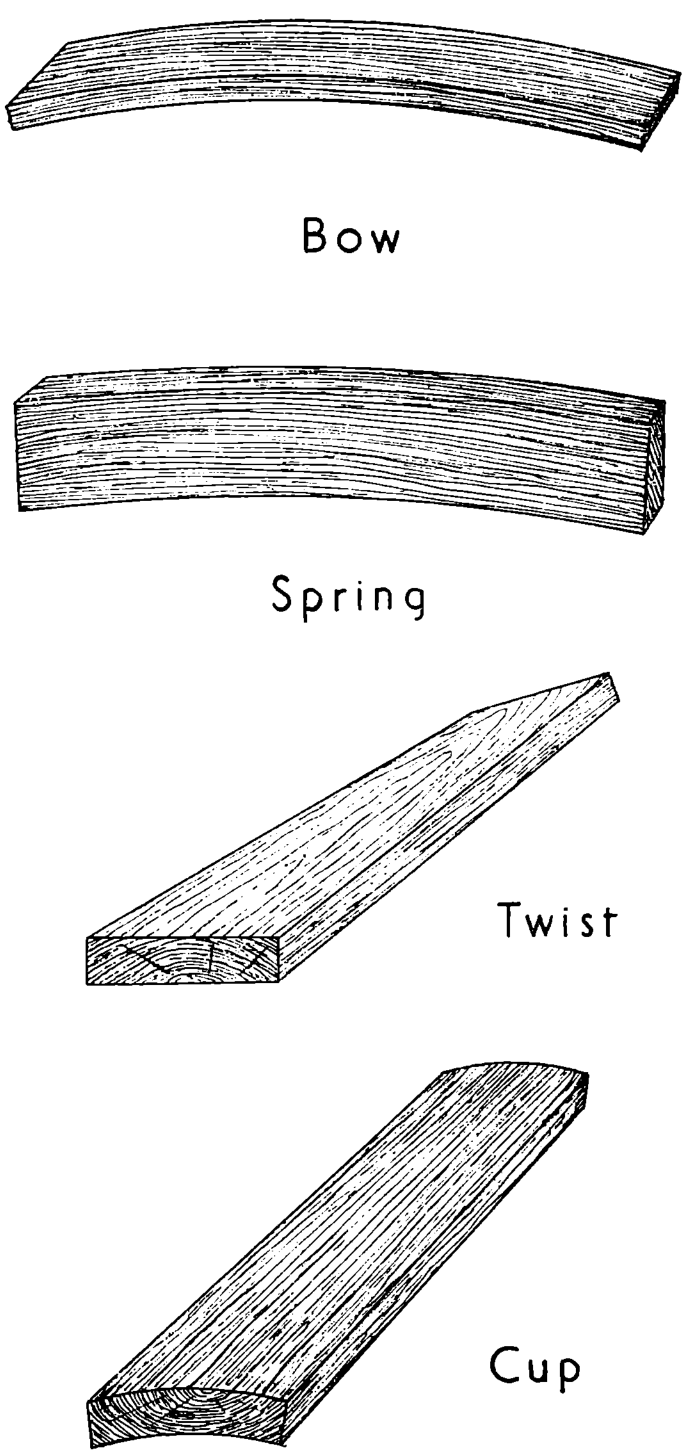

Fig. 21. Seasoning defects.

(5) **Pitch or Resin Pocket**

Denoted as present or absent.

(6) **Seasoning Defects**

(a) *The length and width* of checks and splits shall be measured on a surface of the member.

(b) *Bow.* To be measured over a length of 10 ft. and expressed as the maximum deviation of the face from a straight line joining two points 10 ft. apart.

(c) *Spring.* To be measured over a length of 10 ft. and expressed as the maximum deviation of the edge from a straight line joining two points 10 ft. apart.

(d) *Twist.* To be measured as an angular distortion over a length of 10 ft. and expressed in degrees.

(e) *Cup.* To be measured over a length of 6 in. and expressed as the maximum deviation of the face from a straight line joining two points 6 in. apart.

(7) **Blue Stain**

To be expressed as a percentage of the area of either face which is affected by blue stain after light surface planing.

PERMISSIBLE DEFECTS AND CHARACTERISTICS OF DIFFERENT GRADES

Defect and characteristic	Permissible size of defect or characteristic				
	Grade I		Grade II	Grade III	Grade IV
Knots		Grade I Clear to be same as Grade I except that no knots or blue stain permitted.			
(a) Edge	1/4 thickness		1/2 thickness	3/4 thickness	Unspecified
(b) Margin of face	1/8 width		1/4 width	1/3 width	Unspecified
(c) Centre of face	1/6 width		1/3 width	1/2 width	Unspecified
	Sound knots only		Sound knots only		
Wane (a) Edge	—		1/8 thickness	1/4 thickness	1/2 thickness
(b) Face	—		1/12 width	1/6 width	1/3 width
	—		1/4 length	1/3 length	Length unspecified
Slope of grain	1 in 14		1 in 8	Unspecified	Unspecified
Rate of growth	Not less than 8 rings/in.		Not less than 4 rings/in.	Unspecified	Unspecified
Pitch pockets	Not allowed		Unspecified	Unspecified	Unspecified
Checks and splits	Not exceeding 6″ in length		Exceeding 6″ long shall not be deeper than 1/4 thickness for more than 1/4 length	Exceeding 6″ long shall not be deeper than 1/4 thickness for more than 1/4 length	Unspecified
Bow	1/4″ in 10′		1/2″ in 10′	1″ in 10′	Unspecified
Spring	1/4″ in 10′		1/4″ in 10′	1/2″ in 10′	Unspecified
Twist	3° in 10′		6° in 10′	6° in 10′	Unspecified
Cup	1/16″ in 6″		1/8″ in 6″	1/8″ in 6″	Unspecified
Blue stain	5 per cent		15 per cent	25 per cent	Unspecified

In addition to the requirements listed in the Table, Grades I and II shall be free from fungal decay and insect attack. A certain amount of fungal decay of the "hard rot" type is permitted in Grades III and IV but "soft rot" is excluded. Loose, dead and decayed knots and knot holes shall not be permitted in Grades I and II.

These recommendations for grading have been prepared by the Forest Products Research Laboratory with the assistance of a Committee including representatives of the following organizations:

English Joinery Manufacturers' Association (Incorporated)
Federated Home Timber Associations
Forestry Commission
Home Timber Merchants' Associations of Scotland
National Federation of Box and Packing Case Manufacturers
Royal Institute of British Architects
Timber Development Association Limited

Note—Copies of Forest Product Research Leaflets may be obtained free on application to the Director, Forest Products Research Laboratory, Princes Risborough, Aylesbury, Bucks.

NEW HARDBOARD PLANT OPENED

The following account is reproduced by kind permission of the journal Timber Technology, *and Messrs. Celotex, Ltd. Much of the raw material used comes from Commission Forests.*

The new Hardboard Plant opened by Celotex Ltd. last month at their North Circular Road, London factory is one of the most modern, if not the most modern, and versatile hardboard plants in the world. Costing the greater part of £1 million including certain preparatory construction work previously undertaken, this new factory will more than double the company's hardboard output. In actual figures the new plant will produce 60 million square feet plus of hardboard in comparison with the previous production rate of 30-40 million square feet of the old plant. Besides the increased production figure the new plant will enable Celotex to manufacture some eleven different types of board ranging from $\frac{1}{10}$ inch motor body casing board to $\frac{5}{16}$ inch hardboard and tile board. Some of these products are going to be manufactured especially to meet export market conditions.

Anglo-American Co-operation

The new factory which was opened by Mr. Otis Mansell, Chairman of the Celotex Corporation of America, the parent company, is the result of Anglo-American co-operation and is an expression of faith in the British fibreboard industry. The Celotex Corporation is the world's largest board producer and this new factory will make Celotex Ltd., in their turn, the largest board manufacturers in the Commonwealth. The North Circular Road factory is the largest of its kind in Europe. It was built in 1938. It is very possible that this major increase in output from the new plant could have an important effect on the country's economy because by substantially enlarging the supply of hardboard produced in this country, imports of this material may well be reduced.

The Manufacturing Process

Timber from Britain's forests, mostly Scotch pine, in the form of selected logs, is fed by mechanical conveyor to high speed chippers where it is reduced preparatory to entering a special defibration process. The resultant fibrous mass is disc refined to ensure uniformity of fibre and then pumped to a forming machine which turns it into a continuous wet lap. This wet lap is cut into 18-foot lengths and then fed into a hot hydraulic press of special design and technique which applies high pressures and temperatures to produce a board of outstanding quality.

After pressing, the hardboard sheets are subjected to a heat treatment process and then they are finally sent through a humidifying stage to stabilise and bring them to the degree of humidity required. The manufacturing operation throughout the plant is fully mechanised, the large combination of production units being controlled by a system of accurately timed and synchronised electrical trip switches. If one stage of the production happens to break down, the whole process is automatically halted.

The Equipment

The equipment used in the new plant was chosen with one simple aim in view; to get the best machinery for the job. As no one firm manufactured all the equipment that was required of the necessary performance and standard, the plant was made up of several different makes of equipment, the whole being international in flavour. British, Swedish and German firms all contributed to the impressive list of equipment used in the plant. The majority of the equipment though is Swedish. Celotex Ltd. acting on the experience and advice of their Production Director, Mr. Percy W. Porter, chose the equipment and carried out the installation. The American parent company co-operated at every stage.

The Finished Product and its Uses

The finished hardboard after it has gone through all the different stages of production emerges as a tough, dense, grainless sheet. Made of refined wood fibres it has none of the imperfections of natural wood. It has great strength and rigidity and will not crack, split or splinter. It is suitable for all types of paint, cellulose and stove finishes.

The Export Market

Celotex Ltd. announce that as a result of increased production they are going to increase substantially their exports and they will make boards specially suited to overseas conditions. Where the board is intended for use in difficult climates ranging from almost bone dry to high sustained humidities, it will be specially adapted and treated and made highly resistant to termites, dry rot, mildew and mould. At the moment hardboard is being exported by the company in the form of components of manufactured goods such as cars and prefabricated houses.

GOOD FUEL

By E. J. HALE

Clerical Officer, Alice Holt

A cynic might well say that there's not so much good firewood about nowadays since the builders started to use it. Although such remarks usually raise a smile they contain but little truth, and the firewood trade, although not as prosperous as it was during and immediately after the last war, is still flourishing

Within a few miles of my home on the borders of Surrey and Hampshire there are quite a number of small sawmills with large stacks of firewood nor is this to be wondered at when perhaps 10 to 15 per cent of the timber felled every year falls into the firewood category. Although there is plenty of firewood around it seems a far cry to the years after the first World War when huge quantities of logs, charcoal and kindling wood were exported to France, Holland and Belgium.

A cheerful blaze in the hearth is one of the good things we can look forward to in autumn and how much better than smoky coal is a log fire for with its intermittent crackling and flickering it invites one to draw near and enjoy the delightful sleep-inducing warmth and cosiness. Fortunate then is anyone who has a cache of logs to draw from but even more richly endowed with fireside delight is he who has the right wood to burn. Wood unlike coal has a character of its own with many degrees of combustibility and fragrance when alight. Many woods burn brightly with a merry splutter but it is the sometimes indefinable but often rich woody scent that is its greatest attribute. This aroma of the hearth is a matter of taste. Some people never consider the smell and certainly not the vague variations of it but others are almost connoisseurs and have marked preferences for one kind of wood over another and can tell by the faintly wafted odour what logs we are burning.

Most well known and proved is probably oak for it burns steadily and radiantly for a long time with few sparks. Yew when properly seasoned (two years) is in my opinion better than oak for it burns slowly, gives out a fierce heat, throws no sparks and is clean. Ash, hawthorn and hazel are all good firewoods and share the peculiarity of burning well when freshly cut and quite green. Ash has a pleasant smell which has been likened to a faint perfume of violets. Hazel usually comes in kindling wood size but when large enough for logs it burns with a loud hiss. Plane will hardly ever come our way but it was used in large quantities by town dwellers on the Continent during the war. It needs well drying and then is as good as any log wood, burning slowly and with much heat. Elm wants a lot of drying and is a slow starter but once you get it going it burns well and gives off great heat. Sweet chestnut is hopeless unless it's well seasoned as it will only smoulder, but dried for a year or preferably two it burns fairly well but is inclined to spark and spit a lot. A good firewood for steady burning and plenty of heat and no sparks is beech—much used many years ago in Paris and called *bois d'Andelle*. Apple and pear make really good wood for the fire and my own preference above all others for a pleasant scent is apple. For fragrance when burning my list would be apple, Lebanon cedar, oak, Lawson cypress and *Juniperus virginiana*. Sycamore makes a good bright fire and lasts as long as any wood when burning.

Of the conifers larch is easily the most highly inflammable and the brightest burner—and the quickest—flaring away as soon as it is piled on, but throwing sparks in all directions. Scots pine makes a good fire, burning fairly rapidly but slower than larch; a wide hearth and frequent attention are needed as it sparks a great deal. The roots of this tree are more inflammable than the rest of it and will flare like a torch. It is generally considered that spruce, Douglas fir, silver fir, sweet chestnut, lime, alder, aspen, poplar and willow are all poor firewoods, but I have found that with most of them, if they are stacked to dry for a couple of years, and used on a fire with plenty of bottom heat, they will burn well.

THE SOIL SURVEY OF SCOTLAND

By R. GLENTWORTH

The Macaulay Institute for Soil Research, Aberdeen

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That many different kinds of soils may occur in one district and on one farm is well known to agriculturalists, and local names have sometimes been given to soils. Soils are difficult to describe, and a contributor to the Old *Statistical Account* complained that we did not have sufficient words to describe the many shades of differences between them.

Within the past fifty years the reasons for the development of recognisably different soils have been emerging. For a century or more soils have occupied the attention of agricultural chemists, but their interest was mainly concerned with the topsoil. Russian studies of vegetation and soil changes occurring in the regions extending from the arctic to the sub-tropics have shown that the soils that developed were related to the climate of the region. Later work in the United States of America confirmed this observation. The concept of soil has changed to include not only the topsoil but the subsoil layers down to the lithological parent material from which the soil is derived. In Britain our soils are generally less than four feet in depth. In the tropics they are frequently ten feet or more.

With the gradual realisation that the appearance, or morphological properties, of soils conveyed positive information which could be related to potential agricultural use, soil surveys were commenced, notably in U.S.A. In highly-farmed Britain, with its long established agriculture, soil studies continued to be mainly concerned with soil fertility and with the topsoil. About thirty years ago, however, interest in soil profiles and soil mapping was aroused when American soil surveyors visited Britain, and there was an exchange of personnel with both Russia and the U.S.A. Systematic soil surveys were commenced in North Wales under the late G. W. Robinson and in Scotland under (Sir) W. G. Ogg. G. W. Robinson was in 1939 appointed director of the Soil Survey of England and Wales. Soil surveys by Muir([1]), Kay([2]) and Osmond([3]) had the practical object of mapping soils and correlating them with forestry or orchard crops.

In 1946, the Agricultural Research Council created a Soil Survey Research Board with the brief to prosecute a systematic soil survey of Britain. The Soil Survey of England and Wales is housed at Rothamsted, near Harpenden, Herts., but is distinct in its finances from the Rothamsted Experimental Station. The Soil Survey of Scotland is an integral section of the Macaulay Institute for Soil Research. The Soil Survey Research Board publishes an annual report([4]) in which accounts are given of the soils distinguished and of the progress made in the areas under survey in England and Wales and in Scotland.

The Soil Profile

Physical examination of soils is done by digging a hole about one foot in diameter down to a depth of thirty inches to two feet. In Scottish soils the soil auger has not proved satisfactory. Use is made of all available exposures. The frequency of examination depends on the complexity of the soil pattern and the scale of mapping. The 2.5 inches to the mile Ordnance Survey maps are used as base maps, and selected areas are surveyed when necessary on a scale of six inches to the mile. This latter scale, and also twenty-five inches to the mile, are used for special surveys for experimental farms, Forestry Commission lands, etc.

The lithological composition of the subsoil is examined. In Scotland almost invariably we are dealing with glacial till or fluvioglacial deposits. The till may be derived predominantly from one particular rock type, viz. granite, slate or some kind of schist as is common in north-east Scotland, or it may be a complex mixture of Carboniferous Age rocks—shale, sandstone and lava—as is found in much of the central valley and south-west Scotland. The colour of the soil is readily apparent and is usually related to the inherent colour of the parent material. When excess water, periodic or permanent, is present, grey and blue-grey colours may develop, together with grey, orange and blue-black mottling. These colours bear no relationship to the inherent parent material colour but are highly important in assessing the drainage class of the soil. The soil may be excessively freely drained, freely drained, imperfectly, poorly, or very poorly drained, and this is judged from the colour and degree of mottling within the profile.

Soil structure—the size and arrangement of the soil particles—is observed by the way the soil breaks when a divot is dropped from the spade. The structure may be single grain, platy, prismatic, columnar, blocky, granular or crumb. Within one profile a number of structures will be found in each of the different horizons present.

Soil texture is judged by the feel of the moistened soil between the fingers, and gives an indication of the amount of sand, silt, clay and organic matter present. Structure and the drainage class of the soil obviously bear a relationship to texture. Single grain sands are generally freely to excessively freely drained, whereas clay-textured soils with a prismatic structure often suffer from excess moisture and show characters of poor drainage.

The consistence of a soil refers to the way in which the structural units are cohered and bound together, and such terms as loose, firm, hard, friable, soft and plastic are used to describe the condition.

The kind of change between horizons, or the sequence of layers, such as merging or sharp, and other observations, such as stoniness, roots and earthworms, are also noted in physical examination.

Classification of Soils

The Russians, having observed that soils were a product of the climate, went on to postulate that, under a given climate, the kind of soil developed was a function of the following factors:—

(1) age, or length of time the soil had been forming,
(2) geology, or the kind of rock material from which it was derived,
(3) vegetation, influencing the kind of organic matter and the soil organisms present, and
(4) relief, or topographical position, influencing the degree of freedom of natural drainage.

In a relatively small country such as Britain there is a marked variation in climate from the mountain summits to the low ground, but within the arable regions the factors of geology and relief are of particular concern to the soil surveyor.

The soils of the world are arranged into major soil groups. These units are very wide divisions, and the soils of Scotland could be broadly classified into three groups: podzols, brown forest soils and gleys. Podzol soils are found under heath and moorland vegetation. They have at the surface an accumulation of organic matter under which the mineral soil has a grey appearance and is highly siliceous. The layer may be one inch to twenty-four inches thick but is commonly from two to six inches. Iron compounds have been removed from this horizon and deposited in the layer below to impart a yellow-brown colour.

Brown forest soils have a relatively uniform brown colour throughout, and it is usual to find these soils at the lower elevations on well-drained slopes, often on basic parent materials. These soils are capable of supporting broad-leaved trees. It is thought that in the past the circulation of bases from the decomposition of the leaf litter, together with an earthworm population, has prevented the stratification into the horizons that are found in the podzol. In Britain many variants between the podzol and the brown forest soil can be recognised. Gley soils are grey or blue-grey in colour. These soils are affected by a high water-table and, where there is a seasonal fluctuation, mottling with grey and ochre colours is common and there is no great accumulation of organic matter in the surface horizon. Under permanently wet conditions the gley soils have a peaty surface, and a bluish cast is generally observed below the level of the permanent water-table. Surface water gleys and ground-water gleys can be distinguished. Clayey soils often have the gleying perched in the upper two feet of the profile, and beneath this the natural colour of the parent material appears. In ground-water gleys the gleying, i.e. the presence of grey, blue-grey or ochre mottling, penetrates to bed-rock or to a depth in excess of five feet.

In the systematic soil survey the surveyor is particularly concerned with changes in parent material and drainage class. The mapping unit is the *soil series*, which is defined as a number of soils having similar morphology and derived from similar lithological parent material. The series is given a name, generally that of the locality in which it was originally observed.

In the Scottish Soil Survey, series are grouped into a larger unit, *the association*. This consists of a number of series which are derived from similar lithological parent material but which differ in drainage class. The association name is taken from that of the most wide-spread and dominant series within it, irrespective of drainage class. Essentially the association may be thought of as a hydrologic sequence of soils, varying from freely or excessively freely drained soils to poorly and very poorly drained soils. A complete sequence may not always occur. On clayey parent materials, for instance, it is impossible to find a freely drained soil.

Soil Survey Maps and Memoirs

The final product of the Soil Survey is a soil map which is on a scale of one inch to the mile and uses the 3rd Edition projection of the Ordnance Survey maps. This is the same projection as that of the Geological Survey maps—both Drift and Solid. The map key shows the genetic soil group, the association, the composition of the parent material and the drainage class of the soil. The map is normally accompanied by a memoir describing the soils in detail and discusses the physical features and climate of the area surveyed, solid and glacial geology, pedological methods and definitions, vegetation, agriculture and forestry. The chapters on forestry and agriculture are written by the forestry officers and agricultural advisory officers, respectively, of the area under survey. A technical section dealing with the chemistry of the soils is included.

Three memoirs with accompanying maps have been published on the soils of the country round Banff, Huntly and Turiff (Sheets 86 and 96)(5), Jedburgh and Morebattle (Sheets 17 and 18) (6) and Kilmarnock (Sheets 22 and part of 21)(7).

The map shows the progress of the survey. In future publications it is proposed to group several sheets together in one memoir, e.g. in one group the Fraserburgh (97), Peterhead (87), Aberdeen (77) and Inverurie (76) sheets and in another group the Brechin (57), Banchory (66) and Stonehaven (67) sheets. The Survey will publish the soil maps as they come from the press and before the group memoir is ready.

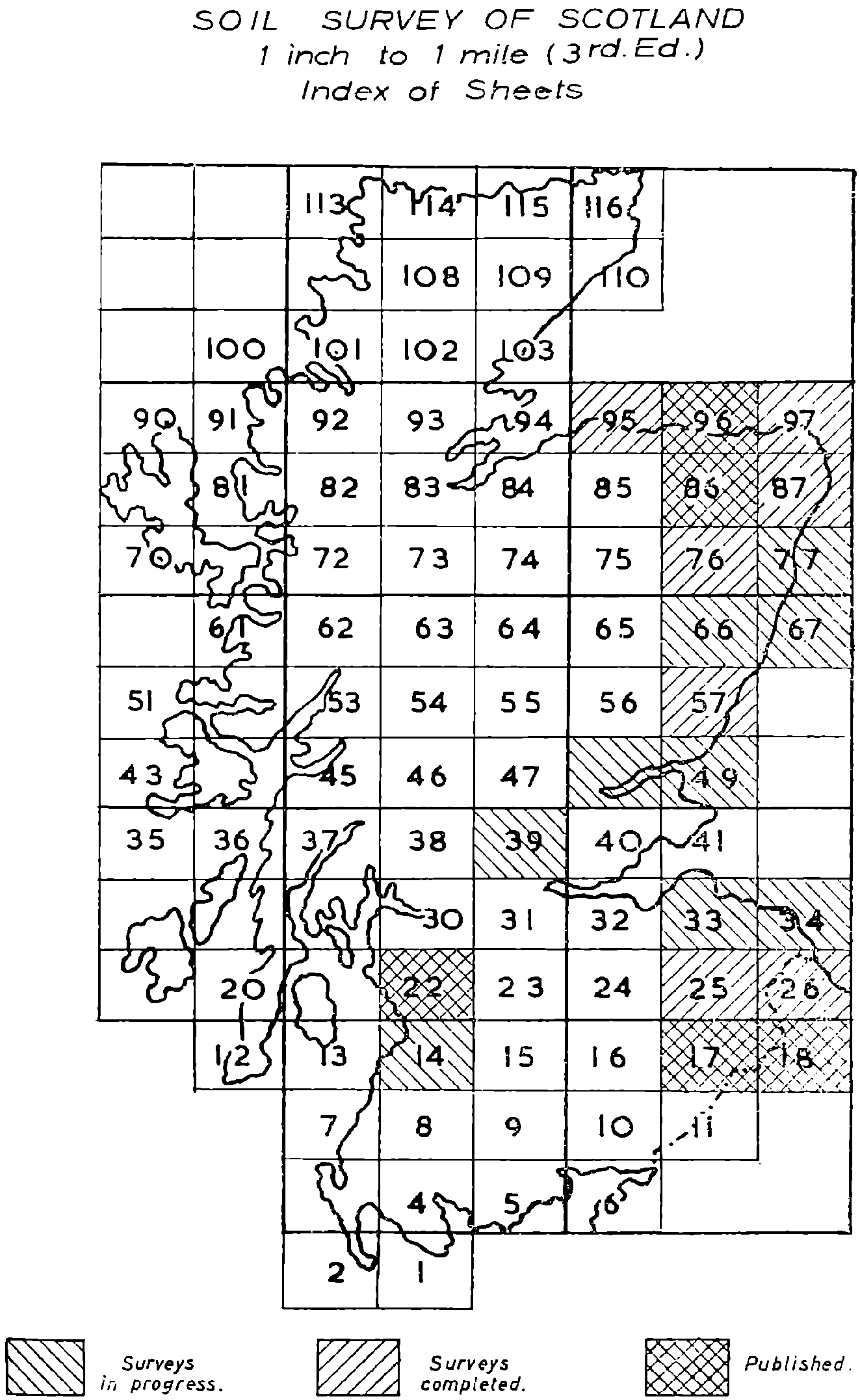

Fig. 22. Progress to date on the Soil Survey of Scotland.

Uses of the Soil Survey

The eighteenth century contributor to the *Statistical Account* already mentioned has also commented that, if a hundred persons were asked to describe a soil, they would give a hundred different answers! Without standardisation of soil description and delineation of the extent of soil series, much valuable knowledge of soil properties must remain of local and prescribed interest. In the work of the experimental farms, particularly with regard to the results of field trials, this information can be applied only in relation to the distribution of a similar soil series, or series closely related to that on which the field experiment was conducted. The work of the Soil Fertility Department of the Macaulay Institute has shown, from the field trials results and chemical studies, that the series distinguished by the Soil Survey are valid units requiring different interpretation of the results of soil tests and showing contrasts in their fertiliser requirements. The advisory analysis of soils for manurial requirements involves the sampling and testing of some 12,000 fields per annum in the North of Scotland province alone. It is hoped that, when advisory data can be grouped on a soil series basis, definite trends in manurial requirements will become apparent to enable safe generalisations to be made. It is also hoped that, as soil maps are published for the south-east and south-west of Scotland, the field trials in these areas will be based upon the soil survey map.

The systematic sampling and study of soil profiles collected in the course of soil survey have clearly defined trends in the distribution of many soil constituents, and have indicated marked differences in phosphate relationships between soils with free drainage and those with poor drainage (Glentworth)(8). The results of investigations by Williams (9) in this line are of great importance in understanding the phosphate requirements of soils in relation to crop responses.

The soil survey is an inventory or stock-taking of the greatest of our natural resources and forms the logical basis on which to conduct a programme of soil research, such as is now being undertaken at the Macaulay Institute for Soil Research, Aberdeen.

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FORESTRY IN RELATION TO LANDSCAPE

By C. A. J. BARRINGTON
Conservator, English Directorate

An address to the Institute of Landscape Architects on 11th April, 1957

I want to tell you, first of all, why it is necessary for us to practice forestry in Great Britain, and why the Forestry Commission has to go on making new forests throughout the length and breadth of the country on land which has been bare for many generations.

One main reason is to reduce our import bill by growing more timber at home, thus helping the Chancellor of the Exchequer with the balance of payments; another is to help build up a reserve of timber in the country in the event of any future emergency; and another, and by no means the least important one, is to help to maintain our rural population.

So far as the balance of payments is concerned, the "Zuckerman" report by the Natural Resources (Technical) Committee, entitled *Forestry, Agriculture and Marginal Land*, recently published, begins as follows:

"Products of the soil account for one half of the total import bill for the United Kingdom, which in 1955 was about £3,900 millions. We buy from abroad one half of all our food at a cost of £1,250 millions; and we import upwards of 85 per cent of our requirements of timber and wood products at a cost of approximately £430 millions. These imports are crucial to the problem of our balance of payments. The importance of their reduction, where economically possible, and of the maximum economic use of our soil, needs no emphasis."

With regard to the population of our rural areas, the total land area of Great Britain, which has a population of 50 millions, is only 56 million acres. This is less than half the area of France. And Russia with 5,600 million acres has a land surface one hundred times as big as ours. On an average, every citizen of our country has at his disposal a fraction over 1 acre; the average Frenchman has 3½ acres at his disposal, and the average American 12½ acres. However, in spite of the shortage of land in this country, the remarkable distribution of our population is such that large areas of what may be called 'Highland Britain' are very sparsely populated, and the movement of the population from these rural areas into the towns, which has been continuous since the industrial revolution, is still going on apace, and there is a danger of the outlying areas of Great Britain becoming completely depopulated, with a total loss of their agricultural output.

The young forests which have been planted since the end of the first world war have already necessitated the building of new villages in remote parts of England, Scotland and Wales, for the express purpose of housing the many foresters and woodmen who are required to work in them. And incidentally these young forests are already producing large quantities of timber. Forestry has therefore already begun to play a most important part in bringing the people back into our under-populated areas, and this of course is directly benefitting agriculture.

Not quite 7 per cent of our total land area is woodland, compared with 71 per cent in Finland, 56 per cent in Sweden, 28 per cent in West Germany, and 20 per cent in France. Even Holland, with 7.7 per cent, has a larger proportion of its land area under forests than has Great Britain. And yet this country, with its maritime climate, its generally mild winters, its comparatively high rainfall and its fertile soils, is probably better suited to tree growth than any other in Europe. Only 1,500 years ago the greater part of our land surface was covered with natural forests.

These natural forests comprised mainly oak, ash, beech, birch and Scots pine. The pine and birch were established on the heathlands and the sandy soils. Ash grew on some of the fertile soils, beech dominated the chalk downlands of the south and south-east, but oak, of a type, covered the greater part of the country.

You can, I expect, picture to yourselves these beautiful vast natural forests, which covered so much of our land for so many centuries after the last Ice Age. Man appeared in this country many thousands of years ago. And the direct result of that human invasion is that today we have so little of our land surface left under forest.

The destruction of the natural tree cover of Great Britain occurred mainly as a result of the clearing of land for agriculture, and as a consequence of the development of iron smelting in the days when charcoal was used for that purpose. The fact that trees were not planted elsewhere to take the place of the natural forest was simply a reflection of the fact that it was easier and cheaper to buy timber from abroad. Timber has been imported into this country since the Middle Ages, and the exploitation of virgin forests throughout the world has resulted in high grade timber being available at our ports at low prices. World supplies of timber, however, are no longer as plentiful or of as high quality as they were; neither is imported timber as cheap as it used to be.

I am not suggesting for one moment that the natural forests which used to grow in this country should have been left undisturbed, for much of the land on which they were growing was very fertile, and it was right and necessary that the forests should be removed and the land cultivated. But we have overdone it in that we have cut the forest from land which is unsuitable for farming and not replanted it; hence our large areas of unproductive land which no other over-populated country would tolerate.

You may not know that during the two great wars of this century, when we were all but brought to our knees through starvation, we were spending huge sums of money and using up precious shipping space by importing timber—timber which could so easily have been grown at home without serious interference with agriculture. Timber is the most bulky cargo in relation to its value, and during the war it absorbed about one seventh of the total shipping entering British ports from overseas; shipping which could well have been used for bringing in food, especially during the lean and hungry forties, which I expect all of you will remember only too well.

I do not want to worry you with too many figures, but it is hard to keep away from them. By 1939 we had become the largest timber importing country in the world, drawing 95 per cent of our requirements from overseas, amounting to twelve hundred million cubic feet. We are still far and away Europe's largest importer of both softwood and hardwood timber. We import over 90 per cent of the softwood we consume, and in spite of large fellings at home nearly two-thirds of the hardwood. And the bill is £430 millions!

Such facts indicate that both from the supply and economic aspects it is essential that we should produce more timber at home. And conditions at home are very favourable to the growth of trees at a much more rapid rate than in most other European countries. For example Scots pine grows two and a half times more quickly in this country than it does in Sweden, and Norway spruce (the Christmas tree) twice as fast. And there is in this country a considerable area of land which, because it is of a low order of production, is most suitable for planting.

In planting this land we have to ensure not only that we do not harm the surrounding scenery but if possible, and it sometimes is possible to do so, that we improve it. It is here that the public can guide and influence us.

Thanks to cheap travel and shorter working hours the city dweller is today able to spend quite a large part of his life out in the country. He takes, therefore, a much greater interest in the treatment of the rural landscape of Great Britain than he used to do. If he sees something going on in the heart of the country that he doesn't like he is not afraid to say so, and his voice carries weight with the powers that be. All this is quite right and proper, although some of his criticisms are made simply because he doesn't realise exactly what is going on; and so the more we can all learn about rural land management the better, and the easier will it be for us to understand the reason for any sudden change which we may see taking place.

I do not support the contention that a large conifer forest will always be a blot on the landscape. I have for a long time studied the reaction of the public to our work, and admittedly it has sometimes created a great hullabaloo, but I am convinced that it is, more than anything else, the sudden change which is brought about when a new forest is created that people object to. They do not realise that, whether you are building a new cathedral or planting a new forest, you will make a sudden change in the appearance of the land on which you are working, and beauty is not made overnight. But if we as a nation are not prepared for any changes, and quick changes if necessary, we shall stagnate.

There can be no disputing the fact that forestry, just exactly like agriculture, is normal land use. Timber is just as much a crop as is wheat. Many people do not realise this. And the argument that forests are not natural to the landscape of Britain is of course untrue. It is the thousands of acres of bare land which man has created by centuries of forest destruction which are not natural. Re-foresting some of our bare land gives us the chance of re-creating the beauty which we destroyed generations ago—especially during the industrial revolution. It also gives us the chance of adding to the wealth of our country a much needed natural resource for which there is a very rapidly increasing world demand. In doing this we not only stop the depopulation of the countryside which I mentioned earlier on, but in fact we reverse the trend.

We have got to have more forests in this country. That is a MUST, whether we like it or not. I personally like it; and the aim is to have, by the turn of the century, five million acres of fully productive forests in private and Commission ownership. We shall then produce each year about one-third of our annual requirements of timber.

What we must do is so to design these new forests that they fit in with the scenery. That is not impossible. A forest may perhaps bring in a rather smaller financial return if attention is given to aesthetic considerations. But does that matter within reason? And there will be an enormous indirect gain by the pleasure afforded to the community if amenity is taken into consideration; if edges are softened; if hard, geometrical lines are avoided; if informal outlines are created; if dense forest is made to merge naturally by groups and isolated trees into farm land; if viewpoints are left unplanted; if species are mixed whenever possible; if the forester looks ahead—and thinks.

Provided care is taken and common sense used, so that some of the admittedly awful mistakes of the twenties and early thirties are not repeated, the beauty of our scenery will not be imperilled by forestry.

FORESTRY FROM THE TOWN PLANNER'S ANGLE

By JOHN CASSON, A.M.I.Mun.E., M.T.P.I.
Lancashire County Council

Much of our advisory work nowadays touches upon problems of tree preservation or scenic improvement, such as the afforestation of waste land in industrial districts, where the views of the town planning department of the local authority often come into the picture. Mr. John Casson has kindly made available to this Journal the following extracts from a paper he presented to the Annual Conference of Landscape Architects at King's College, Newcastle-upon-Tyne, in September 1957. He asks us to state that the opinions he expresses are not necessarily those of the Lancashire County Council; and also to say that detailed responsibility for experimental afforestation and management on the Council's properties rests with Mr. L. A. King, whom many of our staff will remember as the Forester formerly in charge of Grizedale.—Editor.

Tree Planting on Derelict Land

The programme of tree planting on derelict land is carried out under Section 89 of the National Parks and Access to the Countryside Act, and the authority of the Minister of Housing and Local Government must be obtained under Section 103 of the Act for the acquisition of the land either compulsorily or by agreement.

A careful examination of sites is carried out on the basis of annual selection from a five-year forward programme which is reviewed every two or three years; one of the difficulties is delay in securing land acquisition. The factors of site selection in the first place include unsuitability for other purposes, suitable location from a landscape or biological point of view, suitability of soil material available on the surface and liabilities such as excessive fencing costs, dilapidated walls, dangerous embankments, pit shafts, dangers of public trespass and damage by children. Conspicuous sites are selected where possible.

In the earlier stages it was thought that weathered shale or other effectively-weathered waste material promised a greater likelihood of success in tree planting, but in a number of cases this has been disproved although site colonisation is an excellent guide as to suitability for planting. The Bickerstaffe experimental site near Ormskirk was well weathered and colonised but rawer types of shale have subsequently been planted with apparently greater success in some cases—the shale at Bickerstaffe being of a hard dry flaky nature after weathering.

Difficulties of acquisition derive from owners suspecting that the shale or other waste material may become valuable; alternatively, inflated ideas of the land value may prejudice negotiations. Open-cast mining has frequently interfered with the planting programme, and legal restrictions and large 'admitted claims' have resulted in the sites being rejected, while in some cases the National Coal Board wish to retain the site against future tipping contingencies or access for incidental mining purposes. Difficulties of land acquisition are, therefore, the greatest problem in the forward planning of a planting programme.

The **choice of species** involves consideration of the type of ground, extent of colonisation, exposure, atmospheric pollution, erosion and the ecological relationship of the site to its surroundings. Fencing, which accounts for a large part of the cost of planting, is usually required and it is normal to use a wooden post and wire fence with rabbit netting where necessary, in accordance with normal forestry practice.

The species so far used for planting include Sitka spruce, sycamore, beech, Japanese larch, grey alder, birch, lodgepole pine, sweet chestnut, European larch, black poplar, goat willow, red oak, white poplar, mountain pine, Corsican pine, ash, rowan, horse chestnut and Norway maple.

Planting rates vary between 1,500 and 2,000 per acre—again in accordance with normal forestry practice; survival counts are taken and beating-up is carried out annually for the first five years. Weeding is a problem on some sites where colonisation has become extensive, whereas on shale heaps this is generally not so.

The Lancashire Planning Department has two forestry officers on its staff whose duties include such work as the administration of Tree Preservation Orders, and these officers are responsible for the technical management of the programme. An estate van and trailer and a forestry gang consisting of a foreman and eight forestry workers are employed at the present time to carry out fencing, planting and maintenance. This direct labour organisation was employed because of the impossibility of carrying out the work by contract methods.

Expenditure is met from revenue and many sites have qualified for Forestry Commission Small Woods Planting Grants; this practical support from the Commission has been most encouraging. Average costs so far have been £10 per acre for acquisition and £30 per acre for fencing, the total cost of work varying from £50-£80 per acre; after-management has averaged £10 per acre for the succeeding five years but it is emphasised that there are wide variations on the range of sites and for the range of weather conditions during particular years.

The planting has generally succeeded on all the sites included in the programme and it is hoped that in the future these areas will become useful timber-producing sites as well as amenity features. As more experience is gained, attention is being given increasingly to the landscape factors of the planting designs, and particular attention is being given to the planting of shrub layer fringes around the new woodlands.

Planting on spoil heaps

The first positive step which the Lancashire County Council took was in 1951 when a shale heap at Bickerstaffe in West Lancashire, 11 acres in extent and 60 ft. high, was planted with trees. Subsequently grass seeding experiments were carried out on a steep southern slope suffering from sheet erosion and gullying, a common phenomenon on colliery shale heaps. This experiment was successful and led to an annual programme of tree planting on derelict land under Section 89 of the National Parks Act. Since then more than 275,000 trees have been planted on 16 derelict sites covering 143 acres throughout the administrative county. These sites now range from colliery spoil heaps to a haematite mine dump, devasted woodlands, gritstone quarry wastes and a derelict erosion gully in the Rossendale area.

Planting on spoil heaps has been going on for the past five years on sites of varying physical condition, and it is now possible to generalise about the capabilities of colliery shale sites. The impression so far is that in those areas less affected by atmospheric pollution and human interference they are apparently capable of producing reasonable tree crops; in areas where atmospheric pollution and human depredation are more acute, they are capable of bearing a less productive crop, with considerable amenity and biological value.

The main conclusions up to 1957 are:—

(1) Colliery spoil heaps appear to be sufficiently fertile to maintain tree growth.

(2) Sufficient moisture is available to support the early stages of tree growth under average weather conditions, but losses were above average during the dry summer of 1955. This condition also obtained in commercial forestry throughout England.

(3) The choice of species is partly governed by conditions such as smoke pollution and trespass, but pollution does not completely rule out the choice of certain conifers.

(4) It is essential that a pioneer or nurse species be extensively used. In the early stages of the programme up to three species were planted in mixtures on the various site plots. It was found on one plot that where alder was included in the mixture it was acting as a nurse with significant benefit. Subsequently this method has been generally adopted.

(5) Nurse species—Grey alder has proved that it should be the first choice in Lancashire, especially where there is no existing vegetation. Birch is also beginning to establish itself, but does require more careful siting and should only be used on shales that retain their moisture much longer and where, if possible, vegetation has become established. Another good species, particularly where the site is very dry and subject to erosion is white poplar, and this species, with its habit of promoting root suckers, will run several feet during the year and thereby form a retentive moisture-conserving root mat.

(6) Hardwoods—Sycamore and beech are fairly safe to plant though these are much slower than the grey alder, birch and white poplar.

(7) Conifers—Corsican pine and lodgepole pine are the most successful on all sites, even in areas of atmospheric pollution. Japanese larch, while showing a considerable amount of growth during the first three years, has shown a tendency to fail during a very severe drought.

(8) Other species which have been planted subsequently include gean, common alder, lime and Turkey oak, but it is too soon to draw up any conclusions regarding them.

Afforestation in Rossendale

Rossendale, 2,000 years ago, was covered by oak, birch and ash forests and in historic times was well noted for excellent sycamore woods. The history of settlement, however, changed when Henry VII abolished the laws of the Forest of Rossendale "in order to reclaim land". Soon widespread clearance heralded cattle-ranching on a large scale. In the 16th Century new settlers began to infiltrate and the ranches fragmentated into smaller holdings. By the 18th Century, when the textile industry began, Rossendale had become a region of small farms with limited stock and part-time family workers. The history of centuries of colonisation is clearly written on the contemporary landscape and its place-names; bare hills are dotted with small isolated farm houses, as high as 1,250 feet; the majority now stand in ruins, and the land is blackened moor.

This was brought about through the combined effects of a diversion of labour to the better-paid and growing textile industry, soil impoverishment resulting from high rainfall and exposure, followed by atmospheric pollution. The tragedy is that this terrible transformation is accepted as a norm, yet the cold, damp climate and repeated flooding resulting from the dis-afforestation of centuries ago is one very real factor in the emigration from East Lancashire of the young and vital element of its population. There have now been steps by responsible authorities towards rehabilitation.

At Helmshore, near Bury, the experimental farm of the Ministry of Agriculture shows that soil rehabilitation in this region is practicable in spite of 72 tons of solid deposit per annum from the atmosphere on to its 350 acres, and sulphur dioxide pollution ten times greater than average (3.8 parts per 100 million). The visual impact of this farm sets its hilltop location apart from the surrounding bare black hills.

Nevertheless, the difficulties experienced at this farm have shown that a regional clean air policy would make a wonderful contribution to rural rehabilitation in the south of Lancashire.

To their great credit the Irwell Valley Water Board has invited the Forestry Commission to plant a 900 acre watershed at Haslingden Grane, one of the most depressing areas of derelict farmland. It is to be hoped that the Forestry Commission, amongst other bodies concerned with rural land use, will take a positive lead in re-establishing sound ecological conditions in areas such as this. The Commission's task is, however, to raise timber, but atmospheric conditions are a great deterrent, and much of the necessary small-scale planting could not be carried out by their present organisation.

The Lancashire County Council has already planted three typically derelict sites in Rossendale and this, as well as improving amenities, is seen as a contribution towards the improvement of land use and climate; these sites are respectively a disused quarry waste heap, a deep and ugly erosion gully and a steep abandoned roadside field in Rawtenstall.

Areas such as Rossendale require a Landscape Plan and powers to restore their hills to beauty and usefulness. The pattern of rural land degradation is repeated on a tremendous scale in the north of England and the Highlands of Scotland and Wales.

That the processes of disafforestation were continuing until very recently is illustrated by the Forestry Commission's Census of 1947-1949. In Lancashire alone this showed that 15,000 acres of woodlands, of 5 acres and over, had been devastated or reduced to scrub in comparatively recent times. In fact, less than three per cent. of the Geographical County of Lancashire remains as woodlands of five acres and over (30,000 acres). Deduct from this the wooded areas of Furness and the woodland picture for the remainder of the county is indeed a sorry one (about 1 per cent as compared with 7 per cent in the whole United Kingdom, 28 per cent in Germany and 20 per cent in France).

Tree Preservation Orders

This shortage of trees and wooded landscapes has influenced the Lancashire County Council to adopt a strong policy with regard to the control of felling operations, and 54 Tree Preservation Orders protecting a quarter of a million trees on 35,000 acres of Lancashire countryside and towns have been made since 1948. Furthermore, through liaison with the Forestry Commission, very little felling now takes place in the county without replanting being carried out in a proper manner.

The County Council's policy with regard to tree preservation has aimed at the proper management of standing woodlands in accordance with sound forestry, and the creation of new areas of properly-sited woodlands and trees where felling has been necessary to facilitate agriculture or development. It has been found that this policy is superior to one of mere preservation and in the long run more effectively meets amenity objectives.

In spite of what can be done under present powers, it is clear that the Lancashire countryside requires a very much greater proportion of trees and woodlands than it contains at the present time, particularly in the open plains and mosslands, around and between the great urban centres, and to obtain climatic improvement and water control.

The report of the National Resources Technical Committee on Forestry, Agriculture and Marginal Land has thrown a long-awaited and welcome light on rural land use in Britain and has clarified the importance of woodlands in relation to agriculture. This relationship is a basic factor in any conservation policy in the countryside.

Tree Planting

If development of any sort is to be harmoniously blended into the rural scene it is essential that there should be carefully-planned tree planting. In the days of the great estates new building was automatically endowed with sheltering and beautifying trees; the planning of a lovely countryside was a prime objective. The planning authority is today the heir to this tradition.

Tree planting conditions should, therefore, notwithstanding architectural purism, be imposed on the great majority of consents to develop in the countryside where architectural and planting designs should be one. It is often said that tree planting is the planner's palliative, that it hides development which should not be there; the only truth in this comment is that it touches the essence of the problem of conserving a lovely countryside while keeping it vital and modern. Planting, and existing trees and woodlands, should be given as much consideration as services, roads and agriculture, when planning applications are under consideration, because trees are a fundamental element of landscape.

The redevelopment of our towns and cities to make them attractive living-places would achieve much in the conservation of the countryside, by reducing the pressure for sporadic development elsewhere.

THE WOODLANDS OF SUSSEX: QUESTIONS AND ANSWERS

Text of a booklet prepared with the help of the staff of South-East England Conservancy for the Sussex Rural Community Council, Lewes.

(A) Facts and Figures

1. *Q.* What is the total woodland area of Sussex?

   A. 150,000 acres, or 15½ per cent of the County acreage, the largest *proportion* of any County in England.

2. *Q.* How much of this is considered by experts to be suitable for economic management?

   A. 130,000 acres or nearly 90 per cent.

3. *Q.* How much of this is today under properly planned management?

   A. Less than one-fifth of the privately-owned woodlands, plus 20,000 acres of Forestry Commission woodlands. Less than half of this fifth is actually carrying productive crops today: but plans exist or are in preparation to replant the balance of this one-fifth in the next ten years or so.

4. *Q.* What of the other ninety-odd thousand acres for which there is no record that any plans exist?

A. Much of it is at present unproductive because it has been totally felled and is now growing mere scrub, or the best trees have been removed and the woods are now carrying only a sparse crop of poor trees.

(B) FORESTRY AS A RURAL INDUSTRY

5. *Q.* How many men are directly employed, full time, in the woodlands of Sussex at present?

A. Probably some 500, including Forestry Commission staff.

6. *Q.* If all woodlands suitable for economic management were intensively managed, what would be the effect on rural employment?

A. 130,000 acres of intensively managed woodlands could sustain a labour force of approximately 3,000 men and women. In addition, there would be employment (mainly rural, but not necessarily local), in nurseries to grow tree plants, and at sawmills to deal with the produce, and for the services required to maintain woodmen and their families.

7. *Q.* What wages can be expected?

A. Wages of woodmen are already closely related to those of farm workers. Forest operations lend themselves to piece-work rates, and earnings can compare satisfactorily with many other forms of employment.

(C) ADVICE AND ASSISTANCE

8. *Q.* How does an owner obtain advice or additional advice on woodland problems?

A. From or through the Forestry Commission, by writing or phoning, in Sussex, to the Woking address, The South East Conservancy, Danesfield, Grange Road, Woking, Telephone 2270. Local Officers of the Forestry Commission are stationed in Sussex itself, and are available to visit woodlands and give free advice on all aspects of management, planting, marketing of produce, etc. There are also of course professional men, Chartered Surveyors and Chartered Land Agents who can advise themselves, or else give information as to Forestry Consultants who in many cases combine a forestry contracting business with advisory work.

(D) THE DEDICATION SCHEME

9. *Q.* What is this business of 'dedicating' woodlands? What precisely is the Dedication Scheme?

A. Dedication is a device whereby the Owner and the Forestry Commission work in collaboration. An agreement is entered into jointly by the owner and the Forestry Commission. The owner undertakes to manage his woodlands for the main purpose of timber production and to work to approved plans. In return, financial assistance is provided by the Forestry Commission. Full details are available in a Booklet obtainable from the Commission entitled 'Grants for Woodland Owners'.

(E) Approved Woodlands

10. *Q.* If the owner does not wish to dedicate, can he nevertheless obtain assistance?

A. Yes, without actually dedicating he can get certain grants for planting and for various other forestry operations which are carried out under a plan which has been 'approved' by the Commission.

(F) Small Woods

11. *Q.* If a woodland area is too small to be suitable for dedication or for an approved plan, can assistance still be obtained?

A. Yes. A 'Small Woods Planting Grant' is available for the planting of a minimum of one acre on any estate in one year in detached woods of less than 5 acres, narrow strips or belts, and in badly shaped woods of up to 30 acres. On an estate with a total woodland area of less than 150 acres *all woods* are eligible for this grant providing there is no individual and accessible wood exceeding 35 acres in extent.

(G) Grants Available

12. *Q.* What are these grants?

A. Full details are set out in the Forestry Commission publication 'Grants for Woodlands Owners', a free pamphlet obtainable from the Forestry Commission itself and elsewhere. The Grants may be summarised as follows:—

Dedication of Woodlands Scheme, under which an owner undertakes to put his woodlands permanently to timber production: Planting grant £17 an acre, Maintenance grant 5/6 an acre.

Small Woodlands Scheme. Planting grant £17 an acre.

Poplar Planting Scheme. Block planting £8 10*s.* an acre. Poplar planting grant of 2/- per tree where planted in lines.

Approved Woodlands Grants. The grants for planting in 'Approved Woodlands', i.e. areas being worked to an approved plan of operations, will be one half of the rate payable to owners of Dedicated Woodlands.

Scrub Clearance Grants. Grants of £8 10*s.* an acre where the net cost of clearing is £17 to £27 an acre, and £13 10*s.* where the net cost exceeds £27 an acre.

(H) Taxation Reliefs

13. *Q.* What are the benefits for a woodland owner in respect of Taxation?

A. The benefits can be very considerable, both as to Income Tax and Sur-Tax, and also in respect of death duties. Advice should be taken about this most important aspect of woodland management by owners who contemplate forestry work. The Forestry Commission leaflet No. 12 'Income Tax and Estate Duty on Woodlands' gives useful information.

(I) LOANS

14. *Q.* Can an owner obtain loans as well as grants to finance a replanting project?

A. Yes. Subject to satisfactory security the Forestry Commission are prepared to make loans and improvement loans to owners of dedicated woodlands to cover a substantial part of the costs of replanting. Interest is charged. Loans can also be obtained under the Improvement Acts, from the Lands Improvement Company and the Agricultural Mortgage Corporation.

(J) GETTING STARTED

15. *Q.* If an Owner has little or no technical forestry knowledge and no skilled woodmen, how can he get started?

A. He can ask for a visit from an officer of the Forestry Comission, who will advise and help him and give the names of Forestry Consultants and/or Contractors who could carry out the planting and, if necessary, could undertake to maintain the woodlands if the Owner has no staff for this purpose.

16. *Q.* Is smallness of an area a limiting factor?

A. Not necessarily. A wood of one acre can sometimes be as productive and useful, size for size, as a wood of 100 acres. If it is difficult of access, it may be more costly to manage.

(K) FARMING AND FORESTRY

17. *Q.* Need farming and forestry be in opposition?

A. No. Well managed woodlands on a farm can provide shelter, fencing materials, sport, and profit, and can provide alternative work for farm workers when they cannot get on the land.

(L) MARKETING

18. *Q.* Is it true that forestry is such a long-term investment that an owner will get no return for the money he lays out in his own lifetime?

A. This depends upon the size of the scheme and the period over which the replanting is to take place. It also depends upon whether the expression 'return' for the money laid out by an owner implies a net profit or merely means gross income.

For example, in farming, milk production should produce an income immediately, beef production may take three to four years before any income is obtained. So with forestry, the time at which an income is received will vary with what is produced. The growing of Christmas trees may produce an income from the fifth year, poplar should mature at thirty years, but in the case of the production of hard-woods such as beech, ash or oak, a substantial income from mature timber will not arise for fifty to a hundred years. Some income, however, should be derived from thinnings—and in the case of coniferous plantations from about the fifteenth year. Further, if the planting is carries out in one operation, income will be derived according to the species planted, at varying times; but in the case of continuing forestry operations covering a large area and which therefore extend over a period of years, the cost of planting and subsequent tending of the young plants is likely to continue to exceed the income derived from thinnings and early maturing species.

The expenditure on such planting must be considered to be in the nature of capital expenditure, and with the aid of Income Tax benefits which are obtainable, planting offers capital appreciation as its chief financial attraction, *anyhow until such time as through the years well managed woodlands have been built up to the stage when yearly fellings can take place.*

19. *Q.* The difficulty of marketing 'thinnings' is every year alleged by many woodland owners to be insuperable. Is it really so?

A. On the contrary there is a market for thinnings in the form of pit wood, fencing materials and pulp wood. A constant study of the various markets for thinnings, especially those connected with any particular locality, must of course be made. The Forestry Commission is prepared to advise on this if desired.

20. *Q.* How should the thinnings be sold; as they stand in the wood, or after they are felled?

A. It partly depends upon local conditions. There are merchants who will purchase the thinnings that are marked standing, and fell and extract them. The Forestry Commission can advise about prices and also provide a simple form of contract for standing sales. Some of the Forestry Consultants also undertake marketing.

21. *Q.* Who selects the trees to be marked as thinnings?

A. Again, the Forestry Commission will advise and will carry out a sample marking with an owner to show how it is done if an owner requires such advice.

22. *Q.* Does one have to obtain a licence to fell trees?

A. With certain exceptions a licence must be obtained to fell any tree over 3ins. in diameter in woodlands and hedgerows. Application must be made to the Forestry Commission.

23. *Q.* Is there any return from the scrub and coppice cleared from an area before replanting?

A. Sometimes it is possible to market selected produce. Birch between 2 and 7 inches in diameter finds a market for turnery; there is some market for small wood for charcoal burning, and for firewood.

(M) PROTECTION

24. *Q.* What are the main sources of injury to tree crops?

A. Grey squirrels, rabbits, fire, and wind. Young plantations must be fenced against rabbits and a constant war waged against the grey squirrel. The Fire Brigade will give free advice on fire protection. Good thinning will do a great deal to prevent windblow.

(N) AMENITY

25. *Q.* In Sussex the woodlands are much valued for amenity. Will economic management conflict with this?

A. It need not—in fact it can greatly enhance the amenity. Much of the fear of commercial forestry expressed by those seeking to preserve the beauties of the countryside is based on experiences and practices which are equally abhorrent to the modern Forester.

26. *Q.* How is this?

A. Good woodland management will produce continual tree cover of a wide variety of species and age-classes in reasonably intimate mixture, with individual trees of fine form and full crown development. There will be no clear-felling of such a woodland, producing dramatic and unwelcome change to the landscape; but as the different species reach maturity at different times, there will be a gradual, continuous and almost imperceptible replacement of the old by the new, in blocks scattered throughout the wood.

(O) Shooting

27. *Q.* Will good forest management conflict with the sporting value of the woodlands?

A. No—in fact the opposite. Good forestry and pheasants as well as amenity, demand a woodland composed of various species, of various age-classes, and no wholesale clear-felling. Imperial Chemical Industries have recently produced an excellent leaflet on this subject, I.C.I. Game Services Advisory Booklet No. 15 'Forestry and Pheasants', obtainable from I.C.I. Game Research Station, Burgate Manor, Fordingbridge, Hampshire.

(P) Practical Courses Available

28. *Q.* Are there facilities for improving one's knowledge of practical Forestry?

A. Yes. The Forestry Commission runs a number of five-day courses each year at Northerwood House in the New Forest for owners and agents. In addition, courses of six weeks' duration are organised each year for estate woodmen. Particulars of all such courses may be obtained from The Chief Education Officer, Forestry Commission, Director of Research and Education, 1 Princes Gate, London, S.W.7. The Royal Forestry Society of England and Wales also holds annual refresher courses for members.

(Q) Societies

29. *Q.* Are there Forestry Societies to join?

A. Yes. The Royal Forestry Society of England and Wales, which publishes a quarterly Journal, has branches in each County. Field meetings are held at which estate woodlands or Forestry Commission areas are visited. Frequently 60-80 members attend such meetings at which problems common to many woodland owners are discussed. Particulars about joining the Society can be obtained from the Secretary, the Royal Forestry Society of England and Wales, 49 Russell Square, London, W.C.1.

(R) LITERATURE

30. *Q.* What are the publications dealing with Forestry?

A. The Forestry Commission have published, and are continuing to publish, a number of leaflets, booklets, and Forest Records on different forestry subjects. A complete list can be obtained from H.M. Stationery Office. In addition, there are a large number of text books and manuals on Forestry, many recently published and written primarily for owners and agents.

(S) CONCLUSIONS

31. *Q.* Does an owner get more out of it than a purely monetary reward?

A. The growing and management of woodlands can become an absorbing and intensely interesting pursuit. It is a pursuit that can be followed till advanced old age and takes one into the woods to study the trees one has planted, and how they are growing, and to plan for the future. It leads to a wide field of interest in its connection with natural history, soils, and the life of the countryside, and to see trees growing where before there was only useless scrub or bracken is one of the most satisfying sights a man can behold. Nevertheless a sufficient monetary reward—chiefly in terms of capital improvement but also showing by degrees some yearly surplus—will be essential if Britain is to achieve a better position than at present.

32. *Q.* From the employment point of view how long will it take to increase a present Sussex total of some 500 people employed in Forestry to a total of 3,000?

A. Perhaps fifty years.

33. *Q.* Where would Britain then stand among the Timber Producing countries of the world?

A. It has been said that if a civilised and developed country is to be *self-supporting* in timber, some 15 per cent of its acreage should be afforested. At 1914 the British area was some 5.6 per cent only (the lowest in Europe). At the end of the 1939 war the forest area was 3.7 per cent (and some of this was merely open heath). The Government target towards remedying this became 'three million acres of national forest in fifty years from now; plus two million acres of private woodlands rehabilitated'. This would raise the woodland area to 10 per cent. That would provide a third of Britain's normal requirements, but it might also provide several years' reserve of timber for felling in case of war or other emergency.

34. *Q.* How can Sussex achieve its share of this improvement?

A. By the following means:—

(a) Encouraging owners of well-managed woodlands to continue their planting.

(b) Supporting the Forestry Commission to continue to work towards their (national) three million acre target.

(c) Hoping that owners of small areas of woodland will increasingly carry out forestry work with the aid of Advice, Grants and Loans.

35. *Q.* In what way or ways can the Owners of private woods hope to reach their own national target of two million acres?

A. The Sussex Rural Community Council, having had the benefit of a number of discussions with members of the Forestry Commission, the Royal Forestry Society of England and Wales, the Country Landowners Association, the National Farmers Union and with land owners and land agents and others interested in afforestation, are of the opinion that under existing conditions and using existing Societies and Organisations there is really no reason why our own national target should not be reached. It is felt that much more will be undertaken when it is realised by owners how much valuable practical advice is available.

The labour problem which presents itself to those owners who cannot contemplate employing their own woodlands staff (or only a very small one) can be overcome by employing one of the several experienced Forestry Contractors operating in Sussex. There are, of course, other alternatives such as the formation of a 'Co-operative Woodlands Society' or merely of a 'Woodlands Society' but, for the present, and bearing in mind that a forward movement is noticeable it would appear that no new organisation is required but rather renewed interest and fuller use of existing facilities.

(T) Some Final Figures

Farming and Forestry in Britain are both affected by overseas facts which are beyond British control. England, Wales, and Scotland contain 56 million acres to meet all the need of 50 million people. To produce our food we have no more than half an acre for each person. In the meantime world-population is increasing by some 20 millions each year. Some of those twenty millions are already themselves consuming a proportion of the produce which was previously exported to Britain (this applies, importantly, to the whole American Continent).

In respect of Forestry a world-increase in housing and standard of living will perhaps have slower results. But it has been said that Canada is today destroying her woodlands two and a half times faster than she is improving them, and the United States four and a half times faster. If this is the case and if it continues, any exportable surplus will obviously be much reduced.

BRITISH BRYOLOGICAL SOCIETY FIELD EXCURSION, BARNSTAPLE, NORTH DEVON

By I. G. HALL
Forester, Research Branch

The April, 1957, field excursion of the British Bryological Society was held in North Devon with headquarters at Barnstaple. All the localities visited were within twenty miles of Barnstaple. Geologically all lie on either the Carboniferous Culm Measures or the Devonian Series. Apart from duneland most of the areas visited were wooded or treeless hill and valley slopes. Some little time was also devoted to coastal cliffs and rocks. No ground higher than about 750 feet was worked, so that montane or sub-montane species were absent. North Devon is quite well known bryologically and, largely for this reason, there were few outstanding finds. Nevertheless a large number of moss and hepatic species were seen, including some which are rare or unknown in Britain outside the South-West Peninsula. The most interesting and bryologically rewarding day was spent on the dunes at Braunton Burrows.

Thursday, 25th April: Clovelly (The Hobby)

The Hobby, a well known beauty spot, has hill and valley slopes which run down steeply to coastal cliffs below. Generally the soils are of Brown Earth type derived from the Lower Culm Measures. There is evidently a wide range in pH value, since the flora includes sanicle (*Sanicula europaea*) and dog's mercury (*Mercurialis perennis*) at the one extreme and ling (*Calluna vulgaris*) at the other. This difference is naturally also reflected in the moss flora, so that *Fissidens taxifolius*, an associate of basic soils, and *Plagiothecium undulatum* associated with raw humus and acid soils, both occur. The Hobby is well wooded, with pedunculate oak the main species. Much of this oak I judge to be around 120 years, but there is also some much younger. A little planted beech occurs, of which isolated trees appear unhealthy, having slight depressions in the trunk from which a black slimy exudation had flowed. Some well-grown ash was noted and may owe its origin partly to natural regeneration, of which there is an abundance locally. Other woody species included occasional sycamore, birch, cherry, horse chestnut and hazel. Near to the coast the oak are considerably wind blasted, but in more sheltered sites fair growth and satisfactory form is achieved. One must suppose a considerable degree of exposure close to the coast, but it cannot be so severe as on and near the coastline running southwards, from Hartland Point, west of Clovelly, where the full force of westerly gales is experienced. The Commission's Hartland Forest lies in this general region.

On sandy banks two mosses found sparingly were *Epipterygium tozeri*, a Mediterranean species rarely found with us outside Southern England and *Philonotis rigida* also of southern distribution. Commonly occurring species of woodland banks were *Eurhynchium striatum*, *E. praelongum*, *Thamnium alopecurum*, *Fissidens taxifolius*, *Plagiothecium sylvaticum* and *Thuidium tamarascinum*. With these were associated higher plants of varying susceptibility to soil acidity or alkalinity, such as wood sanicle (*Sanicula europaea*), golden saxifrage (*Chrysosplenium oppositifolium*), wood bitter-cress (*Cardamine flexuosa*), red campion (*Melandrium rubrum*), bluebell (*Endymion nonscriptus*), lady-fern (*Athyrium filix-femina*), hart's tongue fern (*Phyllitis scolopendrium*), broad buckler fern (*Dryopteris austriaca*), greater wood rush (*Luzula sylvatica*) a species common in the west of Britain, and Forster's woodrush (*L. forsteri*).

In and about streams and rills and on wet shaded banks and rocks is often a good habitat for bryophytes; *Eurhynchium riparioides* was seen in quantity in the faster flowing stream sections. This is a common enough moss, but it was here most luxuriant and robust in growth. An uncommon species associated with calcareous localities is *Fissidens crassipes*, seen on wet sandstone rocks. Most conspicuous of the hepatics collected was *Conocephalum conicum*, a species useful to know in that it favours calcicole habitats. *Pterygophyllum lucens* was seen in quantity both on stream sides and moist woodland banks. At its best this is one of our most attractive mosses which superficially might be passed over as an hepatic. A little *Dichodontium pellucidum*, common in mountainous districts, occurred on the margins of the slower flowing stream sections.

On tree trunks, especially in moist and shady habitats, a number of characteristic corticolous (or bark inhabiting) species were recorded. *Isothecium myosuroides* and *Hypnum cupressiforme* varieties are ubiquitous, but also seen were two *Neckera* species, *N. complanata* and the much less common *N. pumila*. Of the hepatics, *Frullania tamarisci* grew in great quantity, especially on ash on which the reddish brown colouration imparted by the liverwort was visible from a distance. *F. tamarisci* seems especially common in the west, whereas *F. dilatata* did not seem here much more noteworthy than in other parts of the country where I have seen it. All the foregoing species are easily observed, but it is doubtful if the non-bryologist would notice the tiny hepatic *Microlejeunea ulicina* also seen on ash. *Ulota phyllantha*, a moss which never occurs far from the sea, is with a little practice easily differentiated from *U. crispa* (also found). Greater difficulty was experienced with *U. bruchii* and *U. crispa* on hazel.

Friday 26th April: Hunters Inn and Woody Bay (Between Trentishoe and Martinhoe and nearby coast

The valley of the River Heddon running due north to the sea from Hunters Inn falls rather gradually from 145 feet above sea level. Eastwards the cliff track to Woody Bay runs at about 700 feet elevation. With the possible exception of the Wringapeak headland of Woody Bay, which may be on the Lynton Beds of the Lower Devonian Series, the soils in this locality are derived from the Hangman Grits. Two distinct soil types may be recognised: a fertile reddish loam found alongside the river and streams at lower altitudes and, of widest occurrence, poor infertile hill top and upper hill slope soils. Some ash occurs on the richer valley soils, being commonly associated with hart's-tongue fern (*Phyllitis scolopendrium*), hemlock (*Conium maculatum*), dog's mercury (*Mercurialis perennis*), garlic or ramsons (*Allium ursinum*) and nettle (*Urtica dioica*). Oak, especially at Woody Bay, is widespread on the poorer soils with *Calluna* moorland on treeless hill tops. Some of the oak is apparently of coppice origin and near the coast at Woody Bay is much blasted by the wind. On the most exposed sites the oaks are prostrate, with stricken branches resembling a multitude of skeletal out-reaching hands.

As might be expected the moorland, being at low altitude and lacking bogs and rocky outcrops, was of small bryological interest. All the mosses seen are of common occurrence, such as *Pleurozium* (*Hypnum*) *schreberi*, *Hypnum cupressiforme* var. *ericetorum*, *Dicranum scoparium*, *Pohlia nutans*, *Polytrichum juniperinum*, *Ceratodon purpureus*, and a little *Leucobryum glaucum*, the latter a species also of acidic woodlands. If confirmation of the humus and underlying soil acidity were needed, all these are typical associates of such habitats.

The river and streams examined proved interesting, although no special varieties were found. Deep within shaded rock crevices under a small waterfall the rather uncommon hepatic *Jubula hutchinsiae*, a species of the wetter western half of Britain, occurred in some quantity. Just below the waterfall were masses of *Mnium punctatum*, also a species of wet and shady sites. Hereabouts hemlock (*Conium maculatum*) and scurvy grass (*Cochlearia officinalis*) were growing luxuriantly and in great abundance. *Eurhynchium riparioides* was the commonest moss, growing on submerged or partially submerged stream boulders. On the banks of the lower stream reaches *Pellia fabbroniana*, an hepatic associated with calcareous conditions, was seen. At higher altitudes the soils are more acid and there the stream-side species included mosses such as *Fissidens adianthoides* which also occurs on chalk downland, *Pterygophyllum lucens* and *Acrocladium cuspidatum*, sometimes with the hepatic *Saccogyna viticulosa* and others.

In the woodland there were in addition to the commoner bryophytes a few rather uncommon species. Those worth mention are all mosses and included *Rhynchostegiella tenella*, *R. pallidirostra*, *Barbula cylindrica* (probably) and *Brachythecium populeum*.

On non-calcareous coastal rocks close to the sea *Grimmia maritima*, Britain's most markedly maritime species, was observed in small quantity.

Saturday, 27th April: Braunton Burrows

The dune system of Braunton Burrows, whose highest point is only 85ft. above sea level, is over thee miles from north to south and little over one mile from east to west. Nearest to the sea there are shifting sands and dunes, but further inland there are old fixed dunes, boggy pools, damp hollows or 'dune slacks' and expanses of dry ground. It appears that the unique flora of the Burrows is a result of the long time over which the dunes have been stable, together with their comparative isolation and freedom from much human or animal interference. In addition their southern latitude favours many species not generally distributed in Britain. There are no trees, but shrubs such as sea buckthorn (*Hippophae rhamnoides*) and elder (*Sambucus nigra*) are of local occurrence.

On the drier sandy areas the moss *Tortula ruraliformis*, a characteristic duneland species and an important colonist, was abundant. In places it was co-dominant with *Camptothecium lutescens*, often with sand sedge (*Carex arenaria*). *C. lutescens* is a moss also associated with chalk downland and quarries, whereas *T. ruraliformis* does not often occur inland; both are indicative of calcareous conditions. At least eight *Barbula* species are known from Braunton, including the uncommon *B. hornsuchiana*. Those which I saw, *B. convoluta*, *B. cylindrica*, *B. recurvirostra*, and *B. unguiculata*, are all common species often occurring as colonists of bare soil. Other common mosses were *Pseudoschleropodium purum*, *Funaria hygrometrica* (often seen as a colonist of woodland fire sites), *Trichostomum crispulum*, a somewhat calcicolous species, and *Ceratodon purpureus*, the latter on more acid sands. It will be noted that hepatics are absent from the drier dunes, since they are in general less well adapted to dry conditions than mosses.

The moist hollows or 'dune slacks' proved most rewarding in the numbers of rare mosses and hepatics. Two good finds near the lighthouse were the rare hepatics *Moerckia flotowiana* and *Petalophyllum ralfsii*, which, although nowhere plentiful, were found in a number of separate sites. The rare *Riccia crystallina* is known from the Burrows but was not seen on this occasion. *Pressia quadrata* (probably) a calcicole hepatic, was also present. The occurrence of this species is illustrative of the richness and uniqueness of the flora, in that it is essentially a mountain plant of the north and west of Britain. Two other hepatics which may be mentioned were also listed; these were *Leiocolea turbinata*, which sometimes occurs in chalk pits, and the more common *Riccardia* *pinguis*. A fair number of mosses were found, though none were especially rare. The mountain *Bryum pseudotriquetrum* was common, often in company with *B. pendulum* a species most often seen perhaps in coastal areas. The 'hypnoid' mosses seen were all such as are liable to some variation in appearance, according as they are growing on more or less wet sites. Allowing for some difficulty, therefore, in confident field identification, the following were seen at Braunton: *Acrocladium cordifolium*, *A. cuspidatum*, *Cratoneuron filicinum*, *C. polygalum*, *Drepanocladus aduncus*, and *D. lycopodioides*.

Owing to the absence of shrubs or trees of very large size the corticolous bryophytes seen were not numerous. Some old elder (*Sambucus nigra*) carried *Cryphaea heteromalla* and two *Ulota* species, *U. crispa* and *U. phyllantha*.

Sunday, 28th April: Kings Nympton (Between South Molton and Chulmleigh)

The woods and streams worked around the valley of the River Bray lie at an altitude of between 250 and 500 feet above sea level. Bias Wood, the main woodland area visited, falls rather steeply to the River Bray below and has a predominantly north-west aspect. The soils, derived from culm measures, varied, and sometimes within short distances supported calcifuge vegetation or a rich basic soil type flora. An acidic calcifuge flora is associated with the oak-wood and included bilberry (*Vaccinium myrtillus*) creeping soft-grass (*Holcus mollis*) and associated bryophytes. Ash is locally abundant, sometimes adjacent to oak and accompanied by a rich flora including dog's mercury (*Mercurialis perennis*) and garlic or ramsons (*Allium ursinum*). Incidentally the related and introduced though now thoroughly naturalised triquetrous garlic (*Allum triquetrum*) was seen on hedgebanks, together with another introduced Umbellifer, Alexanders (*Smyrnium olusatrum*).

The list of bryophytes seen is a long one and especially so for the banks and trees bordering the River Bray. For example on tree trunks alone from water level upwards all the following occurred: mosses; *Neckera complanata*, *N. pumila*, *Ulota crispa*, *U. phyllantha*, *Camptothecium sericeum*, *Cryphaea heteromalla*, *Bryum capillare*, *Leskea polycarpa*, *Hypnum cupressiforme* var. *resupinatum*, *Isothecium myosuroides*, *Amblystegium serpens*, and the uncommon *Orthotrichum rivulare;* hepatics: *Metzgeria furcata*, *Microlojeunea ulicina*, *Frullania dilata*, and *F. tamarisci*. Some distance from the river, but also on tree trunks, were the uncommon *Metzgeria fruticulosa* (possibly) and *Tortula laevipila*.

The banks, sandy river margins, and partially submerged boulders and stones also yielded a large number of bryophytes including some rarities. Of *Fissidens* species above four or five were found : *F. taxifolius*, common also on clay banks, *F. crassipes*, *F. serrulatus*, and *F. curnowii*, although the latter can be confused in the field with *F. adianthoides*, probably also present. *F. curnowii* is rare and not often, I believe, found outside the South-West Peninsula; *F. crassipes* and *F. serrulatus* also are rather uncommon. *Eurhynchium riparioides* was again seen on river and stream boulders, where also a little *Fontinalis antipyretica* grew. Mud and the margins of streams and rivers have a characteristic colonising bryophyte flora, but only two mosses in this category were seen, *Physcomitrium pyriforme* and *Webera carnea*. Many hepatics were noted on shady overhanging river banks, including *Riccardia pinguis*, *Lunularis cruciata*, *Lejeunea cayifolia*, a *Cephalozia* species, and *Pellia epiphylla* to mention some. Marshy shaded ground alongside woodland streams and springs and shady wet boulders afford a habitat to some of our choicer bryophytes. In such a habitat *Mnium punctatum* was seen in abundance and growing with great vigour. *Trichocolea tomentosa*, an unmistakable hepatic, was of local occurrence. In addition to these two latter there occurred the following suggestive of flush conditions, *Mnium undulatum*, *Acrodadium cuspidatum*, *Brachythecium rivulare*, and *Ctenidium molluscum*.

In Bias Wood, apart from the moister habitats already mentioned, the bryophytes were somewhat commonplace though numerous in species. On tree trunks hepatics were *Radula complanata*, *Frullania dilatata*, *Microlojeunea ulicina* and, on rotting wood, *Tetraphis pellucida*. On the ground, calcifuge mosses were *Pleurozium schreberi* and *Plagiothecium undulatum*, but also basophiles such as *Eurhynchium striatum* and *E. piliferum*. Hepatics were *Plagiochila asplenioides* and *Lejeunea cayifolia* on the better soils with, on the poorer soils, *Buzzania trilobata* a common associate of Welsh upland oak woods, *Lophocolea* species, and *Calypogeia arguta*.

Monday, 29th April: Westward Ho !

As few members remained until Monday, the tour previously planned was cancelled and the day was spent instead on the coast at Westward Ho! The low cliffs examined to west and bounding the raised beach are on the Culm Measures. North of Westward Ho! the small dune system seen is bounded on the seaward side by a conspicuous pebble ridge.

There was very little of bryological interest on the cliffs, perhaps because they are too frequented. *Bryum capillare*, *Pleuridium acuminatum* (in fruit) often an associate of bare leached woodland soils, and *Weissia controversa* are all that need be mentioned.

Looking north from the duneland visited, the south end of Braunton Burrows is only distant a mile or two. Despite their proximity there is no comparison between the two floras, that at Westward Ho! being poor in the extreme. Yet this is not without interest in that the reason appears to lie largely in the fact that at Westward Ho! the dunes are much more frequented by the general public. In addition grazing by sheep occurs and there are no good 'dune slacks'. *Tortula ruraliformis* and *Camptothecium lutescens* were again common, and were the only bryophytes seen in abundance. Other common mosses were *Weissia tenuis* (probably), *Barbula unguiculata*, and *Pseudoscleropodium purum*. Two rushes are worth note,—sea rush (*Juncus maritimus*) and sharp rush (*J. acutus*), both of them coastal species.

EXCAVATIONS AT STAPLE HOWE, SCARDALE FOREST

By T. H. BREWSTER

From time to time valuable archaeological finds are made in the Commission's extensive properties; the following article, contributed at the suggestion of Mr. T. V. Dent, Divisional Officer in North-East England, illustrates the painstaking care that experts devote to uncovering the precious relics of the past.

During the last six seasons a group of archaeologists led by the writer have been excavating a prehistoric settlement at Staple Howe, Knapton, Malton, East Yorkshire. Knapton Wood, where the site is located, forms part of Scardale Forest in the north-east England Conservancy. When the excavations began the site was in private hands, but the property was purchased by the Forestry Commission in March 1952.

The excavations have uncovered the remains of a complete settlement built by some of the first Iron Age invaders from Europe in the early part of the fifth century B.C.

These Knapton settlers and other allied groups are known to archaeologists in Britain as the Iron Age "A" people. Many settlements of this period have been excavated in the Midlands and in Southern Britain. In Yorkshire there is the site, excavated by Simpson, on the Castle Hill, Scarborough, the badly damaged sites at Grafton in the West Riding, and that at Thornham Hill in Holderness, now destroyed.

Prior to the excavations at Knapton no Iron Age "A" settlement in the British Isles, so far excavated, had yielded a complete plan of all the structures, and produced large quantities of different types of pottery and small domestic objects of bronze, bone, antler, pottery, stone and iron.

Furthermore, the occupation of the site was relatively short and, except for Edwardian picnic parties, had not been occupied for 24 centuries. There had been no disturbance of the structures, apart from erosion, from the day the farmstead was abandoned to the arrival of the excavation party in 1951.

The value of the Staple Howe excavations is that they disclosed a complete plan of an Iron Age "A" occupation site associated with plenty of domestic debris.

As is often the case with archaeological sites, this Knapton settlement was found entirely by chance. Early in August 1950, Michael and Ann Stones of West Heslerton, with two school friends, went picnicking on Staple Howe. Michael picked up a small fragment of crude pottery, and took it to Heslerton School where an archaeological recording scheme was operating for the Ordnance Survey.

A detailed examination was made by the writer in April, 1951, of the find spot, and within thirty minutes more than 2,000 fragments of Iron Age pottery were found. Much of the surface pottery discovered was larger than a medium size saucer and had been exposed to the weather for centuries. Large numbers of bones protruded from the hillside, suggesting a considerable quantity of debris was buried beneath the scree.

Because of the richness of the finds and the possibility that the settlement might be intact, excavations were begun at once. Within a few days it became obvious that the material was very rich, and that the structures might well be intact.

Due to the compactness of the site, it was decided it would be possible to excavate the entire area likely to be covered by huts, and also much of the space straddled by the defences. It was planned to do this in five years, but the adverse weather in 1954 held the work up, and it became necessary to excavate for another season—in 1956. The final excavations were completed in August 1956 and nothing now remains to be done.

The Site

Staple Howe is a huge natural hog-backed hill of solid chalk, half way down the northern slopes of the Wolds in Knapton Wood. To the immediate west, south and east lies a deep ravine. Towards the north-east is Heslerton Hall and to the north-west are East Knapton and the huge white mass of Knapton Silo.

From the top of the Howe, on any clear day, can be seen the immense colourful landscape of the Vale of Pickering, the Howardian Hills to the west, the vast moorland hinterlands to the north-west, Danby Forest in the Allerston group to the north and Oliver's Mount, Cayton Bay, and Gristhorpe to the east.

Staple Howe's basal length, from east to west, is 460 feet, with a maximum width of 220 feet. The maximum height is 85 feet, and the really flat part of the top measures 178 feet, from east to west, and 40 feet from north to south at the widest point.

STAPLE HOWE IRON AGE HABITATION SITE

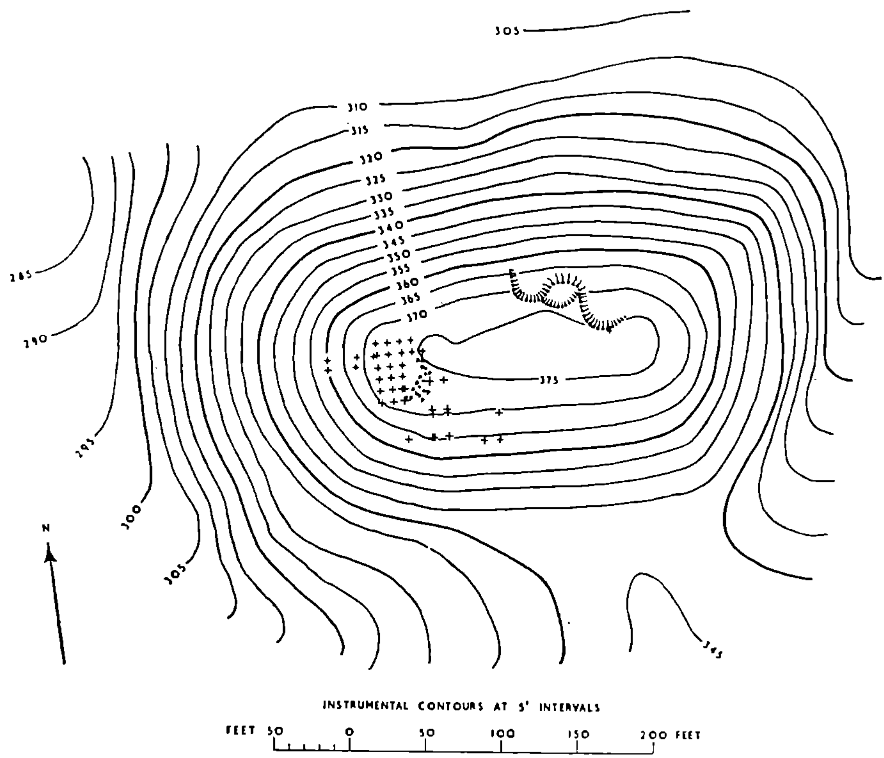

Fig. 23. Plan of the Site.

Throughout the ages frost, rain, and sun have eroded the rock, leaving behind on the slopes a grey chalk scree. When first located the mound was shrouded in a dense ash scrub to within a few feet of the top, which was capped by several ancient and twisted larch trees. Beneath them, and just covering their roots, was a soft green carpet of rockrose and fine short grass. (See Figs. 23 and 24 and Plates 31, 32 and 33.)

The Defences

The steep slopes of the Howe and its fairly flat top provided the Iron Age settlers with an easily defended natural position which they fully utilised. Early in the excavation it became obvious the mound had been defended by a palisade of logs.

Channels following the natural contours, near the top, had been cut in the solid rock to hold the upright timbers of a palisade. These timbers had been securely packed into place by chalk, bones, broken pots, and miscellaneous debris from the huts. (Fig. 25, Plates 35 and 38).

There had been two main stages of the palisade system, the earliest of these being constructed of fairly light timbers, so placed as to follow the edge of the flat hill top. This fence was broken in three places by entrances—one a small side gate on the western end of the southern side; the second a fairly wide main entrance half way along the southern slopes; and the third a small gateway on the north-eastern end of the settlement.

Owing to the lack of space within the enclosure and the weakness of the light palisade, the Iron Age inhabitants increased the area of the site and strengthened their position by placing the fence further down the slope and cutting a deeper channel. This was done on all sides, except on the line from the eastern side of the main entrance to the south-eastern corner of the Howe. In this area the channels were deepened, but not moved.

An interesting feature of the second palisade stage was a single main entrance and the absence of side gates. Obviously these small gates had been a weakness and were done away with.

The final phase of the palisade system was the deepening of the palisade trenches and the replacement of all timbers which had probably decayed. A new slot was cut to the west of the main entrance for the palisade, which curved downhill in its new form, and then swung towards the top, narrowing the gateway and incurving.

It is probable that the light fence within the gate, which swung in an arc north-westwards from the eastern side of the entrance, belonged to the final stage of the occupation.

These last two modifications caused the trackway to enter the settlement in the form of a flat "S" bend.

Throughout the occupation the settlement was much longer than it was wide, due to the shape of the hill. The area enclosed by the final stage of the palisade was approximately 18,000 square feet, of which 12,000 square feet has been excavated.

With the exception of an odd broken stump, there were no signs during the excavation of the palisade timbers, due, no doubt, to their withdrawal when the site was abandoned. It is probable the palisades, in their final form, provided an effective protection for the inhabitants and animals from both man and beast, chiefly the latter.

As a result of the excavations it is known there were guard dogs on the site, and many of their droppings have been found. Dogs alerted by the clink of the scree would sound a warning. Many a false alarm must have been caused by a scurrying hare or slinking fox.

The Buildings

Within the palisades, excavations uncovered several interesting structures. In only one case had the actual walls survived, but the holes cut in the solid rock for seating the timber uprights remained. It is from these postholes we can reconstruct the shape of the huts.

All excavation, except for turf removal, was by trowel and carpet brush, chiefly the latter. The position of each pot rim, base, decorated wall fragment, and all finds of interest was plotted to a fraction of an inch. Using modern survey equipment a detailed plan was prepared of each structure, and 2,000 photographs, some in colour, recorded details of postholes, buildings, and the position of many small finds.

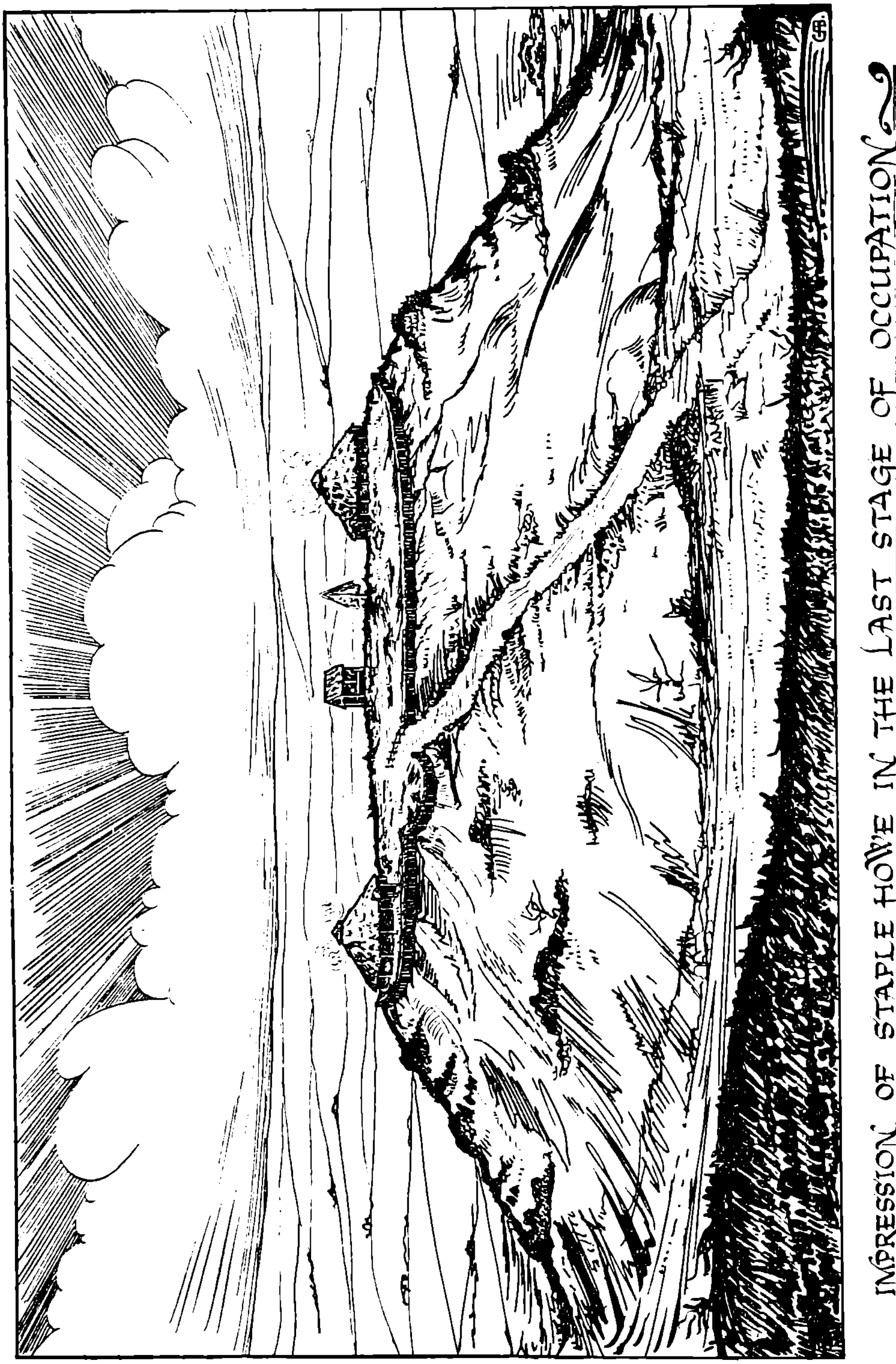

Fig. 24. Artist's Reconstruction of Staple Howe.

Hut I

Three houses, or huts, were discovered, two being of the same round design and situated at each end of the settlement. The hut at the extreme western end was the best preserved. Formerly it was a building 31 feet in diameter, with a porch facing south-east and wooden walls approximately four feet high.

Covering the house was a conical roof, with a hole in the top to let the smoke out. The roof must have been protected with turf, thatch, or bracken. Allowing for the correct slope, the hut's height cannot have been below 10 feet or much above 12 feet. Its appearance would not be unlike a modern circular pig sty.

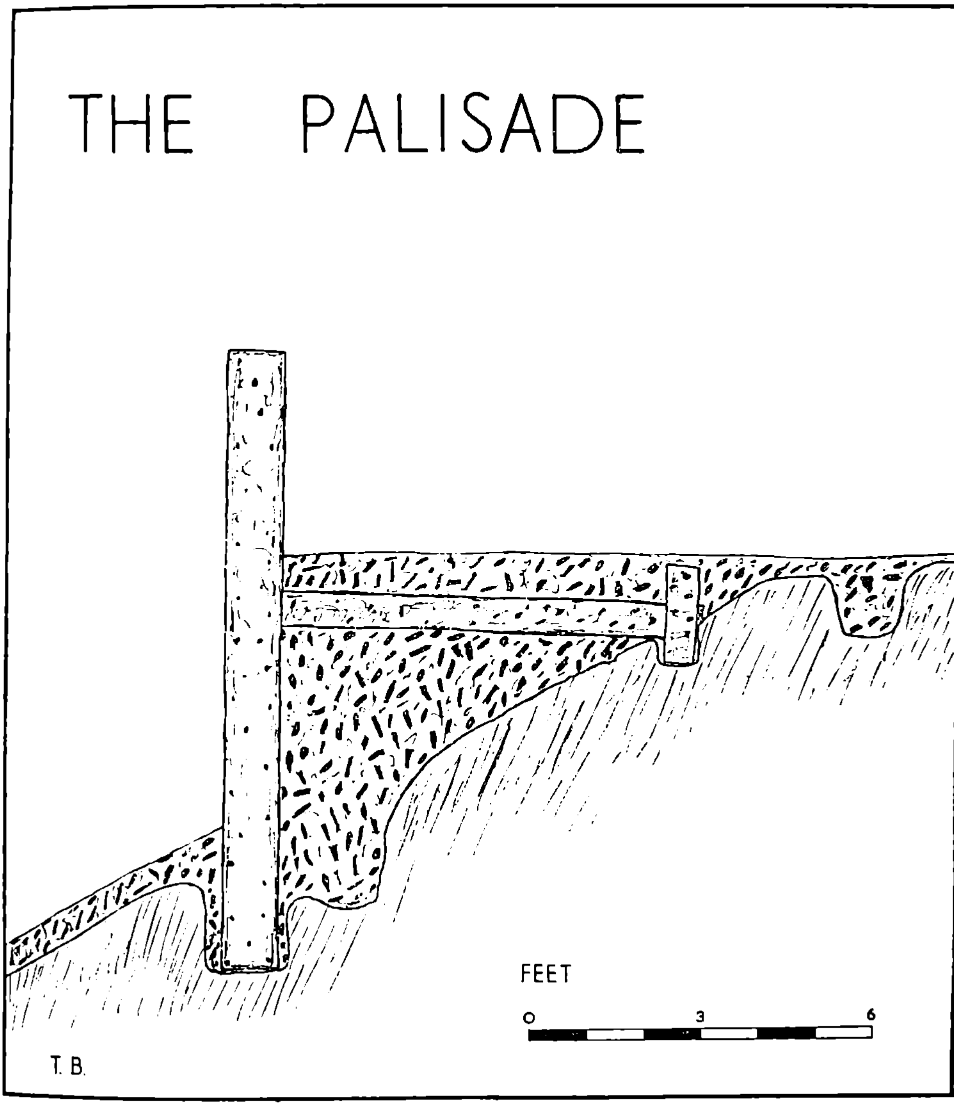

Fig. 25. Cross-section of the Palisade.

In addition to postholes for roof supports there were slots for what we are fairly certain was an upright loom, with a frame shaped like a child's wooden swing.

Just north of the centre and east of the loom were the remains of a clay oven. These primitive ovens had a flat dome, rather like an old style circular beehive. they were heated by wood, and all cooking was by retained heat after the fire had been withdrawn.

Due south of the oven was an open hearth, with reddened and blackened stones. Strewn on the floor were odd items of bone, jet, bronze, and pottery.

Outside the hut and just to the left of the porch many dog droppings, gnarled bones, and dog's teeth were found. Obviously a dog had guarded the entrance to the dwelling. Both of the round huts conformed to the general pattern of Iron Age houses in Britain.

Hut II

To the east of the hut just described, on the northern side of the mound, was a most remarkable oval house 30 feet from east to west, and 20 feet wide. Its floor and southern wall had been hewn out of the solid chalk. On the northern, and on part of the eastern and western, ends there had existed a chalk stone wall approximately 4 feet high. A simple ridge type of roof with rounded ends was indicated by the postholes.

Entrance to the house was gained through an unprotected doorway at the eastern end.

In consequence of the collapse of the dry walls and chalk rubble, all the hut's interior survived undamaged. Even a shallow channel cut by water dripping from the roof remained on the northern side.

Just within the hut, on the southern side of the doorway, was a small platform, probably a seat, cut into the quarried wall. Nearby were the remains of a clay oven, burnt red with fire. The hearth, which was at the western end, was marked by charcoal and burnt stones.

Two systems of channels and pits, connected to the drip line outside the hut, were probably used to collect rain water during heavy storms. Both channels and pits may have been lined with hide to prevent seepage. The nearest water supply known today is 300 yards away, and water carrying must have been an unpleasant "chore".

Splintered animal bones, (Plates 38 and 39), broken to extract the marrow, jet ornaments, pins, spindle whorls and pottery covered, or were embedded in, the earthen covering of the rocky floor.

A small, nearly perfect, pottery "lamp" turned up in the same deposit.

This oval dwelling is most unusual and seems to be a cross between the European rectangular house and native round hut. There is every indication the oval house was the first habitation abandoned before, or just after, the second palisade was built.

The Granary

In the centre of Staple Howe, on the highest point, excavations uncovered five really big postholes, more than two feet deep. At first they appeared to be grain storage pits, a common feature of Iron Age sites in the south. (Fig. 26.)

Further work disclosed that these pits had formed part of a nine-feet-square building with heavy timbers. Such a structure was too small and massive for a hut, and must have been a watch tower, or a building for holding a heavy weight.

Although carbonised grain had been found in the palisades no grain pits or silos have been located. It is thought the five postholes supported a massive timber box-shaped granary with posts at least 14 inches thick, and the bottom about 18 inches from the ground. This would prevent damp or mice affecting the corn. The total capacity must have been about 18 cubic yards, if the reconstruction is correct.

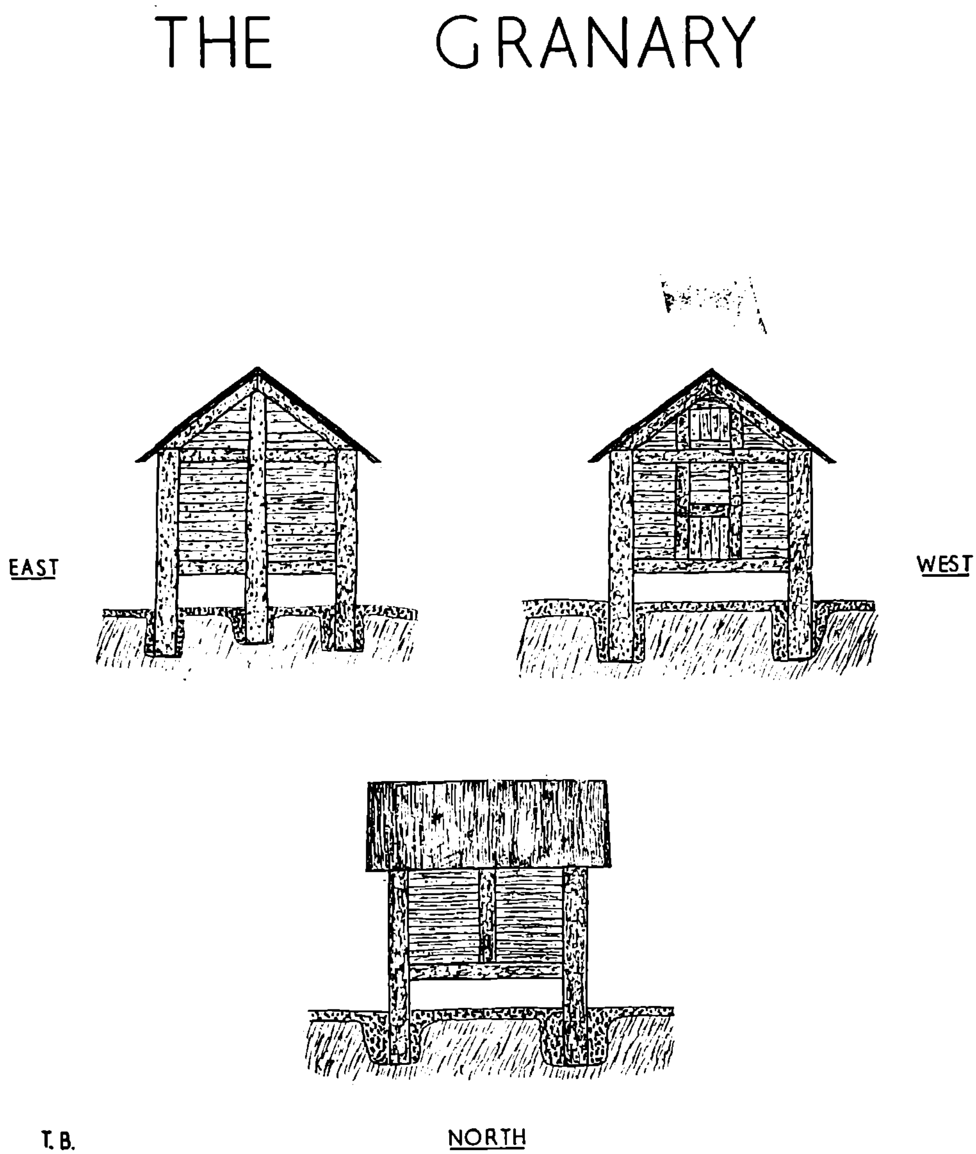

Fig. 26. End views and side views of the Granary.

The Finds

Bronze Objects

Several objects of bronze were found, the most interesting of these being three razors of different patterns. One razor, the largest, has a curved blade and two loops for suspension, probably round the neck. Its condition is good, but the blade had been damaged a little. Another smaller razor with a single loop and blade is the most beautiful object found on the Howe and is in perfect condition. Even the striations caused by sharpening 2,400 years ago and the golden tone of the bronze show through the delicate patina. It was discovered lying on its side in soft earth, where it had probably been hidden, not lost.

The two razors—the third is not complete—are unique in Britain although the largest has some connection with the Llyn Fawr, Wales, Hallstatt razor.

A chisel of bronze, in good condition, was found with the antler "T" piece of its handle 10 inches away from the blade, the wooden haft having perished.

Awls and other bronze finds, including a pair of tweezers, were found. These tweezers were discovered purely by chance on the surface. They match in every way a pair found at Grafton in the West Riding.

Bone Objects

Many pieces of worked bone turned up, the commonest being pins. The most interesting finds were the netting shuttles of bone and antler, with very fine slots, shuttles of this kind were probably used to make hair-nets of human hair. Several double ended pins or hooks of bone, known as gorges, came from the palisade debris.

Similar gorges were used by Eskimos and hunters in Finland for catching certain fish and birds. Doubtless the Staple Howe people manufactured them for the same purpose.

Other finds include a decorated bone scoop, not unlike a late medieval apple corer, and a wild boar's tusk pendant with holes drilled at either end. Cast red-deer antlers were used as levers or "picks".

Jet

Artifacts of jet, while not common, appeared from time to time. Bangle fragments and finger rings in the style of a modern wedding ring were the commonest objects. Jet pendants, beads, buttons, and other ornaments turned up occasionally.

Pottery

A striking feature of the excavations was the ever present scatter of broken pottery. (Plate 37.) The quantity excavated ran into tons. There were two chief types of pot, burnished and plain coarse ware in red, brown, yellow, buff, and black. Cooking pots, both large and small were decorated with finger tip, finger nail, and applied bands. Small beakers and bowls were ornamented, in many cases, with incised grooves or slashes in various patterns.

Of the ceramic finds the most complete were two small oval vessels, divided, in each case, by a thin partition, perforated at the base by small holes. It is thought that these pots were used as lamps with a floating wick and burning seal or other animal oil. A small scoop in fine yellow pottery came from the palisades.

Weaving Equipment

Weaving of woollen cloth was evidently a duty of the Staple Howe Iron Age housewife. This is borne out by numerous broken red and yellow loom-weights of poorly fired local clay, originally weighing about five pounds. Their function was to keep the warp tight in upright looms. Many pottery spindle whorls, used to spin woollen yarn, were scattered everywhere. No bone weaving combs occurred, and it is thought none were made.

Iron Objects

As in the case of Simpson's excavations on the Castle Hill, Scarborough, the paucity of iron objects at Staple Howe was most marked. Only a small iron pin and a ring were found. In the early part of the British Iron Age iron was a rare and precious metal.

Other Objects

Apart from the objects already mentioned, the palisade trenches and the huts yielded stone pounders, hones, broken fragments of clay ovens, sea shells, sharks' teeth, and carbonised wheat.

Coastal Visits

It is obvious the inhabitants of the Howe went to the coast, probably Filey, fairly frequently, possibly in order to get fish and brine. It is likely that wheat was grown on the narrow plateau to the south of, but overlooking, the mound. This strip has a relatively rich soil and is easily worked.

Acknowledgments

The Staple Howe excavations could not have been completed had it not been for the hard work of many volunteers from all over Britain. (Plate 34.)

The Forestry Commissioners, who own the property, have assisted us in every possible way and to them we owe much. In particular I would like to thank Mr. T. V. Dent, Divisional Officer, Mr. R. Marshall, District Officer, Mr. O. Wood and Mr. F. Woodward, Foresters at Scardale Forest. Without their help the excavation would have been impossible.

Throughout the excavation we have had every help and encouragement from Mr. C. W. Phillips of the Ordnance Survey, and to him we are grateful for many things.

STAPLE HOWE: FULL DETAILS OF ILLUSTRATIONS

Plate 31. Staple Howe from the east. Height from ravine 75 feet.

Plate 32. Staple Howe from the south-west. Taken prior to the felling of the larch trees. Note (thinned) scrub ash forest on the Wold slopes and the Howe itself.

Plate 33. View of western end of the Howe showing concrete pegs marking postholes of round hut, Hut I. Note tree stumps (larch) and hollow of oval hut prior to excavation in 1955. Scrub ash forest in distance.

Plate 34. Excavation in progress on the eastern end of Staple Howe. White bucket for unrecorded pottery and bone. Clippers used for removing larch, ash, and rockrose roots. Left to right: Hatty Haines (Canada); Martin Faragher (York); John Pallister (Yorkshire Museum); and Terence Manby of York.

Plate 35. Section of palisade trench on south-eastern end of Staple Howe showing division of trench into first, second and third cutting. Top of trench first—bottom trench third.

Plate 36. North-eastern posthole of granary. Rammed packing still intact in lower half. Scale rests in former position of post. Scale 2 ft.

Plate 37. Broken pottery lamp *in situ* on floor of oval hut. Scale 4 inches.

Plate 38. Ox skull rammed into the palisade trench as extra packing. Horn cores still intact. Scale 4 inches.

Plate 39. Human skull, red deer antler, and ox bones in packing of upper palisade. Probably from a burial, previous to the Iron Age, disturbed by the building of the huts.

Book Review

TIMBERS USED IN THE MUSICAL INSTRUMENT INDUSTRY A SURVEY

Forest Products Research Booklet. Free Issue. November 1956

By F. G. O. Pearson, B.Sc. formerly Sales Officer in our Directorate for England, who is now on the staff of the Forest Products Research Laboratory (Department of Scientific and Industrial Research) Princes Risborough, and Miss Constance Webber, also of Princes Risborough.

The technical requirements for the timbers used in the musical instruments industry are probably more exacting than those of many other industries, and the aim of this survey was to ascertain the particular purpose for which wood is to be used in the making of musical instruments and to know, not only by laboratory tests but also by personal contact with a large number of firms, just how the various species stand up to the test of commercial production.

Reasons put forward for the choice of species were often empirical, resulting from the trials and errors of previous generations of craftsmen. The minimum amount of movement is particularly desirable, reliability is a general requirement, and the report mentions the necessity of considerable selection of the timbers to be used. Eighty-five different timbers were found to be in use or to have been used in the past. While the makers show why certain timbers are liked, other timbers are spoken of with regret " . . . because they are no longer available".

Pianos, organs, the stringed, wood-wind, percussion and classical instruments come under survey, and information is given in some detail for each instrument, together with brief notes on drying methods and glues. Production and export values for 1954 are also included, and the industry gives employment to approximately 9,000 workers.

The practical ways of handling the problems of tone-quality, stresses, atmospheric and climatic difficulties, the trouble of corrosion of metal parts experienced by several firms, and the unusual presence of common salt in particularly large quantities in one species make engrossing and instructive reading.

The report, which is essentially a record of the opinions of different firms, also has a useful *Index To The Timbers* listing, alphabetically, 121 tree names and the latin nomenclature.

This booklet is a free issue, and a copy will be sent to anyone who writes to the Director, Forest Products Research Laboratory, Princes Risborough, Aylesbury, Bucks.

H. Johnston

Publications Branch

MATHEMATIKA

How much wood could a woodchuck chuck if a woodchuck could chuck wood?

With acknowledgments to Sir Norman Frome, C.I.E., D.F.C.

This problem is cited as an excellent example of the method of direct logical deduction reinforced by a rigorous application of differential calculus. The argument of the proof is one of the most elegant of all mathematical concepts and will be found to be a very powerful weapon in dealing with problems of this type.

Now, consider the problem as set forth. It is presented in a form which may lead the unwary astray. The initial reference to the calculation of a quantity may (erroneously, in fact) be taken as indicative of the necessity to derive a formula for the estimation of quantity and for the production of a solution of the formula so derived. This trap should be avoided. In all problems of this type it is the postulate in the second part of the problem which is predominant, i.e., "if a woodchuck could chuck wood". We have, therefore, to examine the truth of this postulate before proceeding to any calculation of quantity, volume or numbers which can be projected over any given distance by a given projector.

Before any woodchuck can chuck wood it is necessary to provide the wood to be chucked. Now mathematics has available large quantities of wood—in the form of logs. It is, therefore, a straight-forward matter to provide the necessary operative material by the expression:

$$\log q \;.\;.\;.\;.\;.\;. \quad (1)$$

where q is a quantity not yet determined.

Now, examine (1)—it is a quantity which, containing only one zero (in the second term of the expression), is of the first order of smallness. The quantity (q) of wood (w) contained in the term "log q" is, according to the given data, to be dealt with by the operator, a woodchuck.

Consider the expression, "woodchuck". It is, by inspection, a quantity of the second order of smallness since it contains zero squared—arising from the two zeros in the second and third terms of the expression.

From the well-known "Theorem of Chuckability" it is an axiom that no chucker of the second order of smallness can chuck anything (whether wood or otherwise) of a higher order, i.e., of the first order of smallness. It follows, therefore, that no woodchuck can chuck log q. This does not mean, however, that the postulate is yet disproved since we have not yet investigated the results of the application of any other function permissible with reference to log q.

The calculus contains a powerful tool in the form of a saw:

Sigma. Σ

Apply this saw to log q :

$$\Sigma \ \log q \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \quad (2)$$

The solution of an expression of this type is easily derived when the fundamental principle of differential calculus is applied—the division of quantities into an infinite number of small elements indicated by the prefix d, thus :

$$\Sigma \ \log q = dq + dq + dq + dq + \text{etc.} \ . \ . \quad (3)$$

that is to say, an infinite number of small pieces of wood are now available in chuckable form.

Having performed a function on the operative, log q, however, it is necessary by the application of the principle that like must be done to like, to carry out the same function on the operator, the woodchuck, i.e.,

$$\begin{aligned}\Sigma \ \text{woodchuck} &= d\,(\text{wood}) + d\,(\text{chuck}) + \\ &\quad d\,(\text{wood}) + d\,(\text{chuck}) + \\ &\quad \text{etc.} \ . \ . \ . \ . \ . \ . \ . \ . \ . \quad (4)\end{aligned}$$

that is to say, an infinite number of small pieces of wood plus an infinite number of small elements of chuck.

Equate (3) and (4) :

$$\begin{aligned} dq + dq + dq + dq + \text{etc.} &= d\,(\text{wood}) + \\ &\quad d\,(\text{chuck}) + d\,(\text{wood}) \\ &\quad + d\,(\text{chuck}) + \text{etc.} \ . \ . \ . \ . \ . \quad (5)\end{aligned}$$

Now, from the nature of the derivation of 'dq' (*vide* (2) and (3)) and from the equation (4) we have:

$$dq = d\,(\text{wood})$$

From (5), therefore, by the removal of quantities known to be equal :

$$O = d\,(\text{chuck}) + d\,(\text{chuck}) + d\,(\text{chuck}) + \text{etc.} \ . \ . \ . \ . \ . \quad (6)$$

Integrate (i.e., produce a summation of) both sides of this equation, which gives :

$$O = \text{chuck},$$

that is to say, the amount of chuck available in any given woodchuck is nil. The postulate is, therefore, provided to be untenable and the calculation of the quantity that can be chucked does not arise.

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At 1st January, 1958

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