

REPORT ON

FOREST RESEARCH

1974

FORESTRY COMMISSION



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FORESTRY COMMISSION

REPORT ON
FOREST RESEARCH

for the year ended
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Page 10, line 4. For 1973, read 1972.

Page 22, 12 lines from bottom. Read Miss C. F. Golding.

Page 74, 8 lines from bottom. For vertical scales of 3 x, 6 x and 12 x,
read 1·1 x, 2·5 x and 4 x.

The 2·5 x scale gave best results.

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All the photographs are from the Forestry Commission's official photographic collection except for Plate 3, which was supplied by the authors. The diagrams were supplied by the respective authors and prepared for publication by the Commission's Photographic Section.

INTRODUCTION

By D. R. JOHNSTON

Director of Research and Development

The Form of the Annual Report

The form of this year's *Report on Forest Research* is different from that of previous Reports. It is very much shorter and there are no reviews of the year's work by the Chief Research Officers. This has been done because it is thought that the Annual Report is not the most suitable vehicle for the publication of research results which are difficult to reference when a number of quite different subjects are included in one document. It is intended to give only a brief review of the year's work in the Annual Report and to publish the results of research work in the appropriate standard publications. It is also intended to give greater emphasis in future to the publication of short reviews of the practical applications of current research work. These will appear as Leaflets, Research and Development Papers, and Current Information Notes.

Organisation

On 1st October 1973 the Management Services Division was disbanded and the two Branches most closely associated with the physical aspects of forestry—the Work Study and Field Surveys Branches—were amalgamated with the Research Division to form a new Research and Development Division.

The reorganisation was followed by some further changes within the Research and Development Division. These were made partly to give a better balance to the administrative and supervisory responsibilities within a larger Division and partly in response to an increasing interest in the wider environmental aspect of forestry. The opportunity was also taken to eliminate some overlapping between the Northern Research Station and Alice Holt in the south, and to avoid supervision at very long range.

The Soils Branch was replaced by two Site Studies Branches, one at the Northern Research Station and one at Alice Holt. The Site Studies Branch (North) will work primarily on an upland site classification and its relationship with the silviculture of commercial coniferous crops. The Site Studies Branch (South) will concentrate on soil and foliar analysis, the long-term effects of trees on the site, lowland and especially hardwood forestry and the problems of establishing trees on difficult sites such as motorway verges and old industrial areas.

The Silviculture Branch (North) will be responsible for research on the establishment and management of commercial crops on upland sites, while the Silviculture Branch (South) will concentrate on lowland forestry and arboriculture. The southern Silviculturists will also be responsible for work on weed control and, in collaboration with the Mensuration Section, on thinning research. The reorganisation has also made it possible to replace one of the Silviculturists in the south with an Arboriculturist who will do research on the selection, propagation, establishment and management of trees outside the forest.

A new Communications Branch has also been formed. This brings together the previous Photography, Publications and Research Information Sections.

Plant Health Legislation

In the early part of 1974, in order to clarify our legislation and (with proper safeguards) to increase the possibilities of trade, the Importation of Forest Trees (Prohibition) (Great Britain) Order, 1965 was amended to make it applicable only to living plants, and the Importation of Wood (Prohibition) Order, 1974 was brought into operation. The second of these orders:

- (a) allowed the importation from Belgium, Denmark, the Federal Republic of Germany and the Netherlands of wood of conifers with bark attached provided it was certified free of the beetles *Dendroctonus micans* and *Ips typographus*. Previously, under the terms of the Landing of Unbarked Coniferous Timber Order, 1961 (now revoked) timber from these countries was allowed entry only after removal of the bark;
- (b) provided controls over the importation from various countries of wood of Sweet chestnut, oak and elm, designed to prevent the entry into Great Britain of *Endothia parasitica* (the cause of chestnut blight), *Ceratocystis fagacearum* and *Ophiostoma roboris* (two fungi that cause oak wilt), new strains of *Ceratocystis ulmi* (the cause of Dutch elm disease) and any of the beetles that carry it, and the elm phloem necrosis virus and its vectors.

Since the importation of wood order came into operation on 1st February 1974, a good deal of timber falling within its provisions has been entering this country, and has been the subject of inspection by staff of the Commission's territorial Conservancies. The Research and Development Division has supported the inspecting staff by providing them with information on the pests and diseases concerned, and identifying suspect organisms; in many cases research entomologists and pathologists have been present when imported cargoes have been examined.

Inspection on 28th March of a certified load of coniferous timber from the Federal Republic of Germany showed that *Ips typographus* was present on more than 10 per cent of the logs. The Embassy of the Federal Republic was informed, and immediate steps were taken (with the willing and active cooperation of the purchaser of the wood) to process the material without delay, and so render it harmless. The incident underlines the fact that at times quite considerable infestations may be overlooked by inspectors at the time of export. Further, of the safeguards built into the importation of wood order, the authority to inspect imported produce is the most important if our forests are to be adequately protected from the entry of new pests and diseases.

Alice Holt Lodge—Seed Testing Station

The Forestry Commissioners exercised the powers vested in them by Section 29 of the Plant Varieties and Seeds Act 1964, as amended by the European Community's Act 1972, and designated and established the Seed Testing Station at Alice Holt Lodge as the official Seed Testing Station for silvicultural, propagating and planting material in Great Britain. This took effect on 1st July 1973.

Visitors and Visits Abroad

Nearly 900 people visited Alice Holt Lodge and there were 70 overseas visitors to the Northern Research Station. They came from 39 countries and parties included private woodland owners from Aquitaine, forestry experts from Finland, and students from the four British universities giving degrees in forestry.

The Scandinavian Seed Orchard Group visited Scottish seed orchards, tree banks and progeny tests.

The week-long Research Appreciation Courses for Conservancy staff were replaced by two-day visits at Alice Holt Lodge. Staff from East England and South West England Conservancies came this year. A course for new entrant District Officers was held at the Northern Research Station. At Alice Holt Lodge a one-day Seminar on the developments in Dutch elm disease was given by Entomology and Pathology staff to local authorities, tree surgeons and Forestry Commission staff. A total of 143 attended talks in the morning and demonstrations in Farnham Park in the afternoon. This type of "teach-in" is a very effective way of communicating research findings.

The number of visitors to Bedgebury and Westonbirt Arboreta rose to 180,000 this year.

A total of 27 members of staff attended overseas conferences and meetings. Eight of these were to IUFRO meetings, and six members of staff have been involved in Common Market meetings concerning legislation.

A number of visits overseas included an inspection of cone crops of Grand fir and Noble fir in the Pacific North West of America by Dr A. M. Fletcher, and a study tour of wood consuming industries in Bulgaria by J. R. Aaron.

Staff Changes

Transfers in: A. T. Jones (District Officer I, Work Study) from South Scotland Conservancy.

New entrants: A Willson (Higher Scientific Officer) to Site Studies South. Dr J. J. Philipson (Scientific Officer) to Physiology. J. O. Morrison (Scientific Officer) to Statistics. S. E. Heritage (Scientific Officer) to Entomology.

Transfers out: D. A. Burdekin began a two-year period of secondment to the Directorate of Research, Department of the Environment. J. R. Aldhous (Assistant Conservator, Silviculture South) to South West England Conservancy. D. B. Paterson (Site Survey Section) to East Scotland Conservancy on promotion to Assistant Conservator. J. F. Morgan (District Officer I, Planning and Economics) to South Wales Conservancy. T. M. Scott (District Officer I, Entomology) to North West England Conservancy. D. M. Hughes (District Officer I, Work Study) to South Wales Conservancy. E. R. Robson (Silviculture North) to North West England Conservancy on promotion to Chief Forester. D. M. Percy (Head Forester, Work Study) to South West England Conservancy. P. H. Hamilton (Silviculture South) to Forestry Commission Headquarters, Basingstoke, on promotion to Higher Executive Officer. Miss N. Murphy (Executive Officer, Finance) to HQ, Basingstoke. Miss M. E. Grant (Clerical Officer, Northern Research Station) to HQ, Edinburgh.

Promotions: A. J. Grayson (HQ, Planning and Economics) to Conservator. Dr J. N. Gibbs (Pathology) to Principal Scientific Officer. Dr D. B. Redfern (Pathology) to Principal Scientific Officer. N. E. Stutter (Administration and Finance Officer) to Principal. Dr G. I. Forrest (Genetics) to Senior Scientific Officer. Mrs J. Birchall (Statistics) to Higher Scientific Officer. Dr C. J. A. Samuel (Statistics) to Higher Scientific Officer. Mrs J. E. Parker (Site Studies South) to Scientific Officer. E. Baldwin (Silviculture North) to Chief Forester. J. D. Low (Pathology) to Chief Forester. F. C. Thompson (Silviculture South) to Chief Forester. A. L. Sharpe (Silviculture North) to Head Forester. G. C. Webb (Genetics) to Head Forester.

Resignations: P. A. Wardle (District Officer I, Planning and Economics). E. R. Adams (Scientific Officer), Planning and Economics. Miss T. M. Crowley (Librarian Grade IV, Research Information). Miss C. A. Spence (Scientific Officer, Statistics).

Retirement: G. P. Moffatt (Senior Scientific Officer, Site Studies South).

Deaths: We report with regret the following deaths:

W. H. Guillebaud, Chief Research Officer 1926-1945, Director of Research 1945-1949.

Professor M. V. Laurie, Chief Research Officer 1946-1959.

A. McInnes, Head Forester in Silviculture (North).

PART I

The Work of the Forestry Commission

FOREST TREE SEED

The Seed Branch continued to be the central unit for seed procurement, extraction, processing, storage and distribution for the whole country including the private forestry sector. The research programme concentrated on the improvement of these seed services.

SERVICE

Seed Marketing Regulations

The Forest Reproductive Material Regulations 1973 (SI 1973 No. 944) came into operation on 1st July 1973 and were designed to conform with the existing directives of the EEC (Common Market). The control and implementation of the Act is vested with the Forestry Commissioners. The regulations cover 14 species most of which are important in British forestry. They are:

European silver fir, European and Japanese larch, Norway and Sitka spruce, Scots, Corsican and Weymouth pine, Douglas fir, Sessile, Pedunculate and Red oak, beech, and poplar cuttings.

The Regulations prohibit marketing of any seed of the above species which do not originate from high quality and officially approved sources. However, in cases of shortages of such material a dispensation can be obtained from the EEC Commission to use substandard seed.

The existing National Register of Seed Sources was revised and the country was divided into four Regions of Provenances (in order to conform with the above Regulations). Unfortunately the Regulations do not cover all important species in this country, i.e. Lodgepole pine, Hybrid larch, Grand and Noble firs. Alternatives to cover this omission are:

- (a) enlargement of species list in the existing Regulations, *or*
- (b) joining another international seed certification scheme mainly that of OECD (the Organisation for Economic Co-operation and Development) which covers the whole world and has no restriction on species.

Seed Procurement

Home Sources

Table 1 lists only those conifer seed lots which were extracted before 31st March 1974. If the collections after 31st March are included then the total seed yield from the 1973 crop is over 500 kg which is the best crop since 1969. The main contribution was made by pines of which Corsican pine from east England gave about 250 kg, i.e. 50 per cent of the total crop of all species. This was quite a good crop and the best for the last 10 years. Scots pine mainly from Seed Orchards came second with about 100 kg. Other main species like Lodgepole pine, Japanese larch, Sitka spruce and Noble fir were limited to about 30 kg each. Unfortunately Hybrid larch, in short supply for several years, yielded only 20 kg, i.e. about one-fifth of the total yearly requirement.

With regards to broadleaved species there was no crop of beechnuts and almost no acorns and the total collection of 587 kg consisted of sycamore (284 kg) and the other minor species.

Import

As usual the shortages from home sources had to be supplemented by imports, though limited owing to a reasonable stock in hand of conifer species and the continued decreasing trend in seed usage. Only 910 kg were imported of which the greater part (650 kg) consisted of Corsican pine with Western hemlock (100 kg) from the west coast of America. Unfortunately there was a shortage of Sudeten larch on the Continent and this species had to be supplemented by European larch of Alpine strain.

In contrast to conifers, the import of broadleaved species was the largest for several years back, due to poor crops at home and increased demand especially by the private sector. Altogether over 10 tonnes were imported of which 6 tonnes were acorns.

Seed Storage

Reduction in seed usage of conifer species has continued and the total stock in hand at 31st March was decreased by 1,000 kg to about 8,500 kg. This gives sufficient reserves for the next three years for the main conifer species including their desired provenances. Exceptions are Hybrid larch, Sudeten larch and *Nothofagus*, the seed of which have been in chronic short supply for several years.

The Branch has continued to provide the services for the Commonwealth Forestry Institute in Oxford for tropical forest seed.

Seed Testing

During the year our Seed Testing Laboratory became an Official Seed Testing Station for forest seed for the whole country. This was connected with entry into EEC (Common Market). Now any seed lot offered for sale must be accompanied by an official seed testing certificate and our laboratories were designated to perform this duty. Additionally we became an accredited member of the International Seed Testing Association (ISTA) and obtained an authorisation to issue International Seed Lot Certificates for exported forest seed.

As the Forestry Commission is the main seed supplier to the private sector and as there is almost no export of forest seed these changes have not increased the load of our testing work excessively.

Table 2 gives the details of our seed testing work. It shows an overall decrease of tests as compared with the previous year. This decrease was caused by less seed testing in research projects, but not in service which was slightly increased from 1,615 to 1,653 tests. Service work was carried out on 508 samples including 69 from sources outside the Forestry Commission.

TABLE 2
NUMBER OF TESTS PERFORMED ON SEED

Kind of Test	Service	Research	Total	Total of previous year
Purity	327	8	335	303
Seed size	337	16	353	323
Germination	655	387	1,042	1,402
Tetrazolium	14	14	28	24
X-Ray	—	60	60	8
Cutting	12	—	12	11
Moisture content	300	6	306	319
Cone test	8	—	8	—
TOTAL	1,653	491	2,144	2,390

Work started on the modernisation of the germination room where an air conditioner has been installed and the old Copenhagen Tank germinators are to be replaced by more reliable and accurate equipment.

Seed Distribution (Table 3)

Conifer seed usage by the Commission has continued to decrease and reached the lowest level ever recorded, i.e. 545 kg. In contrast the private sector remained static with a slight increase of about 50 kg to 1,730 kg. A similar situation persisted with broadleaved species where the private sector took almost twice as much as required by the Commission.

As the planting programme of both sectors are more-or-less at the same level of 25,000 ha/year it can be concluded that the private sector is using too much seed. The total amount of over 12 tonnes of seed despatched was the highest during the last 20 years and was due to recent increase in planting programmes of broadleaved species.

RESEARCH

Scots Pine Seed Orchard Trial

Investigations are continuing into the yield of seeds and extraction problems from the Ledmore Scots pine seed orchard. The study has shown that there were large clonal differences in ease of extraction of seed from cones, which appeared to be related in an inconsistent way to date of extraction; the yield of seed per hectolitre of cones varied significantly between clones; the yield of seed per hectolitre was not directly related to cone size; the germination quality of the full seed varied considerably between clones; the large coned clone which had the highest thousand pure seed weight showed the lowest germination quality; the yield of seed per hectolitre of cones from all clones was approximately half that from general collections, which may indicate pollen distribution problems.

TABLE 3
SEED SUPPLIED FROM CENTRAL SEED STORE 1.4.73 TO 31.3.74

Species	Forestry Commission				Private Forestry			Export Gifts Research	Grand Total
	Registered		Total	General	Registered	Total			
	General	Registered							
Scots pine	1.2	22.8	24.0	98.7	75.5	174.2	100.8	299.0	
Corsican pine	4.2	39.6	39.6	42.8	44.2	87.0	0.9	127.5	
Lodgepole pine (AL)*	0.7	4.2	4.2				0.1	4.3	
" (NC)	15.0	1.1	0.7	23.5		23.5	0.3	1.0	
" (SC)	14.6	0.9	16.1	59.0		59.0	2.5	42.1	
" (SK)	0.1		0.1	10.3		10.3	1.5	76.0	
" (CI)	26.7		26.7	6.5		6.5	0.5	10.9	
" (SI)							1.4	34.6	
Norway spruce	3.7	5.5	9.2	64.8	111.4	176.2	0.5	185.9	
Sitka spruce (Wash)	27.9		27.9	29.0	3.5	32.5	0.5	60.9	
" (QCI)	210.2		210.2	203.6		203.6	4.2	418.0	
Douglas fir	11.8	13.4	25.2	62.5	120.4	182.9	4.0	212.1	
Japanese larch	57.4		57.4	217.1	29.3	217.1	4.9	279.4	
European larch (Alpine)							0.2	29.5	
Hybrid larch " (Sudeten)	14.3	12.7	27.0	19.3	13.4	13.4	1.4	13.4	
Western hemlock	2.9		2.9	43.4	26.8	46.1	0.4	74.5	
Western red cedar	1.3	0.4	1.7	15.8	9.2	25.0	0.2	46.7	
Noble fir	17.8		17.8	129.0		129.0	1.8	148.6	
Grand fir	29.3		29.3	240.2		240.2	1.5	271.0	
Lawson cypress	0.7		0.7	4.8		4.8	0.2	5.7	
Other conifers	9.2		9.2	26.4		26.4	1.4	37.0	
TOTAL CONIFERS	448.9	96.5	545.4	1,296.7	433.7	1,730.4	129.2	2,405.0	
Oak		3,135.0	3,135.0	1,104.1	2,909.0	2,909.0	43.9	6,087.9	
Beech	103.0		103.0	1,104.1		1,104.1	52.1	1,259.2	
Sweet chestnut	252.0		252.0	1,216.0		1,216.0	0.5	1,468.5	
Horse chestnut	3.0		3.0	1,025.0		1,025.0	1.1	1,029.1	
Sycamore	30.0		30.0	64.5		64.5	1.3	95.8	
Nothofagus				0.1		0.1		0.1	
Other hardwoods	3.6		3.6	16.3	0.1	16.4	4.7	24.7	
TOTAL HARDWOODS	391.6	3,135.0	3,526.6	3,426.0	2,909.1	6,335.1	103.6	9,965.3	
GRAND TOTAL	840.5	3,231.5	4,072.0	4,722.7	3,342.8	8,065.5	232.8	12,370.3	

*AL—Alaska; NC—North Coastal; SC—South Coastal, USA; SK—Skeena River, British Columbia; CI—Central Interior, BC; SI—Southern Interior, BC.

Kilogrammes

Seed Pre-Treatment

Studies of pre-sowing treatments of Lodgepole pine and Sitka spruce seed have confirmed the suitability of storing seed naked, in bulk and moist, at 3–5°C for up to six weeks in order to produce rapid and uniform germination in seedbeds. However, in the favourable growth conditions of 1973 there were no significant differences in heights and numbers at the end of the season in comparison with control treatments. The Sitka spruce study confirmed that seed can be dried down to approximately 20 per cent moisture content from the treatment moisture content of more than 30 per cent, without harming the pre-treatment effect. Drying the seed back down to storage moisture contents (approximately 10 per cent) resulted in slower and incomplete germination.

Post-Sowing Seed Losses

An experiment in which 100 seeds of Sitka spruce, Lodgepole pine and Grand fir were sown in a 5 × 5 cm matrix measuring 100 cm × 20 cm at two Research and three Conservancy nurseries confirmed a significant and continuous loss of seed from the seedbed throughout the season. Attempts to recover the seed sown within one week of sowing showed that whereas some of the seed was lost without trace from the seedbed other seed moved laterally on the seedbed away from the position in which it was sown. The sowings at all nurseries except one were covered by "Netlon" polythene netting to protect the seedbeds against birds until mid-June. Despite this protection considerable seed (at times up to 50 per cent of the seeds sown) was lost during the course of the season. The rate of loss of seed from both Research nurseries was consistently less than from Conservancy nurseries, suggesting that seedbed preparation and sowing techniques were perhaps better at Research nurseries.

International Seed Testing Association

The Branch has been busy with modifications to the International Rules for testing forest tree seed and with preparations for the Forest Tree Seed Workshop to be held at Alice Holt in the summer of 1975.

G. M. BUSZEWICZ

A. G. GORDON

PRODUCTION AND USE OF PLANTING STOCK

Conventional Planting Stock

Pre-chilling of Coniferous Seed

Refrigerator pre-chilling without the addition of sand was confirmed as the most reliable technique for Sitka spruce seed of both high and low germination resistance. A three-week period is generally adequate. Such treatment has also given satisfactory results for Lodgepole pine of Washington and Oregon provenances, but its effectiveness for other provenances has still to be confirmed.

Seedbed Herbicides

The herbicides propham, linuron, monolinuron, desmetryne, prometryne, chlorthal-dimethyl and diphenamid were again tested for use on conifer seedbeds. Propham (applied before sowing) and particularly diphenamid (applied before seedling emergence) showed considerable promise. They will be tested again in 1974 together with propyzamide—another potentially suitable post-emergent herbicide, previously untested in British forest nurseries.

Seedbed Cloches

The potential of polythene tunnel cloches to promote rapid germination and early growth of conifer seedlings was again demonstrated. Variations in species response and substantial seedling losses at Newton (Moray) and Alice Holt (Hampshire) due to high temperature damage suggest that timing of the treatment in relation to weather conditions can be critical.

Soil pH in Transplant Lines

Two successive years of raising transplants of Sitka spruce, Grand fir, Lodgepole pine and Western hemlock in beds at pH of from 3.5 to 6.5 at Wareham (Dorset) suggest that the optimum pH for transplant beds for these species lies between 4.5 and 5.5. This result is expected to apply to most common conifer species.

Special Types of Planting Stock

Tubed Seedlings

Large-scale user trials of tubed seedlings continued in North Scotland Conservancy with the production and planting of about 650,000 seedlings during 1973. A survey in Spring 1973 of peatland areas planted with seedlings in 1971 and 1972 showed that initial survival and growth had generally been satisfactory, with high probability of successful crop establishment. Serious browsing damage had occurred at only two of the 20 sites. Along with continued satisfactory results from many forest experiments, these findings support the conclusion that tubed seedlings are suitable planting stock for upland peat areas if sites with serious browsing and weed growth problems are avoided.

Japanese Paperpot Seedlings

Seedlings raised and planted in Japanese Paperpots continue to give good survival and early growth. In East Anglia Paperpot seedlings of Corsican pine can give better performance than transplant stock, and seedlings are now being used for large-scale replanting trials by East England Conservancy. Sitka spruce Paperpot seedlings seem unlikely to offer an improvement in survival or early growth over transplant stock, but the extended planting season and relatively short production period could be advantageous to forest managers.

A. J. LOW

R. M. BROWN

Vegetative Propagation

Grey Poplar, Populus canescens

This tree is probably best reproduced from softwood cuttings under mist. Useful progress was made towards a softwood cutting technique that could aid the nursery trade to build up stocks quickly.

Cuttings taken from young vigorous sucker growth from surface roots of mature Grey poplar rooted extensively and produced sturdier, more vigorous plants than cuttings from the tree itself. Cuttings from both young and old tree sources inserted in Bloxer trays (a technique providing temporary containerisation) grew much faster after bedding out than cuttings put into plain seed trays and bedded out with bare roots.

Cuttings were quickly dipped in naphthyl-acetic acid solution (0.05 per cent) and inserted in a sand-peat medium maintained at 27°C. Root initiation in cuttings from sucker growth began after about seven days, and a good root system developed in 14 days.

Nothofagus

Propagation from softwood cuttings in mist showed *N. procera* to be substantially easier to root than *N. obliqua*, the result contrasting sharply with that obtained last year when few cuttings of *N. procera* rooted at all. The results justify further work on both species.

The cuttings were treated with naphthyl-acetic acid solution as for Grey poplar. True softwood cuttings rooted more readily than semi-hardwood cuttings, and it seems probable that the best results may be obtained in the early part of the growing season, as with other deciduous trees raised under mist.

Other Species

Several thousand softwood cuttings of English, Commelin and Huntingdon elm were rooted. Results varied considerably from clone to clone, but English elm was again more difficult to root than the others.

Some progress was made in raising variegated elms from softwood cuttings. These elms are notoriously hard to propagate other than by budding and grafting.

For the first time beech and lime were raised from softwood cuttings. Beech cuttings, of two types, were taken from 20-year-old hedges; lime cuttings were collected from mature trees. Fast grown 12.5 cm to 15 cm cuttings of beech with

long internodes rooted more readily than 7.5 cm to 10 cm cuttings with short internodes. All the lime cuttings were from vigorous shoots.

The cuttings of both species were treated with naphthyl-acetic acid as for Grey poplar.

The propagation of oak from softwood cuttings was attempted, but three months after insertion only one cutting out of 60 had rooted though three others developed basal callus.

J. JOBLING

PLANTING

Stepping on Peat

The necessity for cutting a step out of the peat turf before planting is often questioned. An experiment at Tywi Forest (Cardiganshire) demonstrated that, there, neither survival nor tree height at three years is affected by stepping. On a molinia peat at 490 m elevation the plants used were Sitka spruce 1 + 1 transplants.

Spacing

As part of the project on fast-growing pines, a spacing experiment has been established at Ringwood Forest (Hampshire). Two species, Monterey pine (*Pinus radiata*) and Bishop pine (*Pinus muricata*), are being tested at four spacings 2 m × 2 m, 3 m × 3 m, 4 m × 4 m, 5 m × 5 m.

J. EVERARD

CHOICE OF SPECIES

Northern Trials

Progress in many trial plantations in Wester Ross, on the Reay Estate (Sutherland), on the island North Uist in the Outer Hebrides, and in Caithness has been reviewed. Similar trials in the Shetland and Orkney Islands were inspected and a paper bringing results up to date has been drafted. Advice was given to crofters and others on shelter and amenity planting to screen oil installations.

A trial of 30 species and provenances on poor peat at Shin Forest (Sutherland) designed to find alternatives to lend variety to those commonly planted, shows that after six years the best broadleaved species is birch (*Betula pendula*) and the most promising conifers are *Picea lutzii* and *Picea engelmannii*.

Air Pollution

Monitoring, by analysis of tree foliage, of possible pollution around the aluminium smelters at Invergordon, Ross-shire, and Fort William, Inverness-shire, continues. Results indicate higher levels of fluorine near the latter but no sign of acute injury. Some areas of spruce were heavily defoliated by insects and this could mask any reduction in growth attributable to pollution. In the southern Pennines a new trial plantation has been successfully established; observations continue in the older trials and advice has been given to local authorities.

Industrial Waste Sites

The excellent start by all seven species in experiments on recently restored open-cast sand and gravel workings at Bramshill Forest (Hampshire and Berkshire) was maintained in the second year. The experiments are designed to test species behaviour on, and the ameliorative measures required to ensure successful afforestation of the compacted and very wet conditions left after return of the over-burden to the worked site. Scots and Corsican pine, Leyland cypress, × *Cupressocyparis leylandii*, and *Nothofagus procera* survived remarkably well in the second year, and Scots pine, Leyland cypress and sycamore were notably vigorous.

No significant improvements in either survival or vigour resulted from planting in cultivated soil or the application of a phosphate fertiliser after planting. Other, more rigorous treatments may have to be tested.

A review was started of tree planting on sand and gravel pits filled with domestic and industrial refuse. So far very few successful plantings have been located.

R. LINES

J. JOBLING

PROVENANCE

Sitka Spruce

The IUFRO collection of some 70 provenances was lined out at three nurseries and suffered further frost damage at the two Scottish sites in April/May. Alaskan lots were less damaged than far southern sources, which resulted in the latter being smaller as 1 + 1 transplants than those from Queen Charlotte Islands, British Columbia. Plants at Wareham (Dorset) were not frosted. This collection will be planted in 1974/75 at sites from north of Wick (Caithness) to Wilsey Down (Cornwall). Southern experiments contain 27 provenances; northern ones have 25 provenances in large plots (on three sites) and 64 provenances in small plots.

A visiting scientist, Dr. J. F. Kraus, compared 64 of these provenances for growth periodicity during the 1973 growing season at Bush Nursery (Midlothian). Further observations will be made in this experiment during 1974. The international experiment using 10 of these provenances grown under a common plan in 13 countries has made a good start at the two British sites and produced much information on seed and seedling stages.

Dr. Kraus also examined, in an older series of experiments, methods for studying site/provenance interaction.

Norway Spruce

Results from three series of experiments are reported in the four papers listed, with abstracts, on pages 87-88 under Lewis and Lines (1973) and Lines (1973; 1974).

Lodgepole Pine

Data from the experiments planted in 1970 suggest some changes in previous concepts if the patterns of growth continue in a similar way. Phenological studies have been made on this series jointly with Aberdeen University. Foliage analysis has confirmed the pattern of provenance variation found earlier.

Grand Fir

Results of a nursery experiment sown in 1972 have been written up. Experiments planted in 1967/68 at three sites show that Darrington, Washington, was best at all sites, followed by two Vancouver Island provenances, while Randle, further south but at a higher elevation in the Washington Cascades, was the poorest.

Engelmann Spruce, *Picea engelmannii*

In a small experiment at Shin (Sutherland) the best provenance after six years was from Kispiox, British Columbia. Trees from the main part of the range in southern British Columbia, Washington and Colorado were progressively poorer in height with decrease in latitude. The Kispiox trees were taller than Sitka spruce planted nearby and may be introgressed with that species.

Red Alder, *Alnus rubra*

This species grows extremely fast on Northern peats but is frost tender. A collection of 10 provenances ranging from Alaska to California was obtained through the kindness of United States and Canadian foresters and will be sown in 1974.

R. LINES

A. F. MITCHELL

M. L. PEARCE

ARBORICULTURE

At Bedgebury Pinetum in Kent, the dwarf conifer collection has been extended and fenced. Two prospects to the lake have been made. The fences and gates bordering the former right of way have been removed, greatly improving many views. Several unpromising plots of hardwoods have been cleared and two replaced with other hardwoods of great growth potential—*Alnus subcordata* and *Nothofagus dombeyi*.

Five new species of conifer were planted.

At Westonbirt Arboretum in Gloucestershire, an improved frontage on the main road south of the entrance has been designed. The last section of untreated woodland in the Arboretum has been cleaned to leave only a light cover of good trees. All the English elms in the Arboretum except the avenue north of Morley Ride have been removed, while those in the Downs are to be injected again against Dutch elm disease. Dame Sylvia Crowe has designed plantings to screen the car-park and for the surroundings to the Visitor Centre.

Thirty-four new estates and gardens were visited and fifty-three were re-visited, to measure trees. One thousand six hundred specimens were added to the central records and nine hundred and fifty previously recorded were updated. Three of the tallest known trees of important species were lost in the January gales. The entire collection of oaks at Kew was examined for identification and re-labelling, in conjunction with members of the staff at Kew.

A. F. MITCHELL

FOREST WEED CONTROL

Control of Grass and Herbaceous Broadleaved Weeds

A number of common grass weed species (e.g. *Calamagrostis epigejos* (L.) Roth. and *Deschampsia caespitosa* (L.) Beauv.) are not well controlled by currently used herbicides, and two new herbicides were tested.

Glyphosate at 2, 4 or 6 kg a.i. per hectare was compared with paraquat at 2 kg a.i. per hectare. The former generally gave better control of *Holcus lanatus* L., *H. Mollis* L., *D. caespitosa*, *Arrhenatherum elatius* (L.) J. & C. Presl, and *Calamagrostis epigejos* at the 4 and 6 kg/ha rates. The difference at the earliest application date (March 1973) was small, but the difference at the latest application date (June 1973) was large. Even 2 kg/ha was better when applied in June.

Propyzamide applications at 4 kg/ha in November 1972 gave better control of a range of perennial grass weeds than both atrazine and chlorthiamid at the same rate applied in March 1973. Propyzamide applications in January 1973 were not so successful. In a separate test for crop tolerance of propyzamide in weed-free nursery conditions Corsican pine, Sitka spruce, Red cedar and oak were undamaged by winter applications up to 8 kg a.i./ha, but Douglas fir did not tolerate doses of 2 kg/ha without some yellowing/browning of foliage. Higher rates, especially in January 1973, caused a number of deaths.

Control of Bracken

A further test of crop tolerance to asulam in weed free nursery conditions confirmed that a wide range of common conifer species will tolerate overall applications of asulam at doses up to 4.5 kg/ha with negligible damage.

User trials testing ULV applications of asulam were laid down in four forests during July 1973, but the first results will not be available until Summer 1974.

Control of Woody Weeds

The results of all ULV trials of 2,4,5-T (for lowland woody weeds) and 2,4-D (for *Calluna vulgaris* L.) between 1969 and 1973, and associated development work on equipment, were reviewed (Brown and Thomson, 1974; Rogers, 1974).

Trials of "drift" spraying of 2,4-D using ULV applicators, to treat more than one crop row at a time, show that this technique does not give as good a result as the recommended single row technique (Rogers, 1974).

The high cost of transporting diluent to upland sites led to trials with knapsack sprayers in which the effectiveness of 2,4-D using various volumes of water diluent were compared. Applications at 225 litres spray solution per hectare gave as good control of heather as applications at 450 litres of spray solution per hectare.

R. M. BROWN

J. M. MCKENZIE

REFERENCES

- BROWN, R., and THOMSON, J. H. (1974). *Trials of ULV applications of herbicides in British Forestry*. Br. Crop. Prot. Council. Monogr. No. 13 (Cranfield Symposium 1974). *In press*.
- ROGERS, E., (1974). *The selection and development of equipment and methods for ULV herbicide spraying in forestry*. Br. Crop. Prot. Council. Monogr. No. 13 (Cranfield Symposium 1974). *In press*.

NUTRITION OF FOREST CROPS

Nitrogen

Nitrogen, as urea, can be applied during winter to seven-year-old Sitka spruce on a peaty iron pan/hill peat site and give better initial height increment response than application in spring/early summer. Although the crop treated three seasons ago now shows a deterioration in colour and growth, increment is still about 75 per cent more than in the untreated controls. Trees where heather has been chemically controlled have maintained their initial response which is as good as that of trees treated with nitrogen.

Experiments in Scotland confirm that nitrogen application at nine to ten years will be required to maintain the initial good rate of growth of Sitka spruce on unflushed hill peat, following earlier PK top dressing and heather control. The maximum growth which can be achieved with frequent nitrogen application, or even the probable growth curve with irregular but practicable nitrogen applications, is unknown. The latter may be Yield Class 12 or possibly 14, compared with Yield Class 6 or 8 if no nitrogen is applied.

Phosphate and Potash

On deep unflushed sphagnum peat following a PK top dressing five years after planting, foliage P and K concentrations are maintained at acceptable levels for at least 10 years in both Sitka spruce and Lodgepole pine. This maintenance of K levels is encouraging, as top dressing had been previously thought to last about six years. However, for Sitka spruce nitrogen levels have fallen dramatically five years after 2,4-D application, confirming the need for nitrogen.

An experiment on hill peat indicates that K input at planting is not so critical in the northern peatlands, due to the slower growth rate in the early stages.

Calcium and Magnesium

Rates of up to 1600 kg/ha of element Ca or Mg applied at planting have had no effect after six years on the growth of Sitka spruce on unflushed sphagnum peat.

Trace Elements

Foliage samples from well grown 7 to 12-year-old Sitka spruce on similar mineral soils, mainly brown earths, derived from 10 different geological types have shown the following ranges of concentrations (ppm in oven dry material) for different trace elements. As the sample trees are all growing well (current leader length more than 50 cm) Sitka spruce is apparently tolerant of a fairly wide range of trace element concentrations.

Ranges of Concentrations

Al	100	—	830	Mo	0.07	—	0.33
B	13	—	29	Ni	1.9	—	15.2
Ba	8	—	62	Pb	0.9	—	7.6
Co	0.11	—	0.47	Sr	5	—	125
Cr	1.6	—	<0.1	Ti	1.9	—	21.4
Cu	2.9	—	5.4	V	<0.1	—	2.3
Fe	20	—	294	Zn	28	—	83
Mn	205	—	1180				

Foliar Sampling Surveys

These surveys have continued in Southern England and Wales. Five surveys were carried out, in some of which pole-stage crops were sampled.

Foliar Sampling Surveys

Forest	Area Sampled (ha)	Number of Samples	Nutrient	Number of Samples Deficient and, in Brackets, Moderately Deficient
Dartmoor (Devon)	440	30	P	9(8)
Kernow (Cornwall)	220	35	P	23(6)
Brecon District (Breconshire)	1,550	85	P	3(43)
Cymer (Glamorgan)	2,737	94	N P K	2(4) 2(32) —(1)
Dyfi (Merioneth)	2,558	142	N P K	2(56) 27(24) 4(6)

J. EVERARD

J. M. MACKENZIE

Maximum Site Amelioration

Further studies have been made to evaluate the growth potential of two fast-growing pines, Monterey pine (*P. radiata*) and Bishop pine (*P. muricata*).

Because the seedlings grow fast they are very suitable for production in Japanese Paperpots. Monterey pine seed only needs moistening to achieve even, rapid germination, but Bishop pine seed appears to benefit from pre-chilling.

The serious disorder in Monterey pine which causes premature yellowing and loss of needles appears to be unconnected with fertility, fungi or insects. Up to 30 per cent of the crop may be affected and die in the first 15 years, followed by further losses later.

Several very fine stands of both species have been examined. A paper on the use of the species has been published (Everard and Fourt, 1974).

D. F. FOURT

REFERENCE

EVERARD, J., and FOURT, D. F. (1974). Monterey pine and Bishop pine as plantation trees in Southern Britain. *Q. Jl For.* **68**, 111–125.

SITE STUDIES

Ill-drained Soils

Borehole Water Level Recordings

The automatic recording system for borehole water levels (*Reports* for 1971 and 1972) has been working for two years in Crychan Forest (Breconshire). The data can be processed to give either the average height of water in a transect of boreholes (Figure 1) or the individual levels plotted to show the form of the water profile between drains.

The crop is Sitka spruce planted in 1949 and subjected in 1969 to experimental drainage treatments. The surface of the peaty gley soil shows a gentle uniform slope; however, there is between 30 and 100 cm of peat above the underlying clay. The crop, which has already suffered some windthrow, has only developed shallow root plates (30 to 40 cm), so it may be inferred that there are rooting difficulties associated with waterlogged conditions within 30 to 50 cm of the surface.

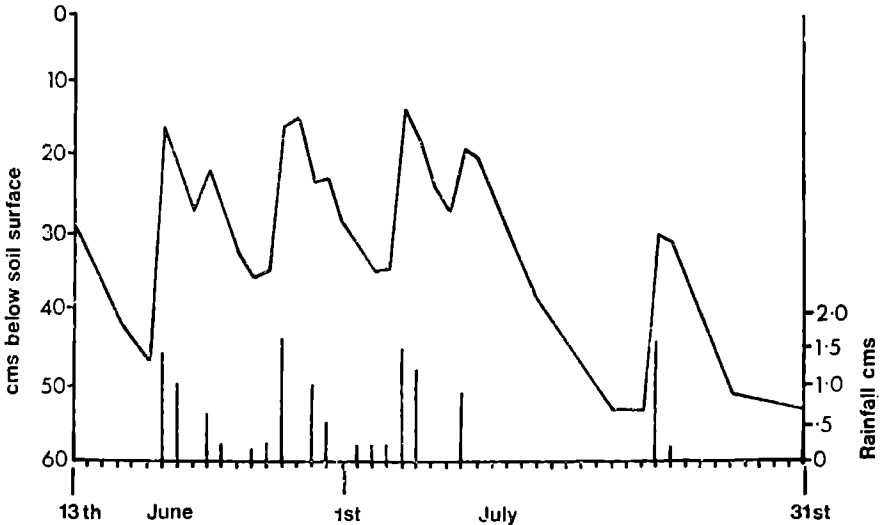


Figure 1: Mean daily water levels in a transect of boreholes, together with daily rainfall amounts, for June and July 1972.

The zone of zero pore water pressure takes about five days to descend to a depth of 45 to 50 cm, discharging not less than 2 mm of water per day. It seems also that the conductivity of the peat and its pore distribution do not greatly change with depth and that a reasonable degree of desaturation takes place with drainage.

This rough sketch of the physical conditions is, however, no substitute for the definition of critical boundary conditions for persistent rooting of peaty gleys.

Oxygen Status of Soils

During the past year we have used the platinum microelectrode to examine the oxygen status of ill-drained soils.

In the laboratory a soil "test bed" has been set up, in which the oxygen diffusion currents have been measured under varying conditions of oxygen concentration, pH, temperature, and scanning time. The aim is to determine the optimum working parameters in order to quantify and qualify the results from the forest. Three soil types have been investigated in the forest to establish those soils in which the technique can be used.

At Crychan there is a difference in oxygen status between three of the treatments, with zero diffusion rates in the undrained plot even in the summer.

W. H. HINSON

R. CARNELL

Indurated Soils

Since 1970 we have been measuring physical and mechanical properties of a wide range of soil profile types derived from a variety of lithologic types, all with indurated material at some depth. Indurated material is defined as hard, dense subsoil layers derived from the former permanently frozen ("permafrost") layer of the late glacial era. It occurs widely in Scotland and commonly gives rise to soils with shallow rooting because either it is itself impenetrable to roots or because it produces gley soils. It occurs much less frequently south of the Border.

Measurements have included hardness, depth and thickness of the layer and we have tried to relate these to the bulk density (pore space), particle size distribution and micromorphology of the layers.

The typical hard indurated materials have between 5 and 15 per cent by weight of clay-sized particles (<0.002 mm). This is possibly related to their ability to achieve such hardness when compacted. Variations in permeability of indurated materials cannot be explained in terms of total pore space. Hardness is always greatest at the top of the layer but is not related to pore space or particle size distribution, and is much less when nearly saturated.

Thin sections of indurated material have been examined through a petrological microscope using transmitted light. The close packing of the sand and silt sized particles is confirmed but there is no obvious preferential arrangement of the clay material with respect to the coarser grains which would suggest a binding action. Boreholes of different depths are being used to assess the moisture regime of different profile types and to confirm the apparent variations in permeability of indurated material.

Because it is impossible to obtain undisturbed samples of most indurated materials for measurements of shear strength, pore size distribution and hydraulic conductivity, we are going to use artificially compacted specimens. These may differ in some important respects from the natural material, but should enable us to relate hardness and strength to moisture content, and perhaps relate hydraulic conductivity to pore size distribution.

Improvement of the rootable depth of these soils should be possible with deep cultivation, especially if organic matter can be incorporated with the loosened indurated layer. There seems no reason why the indurated material should reform under the present climatic and soil moisture regime. The indurated gley soils

are less easily improved, but an experiment is planned which will test deep cultivations without drains, in the hope that the deepened soil will suffer much less waterlogging especially when benefiting from the interception effect of the tree canopy.

D. G. PYATT

DRAINAGE

Extensive examination of borehole readings has led to a substantial reduction in the number being assessed at monthly intervals. Only on deep peat have any significant results been forthcoming and even these are confounded by the disproportionate effect of any rainfall in the period immediately prior to reading. Intensive recording of borehole levels for rundown curves was tried out and the results indicated that this technique may be improved and used more widely.

The general recommendation to use deep double mouldboard ploughs on poorly draining soils is the subject of continued detailed investigation in older crops and in new experiments. In regeneration situations on poorly draining soils, the introduction of an effective low cost drainage system, even at currently recommended low intensities, remains a major problem.

D. A. THOMPSON

CULTIVATION

A major cultivation experiment at Teindland, Laigh of Moray Forest, has been assessed after 25 years. The results confirm that spruce is more responsive to cultivation than pine on ironpan soils.

Examination of old cultivation experiments reaffirms that growth on spaced ploughing tends to catch up with that on complete ploughing after 15 years. That depth of ploughing is related to yield class can be demonstrated from these older experiments but it is not possible to show clearly a relationship between ploughing intensity (i.e. number of passes made by the plough through an area) and yield class.

The ultimate structural changes which might be achieved by soil mixing have led to the development of a rotary mouldboard plough for forestry. This machine will undergo trials during the next year. To assess its capabilities in terms of mixing, experiments are in hand which involve repeated disturbance of the same soil and sampling to determine the distribution of organic material. It is considered that distribution of organic matter will adequately describe the degree of mixing during the trial phase.

Experiments have been established in South and East England in which disc cultivators have been used for both initial site preparation and the mechanical control of weeds, particularly heather. One of the aims of these experiments is to determine the extent to which wheeled tractors can be used for ploughing and subsequent operations such as planting, fertiliser spreading and weeding.

Extensive testing of the Humpy double-mouldboard tine plough for the afforestation of peaty soils has continued in Wales and Scotland. This form of ploughing has been favourably received, and costs appear little higher than conventional methods.

D. A. THOMPSON

J. EVERARD

CROP STABILITY

Tree Pulling

Further samples were taken on the site at Tarsset Forest (Northumberland) at both wet and dry times of the year. The superior stability of trees originally planted on hand-prepared turves from widely spaced turf drains over trees on close spaced ploughing was confirmed. Seasonal variations in soil moisture and the relationships with stability proved to be far more complex than was anticipated.

Wind Tunnel Studies of Topographic Models

A model of part of Wauchope Forest (Roxburghshire) previously tested at Edinburgh University was tested at Bristol University. Twelve wind directions were used in order that long-term averages of wind speeds and directions from the meteorological station Eskdalemuir in Dumfriesshire nearby could be used in the analysis. Computer sampling of the hotwire anemometer signal was carried out to obtain 6 second and 30 minute averages, these being equivalent to gust speed and hourly average respectively. Correlation (significant at 0.1 per cent) was found between the Edinburgh and Bristol results. The 6 second and 30 minute sampling gave similar results and the additional meteorological data did not improve the significance of correlation with tatter flags.

To test the method for mapping a large area, a model of South Kintyre (Argyll) (see Plate 1) was examined at Bristol and relative wind speed maps drawn by hand and by computer. The method seems highly satisfactory and a practical one for exposure zonation.

T. C. BOOTH

Thinning

Monitoring of the "with and without" thinning experiments continues. The Southern experiments have been "helped" by the strong winds and heavy rain experienced by southern Britain in January/February 1974. Line thinned plots continue to throw before unthinned ones; any other gaps in the canopy are also conducive to throw.

Tree Mechanics

Work on sway period and tree damping is still continuing. The 24 ft wind tunnel at the Royal Aircraft Establishment, Farnborough, was hired for 10 days in November 1973. Twenty-four Sitka spruce, 20 Lodgepole pine and four Scots pine were tested to determine their drag coefficient. It was found impractical to conduct any dynamic tests in the tunnel because of the difficult problem of anchoring a tree firmly. A series of debranching experiments was also conducted.

G. J. MAYHEAD

REGENERATION

Natural Regeneration

An experiment was established at Forest of Ae (Dumfriesshire) testing the necessity for and methods of reducing the extremely high stocking usually found in natural regeneration. The crop was Sitka spruce around 2 metres in height. Methods were all applied by hand but one simulated a mechanical treatment.

Artificial Regeneration

No new experiments were laid down. The overcrop of Scots pine was removed from two older P65 experiments designed to test overcrop densities. Damage to the underplanting was related to the number of stems removed. This was in part due to the poorer growth under the higher densities of shade and the resultant burying under lop and top.

T. C. BOOTH

FOREST GENETICS

General

There is now sufficient evidence from earlier programmes of plus tree selection, progeny tests and experimental seed orchards on which to base suitable breeding strategies for the next phase of the tree improvement programme. Most of the resources of the Branch will continue to be deployed on Sitka spruce, which seems likely to remain the most widely used species in future afforestation and re-afforestation programmes. Lodgepole pine, Scots pine, and Corsican pine are important species in certain regions of Britain and with the larches, which are more widely planted and have both a high amenity and a timber production role, will remain on the breeding programme. The investment in each species will be closely related to their expected future importance in British forestry. Investment in Douglas fir will be severely reduced. Nationally this species is not very important and is proving to be difficult to breed largely through problems of grafting, delayed graft-incompatibility, self-fertility, inbreeding problems and shyness to flower—even when successfully grafted.

A much larger number of plus trees will have to be selected and screened to locate a sufficient number which have exceptionally high genetic qualities, flower well as grafted plants, and have well-matched flowering times. Seedling seed orchards, based on highly selected progenies, will be used for those species, for example Lodgepole pine, which normally flower well at an early age.

Progeny Tests

The number of progenies under test has been increased considerably in recent years and by 1973 over 200 progenies were being tested annually. Most of the progenies have been derived from open-pollinated flowers on the parent plus trees. The early data on progeny performances have been mainly based on height assessments. These have shown that relatively few progenies have heights above 10 per cent of the controls, which are usually derived from seed-lots used for normal Conservancy planting but raised under the same conditions as the progenies. The data indicate that height may not be a highly inherited characteristic. For example, of 247 Scots pine progenies now over six years of age, only 11 per cent are really outstanding with height values up to 30 per cent greater than the controls. The same progenies have also produced outstanding growth on a variety of sites ranging from lowland and upland heaths in Scotland, to the Brecklands in East Anglia and heathlands in Surrey. These are the first indications that genotype/site interactions for the outstanding progenies are relatively weak. It has also proved possible to identify vigorous growth behaviour at an early age when the trees are about one to two metres tall. In a Scots pine trial at Glenlivet (Banffshire), for example, the outstanding progenies at 15 years were those which were outstanding at three years.

From considerable data now available it has been decided: to reduce the number of test sites; to increase the number of progenies tested annually to 500; and to use sites on which progenies will grow two to three metres in height in less than six years. Such sites will be cleared and re-used for further tests.

These changes will make it possible to screen many more progenies in a much shorter period; consider many more candidate trees; and greatly increase the number of outstanding parents for further breeding work.

Pollination

A major series of controlled pollinations was conducted in Spring 1973. Almost 500 specific crosses were made among the larch, Sitka spruce, Lodgepole pine and Scots pine grafted plus trees in the tree banks. In most cases, the crossing pattern was based on a four-tester design in which four parent clones were designated as testers and used singly as pollinators on all other clones under test.

Seed and Cone Yield Studies

In 1964 a study was begun in the Scots pine seed orchards at Ledmore, Dunkeld Forest (Perthshire), to obtain information on cone and seed yields from developing seed orchards and to study flower and seed periodicity both between and within clones. The orchards were planted during the period 1956 to 1960 and came into regular production in 1966. Table 4 indicates that orchard seed yields per hectolitre of cones are approximately half those from collections made in forest stands. The orchards were very heavily thinned in Spring 1971 and this accounts for the drastic reduction in total cone and seed production in 1972.

TABLE 4
TOTAL CONE AND SEED PRODUCTION FROM A 0.8 HECTARE CLONAL SCOTS PINE
SEED ORCHARD ESTABLISHED DURING 1956-1960

Crop year		1966	1967	1968	1969	1970	1971	1972	
Seed orchards	Cones collected (hl)	19.1	10.0	92.4	128.4	141.6	157.2	45.8	
	Seed extracted (kg)	4.9	3.2	32.0	70.1	67.5	55.8	10.1	
	Seed yield	g/hl	266	320	344	544	472	353	219
		kg/ha	1.1	0.7	7.3	15.9	15.3	12.7	2.3
General collections in forest stands (g/hl)		856	826	774	679	698	834	—	

Note: hl = hectolitre = 100 litres.

Within the orchard there were wide clonal variations in both numbers of cones and yields of seed per cone (see Table 5), indicating that seed orchard designs must take into account the seed production per clone if a reasonably well balanced seed mixture of the component clones is to be achieved. One clone in a 20-clone orchard produced over 30 per cent of the total cone crop and in a second similar orchard two clones produced 30 per cent of the total crop.

TABLE 5

TOTAL CONE AND SEED PRODUCTION PER CLONE OVER A SIX-YEAR PERIOD IN A 0.8 HECTARE SCOTS PINE ORCHARD

Clone No.	Average Annual Cone Production		Average Number of Seeds per Cone		Total Cone Production 1966-1971 (1,000s)	Kilos pure Seed per Hectolitre of Cones
	1966-68	1969-71	1966-68	1969-71		
20	430	1,490	4.0	17.4	11	0.62
22	5,560	11,360	1.7	5.5	120	0.35
23	340	640	7.4	17.7	6	0.66
24	1,590	6,650	6.3	17.3	49	0.62
25	90	700	2.4	5.5	6	0.21
26	880	3,070	9.0	19.1	24	0.59
27	10	710	8.2	22.5	4	0.66
28	2,220	6,940	4.2	11.2	56	0.62
29	1,950	8,270	5.2	7.2	62	0.30
89	0	80	0	8.1	1	0.41
3110	2,780	9,990	3.8	10.8	86	0.55
3111	2,480	9,310	5.3	11.0	80	0.46
3112	170	1,040	8.0	17.1	8	0.73
3113	580	4,150	3.9	11.9	30	0.54
3114	370	1,270	7.5	16.2	10	0.57
3115	2,089	16,160	3.0	10.7	130	0.42

Biochemical Variation

Studies have continued of possible correlations of biochemical features with vigour and with provenance. A stepwise multiple regression of data from all trees examined in several Sitka spruce progenies growing at Glendaruel (Argyll) showed that the vigour could be predicted from the concentrations of the leucoanthocyanins and two of the stilbenes in the young stems; the relationship had a very high level of significance. This study also showed that certain progenies could be separated from the others by their polyphenol characteristics, but the situation was generally confused by the magnitude of within-progeny variation.

Preliminary investigations of terpene variation in the resin of Sitka spruce have shown that gas-liquid chromatography (GLC) is a rapid and simple method of "finger-printing" a tree. From the limited data so far obtained from shoot apical and stem cortical monoterpene components, it may be tentatively concluded that terpene analysis may be of use in the assignment of trees to relatively fine genetic categories, in the study of the genetics of given progeny lines, and in monitoring the degree of genetic variability or heterozygosity within and between populations. It was found that in the mature part of a tree the monoterpene composition of the cortical resin was remarkably constant over the tree. Out of eight provenances examined, trees of Vancouver Island provenance differed markedly in terpene composition from all others.

Pollen Investigations

Experiments on the induction of male-sterility in larch by applications of the gametocide ethrel (2-chloroethyl-phosphonic acid) have continued; applications of various concentrations were made to branchlets throughout autumn when the first meiotic divisions in the next year's male flower buds were due to begin. Pollen will be collected and assessed for viability.

Work on the assessment of viability and the optimal method of long-term storage of larch pollen has continued.

R. FAULKNER

A. M. FLETCHER

R. C. B. JOHNSTONE

G. I. FORREST

TREE PHYSIOLOGY

Vegetative Propagation

Work on vegetative propagation of Sitka spruce and Lodgepole pine has continued and a start has been made on the selection and propagation of potential stock trees. Most of these are vigorous, well formed plus-tree progenies. Early results of a study on the levels of endogenous promoters and inhibitors of root initiation in the stems of cuttings are shown in Figure 2. There appears to be a positive correlation between these levels and the number of cuttings which root, although considerably more work is required before firm conclusions can be reached.

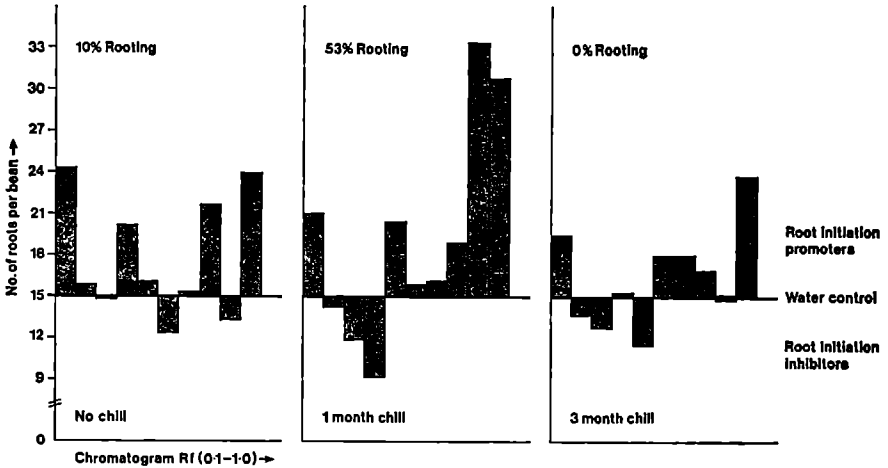


Figure 2. Effect of chilling on the rooting of Sitka spruce cuttings and on the levels of endogenous promoters and inhibitors of root initiation.

Sample: 2.0g fresh weight of stem.

Chromatograms: Whatman 3mm developed in isopropanol: ammonia: water, 10:1:1 (v/v).

Bioassay: Bean *Phaseolus aureus* root initiation.

Physiology of Tree Roots

Detailed studies on effects of root temperature on root and shoot growth have been carried out on Sitka spruce and Lodgepole pine. When air temperature was maintained at 15°C roots were grown at six temperatures from 5° to 30°. Shoot growth (dry weight) of Lodgepole pine increased almost linearly with root temperature up to 30°C, and root dry weight also reached a maximum at that temperature. The curve for Sitka spruce shoot and root dry weight plateaued at around 20-25°C and declined sharply at a root temperature of 30°C. Characteristic responses having been determined, the influence of temperature gradients on root form are being investigated.

Tolerance of Lodgepole pine roots to waterlogging in peat is being studied on plants growing in transparent plastic tubes, the lower portion of the root system being flooded. Submergence for two months at a root temperature of 15°C killed the root tips, so that when the tubes were drained root regeneration took

place a few centimetres behind the tips. Even 24 hours exposure to anaerobic conditions was sufficient to damage the root tip. At 6°C, roots survived two months of waterlogging. The work is being extended to include survival of woody roots.

A study on the nutrition of Sitka spruce with divided root systems has shown that a high nutrient supply to the root tips greatly enhances the development of the woody root from which they are growing (see Plate 2). The differential nutrition also influenced periodicity of the primary roots.

Results from experiments on mechanical stress so far concern only the shoot system. Brief periods (30 seconds a day) of vigorous shaking caused a 30 per cent reduction in shoot extension in glasshouse-grown Sitka spruce, while continuous sway hastened bud set, findings which may have relevance to the responses of the tree to exposure.

M. P. COUTTS

M. R. BOWEN

FOREST PATHOLOGY

Over the period under review just over a quarter of the time of the Pathology Branch was spent on Dutch elm disease, and slightly less was devoted to work on *Fomes annosus*. About ten per cent of its time was spent on Beech bark disease, six per cent on diseases caused by species of *Phytophthora*, and five per cent on *Armillaria mellea*. The remaining time was taken up by advisory enquiries, plant health, and other work. Short accounts of most of the work done are given below, but the results of that on Beech bark disease will be fully reported elsewhere.

D. H. PHILLIPS

Decay caused by *Fomes annosus*

The field work on the project to evaluate the importance of butt-rot caused by *F. annosus* (see *Report* for 1973) was completed during the year. Five hundred trees from 27 plots have now been felled and cut up to measure the extent of infection by *F. annosus*. Individual tree losses and mean values for plots have been calculated by computer. The importance of various factors in influencing the overall losses caused by *F. annosus* will be examined by statistical analysis.

B. J. W. GREIG

J. E. PRATT

Dutch Elm Disease

The Disease Situation

A Dutch elm disease survey of Southern Britain was again carried out, and showed a further increase in disease. Taking account of all elms, including those felled because of disease, the number of trees killed over the last few years exceeds three million out of a total estimated in 1972 at 22.5 million. Although the level of disease in Northern England remains low, the aggressive strain of *Ceratocystis ulmi* has been confirmed in Lancashire, Yorkshire, Durham and Northumberland.

Fungicide Injection

Research on fungicide injection against Dutch elm disease is being conducted with D. R. Clifford of Long Ashton Research Station, Bristol. In 1973 protective and curative treatments were applied (using the system described in the last *Report*) to young (6m) elms artificially inoculated with *C. ulmi*. As benomyl solutions in lactic acid have proved phytotoxic, a solution of methyl benzimidazol-2-ylcarbamate (MBC) in hydrochloric acid was used for most of this work. In these experiments good control in these young trees was obtained with applications of 1.5 litres of 0.25 per cent and 0.5 per cent MBC per foot tree circumference. Much less satisfactory results were obtained on mature trees exposed to natural infection in different parts of the country. In these trials paired trees (one injected, one untreated) were treated either with 1.5 litres of 0.25 per cent MBC or 0.38 per cent benomyl in lactic acid. The trees injected with benomyl/lactic acid formulation differed little from the untreated controls. MBC as MBC HCl gave somewhat better results, both in terms of the number

of trees in which an increase in disease occurred and in the severity of the crown symptoms in affected trees, but it is evident that more information on the dosage necessary for mature trees is urgently required.

J. N. GIBBS

Phytophthora Diseases

During 1972 and 1973, in collaboration with Dr. M. G. Griffin and Dr. S. G. Evans (MAFF, Wye), trials on the control of *Phytophthora* root rot using fungicide drenches were made at a horticultural nursery (sandy loam, pH 5.7) heavily infested with *P. cinnamomi*. The drenches were applied at two week intervals during the growing season, using *Chamaecyparis lawsoniana* 'Ellwoodii' 25-30 cm high as indicators. In 1972 etridiazol (Terrazole) and Cryptonol were applied at 200 ppm a.i. and 0.2 per cent respectively at 10 l/sq m. At the end of the season, the percentages of plants with foliar symptoms (confirmed by isolation to be due to *P. cinnamomi*) were: controls, 59; Cryptonol-treated, 50; etridiazol-treated, 28. In 1973, metatolon (PP 395) and etridiazol were applied at 1000 ppm a.i. and 400 ppm a.i. respectively, at 10 l/sq m. At the end of the season the percentages of plants killed by root rot were: controls, 91; metatolon-treated 88; etridiazol-treated, 30. In plots treated with etridiazol, at least 50 per cent of apparently healthy plants carried viable *P. cinnamomi* in dead root tips. Stem-base and root lesions were also found on apparently healthy plants after treatment with Cryptonol. Hence the absence of foliar symptoms does not guarantee that a plant is healthy. Soil samples also indicated that none of the 1972 drenches had appreciably reduced the soil population of *P. cinnamomi*.

As seen above, etridiazol gave some control, but at the rates used it is unlikely to be economic for nursery stock. Further, if following its use *P. cinnamomi* can persist on the roots of seemingly healthy plants, the distribution or sale of such treated stock is likely to lead to further spread of the disease. At present, overall soil sterilisation, or containerisation of disease-free stock combined with rigorous nursery hygiene, offer the best approach to control.

In a subsidiary trial, plants of *C. lawsoniana* 'Merrist Wood', thought possibly to be tolerant to *P. cinnamomi*, were found to have no appreciable resistance to the fungus.

C. M. BRASIER

R. G. STROUTS

Advisory Services

Excluding the many queries on Dutch elm disease in the South, 549 enquiries were received at Alice Holt and 159 at the Northern Research Station.

Alice Holt

In Sussex, death of several 65-year-old *Taxus baccata* from *Phytophthora cinnamomi* root rot was apparently associated with the annual application of farmyard manure. Such an association between the use of farmyard manure and *Phytophthora* root disease has been noted on several other occasions.

Phytophthora citricola was isolated from dead rootlets of a dying *Viburnum tinus* in Somerset.

Prolonged hot dry summer weather led to a very distinctive browning of the older foliage (especially of the lower crown) of *Cupressocyparis leylandii* clone 20 'Stapehill'.

Winter gale damage was followed by many enquiries on decay and safety of trees. In the case of two fallen beech, *Grifola gigantea* (*Polyporus giganteus*) appeared to have caused extensive decay of the roots. This fungus is said to infect only sickly old trees, but in both these cases growth measurements suggested that infection by the fungus had preceded reduced growth and evident symptoms of ill-health.

A commonly recommended method of destroying tree stumps by burning after treatment with saltpetre and paraffin was tested. From the results and from information provided by others, the method appears to be generally ineffective.

C. W. T. YOUNG

R. G. STROUTS

Northern Research Station

Following the first record of the aggressive strain of *Ceratocystis ulmi* north of the Humber–Mersey line, near Newcastle, several more occurrences of Dutch elm disease were investigated. The aggressive strain was obtained from nine localities, again in the Newcastle area.

A dieback of poplar at West Linton (Peeblesshire) and Catterick (Yorkshire) was associated with *Pollaccia elegans*, the imperfect state of *Venturia populina*, which has previously been recorded only once in the British Isles (Baker, 1972). The closely related fungus *Pollaccia radiosa* was found in Midlothian on aspen (see also *Report* for 1973).

The root rot fungus *Helicobasidium purpureum* caused severe losses in two-year-old Sitka spruce transplants in a nursery near Glasgow newly established on former pasture land. Other nursery diseases included *Sirococcus strobilinus* on the Black Isle, and *Botrytis* sp in Aberdeenshire, in both cases on Lodgepole pine.

Other notable occurrences were *Phytophthora* sp on dying roots of Lawson cypress, the leaf spot fungus *Phyllosticta tiliae* on lime, and two cases of canker and dieback of willows, one associated with *Discella carbonacea* and the other with a *Gloeosporium* sp.

Spring frost on 28th–29th April caused widespread damage, and frost in mid-August damaged needles and shoots of Sitka spruce in North Scotland.

Severe browning—probably a form of “top dying”—was widespread in North East Scotland during 1973.

D. B. REDFERN

S. C. GREGORY

J. D. LOW

REFERENCE

BAKER, J. J. (1972). *Report on diseases of cultivated plants in England and Wales for the years 1957–1968*. Tech. Bull. Minist. Agric. Fish. Fd, 25.

FOREST ENTOMOLOGY

The European Spruce Sawfly, *Gilpinia hercyniae*

The area of spruce infested by *Gilpinia hercyniae* Hartig in mid-Wales has increased. Some of the worst affected crops are showing signs of recovery following the partial collapse of the sawfly population due to the naturally occurring nuclear polyhedrosis virus. Some dead tops of Norway spruce have been seen.

Numbers of apparently healthy cocoons in these areas are still high: 40 per m² compared with 80 per m² in 1971.

Fifty square miles of this area have been systematically surveyed by Conservancy staff, under the guidance of the Unit of Invertebrate Virology, Oxford University (UIV). The UIV is continuing to investigate this virus epizootic. The Photographic Branch (Alice Holt) is again providing aerial records of certain areas defoliated in 1973.

Distribution surveys of *G. hercyniae* were begun but no larvae found in the South West, North West or North East England Conservancies. Very small numbers were collected in the East England Conservancy.

Continuous sampling has not revealed a parasite complex capable of effecting any measure of control. A three-year programme, involving collections in Europe of specific parasites of *G. hercyniae*, has been implemented by the Forestry Commission and is being carried out by the Commonwealth Institute of Biological Control. Material collected has been received and is now being bred at Alice Holt. Suitable parasites will eventually be released in the infested areas.

R. M. BROWN

D. J. BILLANY

Pineapple Galls caused by *Adelges abietis*

The present recommendation for gall control of using gamma BHC has not been improved upon, provided that the application is not too late in the spring. The disadvantages are that BHC will kill most of the adelgid predators, and that repeated applications may cause the spruce spinning mite to become a more serious pest. Other kinds of chemicals are being tested. The practice of replanting gaps in Norway spruce grown for Christmas trees results in young trees becoming infested from adjacent older trees. Complete clearance of trees after the seventh year not only gives chemical control equipment easy access but appears to reduce attack, therefore the number of insecticidal applications would be fewer.

C. I. CARTER

Green Spruce Aphid, *Elatobium abietinum*

The severe early winter attack of December 1972 in several upland sites caused a number of leader deaths to young Sitka spruce; growth of other infested trees in these areas was notably retarded. Subsequent growth and recovery is being investigated at some forest sites and under controlled conditions at Alice Holt.

It is also suspected that Honey fungus (*Armillaria mellea*) has taken advantage of the weak condition of severely defoliated trees; in three areas deaths have resulted.

The less frequent phenomenon of early winter attack has occurred again this year in South West England and North Scotland.

C. I. CARTER

The Pine Looper Moth, *Bupalus piniarius*

Annual Pupal Survey

The survey was carried out as in previous years. Half of the units showed increases. The other half returned decreases or the same level. The highest number at any one forest, although less than 1973, was again Cannock (Staffordshire) with a *forest average* of 10.72 (maximum compartment 18.0). Culbin (Moray) has also recorded a reduction to half the 1973 levels, now having a *forest average* of 2.31 per m². The next highest areas are Roseisle (Moray) with a *forest average* of 3.15 (last year 0.14) and Wykeham (Yorkshire) with 3.03 (last year 1.35).

R. M. BROWN

D. J. BILLANY

Elm Bark Beetles

Emergence Studies

The pattern of beetle and parasite emergence was similar to that of previous years. For the first time *Dendrosoter protuberans*, a braconid used unsuccessfully in America for biological control of *Scolytus multistriatus*, emerged in fairly large numbers.

Many of the insects were not identified and have been passed to the British Museum (Natural History). A list of species and figures for emergence in terms of surface area of logs will be produced.

Elm Palatability Trials

In the past it has been thought that some elms were less palatable to bark beetles than others. An experiment to test this showed no large differences in feeding on any of six species when compared with English elm. Both *Scolytus scolytus* and *S. multistriatus* fed equally well on any of the elms.

Biological Control

An experiment was laid down jointly with Imperial College to test the efficacy of a nematode/bacteria complex as a post-infestation spray treatment to prevent the emergence of *Scolytus* beetles. Early results show some promise, but the experiment will not be complete until late 1974.

C. WALKER

Control of Dutch Elm Disease

Aerial Spraying of Uninfected Elms

Further work during 1973 tested methoxychlor applications by helicopter at various concentrations and rates. Methoxychlor at 3 and 6 per cent at the rates of 9.1 and 22.7 litres per tree was applied to healthy elms at Sherbourne Estate, Warwickshire. Only the heaviest dosage of methoxychlor (22.7 litres at 6 per

cent) significantly reduced crotch-feeding at six weeks after spraying. At 10 weeks after spraying no treatment effectively controlled beetle crotch-feeding. Visual assessment of disease of the tree crowns showed no significant differences between treatments, though the 22.7 litres of 6 per cent methoxychlor treatment suffered the lowest disease incidence overall.

Additional work in the same area tested aerial sprays of 0.45 kg active ingredient methoxychlor per tree applied at varying dilutions. Residue analysis of methoxychlor deposits indicated that coverage of the tree was good. Insecticide deposits were shown to decline by about half during the 14-week period after spraying. None of the treatments effectively controlled beetle feeding.

Log Spraying

In November 1972 and February and April 1973 a spray of 0.5 per cent gamma BHC in paraffin (premium grade) was applied to the trunks of freshly felled, recently dead or dying elms free of elm bark beetle broods. The object was to test this treatment as a means of preventing elm beetle breeding in winter-felled elms during the ensuing summer.

Assessments of beetle entry showed this treatment to be highly effective. (Scott, King and Walker, 1974).

C. J. KING

The Larch Web-spinning Sawfly, *Cephalcia alpina*

Severe defoliation of Japanese larch occurred again at Margam Forest (Glamorgan) and also in eight other forests in Wales and North West England. The crops affected range from 22 to 43 years and appear to be otherwise healthy. In one area some adjacent European larch compartments were defoliated. Aerial records of damage were made of some areas by the Photographic Section.

Considerable numbers of larvae in most of the infested areas died from a disease which has still to be identified; no parasites have yet been found here.

Collections of larvae are to be made in areas of Holland and Germany which suffered outbreaks of this insect in 1940–1950 in the hope of obtaining suitable parasites for release in our infested areas.

R. M. BROWN

D. J. BILLANY

The Larch Bark Beetle, *Ips cembrae*

Work on the bark beetle, *Ips cembrae*, has shown that larch logs felled at any time from September onwards may be attacked the following spring. Maturation feeding, which is normally by boring in larch shoots, may also take place in shoots of Douglas fir. The insect, not previously found in Britain south of the Scottish Highlands, has been found established in Glentress Forest (Peeblesshire).

J. T. STOAKLEY

Control of *Hylobius Abietis* and *Hylastes* spp.

Dipping Treatments

A wide range of organo-phosphorous insecticides, as well as the standard BHC treatment, were tested during 1972 in Brendon Forest (Somerset). Total

dipping treatments included bromophos, tetrachlorvinphos and chlorpyrifos at 1 and 3 per cent, pirimphos ethyl at 0.5 and 2 per cent, and Gammacol at 1.6 per cent.

Weevil populations were so high that all trees were severely damaged during the first year, causing premature closure of the experiment. Only chlorpyrifos (Dursban) and tetrachlorvinphos (Gardona) treatments showed any reduction in weevil feeding damage.

Systemic Insecticides to Japanese Paperpot-Grown Stock

Work continued on the systemic organo-phosphorous insecticide Thimet (phorate), testing various levels and times of application to Sitka spruce (see 1973 *Report*), with Thimet at 0.05 and 0.1 g active ingredient per plant. Assessments and bioassays showed that the insecticide had largely disappeared from the plants. All but topical applications of this granular insecticide proved to be phytotoxic to the young plants.

Further experiments were initiated using Corsican pine treated with 0.5 and 1.0 g active ingredient per plant. One tenth of the insecticide dosage was applied initially during the hardening off period and the remainder after planting out. Granules were scattered on the soil surface around each plant. Both levels of insecticide significantly reducing weevil damage but height growth of the plants was reduced and some phytotoxic effects noted at the higher dosage rate.

C. J. KING

Enquiries

During the year 74 written enquiries were sent to Alice Holt from Forestry Commission staff and 30 to Northern Research Station. One hundred and fifty private enquiries were received at Alice Holt and 19 at Northern Research Station.

REFERENCE

SCOTT, T. M., KING, C. J., and WALKER, C. (1974). Trials with insecticide sprays to control Elm bark beetles in logs. *Q. Jl For.* **68** (2), 167-170.

WILDLIFE MANAGEMENT

In grey squirrel management research, cage-trap trials proved the Fuller "Tele-trap" an adequate substitute for the Fuller "Bullseye". A squirrel lure failed to attract squirrels to traps. Alternative anti-coagulant poisons are being compared with warfarin. On the red squirrel front, continued investigation of Corsican pine cone and seed predation suggested that some 10 per cent of the cones had been utilised by January; no obvious basis for cone selection could be identified.

The annual Squirrel Questionnaire indicated no change in the overall range of either species. Red squirrel damage increased slightly; grey squirrel damage decreased considerably. Grey squirrel damage to an increasing range of conifers in Wales is being investigated.

Field vole (*Microtus agrestis*) activity as indicated by thrown quadrats may be the most practical, simple method for management purposes among those available for estimating numbers, activity or changes in abundance. Spot-weeding was associated with reduced vole activity compared with activity at non-weeded trees. Medium grade cut wheat proved as satisfactory a bait base as fine grade cut wheat.

Kestrel nest boxes were perched on by various predatory and scavenging birds and provision of perching poles may be useful for assessing and assisting avian predation in vole-susceptible plantations.

Netting a proportion of nursery beds confirmed that bird predation is responsible for otherwise unsuspected losses of seed and seedlings. Census of breeding birds in hardwoods among extensive conifers suggested that isolated islands of less than two hectares are unlikely to alter species composition or numbers significantly.

In fencing trials, Weldmesh continued to compare well with woven field and hexagonal mesh netting.

The five-yearly Mammal/Bird/Damage Questionnaire required returns on a 10 km basis to produce data compatible with other recording schemes.

JUDITH J. ROWE

ENGINEERING SERVICES

A seed germination unit has been designed and tested under workshop conditions. Four units are being built for the Seed Branch. The temperature gradient plate has been modified and re-built.

The wide range of work carried out this year has been related to the modification and improvements to existing designs. This has included the manufacture of a further Quiz for the Show Unit, 50 tree injectors, 24 flow gauges for tree injection work, temperature probes, height units, tree shoot samplers and bark samplers.

R. E. STICKLAND

FIELD SURVEYS

Topographic Surveys and Assessment Projects

About 60 per cent of the staff resources in the Section were spent on routine topographic surveys and crop assessments. Completed work is summarised in Table 6. For the third year, the survey to determine the distribution of Dutch elm disease was continued and the area extended to include parts of northern England. Assistance was given on 38 courses for the private sector on tree injection methods. A new classification to define national standards for broad-leaved growth was introduced.

Plot data from fertilising operations in West Scotland Conservancy were collected for the second time (see 1972 *Report*) and are being analysed. A project was set up to obtain a national estimate of the area of crops in the thinning stage where basal area differs significantly from the management tables due to underthinning. The results of the pilot project set up to correlate crop growth with the Site Group classification will be published during the coming year.

L. M. SIMPSON

TABLE 6
TOPOGRAPHIC SURVEYS AND CROP ASSESSMENT

	New Surveys (ha)	Revision Surveys (ha)	Total (ha)
Scotland	28,000	5,600	33,600
England and Wales	4,800	17,000	21,800
Great Britain	32,800	22,600	55,400
Total			

Site Survey

Working from three team centres in Scotland and one in Wales, routine site surveys were completed covering 36,000 hectares and mapped at 1:10000 or 1:10560 scale. This work was predominantly the detailed mapping of the plantable reserves which is expected to be completed by the end of 1974. Soil demonstrations and site appreciation courses were organised for Forestry Commission personnel in the Scottish Borders, Argyll, Galloway and Sutherland.

R. D. L. TOLEMAN

Mensuration

The preparation of a *Forest Mensuration Handbook* was completed during the year and this will be published shortly. This contains procedures and tables required to meet the needs of measurement in most situations.

Yield tables for *Nothofagus* species (*N. procera* and *N. obliqua*) were produced (Christie *et al.*, 1974). These highlight the high production capability of the species and the relatively early culmination of maximum mean annual increment.

The publication of these tables marks something of a milestone in the development of yield table construction, since the analysis of the individual plot data and their subsequent synthesis into yield tables was achieved almost entirely by computer.

Progress was maintained in establishing new permanent sample plots on upland sites, mostly in Scotland and northern England. A new replicated experiment was established in middle-aged Corsican pine in Kings Forest, Thetford. The principal aim of the experiment is to examine the effects of very long thinning cycles. The treatments include a 20-year thinning cycle which required the removal of a thinning volume some four times greater than that which would be considered a conventional average volume.

G. J. HAMILTON

REFERENCE

- CHRISTIE, J. M., MILLER, A. C., and BRUMM, L. E. (1974). *Nothofagus yield tables*. Res. Dev. Pap. For. Commn, Lond. 106.

WORK STUDY

Forest Management Studies

Nurseries

The handling of container plants and the mechanisation of lifting and bundling transplants are currently being examined.

Planting

Studies have commenced on the mechanical planting of Japanese Paperpots, and also on new planting machines which have hydraulically controlled planting arms as opposed to the usual dibble cutting continuous furrow.

Ploughing

Work is in hand on providing a continuous stepped profile to the furrow slice on peat. A prototype rotary mouldboard plough is ready for trial, the objective being to obtain a thorough mixing of soil horizons and some reduction in drawbar pull. Work continues on the design and construction of a vibrating plough sock.

Draining Reafforestation Areas

Trials of the Nicolas DR100 brushcutter for chopping brash in the path of the draining plough have been promising, but some modifications of machine and method will be necessary.

Drains Maintenance

A modified hydrostatic crawler tractor has been purchased and will tow the Meri rotary ditcher which shows considerable promise.

Weeding

For mechanical weeding a range of portable brushcutters was evaluated as well as a pedestrian-controlled weeding machine. The main effort was concentrated on herbicides applied by ultra low volume techniques, which are now being rapidly developed using new types of equipment and chemical formulations. Granular herbicide applicators were also studied and reported on.

Traction

The most urgent need in the Forest Management field is the provision of a suitable rough terrain tractor for establishment work, and the design of a prototype 6 × 6 low ground pressure hydrostatic tractor is being studied.

Fertiliser Distribution

Fertiliser distribution by tractor mounted equipment on heathland pre-planting sites or in young plantations at wide spacing on moderate terrain has been shown to give even distribution and accurate application more cheaply than by aircraft.

Brashing

Trials of lightweight chainsaws have shown them to be unsuitable for conventional brashing but they promise to be useful for opening access routes to unbrashed plantations prior to thinning.

Harvesting Studies

Skidders

The hydrostatic forest tractor programme is virtually completed and eight tractors will soon be operational. Commercial production by Roadless Traction Ltd will follow in 1974. The tractors have maintained their promise and favourable publicity has been given by press, television and trade publications. Studies of the Clark Ranger 664 skidder with winch and grapple are almost completed and similar studies of the Timberjack 360D are in progress. Outputs for the various County skidders are being updated.

Forwarders

Various types continue to be studied, predominantly the Volvos SM868 and 462, the Gremo TT12, the Chieftain and Highland Bear.

Cable Cranes

Evaluation of the Smith winch gave indication of some promise but future development by the manufacturers is uncertain. Work on the clockwork carriage is sufficiently encouraging to warrant further design study. Load diversion continues to present problems.

Chipping

The timber supply shortfall of the next decade highlights the importance of residue utilisation and studies continue urgently on supply, demand, equipment and methods, such as brash disposal from processor operations.

Processors

Staff are being trained and harvesting systems studied preparatory to the introduction of a Pika processor which will be evaluated over a range of terrain conditions.

Mechanical crosscutting systems using equipment such as the grapple saw are also being developed.

Harvesters

Work is already in hand on shears and other felling devices and it is hoped to commence studies of the Timberjack RW30 harvester in the summer of 1974.

Work Measurement

Standard Time Tables continue to be re-tested and converted to Output Guides for other than major production operations. Work is in hand for initial synthesis of felling data relating to the changed methods of harvesting mechanisation and for subsequent field study validation.

Machinery Research and Development

The main effort of the workshop has been concentrated on the production of five further hydrostatic forest tractors to meet urgent field requirements in advance of commercial production. Work has almost been completed on a double-drum radio-controlled winch for use on conventional agricultural tractors, and a load assembly winch as auxiliary equipment for felling is in the construction stage. Modifications to the hydrostatic crawler tractor have been formulated and agreed with manufacturers. Specifications and designs were drawn up for the 6 × 6 low ground pressure rough terrain vehicle. Despite considerable supply problems work has been completed very close to schedule.

Safety

General

Publication of the *Safety and Health at Work* Bill and its subsequent discussion with Home Grown Timber Advisory Committee led to the formation of a Safety Council for the Forest Industry. Work continues on Codes of Safe Working Practice. These developments have been given a high priority in the light of the accident rate in production operations.

Chainsaws

These machines, which are used by some 1,100 men in the Forestry Commission, are the subject of continuous review and safety improvements include the chain brake, safety throttle, lower vibration and noise characteristics and standardisation to a safety chain.

Noise

Progress has been made but the need continues for better cab design and reduced noise level on forest machines, particularly on the larger skidders.

Workers' Clothing

A scheme for the provision of subsidised waterproof clothing and safety boots has been commenced and has been well received.

I. A. D. GRANT

STATISTICS AND COMPUTING

The main responsibilities for giving statistical advice and a computing service have continued with few changes.

Statistics

J. Morrison analysed an experiment on the long-term (11 years) storage of *Abies procera* seed using a Weibull model of survival times. The analysis gave useful conclusions and pointed to necessary improvements in experimental techniques. It will be fully reported elsewhere.

In collaboration with J. F. Kraus, a visiting scientist, Alwena Roberts studied relations between methods of interpreting the provenance \times site interactions obtained from the data of a series of Sitka spruce provenance trials.

The third annual Dutch elm disease survey (i.e. that for 1973) was designed on the basis of sampling previously surveyed strips with probability proportional to the number of non-woodland elms found in them in 1972 and using counties as the only level of stratification. The results of these surveys will be published elsewhere.

Computing

Jean Birchall and G. Bell programmed a system to summarise field assessments from most designs of experiments. This facilitates the use of audio-tape recorders in data collection. They also showed that high fidelity earphones significantly aided transcription of such data to punch cards (see Plate 4).

Jane Smyth applied a linear programming method to the problem of optimising the distribution of outstationed research foresters with respect to costs of the travelling to the sites of forest experiments. J. Hall programmed a related system for planning and helping to control the schedule of field work of Silviculture South Branch.

C. Samuel used the IBM 1130 CSMP and a simple model of forced harmonic motion to simulate idealized windthrow conditions in forest stands. Potentially dangerous combinations of wind and tree frequency were identified.

Jean Birchall and C. Samuel surveyed the current state of the calculating machine market and the Division's use of these machines, and gave advice which was used in decisions which roughly doubled the number of machines on stock at Alice Holt.

Students

The Branch was helped by three students during the year. J. Whitmore helped to analyse various experiments designed to estimate optimum plot size in field progeny trials. D. Irvine and J. Marshall helped to summarise information from an extensive survey of *Fomes annosus* in Sitka spruce. J. Marshall also worked on a method for studying a possible effect of fertilisers on the specific gravity of the wood of Sitka spruce trees.

D. H. STEWART

R. S. HOWELL

RESEARCH INFORMATION

The three Sections, Research Information, Photography and Publications, have been combined to form a new Communications Branch. The transfer of Publications to Alice Holt Lodge in 1975 will concentrate staff and facilities under one roof and provide an opportunity to improve the services given.

Two hundred new books were acquired and nine new periodicals subscribed to by the library. The number of loans was maintained at 3,184, with a further 883 borrowed from outside libraries. The increasing demand for loans was met by the provision of photocopies which more than doubled to approximately 1,500. A questionnaire on the use of the library showed that 98 per cent of our customers were satisfied. Changes and shortages of staff have been a major problem through the year, but existing current awareness and SDI services have continued.

The need for a Liaison/Information Officer at the Northern Research Station has now been recognised.

O. N. BLATCHFORD

PHOTOGRAPHY

General

The demand for "populist" material has only been met by a reduction in the service to Research Branches.

The load put upon the Section led to deterioration in, and dissatisfaction with, the service provided.

This problem has been under review for some time and it was agreed that, in future, the Photographic Section at Alice Holt would be responsible solely for scientific and technical photography, aerial photography, film production, and the provision of an advisory service for audio-visual aids.

Photographic Collection

Work began on the splitting of the Photographic Collection. General material will in future be lodged with the Information Branch in Edinburgh. Material appropriate to Research and Development Division will be retained at Alice Holt.

We will no longer provide a comprehensive loan service of slides for lectures, but the Section will continue to supply slides and prints of scientific and technical subjects for specific purposes.

Film Library

As with slides, distribution of Information Branch films will now be dealt with in Edinburgh.

Aerial Photography

The baggage door camera mount has proved effective and has aroused interest amongst other users of Supplementary Aerial Photography.

Some slight alterations are needed to allow a wider range of lenses of differing focal lengths to be fitted.

A second door is now being made.

I. A. ANDERSON

PUBLICATIONS

The following seven new priced publications were issued through Her Majesty's Stationery Office during the course of the year. Previous issues are shown in *Sectional List No. 31* available free of charge from Her Majesty's Stationery Office, and in *Forestry Commission Catalogue of Publications* from the Publications Section, 25 Savile Row, London W1X 2AY. *A complete Check List of Forestry Commission Publications 1919-1973* was published as Research and Development Paper No. 100.

Bulletin

- No. 47. Work Study in Forestry, edited by W. O. Wittering (£1.00).

Forest Records

- No. 86. Crossbills, by Bruce Campbell (previously Leaflet No. 36) (14p)
No. 88. Cold Storage of Forest Plants, by R. M. Brown (22p).
No. 89. Titmice in Woodlands, by C. E. Palmar (previously Leaflet No. 46) (17p)

Booklet

- No. 37. Volume Tables for Smallwood and Round Pitwood, by G. J. Hamilton (12p).

Leaflets

- No. 55. Hydratongs, by F. B. W. Platt and P. Wood (10p).
No. 56. Grey Squirrel Control, by Judith J. Rowe (12p).

In addition ten priced publications sold by Her Majesty's Stationery Office were reprinted after varying degrees of revision. The first four in a series of wall charts, *Forest Trees in Britain* were produced for the Conservation and Recreation Branch of Forest Management Division and published in conjunction with Educational Productions Ltd of Wakefield, Yorkshire. The titles issued are for English oak, Silver birch, Scots pine and Douglas fir and are priced individually at 40p or £1.50 the set.

The responsibility for the production of unpriced information pamphlets was transferred to Headquarters Information Branch on 1st April 1973.

Research and Development Papers

Twelve of these unpriced papers were produced, mainly for internal use, and are listed below. Single copies are available on request from the Forestry Commission, 25 Savile Row, London W1X 2AY.

- No. 96. Construction and Application of Stand Yield Models, by G. J. Hamilton and J. M. Christie.
No. 97. Report of a Working Party on Lorry Transport of Roundwood, by P. C. Ormrod and R. C. Stern.

- No. 98. International Norway Spruce Experiment at The Bin, Huntly Forest, Aberdeenshire: Results up to Twenty Five Years, by R. Lines.
- No. 99. Inventory Provenance Test with Norway Spruce in Britain: First Results, by R. Lines.
- No. 100. Check List of Forestry Commission Publications, 1919-1973, by P. Mayne.
- No. 101. Flushing Time for Norway Spruce, by R. Lines.
- No. 102. Production Planning in the Forestry Commission, by D. R. Johnston.
- No. 103. Survey of Losses of First Year Conifer Seeds and Seedlings in Forestry Commission Nurseries, by L. A. Tee and S. J. Petty.
- No. 104. Public Demands on Forests in Relation to Forest Wildlife, by Judith. J. Rowe.
- No. 105. Summary Report on the IUFRO 1938 Provenance Experiments with Norway Spruce, *Picea abies*, Karsten, by R. Lines.
- No. 106. Nothofagus Yield Tables, by J. M. Christie, A. C. Miller and L. E. Brumm.
- No. 107. Organisation of Outdoor Recreation Research and Planning in the Netherlands, by R. M. Sidaway.

H. L. EDLIN

PLANNING AND ECONOMICS

Corporate Planning

Considerable programme planning, notably in the fields of plant production, planting programmes, harvesting, marketing, staffing and finance is necessary in an enterprise like the Forestry Commission, whether an overall plan exists or not. No single, comprehensive document called a corporate plan has been available in the Commission. Following the Ministerial statement of 23rd October 1973, work began in readiness for issue in June 1974 before Conservators begin the annual round of preparing basic budgets and programmes in July.

The various plans for activities are, of course, already articulated. For example, the interdependence of road-building and harvesting first thinnings implies that the two activities must be considered together. With such articulation already ensured, the role of the Corporate Plan is rather more limited than otherwise, but there are areas in which either more detailed local elaboration of plans or optimisation through central planning is required. The role of corporate planning is not however to deal with local problems, but to develop a strategic view. The principal goals are therefore to create a full awareness among staff of the environment within which the Commission is likely to operate and the Commission's functions and general strategy; to set down plans in accordance with its objectives; and to establish the targets for particularly important outputs and inputs.

The Branch is responsible for assembling the contributions of the various Headquarters Divisions and to match these Commission-wide. In the 1974 edition of the Corporate Plan, Headquarters analytical work has covered reviews of changes in such variables as growth in productivity of both non-industrial and industrial labour, the real cost of operations and the assessment of effects of specification changes on these variables. Forecasting for the 10 years term of the Plan is then based on named programmes combined with forecast costs etc, which include assessment of the effects of changes in the efficiency of resource use.

G. M. COWIE

A. J. GRAYSON

Spacing of Conifers

The implications of spacing for future wood revenue have been reviewed. The subject is difficult owing to uncertainty about the effects of spacing on wood characteristics, and the effects of these on timber value where technologies of wood utilisation are liable to alter significantly between planting and harvesting. Preliminary results based on a range of price effects are that in Scots pine and Sitka spruce the net discounted revenues at 5 per cent associated with different spacings are likely to be highest for spacings of over 2 metres. When combined with estimates for costs of forest management operations and roading for different spacings, the implication is that a spacing for conifers of some 2½ metres may well be optimal at the internal discount rate of 5 per cent used by the Commission.

J. DEWAR

A. J. GRAYSON

Production Forecasting

Following the production forecasting and planning connected with the financial reconstruction, forecasts were computed for Districts and Forests in all Conservancies. All these forecasts provide figures by 7, 18 and 24 cm top diameter size classes. Subsequently a major series of forecasts was run to give details by 7, 12, 15 and 18 cm size classes, for a study involving the utilisation of intermediate sizes of roundwood. Current work is mainly concerned with updating forecasts after new surveys have been completed.

J. DEWAR

Monitoring Use of Day Visitor Areas

During the last three years, traffic counters have been installed on a trial basis on forest recreation sites. It was decided to gain wider experience of this type of equipment and establish a regional network of installations, to give some indication of regional, seasonal and other variation in total use. A few other examples of daily attendance records have been incorporated into the scheme, for example, ticket sales, honesty box takings and visitor books at information centres. Generally recording began in June 1973 and continued until October.

A standard method of recording has been adopted and all sets of data have been processed on the traffic counter data processing (TCDP) computer package at Alice Holt. This suite of programmes summarises the data, tabulates and prints bar charts of daily and average day of the week, weekly, and monthly readings. Conservancy staff can receive a summary of the data soon after the end of the season.

These records rarely provide an accurate account of visitor use. Occasionally it may be necessary to calibrate the counter in terms of a recognised measurement such as visits, visitor hours or even stock of cars parked at the peak hour. Such calibration involves extra expense and, unfortunately, each installation requires individual calibration as there are no general rules of thumb for converting the record into recognised units of use.

Analysis of variations in seasonal use is being attempted where continuous recordings are available. In modelling the relationship between average weekly visits and number of the week in the year, some success has been achieved using five degree polynomials for data excluding Bank Holiday weeks. Further work is being done with less restrictive functions than polynomials to cover peak use periods. It is also hoped to model use in relation to day of the week and weather variables. Better design of sample surveys will follow, and may lead to the recognition of objectively definable classes of sites differing in their seasonal use.

A. J. GRAYSON
R. Q. OAKES
R. M. SIDAWAY

Pilot Survey of Campers on Forestry Commission Campsites and Other Recreation Studies

It is intended to conduct surveys on Commission campsites of the reactions of campers to the management facilities on the sites. Comparisons of the holiday characteristics and market profile of these campers will be made with those of respondents to national camper surveys.

A pilot survey in September 1973 on six campsites, was designed to test alternative survey methods. Self-completion questionnaires were distributed by campsite wardens or interviewers. Interviews of varying length and combinations with a self-completion questionnaire were also tested. Postal response rates were high at around 60 per cent without a reminder letter and there was no significant difference between methods overall. The occasionally very low response rates to the warden-distributed questionnaire may be attributable to the method of distribution. A 20-minute direct interview on campsites appears technically feasible but costly. Generally the combined direct interview and self-completion questionnaire is preferable. This method supplies profile data to check for possible bias and allows the respondent time to consider attitude or opinion questions at leisure.

Reports were prepared in conjunction with Dr. M. C. D. Speight of Trinity College, Dublin, on site conditions on informal camping areas and day visitor sites in the New Forest. Oblique aerial 35mm black and white photographs were obtained of peak conditions in the camping areas. Advice on monitoring surveys continued to be given to Conservancy Recreation Planning Officers. The supervision of research grants and contracts for work on recreation survey and planning, notably in Scotland, assumed an increasingly important role.

R. Q. OAKES

R. M. SIDAWAY

TIMBER UTILISATION

Use of Bark in Horticulture

Experiments on the use of bark as a medium for growing cucumbers have continued at the Lee Valley Experimental Horticulture Station and the Glasshouse Crops Research Institute, and on pine bark for mushroom casing at the former location with encouraging results. Although the yields obtained for both crops are marginally below those given by peat, improvements can be anticipated with increased experience in their nutrition and in discovering the best particle size of the bark. Additionally, trials have been initiated on the use of bark in watercress beds by the Agricultural Development and Advisory Service at Alresford, Hampshire, and it is already apparent that for this purpose a large particle size is preferable.

In an attempt to obtain a better understanding of phytotoxicity shown by fresh bark of some species such as the spruces and Douglas fir, preliminary determinations of the terpene content of all major coniferous barks (except Lodgepole pine) have been undertaken at the Tropical Products Institute, together with an assessment of the extent to which the terpenes are reduced by the activity of thermophilic bacteria during storage in large heaps. (Checks with thermistors have shown that temperatures above 70°C can be achieved within a few days of building up the pile of bark).

Results from gas-liquid chromatography analyses at the Institute have already shown that the thermophilic activity results in a substantial reduction in the monoterpene content:

Age of Stack	Moisture Content % dry weight	Volatile Oil Content % dry weight	Monoterpene Content
1-8 weeks	250	0.105	% 0.01
8-12 weeks	320	0.15	0.006
12-16 weeks	215	0.115	0.0025

Mixed Conifer Bark Undergoing Thermophilic Bacterial Fermentation (Mean of two replicates)

During the year two further organisations (in Sheffield and in Glasgow) started marketing bark to the horticulture industry.

Chipping in the Forest

Visits to nearly all pulp, chipboard and fibreboard manufacturers have confirmed that a number of members of these industries are willing to accept supplies of wood chipped in the forest, subject to the chip dimensions meeting their specifications. Consequently a joint project with the Work Study Branch has been launched to investigate the technical and economic feasibility of chipping wood from tops and branches, which are normally considered uneconomic to harvest. None of the portable chippers tried during the year were considered satisfactory for this purpose.

J. R. AARON

[An account of the work carried out under the Joint Research Programme on Home-grown Timber, by the Princes Risborough Laboratory and the Forestry Commission, is given on p. 81. *Editor.*]

PART II

The Work of Other Agencies

NUTRITION AND FOREST SOILS

RESEARCH ON FOREST SOILS AND TREE NUTRITION

By H. G. MILLER and B. L. WILLIAMS

The Macaulay Institute for Soil Research, Aberdeen

Nutrition of Sitka Spruce

Investigations of the relationship between tree growth and nutrient uptake in pole-stage Sitka spruce, the plans for which were outlined in the *Report* for 1973, commenced in May 1973 with the application of fertiliser to the first two of a series of six experiments. The experiment at Fetteresso, Mearns Forest (Kincardineshire), has proceeded satisfactorily but some problems with insect contamination of rain gauges and with excessive volumes of stemflow have arisen at Leanachan Forest (Inverness-shire). These have necessitated design changes which will be incorporated into the experiments to be established in 1974 at Strathyre Forest (Perthshire) and at Elibank and Traquair Forest (Peeblesshire).

At neither of the existing experiments has there been detectable fertiliser contamination of the out-flow water from the experimental area.

Nutrition of Pines

Examination of the results from the experiment in pole-stage Corsican pine at Culbin, Laigh of Moray Forest (*Reports* for 1965 to 1973), continues and details of the distribution of growth in this experiment have recently been published (Miller and Cooper, 1973). Measurements of rainfall over two years in this experiment show that although throughfall accounts for about 66 per cent and stemflow about 3 per cent of the gross rainfall received, stemflow contains up to 23 per cent of the nutrients reaching the soil surface in rainwater. True release by crown leaching, as distinct from aerosols and dust washed down from the canopy, is estimated to account for 6.0 kg potassium, 1.5 kg calcium, 3.0 kg magnesium and 19.9 kg sodium per ha per annum, equivalent to 44, 8, 48, and 89 per cent, respectively, of the total release through litter fall and crown leaching. Almost all the release of nitrogen and phosphorus was in the litter fall. Nitrogen, however, was released into rainwater at certain periods of the year, and the seasonal pattern of foliar release and absorption closely resembles the seasonal patterns reported in the literature for variations in levels of soluble nitrogen in conifer foliage.

Attention is now being given to the whole-tree data from this experiment. It has been necessary to recalculate the weights per unit area using a correction factor for the bias inherent in estimates derived from logarithmic regressions,

such as the logarithmic transformation of the allometric equation used in this study. Inclusion of this correction has increased the estimates for the weights of small and variable components, such as needles greater than two years old, by as much as 50 per cent, but for the whole tree the correction seldom exceeded 1 per cent.

The Leaf Area Index in this crop three years after first fertiliser application, ranged from 2.8 in the control plots to 5.0 in the most heavily fertilised plots, although when total-needle area, rather than plan area, is used, these values increase to 8.2 and 14.1 respectively. When estimating total-needle area from plan area for these trees it was necessary to include a quadratic as well as a linear term in the regression.

In the glasshouse the efficacy of different phosphate fertilisers supplied by the Forestry Commission is being examined in a series of pot experiments on tree seedlings grown in peat.

Nitrogen Mineralisation in Peat and Mor Humus

The effect of total nitrogen content on rate of nitrogen mineralisation in peat has been studied by incubating samples containing approximately 1.0, 1.5 and 2.0 per cent nitrogen under both aerobic and anaerobic conditions, and at temperatures of 2°, 10°, 20° and 30°C. After incubation for one month, at all temperatures, the levels of mineral nitrogen produced increased with increasing total nitrogen content, but the effect of increasing temperature was more pronounced in samples incubated under anaerobic conditions. Prior freezing, at -15°C, of samples of these peats markedly enhanced mineral nitrogen production; indeed after two weeks incubation at 10°C the rate of mineral nitrogen production in such samples was comparable to that achieved at 30°C by peat not subjected to the initial freezing treatment.

Mineralisation of nitrogen in different peats is being investigated using samples representing most of the bog types defined by the Forestry Commission. Samples have been obtained from both Penninghame Forest (Wigtownshire) and Naver Forest (Sutherland). Incubation studies are now in progress and duplicate samples are being analysed for the total contents of most major nutrients.

Samples of humus are taken each year from a factorial experiment at Culbin (Laigh of Moray Forest) designed to test the response of pole-stage Scots pine to various forms of nitrogen fertiliser in factorial combination with phosphorus and lime (*Reports* for 1969 to 1973). These samples are analysed and the release on nitrogen and carbon on incubation determined. Lime applied in 1968 continues to show a marked effect on acidity and calcium content of the humus, but the increased evolution of carbon dioxide during incubation detected during the years immediately following application is now absent. Nitrogen fertilisers initially stimulated production of mineral nitrogen but by 1973 this effect appears to be confined to humus from those plots that also receive lime.

REFERENCE

- MILLER, H. G., and COOPER, J. M. (1973). Changes in amount and distribution of stem growth in pole-stage Corsican pine following application of nitrogen fertiliser. *Forestry* 46, 157-190.

FOREST PATHOLOGY

CONIFER SEEDLING PATHOLOGY

By G. A. SALT

Rothamsted Experimental Station, Harpenden, Hertfordshire

Closure of the Forest Research Nursery at Wareham in March 1974 provides an opportunity to summarise the results of experiments that have been testing the same treatments applied to the same plots annually for several years. One such experiment (W.95) was the sole survivor of several experiments started in different nurseries in the early 1960s to test the effect of fungicidal seed treatment and partial soil sterilization on survival and growth of Sitka spruce seedlings.

Twenty plots each a yard square were arranged in four replicate blocks of five and each plot split for a test of fungicide seed treatment. Untreated seed was coloured with redlead in 1964 and 1965 and with lithofar red from 1966 to 1973. The fungicide was applied as a 50 per cent Thiram dust at the rate of 1 part to 100 parts by weight of seed, except in 1964 when liquid methoxyethyl mercury chloride was used. Table 7 shows that fungicidal treatments had virtually no effect on seedling numbers in any of the 10 years tested. This result is important as about 3 per cent of the seeds sown between 1964 and 1970 inclusive were naturally infected by the fungus *Geniculodendron pyriforme* (Salt, 1974). Evidently the risk of measurable losses at Wareham was negligible when infected seed was sown at the normal time between mid-March and mid-April. Seed sown early in February 1968 in another part of the same nursery suffered considerable loss from this fungus, so that climate was probably limiting disease spread in normal sowings.

TABLE 7
NUMBER OF SITKA SPRUCE SEEDLINGS PER m² (W.95)
(Each figure the mean of 20 sub plots) (°)

Year	Ident. Number of seed	Third germination count in June		Final count in October	
		None	Fungicide seed treatment: Thiram	None	Thiram
1964	60(7111)1	1,543	1,547(°)	1,717	1,666(°)
1965	61(7972)	1,864	1,868	1,980	1,918
1966	„	1,664	1,623	1,732	1,660
1967(°)	„	1,307	1,165	1,314	1,233
1968	„	1,065	1,106	1,060	1,054
1969	„	1,136	1,080	1,121	1,099
1970	„	1,209	1,167	1,075	1,126
1971	65(7972)	1,048	1,093	959	954
1972	70(7972)5	1,273	1,266	1,257	1,247
1973	70(7972)5	1,283	1,259	1,239	1,263
10-year Mean		1,339	1,317	1,345	1,322

Notes:

- (1) Seed rate decreased from 2,150 to 1,675 per m².
- (2) Methoxyethyl mercury chloride used instead of 50 per cent Thiram.
- (3) Five counts in each sub plot, each of an area 45 × 5 cms.

Formalin was applied as a 38 per cent solution of formaldehyde at the rate of 250 ml per square yard diluted with usually 4½l water. Where applied every year during the winter it did not affect seedling numbers or growth (Table 8), either in years when growth was good (1968) or poor (1964, 1972). However formalin applied only in alternate years usually increased growth in the year when applied and decreased it in the year after. A similar result was obtained with wheat at Rothamsted (Salt, 1971), where take-all disease was a contributory factor. Jenkinson and Powelson (1970) showed that when nitrogen was limiting growth a second fumigation was less effective than the first. This was attributed to the elimination of part of the soil biomass during fumigation and its incomplete recovery, even after several years.

TABLE 8
HEIGHTS OF SITKA SPRUCE SEEDLINGS (CM)

Year	Untreated	Soil treatments		Formalin in alternate years	
		Residues from chloropicrin in 1960 to 1962	Formalin every year since 1960	For this crop	For previous crop
1964	3.30	3.00	3.68	—	—
1965	7.42	7.79	7.20	—	—
1966	8.18	9.92	8.80	—	—
1967	8.30	8.18	8.78	—	—
1968	9.84	10.24	9.92	—	—
1969	6.52	7.08	6.64	9.01	7.12
1970	7.24	7.06	8.62	9.38	5.76
1971	7.48	7.59	7.14	7.68	6.89
1972	5.37	5.60	5.90	5.80	5.22
1973	6.90	7.22	6.68	8.18	7.34
10-year Mean	7.06	7.37	7.34	—	—
5-year Mean	6.70	6.91	7.00	8.01	6.47

Declining responses to annual applications of formalin were recorded in another experiment at Wareham (W.238), where formalin was applied each year from 1969 to 1973 to plots that had been differentially limed to give soil pHs (in CaCl₂) ranging from 3.5 to 6.0. The experiment was part of an investigation into stunted growth, a problem in nurseries on near neutral "agricultural" soils where partial soil sterilization produced striking increases in growth (Benzian, 1965). Soil pH was unaffected by the formalin treatments and Table 9 shows the mean pH obtained from the different amounts of ground limestone applied once before sowing in 1969.

TABLE 9
EFFECT OF A SINGLE APPLICATION OF LIMESTONE IN 1969 ON SOIL pH
(Means of untreated and formalin-treated plots)

Limestone (tonnes/ha):		0	1.5	3.0	6.0	12.0
Soil pH (in 0.01 CaCl ₂)	October					
	1969	3.50	4.38	4.86	5.84	6.42
	1970	3.56	4.00	4.52	5.66	6.34
	1971	3.54	3.80	4.16	5.17	6.14
	1972	3.54	4.00	4.38	5.18	6.02
	1973	3.78	4.00	4.26	4.98	5.86
	Means	3.58	4.04	4.44	5.37	6.16

Table 10 shows that limestone applied at 1.5 and 3.0 tonnes/ha was beneficial and increased growth in all years. Even the high rates, up to 12.0 tonnes/ha, increased growth in the first year but caused marked stunting in the second and severe stunting in the third and fourth years. This result probably reflects incomplete mixing of the lime and possible rooting below the level of incorporation in the first year, and a progressively deeper and more intimate mixing during the second and third years. The slightly improved growth at high rates of liming in the fifth year was probably the result of soil pHs drifting towards acidity.

TABLE 10
EFFECT OF LIMING AND FORMALIN ON GROWTH (HEIGHTS IN CM)

Limestone (tonnes/ha):		0	1.5	3.0	6.0	12.0	Means
1969	Untreated	4.70	8.08	8.94	8.72	7.51	7.59
	Formalin	7.06	8.91	8.83	9.67	7.68	8.43
1970	Untreated	6.76	7.48	6.95	5.16	4.34	6.14
	Formalin	11.18	10.98	10.38	9.63	7.60	9.95
1971	Untreated	6.63	7.62	7.23	4.70	2.58	5.75
	Formalin	7.30	7.56	7.90	7.26	6.76	7.36
1972	Untreated	5.15	6.30	6.42	4.45	2.70	5.00
	Formalin	5.36	5.28	5.02	4.70	3.50	4.77
1973	Untreated	7.08	8.54	9.27	7.24	4.80	7.39
	Formalin	7.42	7.23	7.50	6.58	4.80	6.71
Means:	Untreated	6.06	7.60	7.76	6.05	4.39	
	Formalin	7.66	7.99	7.93	7.57	6.07	

In highly limed plots formalin maintained good growth during the first three years when seedlings in untreated soil became stunted, but its beneficial effect declined in the fourth and fifth years. In lightly limed plots formalin had little effect except in 1970, when it increased growth over the whole pH range. Unexpectedly formalin also increased growth in the most acid soil each year, but especially in the first and second year. Neither formalin nor liming had any measurable effect on seedling numbers.

The stunted growth on heavily limed plots could not be related to the introduction or increased incidence of root pathogens. *Pythium* spp. common in nurseries on "agricultural" type soils remained rare at Wareham. Powelson and Jenkinson (in the press) using soil sampled from this experiment in 1972 found that liming greatly increased the soil biomass, measured by oxygen consumption, and that the flush of decomposition after fumigation was greater in the neutral than in the acid soils. This might help to explain the fumigation response in neutral soils, but does not explain the cause of stunting nor the growth response in acid soil, for which there is no satisfactory explanation at present.

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VIRUS DISEASES OF TREES

By J. I. COOPER

*Unit of Invertebrate Virology, Commonwealth Forestry Institute
University of Oxford*

Nematode transmitted viruses with polyhedral particles (NEPO) were detected in leaves of plants in five genera of the family Oleaceae and in other genera. Arabis mosaic virus was detected in *Fraxinus excelsior*, *Syringa vulgaris*, *Ligustrum vulgare* and *Jasminium officinale* and was associated with chlorotic or yellow ring or chevron patterns. Raspberry ringspot virus was transmitted from *Forsythia sybaldii suspensa* and *F. intermedia*. NEPO viruses were also detected in plants of different families. Cherry leaf roll virus was associated with chlorotic mottle symptoms and great diminishment (2/3 area) of leaf area in *Betula pendula*. The roots of *B. pendula* growing at a different site yielded arabis mosaic virus and this virus was detected with tobacco rattle virus in the roots of *Populus* × *euramericana* hybrids. Patches of dead and dying hybrid poplars were observed at a site in Suffolk and tomato black ring virus was detected in soil from inside but not outside the regions of poor growth.

An isolate of poplar mosaic virus from clone OP226 growing in Bedfordshire had few if any serological determinants held in common with an isolate of the virus from West Germany yet many, perhaps all, determinants were common to an isolate from Italy. The poplar mosaic virus isolate from a United Kingdom source had few if any antigenic properties in common with two different viruses of similar length, ryegrass mosaic and potato virus S.

Three of 24 seedlings of *Cedrela fissilis* grown from seed collected in Brazil showed a yellow colouration of the leaf veins which later affected interveinal tissue too. The disease developed in two of eight visually healthy seedlings inarch-grafted with the affected material.

[During the period under review, support for this work, which was begun by Dr. G. Biddle, was taken over by the Natural Environment Research Council.
Editor]

FOREST ZOOLOGY

REPRODUCTION IN THE GREY SQUIRREL

By ADRIAN DUBOCK and ELIZABETH JOHNSON

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The broad outlines of the reproduction of the grey squirrel are known, but the details need further study. For example, although it is established that squirrel populations show two peaks of litter production a year, it is not clear how frequently individual squirrels have two litters. It seems likely that breeding is influenced by environmental factors as there is some evidence that artificially reducing the numbers of a population will lead to an increase in litter production. Conversely, we have evidence from the spring of 1973 of a delay in breeding which may have been related to the high population density in our experimental forest area.

We are studying squirrels in the field and in captivity in order to establish:

- (1) When the squirrels become sexually mature.
- (2) Whether the gonads regress in the winter and to determine the external factors responsible for such changes.
- (3) Whether female squirrels are induced or spontaneous ovulators.
- (4) Whether we can manipulate the breeding by the use of reproductive inhibitors such as long-acting oestrogens.

The results so far obtained indicate that the male squirrel as well as the female shows seasonal activity of the gonads. During the summer months the testes of mature squirrels are large and actively producing spermatozoa. Regression of the testes begins about August and the testes become small and inactive. In the female during the non-breeding season the ovaries contain only small primary follicles and these enlarge during the breeding season with concomitant enlargement of the uterus.

These seasonal changes in the testis and ovary are illustrated in Plate 3 (see central inset).

It is assumed that the gonads normally recommence activity in December since litter production may occur in January. However, in the spring of 1973 the squirrels in the experimental forest area at Alice Holt remained reproductively quiescent, with small ovarian follicles and inactive testes, until March, when the ovaries and testes developed rapidly and pregnancies ensued.

In the field it is important to distinguish between the juvenile and adult animals. The age of animals is being determined by means of X-rays of the long bones in order to assess the fusion of the epiphyses. In captive animals the epiphyseal notch has not completely fused by 13 months of age and these squirrels are not yet sexually mature. All sexually mature animals caught in the field show fusion of the epiphyseal notch.

In male squirrels the testes of juveniles in the winter may be distinguished from inhibited testes of mature males by the thickness of the connective tissue covering, the tunica albuginea. This covering is thin in juveniles and very thick in mature males (Plate 3, A).

The progress of the sexual cycle in captive female squirrels is being followed by means of vaginal smears, and hormone assays are being developed. Female squirrels in the field will always mate at oestrus. With captive animals it should be possible to determine whether ovulation is induced or spontaneous and whether the female squirrel has only one or a number of sexual cycles during the breeding season. Experiments are also in progress to determine whether daylength is an important factor regulating the seasonal activity of the gonads.

EFFECTS OF FOREST MANAGEMENT PRACTICES ON SONGBIRD POPULATIONS

By MARJORIE W. ADAMS

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During the spring of 1973, a breeding census of small songbirds was undertaken in seven woodland areas throughout Wales. Each study plot was 12 hectares in area. Three were in conifer plantations, three in broadleaved woods, and one in a mixed wood. The size and species composition of the bird population in each type of woodland was compared, and an "index of diversity" was calculated for each population. Observations and measurements were made on each woodland plot in order to determine which parameters might influence the bird population of the woodland. Descriptions of the study areas are given in Table 11.

TABLE 11
DETAILS OF WOODLAND STUDY AREAS

<i>Location (Grid Ref.)</i>	<i>Dominant species</i>	<i>Planting date</i>	<i>Mean ht, main storey</i>	<i>Density, mature trees/ha</i>	<i>Under- storey</i>	<i>Ground vegetation</i>
<i>Woods on agricultural land:</i>						
M1 Sain Ffagan (31/113772)	Oak Beech Scots pine	1884– 1923*	23m	525	Young broad- leaved trees	Bramble Grass
B1 Tintern Forest (32/521074)	Oak Beech	1880	25m	250	Holly (sparse)	Bramble Bracken
C1 Tintern Forest (32/508065)	Corsican pine Scots pine	1922–23	21m	450	None	Bracken Bilberry Bramble
<i>Woods on moorland:</i>						
B2 Coed y Crofftau (32/030236)	Birch Ash Alder Oak	(relict wood)	12m	275	Hazel Hawthorn	Grass
B3 Coed y Rhygen (23/679370)	Oak Birch	(relict wood)	14m	375	Hazel Hawthorn Rowan (sparse)	Grass
C2 Glasfynydd Forest (22/857241)	Sitka spruce Norway spruce	1929	19m	600	None	Brashings
C3 Hafod Fawr, Beddgelert Forest (23/723403)	Sitka spruce	1927–28	21m	275	None	Brashings

* Planted in small blocks; many minor species present. Unmanaged since 1946.

Breeding pairs were located using an adaptation of the method described by Williamson (1964), based on mapping the location of singing males. An index of diversity was calculated for the population in each woodland plot, using the formula:

$$\text{diversity index} = - \sum_i p_i \log_e p_i$$

where p_i is the proportion of the population represented by a given species in the series. (MacArthur and MacArthur, 1961). This index reflects both the total number of species present and their proportional representation; thus a population consisting of equal numbers of two species will have a higher index of diversity than a population dominated by one species, with only a small number of the second species.

The results of the census, together with the indices of diversity, are given in Table 12.

TABLE 12
BREEDING CENSUS: NUMBER OF PAIRS IN EACH WOOD

Wood:	M1 (<i>Sain Ffagan</i>)	B1 (<i>Tintern</i>)	B2 (<i>Coed y Croftau</i>)	B3 (<i>Coed y Rhygen</i>)	C1 (<i>Tintern</i>)	C2 (<i>Glasfynydd</i>)	C3 (<i>Hafod Fawr</i>)
Chaffinch	12	7	7	4	4	6	7
Wren	27	28	13	15	34	11	9
Robin	10	6	7	4	3	3	4
Dunnock	2	1	—	—	2	—	—
Goldcrest	11	5	2	4	9	11	31
Coal tit	5	5	6	3	7	2	4
Blue tit	7	8	5	2	—	—	—
Great tit	5	3	6	2	—	—	—
Marsh tit	1	2	—	—	—	—	—
Nuthatch	1	1	3	—	—	—	—
Treecreeper	—	—	1	1	—	—	—
Blackbird	10	5	3	—	—	—	—
Song thrush	1	1	—	—	—	—	—
Mistle thrush	—	1	—	—	—	1	3
Wood warbler	—	1	3	3	—	—	—
Willow warbler	—	—	4	10	—	—	—
Blackcap	6	—	—	—	—	—	—
Chiffchaff	6	—	—	—	—	—	—
Pied flycatcher	—	—	6	7	—	—	—
Redstart	—	—	2	2	—	—	—
Total	104	74	68	57	59	34	58
Pairs/100 ha	867	616	574	475	492	283	483
Number of species	14	14	14	12	6	6	6
Index of diversity	2.30	2.10	2.47	2.21	1.31	1.52	1.37

The number of breeding pairs in each wood was generally similar; slightly more were found in broadleaved woods than in coniferous woods. The number of pairs of breeding birds in the mixed wood was substantially higher than in any other wood. This wood has been unmanaged since 1946; there is an understorey of broadleaved trees, and thick undergrowth. Studies during the spring of 1972, in a managed mixed wood without undergrowth, did not show an

increased number of breeding pairs. This suggests that the increased bird population in M1 may be due to the development of additional layers of vegetation, rather than to the variety of tree species. The density of breeding pairs was slightly higher in woods B1 and B2; each of these woods had moderately developed understorey or ground vegetation layers. Studies during 1971 and 1972, of broadleaved woods without undergrowth, suggest that the increased density of birds in B1 and B2 was again due to additional vegetation layers rather than to the presence of broadleaved trees. No suitable coniferous woods were found with vegetation layers comparable to those in M1, B1, or B2. Development of secondary vegetation layers is generally limited in conifer plantations.

The density of breeding birds in one coniferous wood, C2, was unusually low. In particular, the number of goldcrests was far lower than in C3, a similar moorland spruce plantation. This may be due to the increased density of trees in C2, resulting in decreased light penetration.

The index of diversity in the coniferous woods is considerably lower than in the broadleaved or mixed woods. This reflects both the fact that fewer species were found in coniferous woods, and that populations in coniferous woods were generally dominated by a single species, either the goldcrest or the wren. The index of diversity for C2 is higher than either of the other coniferous woods, although the number of species present is the same. However, the population of C2 is not dominated by any single species, so that the proportional representation of each species is more nearly equal; therefore the index of diversity is higher.

Other factors, such as the tree species composition, tree height, and location in moorland or agricultural areas, did not appear to influence the size and diversity of the songbird population, although certain changes in bird species composition were observed, such as the presence of the pied flycatcher and redstart in relict broadleaved woods.

Previous censuses have been taken during winter and spring, from November 1970 to February 1973, in a variety of woods. Most of these woods were approaching economic maturity. Spring censuses consistently indicated that similar densities of breeding birds occur in broadleaved and coniferous woods with similar vertical layering. The average number of birds in winter censuses from November 1970 to February 1973 was slightly higher in coniferous than in broadleaved woods. In censuses taken during the winter of 1972-73, numbers of birds were lower in both coniferous and broadleaved woods located on moorland. Although numbers of birds were similar in broadleaved and coniferous woods, the number of species present and the index of diversity were consistently higher in broadleaved woods.

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ENVIRONMENT

ENVIRONMENTAL EFFECTS ON SHOOT GROWTH IN CONIFERS

By D. C. MALCOLM and C. F. GOLDING

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The experiments outlined in the previous *Report* (1973) have been carried out and their results are being analysed.

The results of the experiment on the effects of temperature on flushing and shoot extension of both clones and diallel-crosses of Sitka spruce, confirm marked differences in response. Some progenies show considerably faster rates of growth than others at 20°C (constant), while at 8°C (constant) these differences were less marked. All plants in the 20°/8°C (day/night) treatment eventually achieved greater height growth than 20°C (constant). The growth curves have been fitted by the Gompertz function and the data subjected to analysis of variance.

The flushing and extension growth of the same clones and progenies in the field, recorded during 1973, are being analysed similarly for comparison with the growth room data.

A second experiment examined the effects of different temperature regimes on the photoperiodic control of bud set and maturation in a complete provenance range of Sitka spruce. The plants were moved into the growth rooms at mid-summer and received reductions in photoperiod of 30 min per week. All provenances ceased growth at a photoperiod of 16 hr in the cooler temperature regimes of 8°C/5°C and 12°C/7°C (day/night), whereas growth continued in southern provenances until a photoperiod of 12h was attained in the 16°C/9°C and 20°C/11°C. It is concluded that temperature can have a marked influence on the photoperiodic control of growth cessation. The effect of these treatments on flushing and subsequent extension will be followed in the open, during the current season.

A third experiment to assess the chilling requirements for satisfactory flushing in Sitka spruce provenances is nearing completion. A range of provenances and clonal material which had set bud in the open were transferred to three chilling regimes (0°C, 3°C and 6°C) for periods of one, two, four, six or eight weeks. After chilling, the plants were placed in a greenhouse under long day and controlled minimum temperatures. Time to flushing of terminal and sub-terminal buds has been recorded, and assessments made of subsequent extension growth.

These experiments, which are being written up and published elsewhere, have already provided useful information for the production of experimental material in growth rooms, and together with other field measurements give an indication of some of the temperature effects on the vegetative growth cycle in Sitka spruce.

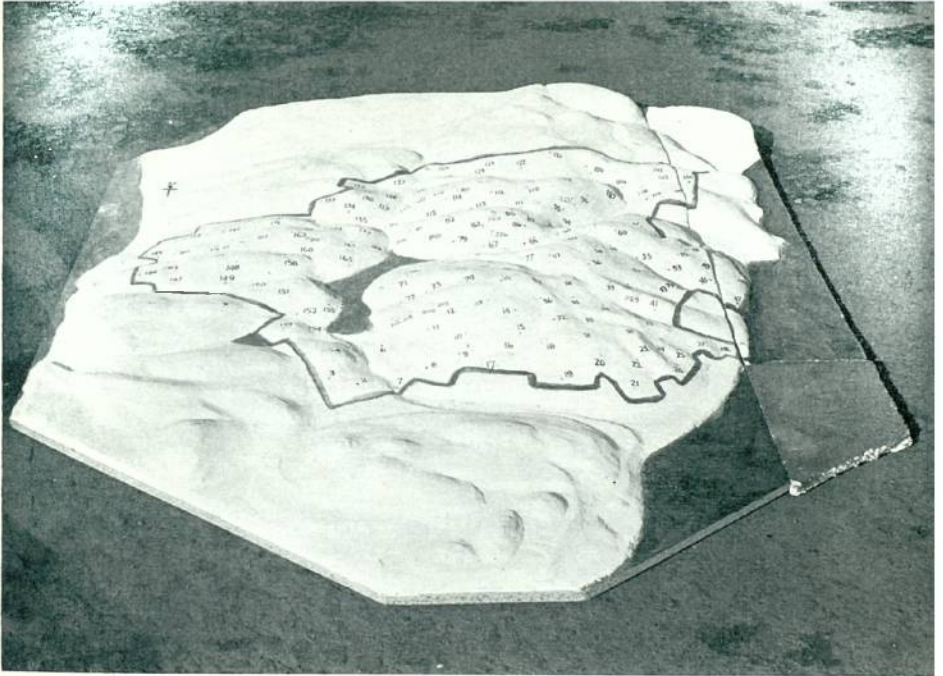


PLATE 1. Crop Stability (p. 28).
Topographic model of part of Kintyre Peninsula used in wind tunnel studies at Bristol University.
Vertical scale 2.5 x horizontal. C. 4959.

PLATE 2. Physiology (p. 35).
A Sitka spruce tree with divided roots. The root on the left was supplied with tap water only, that on the right with nutrient solution. C. 4955.

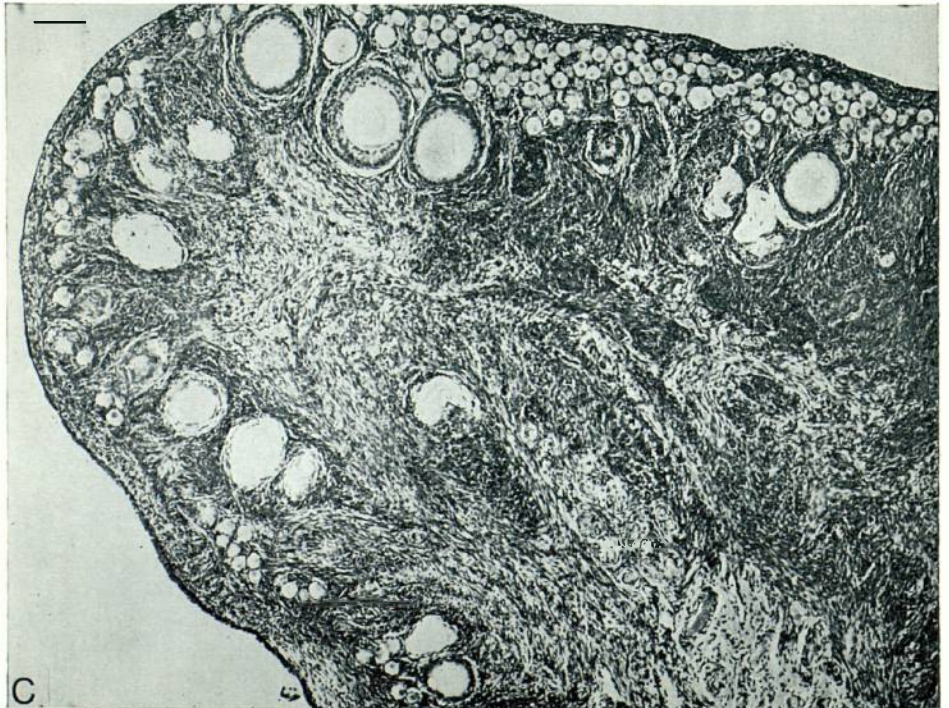




PLATE 3. Dubock and Johnson (p. 67).
Reproduction in the Grey Squirrel.

- A. Regressed testis with small inactive tubules.
- B. Active testis with large tubules containing sperm.
- C. Regressed ovary with small follicles.
- D. Active ovary with well developed follicles.

Magnification is shown by a line which represents 0.1 mm.



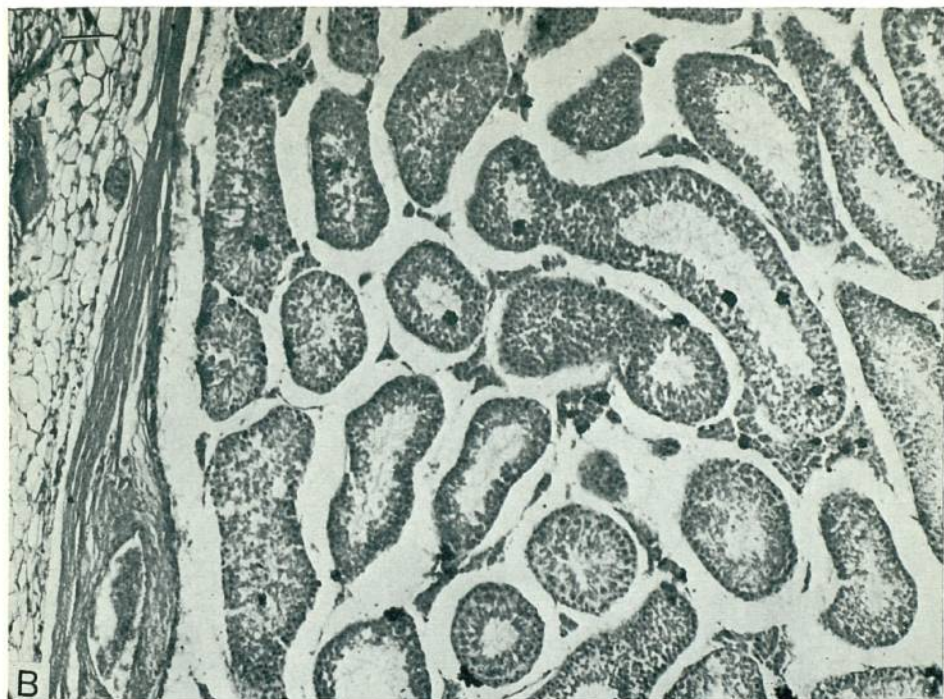




PLATE 4. Statistics and Computing (p. 50).

An IBM 029 card punch and a Philips 0096 dictation machine fitted with hi-fi earphones are used to transcribe data, which have been tape recorded in the field, onto punch cards. C. 4990.

RECREATION

THE RECREATIONAL POTENTIAL OF FORESTRY COMMISSION HOLDINGS

By BRIAN GOODALL

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Forest Environments and Recreational Requirements

Forest recreation is regarded as any form of outdoor recreation in a forested environment. Thus pleasure driving in the New Forest or game fishing on a Highland forest river are examples of forest recreation. Minimum or threshold requirements were established for some 40 activities, ranging from picnicking to skiing. The threshold approach is critical to the possible introduction of informal or casual recreational activity to a given forest. Unless the minimum conditions are met within that forest it will not be considered amongst the alternatives when choosing a site for the activity in question.

Analysis of data supplied by recreational organisations revealed common elements among user requirements. Since the recreational activities considered are not unique to forest environments these factors may be grouped as basic or physical conditions and mantle or forest characteristics. Amongst desired physical conditions the most frequently mentioned factors were climate, space, slopes, dissection, ground texture, local accessibility and attractiveness of water bodies. The mantle or intra-forest characteristics which emerged as significant were forest layout, height of trees, penetrability of plantations and spacing of trees, variety of tree species, a screening factor and the existence of forest route networks.

A Forest Recreational Potential Index

Detailed quantitative information for the factors identified above was obtained for a stratified sample of Forestry Commission holdings (Goodall and Whittow, 1972). This data, weighted according to the relative importance of the factors as discerned by recreational organizations, was used to construct an index against which the character of any forest could be measured to reveal its recreational potential. Calculation of the index was based on the form

$$P_R = P_1 + P_2 - P_3$$

where P_R was a measure of forest recreational potential on a scale from 0 (low) to 100 (high).

P_1 was a measure of topographical suitability based on the physical factors above.

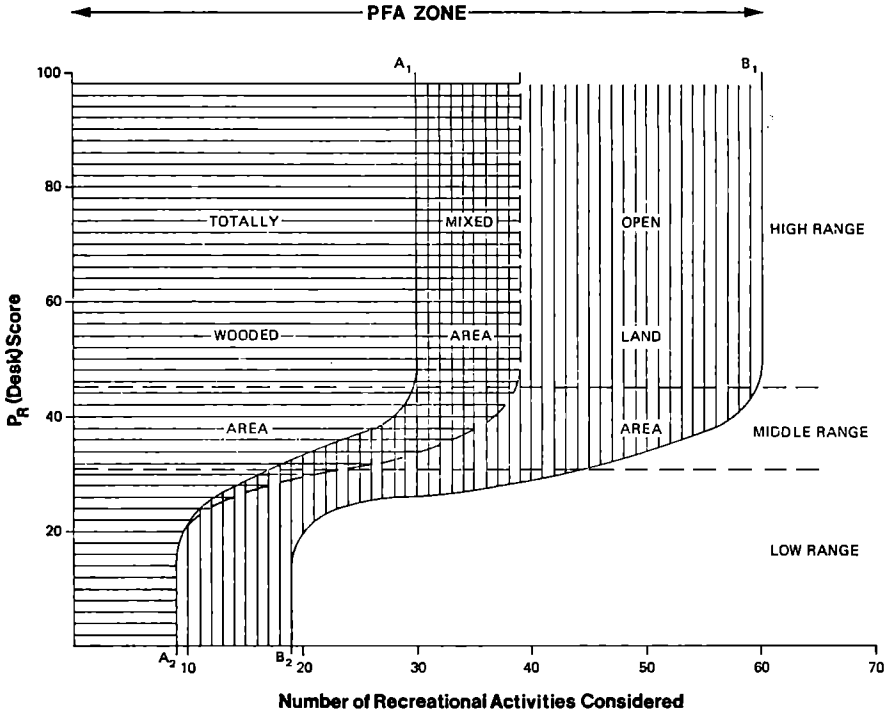
P_2 was a measure of mantle suitability based on the forest characteristics above.

and P_3 was a measure of accessibility/uniqueness based on intra-forest accessibility and proportion of woodland in a region.

Spearman rank correlation tests of the relationships P_R/P_1 , P_R/P_2 , etc. reveal that P_1 and P_2 are both significant in determining the rank order of P_R and that both are positively correlated with P_R , whereas P_3 (treated as an access penalty) is negatively correlated. The exercise was repeated as a desk study using surrogates for the above factors derived from Ordnance Survey and Forestry Commission stock maps. For the sample forests a Spearman test showed the field and desk versions to be significantly correlated at the 0.1 per cent level. The desk approach may therefore be substituted for the field study and used as a priority ranking device in the formulation of recreation strategies at national and conservancy levels.

Interpretation of the Index

The P_R scale may be related to the number of possible terrestrial activities and a potential forest activity zone distinguished as shown in Figure 3. Inflexions in the A_1 A_2 and B_1 B_2 boundaries represent thresholds on the scale, the lower based on the increasing importance of gentle slopes and the higher



A_1 — A_2 = Maximum number of activities that could take place in a totally wooded environmental area.

B_1 — B_2 = Maximum number of activities that could take place within a forest administrative unit.

Figure 3: The zone of potential forest activities.

on a significant proportion of mature trees. Thus a forest with a low P_R score is only likely to offer opportunities for recreational activities able to use forest roads and/or steep slopes, whereas in a forest with a high score the availability of areas of gentle slopes, mature woodland and open space increases the range of possible activities.

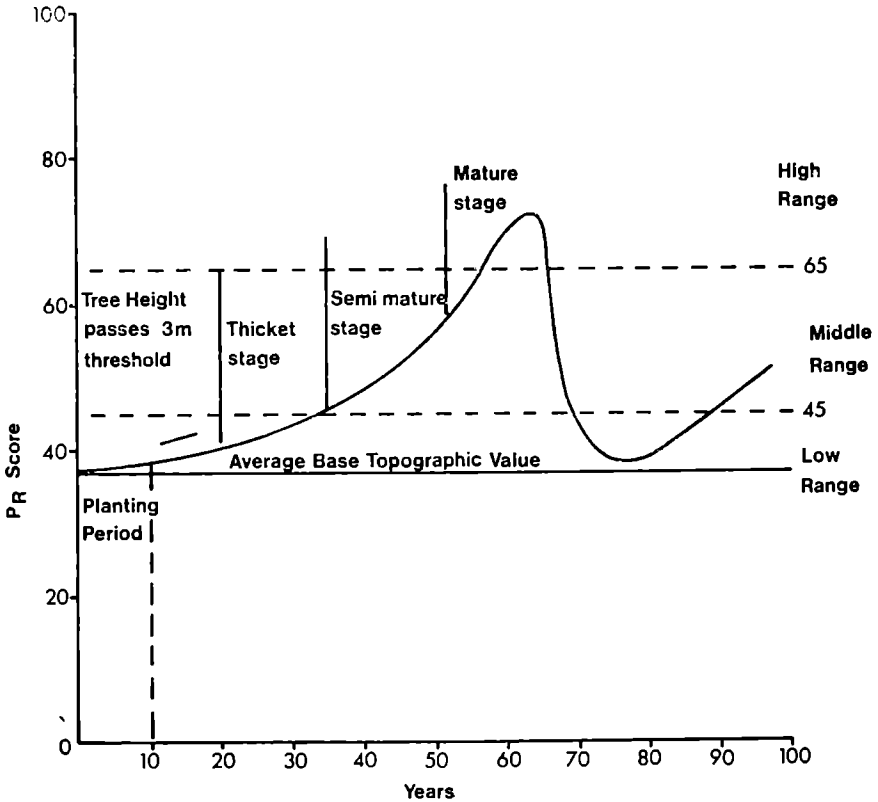


Figure 4: Projected trend of the P_R score of a hypothetical forest through time.

The P_R score for any forest changes over time. Although P_1 is constant, P_2 depends upon tree height and felling practices. The trend of P_R for a hypothetical forest over a 60-year rotation where all planting has been concentrated in a short period is shown in Figure 4. With a phased rotation the curve would be flatter. Thus, by projecting P_2 , it is possible to predict the future potential of a forest. The implications for forest management in respect of maintenance or improvement of potential should also be obvious.

The Recreational Potential of the Commission's Estate

The recreational value of forest stems from positive attractive features. Unattractive forest characteristics can, at a given time, negate advantages

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stemming from the availability of suitable physical conditions. Positive forest characteristics cannot, however, offset unsuitable physical conditions. A wide variety of conditions exist within the Commission's holdings (Goodall, 1973) and the P_R index provides an opportunity of evaluating the relative importance of the potential supply.

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SCOTTISH TOURISM AND RECREATION STUDY

By M. L. OWEN

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The background to the Scottish Tourism and Recreation Study and early work on the project were outlined in the *Report* for 1973. The programme of research is still continuing and final reports are due in June 1975. Since the pilot survey of 1973, the Scottish Arts Council has joined the four original sponsors and the major field surveys and coding of data have been completed; by the end of April almost all the information had been transferred to punched cards. The general framework for the presentation of results has been agreed between the sponsors and the Unit, and the project is entering a phase which will primarily be concerned with analysis and reporting.

During the winter of 1972/73 the results of the pilot survey and implications for the organisation and content of the main surveys were considered and preparation for the field work made. The content of the questionnaires was altered to such an extent that further pilot surveys became desirable. In the case of the cordon survey timing of the field work made this an impracticable proposition, but a second pilot for the home interview questionnaire was implemented in June 1973. Other modifications included an extension of the cordon survey to take in a larger part of the early holiday season, and the adoption of an incentive scheme to encourage respondents to return self-completed questionnaires. In addition, the Unit agreed to collect data in such a way that it could be stored in and analysed by the TRIP system (Tourism and Recreation Information Package). This computer-based system has been devised within the Tourism and Recreation Research Unit especially for the storage and analysis of tourism and recreation data. The cordon survey extended over a period of five months from 24th May 1973 to 17th October 1973. Interviewing took place at five road locations (A75, A74, A7, A68, A1) near the Scottish/English Border; at three airports (Prestwick, Glasgow, Edinburgh); on ferries travelling from Stranraer and Ardrossan to Ireland and on trains and coaches and buses travelling south from Scotland. Although, *in toto*, all respondents were asked the same questions (70 in all), whether they were asked direct or through the self-completed questionnaire varied with the situation. Thus, the direct questionnaire for rail travellers, who were interviewed during their journeys, was larger than that used at airports, where delays could not have been tolerated. The total number of interviews achieved is shown in Table 13.

TABLE 13
CORDON SURVEY INTERVIEWS

	<i>Road</i>	<i>Rail</i>	<i>Airport</i>	<i>Ferry</i>	<i>Coach/bus</i>	<i>Total</i>
Number of interviews:	6,319	2,402	1,295	750	830	11,596

The offering of incentives to lift the response rate for self-completed questionnaires was a marked success. The incentive scheme took the form of a draw, prizes for which consisted of hampers of Scottish Fare. The response rate was lifted from 48 per cent for the pilot survey to nearly 70 per cent for the main survey period.

Interviewing for the home interview survey was undertaken during the months of August and September 1974. The sample was drawn from valuation rolls for the whole of Scotland according to a sampling fraction calculated to generate a total of 7,000 interviews; the method ensured that all areas of Scotland were represented according to density of population.

A very tight organisation of the field work was essential since a large number of interviews was required in a short time for a relatively large area where the population was often scattered. Teams of interviewers operated from regional centres controlled by one national headquarters. The questionnaire itself was very comprehensive; it included 169 questions and took an average of 50 minutes to complete. Table 14 shows the number of interviews achieved by region.

TABLE 14
HOME INTERVIEW SURVEY INTERVIEWS

<i>Regional Centre</i>	<i>Number of interviews</i>
Aberdeen	556
Ayr	551
Borders	338
Dundee	868
Edinburgh	1,196
Glasgow	1,253
Hamilton	1,165
Inverness	369
Stirling	519
Total	6,805

The coding of more than 18,000 questionnaires has been a major undertaking, particularly since a feature of the Scottish Tourism and Recreation Survey is its consideration of data within a spatial context. Data for demand are not always easily attributable to geographical locations, but for this survey, the questionnaires were specifically designed for the purpose and maps were incorporated with a spatial analysis in mind. The punching of the data onto computer cards is presently being undertaken and will soon be completed; in all, more than 200,000 cards will be required.

The framework of analysis and publication procedures have been discussed and agreed with the sponsors; reporting will be undertaken under the following eight headings:

The Holidaymaker	Other Regional Reports
The Recreationist	The Theatregoer
Demand Atlas	The Woodland Visitor
Highlands and Islands Development Board	Supply/Demand

In the meantime, results will be provided for the sponsors in the form of computer output.

ENVIRONMENTAL PERCEPTION AND RECREATION

By A. J. VEAL

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This research is a desk study commissioned jointly by the Forestry Commission, the Countryside Commission and the Sports Council. Its aim has been to review techniques which have been developed by geographers, psychologists and others, for studying, measuring and understanding the individual's perception of his environment, and to examine their usefulness in recreation research and planning.

A number of papers have been produced during the course of the study and discussed with officers from the sponsoring bodies. The first of these (Veal, 1973) examined the question of perceptual capacity. It concluded that perceptual capacity was a relationship between apparent levels of recreational use and satisfaction of the user, rather than a single identifiable level of use. Methods were put forward for examining this relationship, including a decision-making model of the choice of recreation site, calibrated using discriminant analysis.

A second paper (Veal, 1973a) reviewed the various devices used by recreation modellers to arrive at measures of site attraction and ways in which recreational interviews have attempted to gain information on attraction and preference through questionnaires.

A third paper (Veal, 1973b) explored ways in which repertory grid and semantic differential techniques could be used to examine the individual's perception of available recreation opportunities as a whole, and how this approach could be incorporated in area recreation planning. In addition the possible uses of perception techniques in research on country parks, forests and sports centres were examined. In the case of forests it was suggested that techniques designed to identify people's perceptions of far places are relevant for forest areas which cater for holiday-makers. Much of American research on wilderness perception, though not immediately translatable to the British context, has methodological interest, and points up the conflict between the view that forest recreation areas should be "natural", and on the other hand, the desire for the comforts of civilisation such as surfaced roads, lavatories and water supplies. Other areas in which perception techniques would be relevant are in assessing attitudes to landscape, to scenic routes, and to camp-site facilities.

The final report from the study (Veal, 1974) summarised the previous papers, reviewed techniques and applications in more detail, and included an annotated bibliography of some 400 items. The review illustrates how almost the whole range of social science research techniques have been used to elicit perceptions of, and attitudes towards, the recreational environment. There has, however, been little testing of reliability or validity of techniques in recreational contexts and very little evidence is available on whether or not the results from such studies have been useful in policy decisions. The techniques reviewed are: "ordinary" questions, attitude checklists, attitude statements, the semantic differential, repertory grids/personal constructs, mental maps, gaming, pictorial

displays, observation, and measurement of physical responses. The more popular techniques in recreation are the straightforward question, attitude checklists, pictorial displays and observation. Some of the techniques which may be promising in some contexts have yet to be fully used "in the field"; examples are the repertory grid which has been primarily a psychologist's "laboratory" technique, and the mental map which has been developed using highly educated groups of the population. A key recommendation of the study is that comparative methodological survey work needs to be carried out, either by mounting special projects or by the addition of a monitoring/coordinating element to on-going work being sponsored by, or carried out by, public recreation authorities. Uses of techniques in particular recreational contexts are reviewed under the following headings: attitudes to recreation in general; urban recreation; countryside recreation; tourism; roads-pleasure driving; on-site activity, perceptual capacity etc. It is noted that urban recreation has been relatively neglected so that there is scope for the use of perceptual techniques in almost any area of urban recreation. In other areas the use of perception techniques in exploring overall perceptions of recreational opportunity, as outlined in an earlier paper, is seen as an area of research with potential. Other research areas are the differences in perceptions between different managers and recreationists and the differences between different groups of users; tourism strategy; the development of the second home market; the planning of scenic routes; and perceptual capacity. In addition to the proposed comparative methodological research, a priority area for research, it is suggested, is research into the use of environmental research findings in policy formulation and decision making.

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TIMBER UTILISATION
JOINT RESEARCH PROGRAMME ON
HOME-GROWN TIMBER
PRINCES RISBOROUGH LABORATORY AND FORESTRY
COMMISSION

By T. HARDING

*Princes Risborough Laboratory, Building Research Establishment,
Department of the Environment*

During 1972, agreement was reached whereby the Forestry Commission, as the Forest Authority, would support research on home-grown timber at the Princes Risborough Laboratory to the extent of about 4 man-years of research time per year. This support commenced in April 1973 and will be reviewed annually. It was agreed that the research would be concentrated in two main areas: (a) forest management studies and (b) sawmilling and associated utilisation sectors.

Evaluation of Forest Management Practices

Two sub-projects were formed to cover the objectives: (a) the development of non-destructive techniques which can be applied to the standing tree for estimating the density and fibre yield that will be obtained, and (b) evaluation of the effects of tree spacing, thinning practice and fertiliser application on wood density and fibre yield.

**The Effect of Pruning on the Quality and Value
of Douglas Fir Sawn Timber**

During 1971, a compartment in the Monaughty section of the Laigh of Moray Forest (Moray) became due for clear felling. The compartment had been planted with Douglas fir in 1924 and from age 14 onwards pruning treatments and thinning had been applied regularly. The operations had been very carefully recorded, thus offering a rare opportunity to carry out a sawmilling study on material from a very well documented experiment.

The knotty core of each pruned log was converted as the cant and the remainder was sawn into 25 mm boards. Approximately 60 per cent of the total sawn volume, or 80 per cent of the board volume, was clear of all knots. Growth rate averaged six rings per 25 mm, excluding much of the timber from the highest grade, but its quality was nevertheless excellent. From a timber quality point of view the pruning exercise, now completed, was most worth while but more work is being carried out on the economics of the pruning before the final report is presented.

Assessment of 40-50 year-old Sitka Spruce

A comparison has been made of the timber from three yield classes in order to (a) determine the percentage yield of sawn timber outturn, (b) determine the

sawn timber grade yields in both the green and air-dried conditions, (c) assess the woodworking characteristics based on standard machine tests, and (d) determine density, bending strength, stiffness and incidence of spiral grain on growth.

Conversion, Processing and Utilisation of Home-Grown Timbers

Four sub-projects were formed to cover the objectives: development of a computer model for the conversion of softwood sawlogs; evaluation of specific items of sawmill equipment for the conversion of home-grown sawlogs; provision of information on the optimum sawmilling system or range of systems for the conversion of home-grown sawlogs; and evaluation of the use of sawn Sitka spruce for the manufacture of trussed rafters.

The Splitting on Nailing of Larch and Douglas Fir

This investigation, now completed, was undertaken following a suggestion that the use of larch and, to a lesser extent, Douglas fir could be expanded in the box-making and packaging industries if the incidence of splitting could be reduced.

The investigation showed that: there is little difference in its splitting characteristics when larch is nailed green and air dried; Douglas fir appears to be more prone to splitting on nailing compared with larch; end splitting is unlikely to occur with either Douglas fir or larch when using the CP 112 recommended spacings for nailing; spacing and end distance along the grain of half the CP 112 values is probably suitable for larch, but Douglas fir would probably require a larger spacing than larch for satisfactory results; where improved nails of comparable gauge to round wire nails are used, there is only a marginal, if any, reduction in the incidence of splitting; considerable difficulty was experienced in driving some ringed shank nails in larch; on the basis of their withdrawal strength, improved nails two gauges and possibly up to four gauges narrower could be used compared with round wire nails; use of narrower gauged improved nails could be expected either to reduce the incidence of splitting at the spacings appropriate for round wire nails of larger gauge, or allow nailing at closer spacings and nearer to the end grain.

Stress Grading of Home-Grown Softwoods—Corsican Pine

This was the fourth in a series of investigations initiated in 1969 to explore the advantages of applying machine grading techniques to Scots pine, Sitka spruce, Douglas fir and Corsican pine. Results for the first three species have been given in the 1971-73 *Reports*. The investigation on Corsican pine has been completed and data derived to permit the machine stress grading of this species. A combined report on all four species is being prepared for publication.

APPENDIX I

Publications by Forestry Commission Staff

Priced publications issued by the Forestry Commission are available from Her Majesty's Stationery Office at addresses shown on the back cover

AARON, J. R. (1973). Bark: A potentially useful by-product. *J. Inst. Wd Sci.* 6(3), 22-27.

Outlines the attempts made by the Commission since 1955 to find uses for conifer bark. These include extractives, control of oil pollution, litter for poultry and cattle, and as a substitute for peat in horticulture. The latter, which has become a commercial reality, is dealt with in some detail. The suitability of the individual species of bark for different uses is also considered.

BARDY, D. A. (1973). Harvesting with chainsaws. 1. Felling conifers. *For. home-gr. Timb.* 2(1), 36-39. 2. Cross-cutting—working techniques. *Ibid.* 2(2), 33.

These and subsequent articles describe the many and varied situations which the chainsaw operator meets, and attempt to set down the most appropriate techniques which experience has shown to be safe and efficient.

The techniques described are based upon analytical studies carried out in Forestry Commission conifer working and are not therefore entirely appropriate to hardwoods. Many of the decisive factors are, however, relevant.

The individual tasks which are commonly undertaken by chainsaw operators are covered. Material has been drawn extensively from the Forestry Commission's chainsaw training manual.

BARTHOLOMEW, W. (1973). Chainsaw sculpture. *For. home-gr. Timb.* 2(1), 33.

Describes how rough stools, barrel-shaped chairs and bird boxes were made by means of chainsaws. At Kielder Forest wooden equipment for an adventure playground for children was fashioned by using a Husqvarna 180s.

BELL, T. I. W. (1973). Erosion in the Trinidad teak plantations. *Commonw. For. Rev.* 52(3), 223-233.

Teak has been planted in Trinidad for 59 years, mainly as a pure crop at 6 ft × 6 ft spacing. As a result of repeated burning most of the coppice and natural regeneration of mixed species in these plantations has been killed. Soil erosion under the teak crop has caused concern for many years. Data from a run-off investigation are quoted and emphasise the problem. Teak planting trials, where a mixed broad-leaved undergrowth is retained, are described.

It is pointed out that an undergrowth of mixed species must be maintained and fires must be prevented in teak plantations if serious erosion is to be avoided. Planting of teak in strips of three rows separated by unplanted strips is recommended on a trial basis. If soil erosion cannot be reduced to a degree less than that of soil formation, consideration should be given to abandoning the policy of teak planting in Trinidad.

BIGGS, D. (1973). *Cablecrane design studies*. Res. Dev. Pap. For. Commn, Lond. 94.

The need to extract heavier loads over greater distances in mountainous regions using a cablecrane system gave rise to the following three questions: Is the existing equipment able to satisfy the new requirement? If not can it be so extended? Or is it necessary to design a completely new cableway system? In order to provide answers it was necessary, not only to determine the strength (and other relevant factors) of each component, but also to examine the system to determine its performance when subjected to the increased loads. This note outlines the present and future requirements as specified by the Forestry Commission; evaluates the forces likely to be imposed on such a cableway system; considers that the present equipment should be limited to a maximum extraction load of approximately 1,500 kg, and outlines the general design criteria for a new cableway extraction equipment.

BRASIER, C. M., and GIBBS, J. N. (1973). Origin of the Dutch elm disease epidemic in Britain. *Nature* 242(5400), 27 April, 607-9.

Evidence is presented that the current Dutch elm disease epidemic in Britain most probably originated in the importation—during the 1960s—of Rock elm logs (*Ulmus thomasii*) infected with the aggressive strain of *Ceratocystis ulmi*.

BRASIER, C. M., and SANSOME, EVA* (1973). Intracellular spore formation in *Ceratocystis ulmi*. *Trans. Br. mycol. Soc.* 61, 588-590.

Describes the formation of intracellular spores within the hyphae of aggressive and non-aggressive isolates of *C. ulmi*. Some spores were apparently formed like conidia from narrow hyphae growing within very broad hyphae; others were apparently formed by direct differentiation of cell contents.

BROWN, ROGER M. (1973). *Cold storage of forest plants*. Forest Rec., Lond. 88 (HMSO 22p).

A review of the technical requirements for satisfactory cold storage of forest planting stock in Great Britain, concluding with recommendations for cold storage. The two main types of cold store are described and important factors to take into consideration when constructing a cold store are discussed.

BROWN, ROGER M., ROGERS, E. V., and THOMSON, J. H. (1973). Ultra low volume spraying—a new approach to forest weeding. *For. home-gr. Timb.* 2(6), 39-40.

A description of the ULV technique of applying 2, 4, 5-T to lowland woody broadleaved weeds and 2, 4-D to heather (*Calluna vulgaris* L.) developed by the Forestry Commission since 1969, together with a brief résumé of the results of trials.

BURDEKIN, D. A., and EDLIN, H. L. (1973). Dutch elm disease. *Span* 16(2), 74-76.

The current severe epidemic of Dutch elm disease in England is the subject of a great deal of interest, not only from the public but from landowners, professional foresters and plant pathologists. The most alarming aspect of the disease is the speed with which it has spread and defied control measures in three countries with strong traditions of tree care and research—the Netherlands, Britain and the United States. This article reviews the subject from the points of view of amenity, control and economic impact.

CARTER, C. I., and EASTOP, V. F.† (1973). *Mindarus obliquus* (Chol.) (Homoptera, aphidoidea) new to Britain and records of two other aphids recently found feeding on conifers. *Entomologist's mon. Mag.* 108, 202-204.

An account is given of the occurrences of *Mindarus obliquus* on spruce in Britain, and features are described that distinguish it from *Mindarus abietinus*.

Two other aphids *Aphis gabrae* and *Aulocorthum circumflexum* have now been found feeding on young conifer foliage. Both of these species are polyphagous and known vectors of a number of plant viruses. The use of these species in the transmission of possible conifer viruses is suggested.

CHARD, J. S. R. (1973). Forestry in Staffordshire. *Forestry* 46(1), 21-30.

A brief survey of the woods and forests of Staffordshire, their past history, their extent and composition, and their present day problems and potential.

CHRISTIE, J. M., MILLER, A. C., and BRUMM, L. E.‡ (1974). *Nothofagus yield tables*. Res. Dev. Pap. For. Commn, Lond. 106.

The general yield class curves and normal yield tables provided here are applicable to *Nothofagus procera* and *N. obliqua*. Their construction is based on measurement data taken from some 30 sample plots located in various parts of the country.

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‡FAO Fellow.

EDLIN, H. L. (1973). *Atlas of plant life*. 128 pp. 179 illus, 34 maps. London: Heinemann, £2.95. French edition, *Atlas des plantes*. Paris: Nathan (1974).

Atlas of plant life presents a continent-by-continent review of the world's wild and cultivated plants. Full colour illustrations accompany the text and easily identifiable symbols show distribution on attractive colour relief maps. Many of the plants are shown in their natural settings, a presentation that establishes the "atmosphere" of each region—from the dark, impenetrable rain forest of central Africa to the brilliant flame trees of south-east Australia. Crop plants are discussed in the chapters featuring the areas in which they are now mainly cultivated.

The text relates plant distribution to climate and other natural factors and also to man's intervention—a theme that is further explored in the final chapter, which looks at some important examples of man-made plant migrations.

EDLIN, H. L. (1973). Woodland notebook: Photographing forests. *Q. Jl For.* 67(2), 140–149.

Written from the standpoint of an amateur photographer using simple equipment, this article discusses the problems of securing meaningful photographic records of growing forests. Tree canopies intercept a proportion of daylight that may vary from 10 to 90 per cent, depending on kind of tree, time of day, and season of year. Photographs taken from outside the canopy, whether from above or one side, cannot show the character of the stems beneath it. Below the canopy, deep shade and the obstruction of tree trunks present problems, while upper foliage cannot be seen. Usually the best results are secured by taking advantage of clearings or rides that expose trees from tip to foot. This allows fairly even illumination, but it is still difficult to judge a film exposure suited to all parts of the picture; types of film that allow latitude for some over-exposure or under-exposure consequently give the best overall results.

EDLIN, H. L. (1973). Woodland notebook: Forests on Table Mountain. *Q. Jl For.* 67(3), 210–220.

The slopes of Table Mountain, towering above the seaport city of Cape Town in South Africa, provide an impressive setting for flourishing forests of sub-tropical pines and eucalyptus trees. Some of these are owned by the state, others by the municipality, while much open land is administered by the regional authority. Except in times of high fire risk, the paths through the forests are open to the public and are much used for recreational walking towards high viewpoints. The success of introduced trees raises problems, which are fully appreciated, for the conservation of the Cape's unique and exceptionally beautiful native flora. Rare species enjoy legal protection and are effectively displayed in botanic gardens, notably at Kirstenbosch.

EDLIN, H. L. (1973). Woodland notebook: Action photos in forestry. *Q. Jl For.* 67(4), 314–325.

Action photos, showing men and machines engaged on actual operations in the woods, are coming into increasing use for many practical applications in forest management. They now play a part in worker training, work study aimed at increased efficiency, publicity, and the advertising of machinery. Improvements in cameras and films bring such photos within the reach of professional foresters who may only rank as amateurs in the photographic field. The difficulties presented by the light and shade of the woodlands, and the constant movement of the subject to be recorded, are discussed. Hints are given on getting acceptable photos, which can serve as valuable records of past operations or recent developments in techniques. Five representative pictures are reproduced.

EDLIN, H. L. (1973). *Trees and timbers*. 88 pp. 60 illus. London: Routledge & Kegan Paul, £2 (paper-back £1).

A look at one living tree is the starting point for this guide to forests, wildlife and the wide range of uses for trees and timbers. The Author shows how to observe and name every part of each tree—heartwood, sapwood, bark, buds, shoots, foliage, flowers and seeds. Features that distinguish one kind of tree from another, at all times of the year, are described and

illustrated, and the forester's work in raising and tending plantations and harvesting timber is outlined. The reader is introduced to the wealth of poetry, literature, painting and design that is inspired by forest life. A survey of forests overseas demonstrates how important they are for the conservation of soil, wild life, recreation and the world timber trade.

EVANS, J. (1973). *Resurvey of second rotation Pinus patula in the Usutu Forest, Swaziland*. Report for the Government of Swaziland of UK Overseas Development Administration Technical Assistance Research Scheme R.2754.

The project was undertaken in June and July 1973 at the request of the Swaziland Government and was a follow-up to some post-graduate research carried out by the writer, between 1968 and 1971, into an alleged decline in growth of second rotation conifers compared with the first. This resurvey was done at a time when second rotation areas were 10 years old, and only about one-third remained of the first rotation crop. It was found that, at ten and nine years, the growth of the second rotation was still slightly better than the first but that the differences of about 5 and 8 per cent were not statistically significant. There was very little difference between the rotations in increment put on in the four years from age six to ten and five to nine. The growth of the more recently planted crops was found to be better than both the older second rotation and the first rotation. It is considered that by the end of the rotation, if future rainfall amounts are about average, a slight decline in second rotation growth (0-5 per cent?) might be evident; it is not likely to be statistically significant overall because of the large variation present.

EVERARD, J. E. (1974). Ligniculture—modern silviculture in France. *For. home-gr. Timb.* 3(1), 24-26.

Shows the results of a study of modern methods used in France to establish coniferous plantations, and of how far these methods might be applied in Great Britain.

GORDON, A. G., and TEE, L. A. (1973). Seed and seedling losses in nursery beds. *Q. Jl For.* 67(2), 150-153.

The annual loss of seeds removed from or destroyed in seed beds by pests, rain, wind, etc. exceeds £40,000 in value. This is bad enough in itself, but with good seed in short supply, nurserymen should ensure by every possible means that their seed beds are protected.

GREGORY S. C., and PETTY, J. A.* (1973). Valve action of bordered pits in conifers. *J. exp. Biol.* 24(81), 763-767.

The pressure needed to displace a bordered pit membrane to seal a pit aperture is compared with that needed to force an air-sap meniscus through the largest pit membrane pore. The former is smaller for early-wood pits, which thus prevent spread of air bubbles in the transpiration stream.

HAMILTON, G. J. (1973). *Volume tables for smallwood and round pitwood*. Bookl. For. Commn 37 (HMSO 12p).

HAMILTON, G. J., and CHRISTIE, J. M. (1973). *Construction and application of stand yield models*. Res. Dev. Pap. For. Commn, Lond. 96.

The paper describes the need for yield models within the Forestry Commission, briefly reviews the source of data, and outlines the methods of model construction which are used. The model building program described is a development of that used to construct the normal yield tables contained in Forestry Commission Booklet No. 34 entitled *Forest Management Tables (Metric)*. The program accommodates different initial spacings, thinning intensities, thinning cycles and thinning types for any yield class of most of the commercial species used in Britain. The uses of the models in production forecasting, economic appraisals, and valuation are described.

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JOHNSTON, D. R. (1973). *Production planning in the Forestry Commission*. Res. Dev. Pap. For. Commn, Lond. 102.

The first attempts at objective, long-term production planning in the Forestry Commission were made in the early 1960s. They suffered from two major shortcomings. First, insufficient allowance was made for departures from standard cutting regimes, and secondly not all the abnormalities of the crops were allowed for.

In the current system five stages are recognised: the forecast of potential yield; the forecast of production; the production plan; sales plans; and the annual harvesting and marketing budgets.

The inventory data are collected partly by specialist surveyors of the Field Surveys Branch and partly by quinquennial sample checks by the local staff collaborating with the specialist surveyors.

Non-standard cutting schedules are defined by the Conservator.

All the long-term forecasts and plans are produced by a computer.

In the future, more attention will be paid to the measurement of standing volumes and to monitoring the development of the growing stock.

JOHNSTONE, R. C. B. (1973). *An approach to selection for second phase clonal seed orchards*. Paper for International Symposium on genetics of Scots pine, 1973. Warsaw: Polish Academy of Sciences. 8 pp.

Half-sib Scots pine plus tree progeny tests are indicating that few parent trees provide very vigorous offspring. The proportion of the parent plus trees to be included in second-stage seed orchards will be low. Most progenies which have outstanding vigour show this at an early stage and on a wide range of sites. It is suggested that progenies should be tested over a short period of five-seven years on sites where growth will be rapid. This will permit faster screening of progenies and so allow more candidate breeding trees to be considered with the same resources.

LEWIS, A. B., and LINES, R. (1973). *Flushing time for Norway spruce (Picea abies (L.) Karst.): A comparison between assessments in the nursery and forest stages*. Res. Dev. Pap. For. Commn, Lond. 101.

A comparison of "stage of flushing" assessments carried out on the same provenances of *Picea abies*, as transplants in the nursery and in the forest three years after planting out, produced a highly significant correlation between the two assessments. There were large differences in flushing among geographical groups of provenances, East European sources flushing much later than Austrian ones.

LINES, R. (1973). Climatic changes and their possible effects on forestry in Scotland. *Scott. For.* 27(2), 103-109.

Studies of long-term climatic changes show that the warmer first half of the 20th Century may be followed by a cooler second half, and in particular there seems to be a decrease in westerly weather types and an increase in easterly types associated with high pressure over Scandinavia.

If this assumption proves true and if the scale of the climatic change is large, it is likely to affect forestry in several ways depending on whether the effect is simply a lowering in temperature or a change to greater extremes of hot and cold weather. A large part of current planting is above the 1,000 ft contour, and any climatic change is likely to have its biggest effect on sites where conditions are already marginal. Changes in mean temperature may be slight but could be associated with more frequent unseasonal frosts. Climatic change could influence silviculture, management practices and soils.

LINES, R. (1973). *International Norway spruce experiment at the Bin, Huntly Forest, Aberdeenshire. Results up to 25 years*. Res. Dev. Pap. For. Commn, Lond. 98.

The IUFRO experiment with Norway spruce, *Picea abies* (L) Karst., was planted in 1942 at The Bin, Huntly Forest, Aberdeenshire. Results at the nursery stage are presented showing

that seedling dry weight of provenances was related to seed weight and that northern lots had a lower moisture content. Survival was high, though early growth was slow for all provenances and the site proved to be somewhat irregular in soil vegetation type. Nevertheless height differences were significant, with Romanian and South Polish provenances superior to those from Alpine and Scandinavian groups. Flushing patterns were similar in consecutive years. Scandinavian origins had markedly more indumentum on young shoots than Alpine or East European groups.

LINES, R. (1973). *Inventory provenance test with Norway spruce in Britain: first results*. Res. Dev. Pap. For. Commn, Lond. 99.

Three experiments were planted in Britain with a collection of up to 1,100 provenances of Norway spruce *Picea abies* in 1968. At Salisbury (Cranborne Chase Forest), Wiltshire, all provenances were included; at Drummond Hill, Perthshire, and Minard (Kilmichael Forest), Argyll, 200 were used (a different set at each site). The sites are described and results are shown for assessments of flushing and height after three years' growth in the forest. Early flushing provenances predominate in South Austria, Scandinavia and in parts of West Germany. Late flushing origins are Romania, Poland, East Czechoslovakia and North-west Russia. Some South European regions also contained late flushers. Height was examined principally as height increment because provenances were markedly different in size at planting. At both Drummond Hill and Minard there was a similar rank order of provenances for height increment with Romanian, Polish and Hungarian provenances significantly taller than those from France, Switzerland and most of the Scandinavian ones.

LINES, R. (1974). *Summary report on the IUFRO 1938 provenance experiments with Norway spruce, Picea abies, Karsten*. Res. Dev. Pap. For. Commn, Lond. 105.

Fifteen of the 25 experiments planted with Norway spruce *Picea abies* (L.) Karsten, using seed distributed by IUFRO in 1938, survive. Relative heights at 17–25 years are tabulated. Flushing stage was also compared at two of the 1938 experiments and these data are compared with flushing stage in two of the 1968 IUFRO experiments. The results show that for height growth there was a considerable similarity in the pattern of provenance performance over a wide range of sites. There was little evidence for strong site/provenance interaction. Certain groups of provenances notably from Romania, Poland and Western USSR were outstanding for height growth, while far Northern and far Southern provenances grew poorly. Flushing appears to be under strong genetic control as provenance behaviour was very similar in Sweden and Scotland in the 1938 experiment and also when comparing the same provenance regions in the 1938 and 1968 experiments.

LOW, A. J., and SHARPE, A. L. (1973). The long-term effects of organic and inorganic fertiliser regimes at Teindland nursery. *Scott. For.* 27(4), 287–295.

Contrasting fertiliser regimes based on hop waste only, inorganic fertilisers only, and a combination of the two were used annually for 20 years to raise one-year pine and spruce seedlings in a heathland nursery. In most seasons, all three regimes gave satisfactory seedling growth and yield. There was no evidence of a decline in seedling quality caused by repeated annual use of the purely inorganic regime.

LOW, J. D., and GREIG, B. J. W. (1973). Spring frosts affecting the establishment of second rotation crops in Thetford Chase. *Forestry* 46(2), 139–155.

Spring frosts in Thetford Chase cause a major reduction in the growth of young Corsican pine and very severe frosts or repeated frosting may kill the trees. Records of temperatures taken on a range of sites and in different conditions have shown that (a) spring frosts occur every year at Thetford, but the severe frosts which kill trees outright may only occur once every few years, (b) frost damage to plants mainly occurs when the trees are less than 18 in (45 cm) tall, (c) forest clearings larger than 5 acres (2 ha) do not act as artificial frost hollows, (d) cold air flows down slopes of more than 1° and accumulates at the bottom, forming a frosty zone.

Studies showed that frost damage can be minimized by (a) complete cultivation, (b) deep ploughing, (c) underplanting, and (d) strip felling. The benefits of these measures are demonstrated by temperature records and by measurements of tree growth.

Methods of reducing frost damage are necessary in areas prone to spring frosts if crops of Corsican pine are to be successfully established at low cost.

MAIR, A. R. (1973). Dissemination of tree seed: Sitka spruce, Western hemlock and Douglas fir. *Scott. For.* 27(4), 308-314.

As coniferous crops approach felling maturity, which in some instances is forestalled by windthrow, restocking by natural regeneration from remaining uncut edges must seem an attractive proposition to many foresters, especially with rising costs, both of nursery stock and labour for replanting.

The main factors affecting the quantity and distance of seed dispersal are the tree species, stand composition, height of seeding trees, periodicity of seedfall and the meteorological conditions of the locality.

This paper summarises available data on these factors in respect of Douglas fir, Western hemlock and Sitka spruce. Information applying to British conditions is very limited. A few seeding studies have been carried out on Sitka spruce in south and west Scotland, but these have been of short duration.

The three species are dealt with separately and summarised data are given in diagrammatic form.

MASLEN, N. R., and CARTER, C. I. (1973). *Cinara escherichi* Börner (Homoptera: Lachnidae), a new record with a key to the other British pine-feeding *Cinara* species. *Entomologist* 106, 241-246.

The occurrence of a new species of pine aphid in Britain is recorded with information on distribution and host plants in Europe. An illustrated key is given that enables adult females of the genus *Cinara* on pine to be identified to species.

MAYHEAD, G. J. (1973). Windthrow problems. *Coedwigwr* 25, 16-20.

The reasons for financial loss from windthrow are summarised, as is the current research effort in the Forestry Commission. A method of calculating critical height and critical windspeed is illustrated. The sway period of trees is predictable from breast height diameter and tree height. It is concluded that no great advances in windthrow prevention seem likely in the foreseeable future. The major short-term financial savings will arise from managerial skill aimed at anticipation and coping with throw.

MAYHEAD, G. J. (1973). Some drag coefficients for British forest trees derived from wind tunnel studies. *Agric. Met.* 12(1), 123-130.

A wind tunnel was used to determine the drag coefficients of a variety of commercial conifers 19-28 ft (6-8 m) tall. The drag coefficients varied within and between species and with windspeed. Fixed drag coefficients were estimated for use in critical tree-height calculations. The practical applications of drag coefficients and critical tree heights are discussed.

MAYHEAD, G. J. (1973). The effect of altitude above sea level on the yield class of Sitka spruce. *Scott. For.* 27(3), 231-237.

The yield class-elevation relationship for Sitka spruce in Great Britain is not constant. A series of linear equations are presented which describe the relationship for eight different regions; predicted altitudes for GYC 6 vary from 350-890 m. The results should be of use in appraising yield potential.

MAYHEAD, G. J. (1973). Sway periods of forest trees. Letter in *Scott. For.* 27(3), 256-257.

Answers criticisms of his article (*Scott. For.* 27(1), 19-23) on comparison of trees with metal rods.

MAYNE, P. (1973). *Check list of Forestry Commission publications, 1919-1973*. Res. Dev. Pap. For. Commn, Lond. 100 (revision of Forest Rec., Lond. 58).

This is an historical record of work done during the first fifty-four years of the Forestry Commission's existence, until the end of 1973. It serves five purposes; it helps administrators

to locate Acts of Parliament, reports, and other papers relevant to their work; it aids librarians and bibliographers to check the existence, description and availability of particular publications; it helps research workers to locate documents needed for scientific or historical studies; it shows the main trends of activities over the years, particularly in the research field, since most investigations give rise to a group of published papers; it shows to a large degree who the active workers were; and also, since many papers are quite recent, who is still likely to be active in any particular field.

MITCHELL, A. F. (1973). Conifers in the western United States; some observations on bark. *Jl R. hort. Soc.* 98(10), 449-452.

On a tour extending 3,700 miles by bus from Seattle to Los Angeles, the colour and form of the bark was noted, particularly for six species. In Britain, *Pinus jefferyi* and *P. ponderosa* are distinguishable by bark alone, as are *Abies concolor* and the comely *lowiana*, whereas *A. magnifica* and *v. shastensis* are separable only by the cone. In the USA both *P. ponderosa* and *P. jefferyi* have orange-brown to deep red-brown bark, some of each very distinct but many not separable. Low's fir throughout its range towards *A. concolor* has the same coarsely ridged black and ashen grey bark. *A. magnifica* has a deep red bark quite distinct from the black and grey on *v. shastensis*.

MITCHELL, A. F. (1973). Some trophies of 1972, jottings from a tree hunter's notebook. *Int. Dendrol. Soc. Yearbook 1972*, 40-44.

The dimensions of 115 trees measured during 1972 are given with some notes on them. The regions covered include Dorset, Devon and Cornwall, Cumberland, South Scotland and Suffolk. Many of the biggest specimens known in Britain were remeasured. Several examples are given of the remarkably rapid growth of the Hybrid wingnut *Pterocarya x rehderana*.

MITCHELL, A. F. (1973.) Memoirs of a tree hunter. In *Batsford's gardeners' bedside book*, pp. 197-204. London: Batsford.

Light-hearted account of the more unusual and interesting events and people encountered in twenty years of measuring trees.

MITCHELL, A. F. (1973). Identikit for conifers. *Amat. Gdng*, 5 May, pp. 26-27.
Twenty drawings of genera with description of main features and disciplines.

MITCHELL, A. F. (1973). Colour in dwarf conifers. *Amat. Gdng*, 29 Sept., pp. 2-3 and 20.
Résumé of the value of dwarf conifers and some of the most useful in each main genus.

MITCHELL, A. F. (1973). Ivy on trees. Letter in *Q. Jl For.* 67(4), 359-360.

Notes some of the manifold benefits to wildlife from ivy, for cover, roosting, hibernating, nesting and feeding. It is maintained that except on ash trees, a healthy crown of leaves keeps the ivy from growing out to endanger the tree until the tree is senile.

OAKLEY, J. S. (1974). Trees follow the plough. *Fm Contractor*, 12 Feb./March, 46-47.

A discussion of the ploughing needed in forestry in relation to the soil types encountered and the needs of growing trees. From these considerations the author suggests the type of equipment that should be used for a range of working situations.

ORMROD, P. C., and STERN, R. C. (1973). *Report of a working party on lorry transport of roundwood*. Res. Dev. Pap. For. Commn, Lond. 97.

Examines existing methods of lorry transport, together with loading and unloading methods, and considers means of controlling or reducing costs.

PHILIPSON, J. J., (HILLMAN, J. R.*, and WILKINS, M. B.*) (1973). Studies on the action of abscisic acid on IAA-induced rapid growth in *Avena* coleoptile segments. *Planta* 114, 87-93.

A linear displacement transducer has been used to monitor the growth of a column of *Avena* coleoptile segments in flowing solution. IAA at 10^{-6} M in phosphate buffer of pH7

*Botany Department, University of Glasgow.

promotes growth after a latent period of treatment with 10·9 min, the initial maximum growth rate occurring after 25 min. Simultaneous treatment with 10^{-5} M ABA does not affect either the latent period or the initial maximum growth rate in response to the IAA treatment, but subsequently gives rise to an inhibition of growth detectable after 30 min. In contrast, pre-treatment with ABA for 100 min increases the duration of the latent period and reduces the initial maximum growth rate. Removal of the ABA rapidly relieves the inhibition of IAA-induced growth but a growth rate comparable to that of material treated only with IAA is never attained. Studies using 2-(14 C)ABA and 1-(14 C)IAA suggest that the latent period before ABA inhibition of growth is detectable is not due to a lag in ABA uptake, and that ABA is not acting by reducing IAA uptake.

PHILIPSON, J. J., (HILLMAN, J. R.* and WILKINS, M. B.*) (1973). The effects of temperatures and IAA concentration on the latent period for IAA-induced rapid growth of *Avena* coleoptile segments. *Planta* 114, 323-329.

Indoleacetic acid buffered at pH 7·0 induces a high growth rate in *Avena* coleoptile segments after a latent period, the duration of which is dependent upon both IAA concentration and temperature. A minimum latent period of 7·3 min is observed at 25°C with 10^{-9} M IAA in phosphate buffer at pH 7·0.

In contrast, 5×10^{-3} M IAA made up in 0·01 M KH_2PO_4 alone, promotes elongation almost immediately, regardless of whether the segments have been previously incubated in 0·01 M KH_2PO_4 at pH 4·7, or phosphate buffer at pH 7·0. This immediate response is unaffected by 10^{-4} M KCN which abolishes the rapid growth induced by 5×10^{-3} M IAA buffered at pH 7·0 but does not affect the immediate appearance of low-pH-induced growth. Since we consistently find solutions of 5×10^{-9} M IAA in 0·01 M KH_2PO_4 to have a pH of 3·5, our results indicate that the immediate growth response elicited by this solution is attributable to its low pH rather than to the presence of IAA as previously reported in the literature.

(McWHA, J. A.*) PHILIPSON, J. J., (HILLMAN, J. R.* and WILKINS, M. B.*) (1973). Molecular requirements for abscissic acid activity in two bioassay systems. *Planta* 109, 327-336.

Twenty-two analogues of ABA have been tested in the *Avena* coleoptile and lettuce germination bioassays. Ten of these analogues were considerably more active than ABA itself as inhibitors of lettuce germination, but in the *Avena* coleoptile assay their activity never significantly exceeded that of ABA. The molecular requirements for activity also differ in the two assay systems, although the presence of the ring double bond is a requirement of both.

PLATT, F. B. W., and WOOD, P. (1973). *Hydratongs*. Leaflet For. Commn, 55 (HMSO 10p).

Agricultural tractors play an important part in extracting timber in the flat sandy pine forests of East Anglia. Hydraulic tongs which fit on the three-point linkage at the back of the tractor have been developed by the Work Study Branch and are described in this leaflet. They are now available commercially.

PRIOR, R. (1973). *Roe deer management and stalking*. Booklet No. 17. 82 pp. Illus. Fordingbridge: The Game Conservancy. 75p.

The purpose of this booklet, published in co-operation with the British Deer Society and the Forestry Commission, is to summarise the theory on which modern roe management is based, and to show how a reasonable balance can be struck between the occupation of our woodlands by deer, and the other activities which may take place in them; in particular, forestry and game shooting.

The principles of management are examined from a conservationist's point of view: that with wise use roe represent a renewable resource, capable of yielding a harvest both in terms of sport and venison, with which to balance the limited degree of forest damage that is unavoidable when these deer are present. For this reason, the natural history of the roe is first discussed so that the measures suggested for managing a roe population and for reducing forest damage can be fully understood. In contrast to the management of game birds, where preparations for a limited number of days' shooting occupy most of the year, the work and the pleasure of roe management go hand in hand, and much of the time the roe stalker will

*Botany Department, University of Glasgow.

have a rifle on his shoulder. For this reason a full section is given up to suitable rifles and equipment so that roe can be managed not only efficiently, but also as humanely as possible.

PRIOR, R. (1973). British Roe for foreign stalkers. *Country Life*, July 26, 253–254.

Discusses the adaptability needed by a professional stalker in introducing foreign visitors to the sport in Britain, where conditions may vary greatly from those of their home country. The commercial aspect is also discussed.

RAY, A. (1973). Husqvarna 165R clearing saw. FC/HGTAC Technical Note No. 11. *For. home-gr. Timb.* 2(6), 46.

It is not always possible to use tractor-mounted or pedestrian-controlled wheeled weeding machines. In certain circumstances, a portable clearing saw has advantages. Costs and outputs are given.

REDFERN, D. B. (1973). Growth and behaviour of *Armillaria mellea* rhizomorphs in soil. *Trans. Br. mycol. Soc.* 61(3), 569–581.

The number and dry weight of rhizomorphs produced from woody inocula containing *Armillaria mellea* (Vahl ex Fr.) Kummer and buried in soil varied with soil type and incubation temperature. Fewer rhizomorphs were initiated at 15°C than 25° but the total dry weight of rhizomorphs was approximately the same. Within as yet undefined limits the growth rate of individual rhizomorph systems may be inversely proportional to the total number of systems supported by a good base. Rhizomorphs growing from mineral soil into peat branched at the point of entry into the peat and formed complex systems within it. Distribution in soil varies with depth, but the main concentration occurs between 2.5 and 20.0 cm below the surface, rarely below 30.0 cm. On one site, rhizomorph growth rate was estimated at 1 m per year. Behind the growing tip rhizomorphs are hollow but farther away the centre becomes filled with a compact mass of cells. It is suggested that felling, and rhizomorph severing following soil disturbance caused by timber extraction or ploughing, may cause a rapid increase in activity by *A. mellea* and any newly planted trees would be at maximum risk.

ROWAN, A. A. (1973). From horses to hydrostatics: how extraction was mechanised. *For. home-gr. Timb.* 2(3), 19 and 22.

Plots the history of the harvesting process, looks at two of Britain's biggest makers, and reviews some new equipment to ease the burden of bringing timber from the forest to the roadside.

ROWE, JUDITH J. (1973). *Public demands on forests in relation to forest wildlife*. Res. Dev. Pap. For. Commn, Lond. 104.

The importance of wildlife, particularly non-timber plants and non-game animals, in adding to the quality of the forest environment has become increasingly recognised. Fundamentally, all forest wildlife depends on, or forms part of, the forest habitat and wildlife management techniques should be incorporated in practical forest management as they are developed. Foresters are increasingly aware of the need to broaden their basic management skills in order to practise the type of environmental forestry which will become more important in the future. Forest research must therefore be concerned with defining the essential management problems and then employing and working with specialists in the relevant disciplines to solve them. Only by co-operation between forest research workers and their colleagues in such fields as recreation, sociology, economics, landscape architecture and wildlife management will it be possible to develop mutual understanding of the specialist techniques and language and to incorporate these in forest management for the future.

ROWE, JUDITH J. (1973). *Grey squirrel control*. Leaflet For. Commn, 56 (HMSO 12p).

Describes methods available for reducing number of grey squirrels and the strategy adopted.

SCOTT, T. M., and BROWN, RONALD M. (1973). Insecticidal control of the Pine looper moth in Great Britain. 3. Aerial spraying with Tetrachlorvinphos. *Forestry* 46(1), 81-93.

In 1969 the routine annual survey of pupal populations of *Bupalus piniarius* L., the Pine looper moth, did not include the forest areas of Wykeham and Langdale where, unnoticed, a build-up of the population to epidemic proportions had taken place resulting in the complete defoliation of 150 acres (61 ha). Surveys carried out in these and the surrounding areas in 1970 revealed extremely high counts, indicating the strong possibility that insecticidal control would be necessary. Alternative insecticides to DDT were screened and the more promising were field-tested resulting in the selection of tetrachlorvinphos. Egg counts were used to confirm the presence of a damaging population and to define its boundaries for control spraying which was carried out over 1,300 acres (526 ha). Estimates of larval mortality and later assessments of pupae indicate that the control operation was successful.

SIDAWAY, R. M. (1974). *Organisation of outdoor recreation research and planning in the Netherlands*. Res. Dev. Pap. For. Commn, Lond. 107.

The paper reports on a study visit made to the Netherlands in June 1972. An account is given of the organisation of recreation planning and management and the current research programmes of the principal recreation agencies. Some consideration is given to the use of research in planning and possible implications from Dutch experience for the Forestry Commission.

SIDAWAY, R. M., and OAKES, R. Q. (1973). The recreation planning officer's guide to recreation surveys and monitoring. *Recreation News Suppl.* 10, 37-42.

A paper given to a course for Forestry Commission Recreation Planning Officers in March 1973, which classifies types of recreation survey, the survey methods commonly used and the appropriate survey technique for common problems when quantitative information on recreational use is required.

For five types of day visitor monitoring survey, an outline of the sampling design, costs, information obtained and the comparative snags and advantages are set out in the form of a large table.

SPENCER, J. A., and SAMPSON, D. (1973). Relating forestry to recreation and the landscape: Forest recreation and the Forestry Commission. *Suppl. Forestry*, pp. 49-54.

The Forestry Commission has recognised that management for recreation is an essential part of forest management, and systematic planning for recreational development is now being carried out to enable the Commission to achieve its recreational objectives. It is felt that the day visitor should be invited to take an interest in the forest surroundings, the wildlife it supports, and the forestry activities that take place. Forest information centres have been set up for this purpose. In addition to camping, forests are being used for horse riding, pony trekking and orienteering; nature trails, observation huts and photo-hides form links between recreation and conservation and education.

An appendix sets out the recreation policy of the Commission.

STERN, R. C. (1973). The future supply and demand for wood and wood products. *Q. Jl For.* 67(4), 307-314; *Scott. For.* 27(4), 345-352; *Commonw. For. Rev.* 52(3), 254-259.

Doubts are often expressed on the future of wood, not only in a world context but also in the particular circumstances applying to Great Britain. An attempt is made to review as objectively as possible the current position under three headings: World situation, Europe and Britain.

STERN, R. C. (1973). The production of high value hardwoods. *Timb. Grow.* 48, May, p. 11.

Considers the supply and demand for good quality hardwoods with particular reference to production in Europe and the British Isles, and examines the profitability of growing ash, oak, elm and sycamore on good sites at wide spacing (150 trees per hectare), with pruning to a height of six metres.

STOAKLEY, J. T. (1973). Laboratory and field tests of insecticides against Douglas fir seed wasp (*Megastigmus spermotrophus* Wachtl). *Pl. Path.* **22**(2), 79-87.

Tests were made to select insecticides which would kill adult seed wasps in crowns of cone-bearing Douglas fir trees. In the laboratory, gamma BHC, malathion and diazinon were found to be active against females. In further tests, on males and females, gamma BHC and malathion were active when the insects were allowed contact with treated surfaces; fenitrothion was less active. The effectiveness of gamma BHC was partly due to fumigant action whereas malathion and fenitrothion had no fumigant effect. In separate field experiments between 1962 and 1966 in Kent and Herefordshire, gamma BHC and fenitrothion gave no control but malathion gave good control. In 1968, trees in Kent to which malathion was applied three times at 10-day intervals during June had about 13 per cent infestation of potentially sound seed, when assessed in September, compared with about 45 per cent infestation on unsprayed trees. Malathion plus gamma BHC did not further reduce infestation.

TEE, L. A., and PETTY, S. J. (1973). *Survey of losses of first-year conifer seeds and seedlings in Forestry Commission nurseries 1972*. Res. Dev. Pap. For. Commn, Lond. **103**.

It has been established that considerable amounts of conifer seed sown in Forestry Commission nurseries disappear from the seedbeds before germination.

This report gives estimates of the yields and losses for eight conifer species from 12 different Commission nurseries ranging from Rogate nursery in Sussex to Dornoch nursery in Sutherland. Where losses for individual sowings are more than the expected norm for the species, finches have been mainly responsible for the excess loss. Bird damage can be eliminated by covering seedbeds for 12 weeks with polythene netting.

Forestry Commission nursery records show losses of viable seed higher than they actually are, as nursery foresters underestimate their stock of germinated seedlings. After allowing for this stocktaking discrepancy approximately 20 per cent of the viable seed sown disappears from the seedbed before germination. No single factor has been found responsible for this loss.

Methods used in the production of conifer seedlings vary considerably throughout the Commission nurseries, but no definite correlations have been found between these techniques and treatments and the yields obtained in various nurseries.

THOMSON, J. H., and NEUSTEIN, S. A. (1973). An experiment in intensive cultivation of an upland heath. *Scott. For.* **27**(3), 211-221.

A 21-year-old experiment is described in which the growth, root development and stem form of Japanese larch, Lodgepole pine and Scots pine are compared on an ironpan soil as indurated material. Deep complete ploughing increased yield of larch and Lodgepole pine (in mixture) by ca. 20 per cent and improved the straightness of stems by reducing the proportion of windswayed trees. Sitka spruce, a minor species in the experiment, also showed positive responses to cultivation intensity.

It is suggested that the longevity of effect of the best cultivation treatment (deep complete) may be limited to 15-20 years.

WALKER, C. (1973). Interception of the North American native elm bark beetle (*Hylurgopinus rufipes* Eichh.) imported from Canada into Britain in logs of Rock elm (*Ulmus thomasii* Sarg.). *Pl. Path.* **22**(3), 147.

A record of the detection of the North American native elm bark beetle in logs of Rock elm imported into Britain. Photographs of the adult beetle and the breeding gallery system are included along with a description of the stages of the insect present.

WHAYMAN, A. (1973). Fibre-film rope as chokers. FC/HGTAC Technical Note No. 9. *For. home-gr. Timb.* **2**(6), 45-46.

The output of light agricultural tractors has been increased dramatically by fitting hydraulically-operated tongs onto the three-point linkage. The equipment is described and costs and outputs are given.

WHAYMAN, A. (1974). Gremo TT-12 forwarder. FC/HGTAC Technical Note No. 12. *For. home-gr. Timb.* 3(1), 41.

The Gremo TT-12 is a forwarder with a 12 tonne capacity. Outputs and costs are given.

WINTER, T. G. (1974). *Acleris cristana* (Denis and Schiffermuller) (Lepidoptera, tortricidae) attracted to light. *Entomologist's Gaz.* 25(1), 8.

Records of *A. cristana* caught in a Rothamsted light-trap at Alice Holt, Hampshire, are given. The availability of the host plant *Prunus spinosa* L. in the area is discussed.

WITTERING, W. O. (1973). *Work study in forestry.* Bull. For. Commn, Lond. 47 (HMSO £1).

Paper produced for an international course on work study in forestry by the Forestry Commission for the joint FAO/ECE/ILO Committee on Forest Working Techniques and Training of Forest Workers held at Wymondham College, Norfolk, and Newton Rigg College of Agriculture and Forestry, Cumberland, in July 1971.

WITTERING, W. O. (1973). Clearway weeder. FC/HGTAC Technical Note No. 6. *For. home-gr. Timb.* 2(3), 26.

A technical report on a small, hydrostatically-powered pedestrian-controlled weeding machine which cuts by means of a rotating bar.

WITTERING, W. O. (1973). Trees and superstition. *For. Home-gr. Timb.* 2(6), 22-24.

A look at the association of trees with ghosts, religion, evil, luck, and miraculous cures!

WITTERING, W. O. (1973). Work problems in the timber industry. *For. home-gr. Timb.* 2(4), 45.

The author describes the proceedings and decisions reached at the second tripartite technical meeting for the timber industry which took place at the International Labour Office in Geneva in April/May 1973, at which he and Mr. T. H. McGeorge of Establishments Division represented the UK Government.

WITTERING, W. O. (1973). Bush Hog weeding machine. FC/HGTAC Technical Note No. 8. *For. home-gr. Timb.* 2(4), 41.

A technical report on this popular rear-mounted, tractor-powered rotating bar weeding machine.

WITTERING, W. O. (1973). Work study in the Forestry Commission. *Wk. Study Mgmt Serv.* 17(5), 318-320.

The beginnings of work study in forestry are described and followed by a short history of work study in the Forestry Commission. A description of the organisation of the Work Study Branch and its achievements to date is followed with a glimpse at the problems confronting the Commission in the future.

WITTERING, W. O. (1973-74). Philately for foresters. *For. home-gr. Timb.* 2(2-6) and 3(1).

This is a regular series of short "snippets" for readers who are interested in philately. The topics covered bear a relation to forestry and forest industries and related subjects.

WITTERING, W. O., and BURDEKIN, D. A. (1973). Controlling *Fomes annosus*—new equipment for an old problem. *For. home-gr. Timb.* 2(3), 17.

A "squezy-bottle" applicator fitted with a brush and an anti-drip collar is described and information on costs of treatment is given.

WORK STUDY BRANCH (1973). Hydratongs. FC/HGTAC Technical Note No. 10. *For. home-gr. Timb.* 2(6), 45-46.

The use of man-made fibres has greatly increased the strength of smaller diameter fibre ropes and exuded fibres have made such ropes comparatively cheap. Their lightness and strength has opened up the possibility of using fibre rope as chokers for extraction purposes.

APPENDIX II

Main Fields of Research

Forest Tree Seed

Testing and improvement of seed qualities and productivity
Seed procurement, extraction, processing, storage, testing and distribution

Silviculture South

Plant production—amenity and broadleaved
—conifer

Lowland silviculture—broadleaved
—conifer

Weed control (and fire protection)

Upland silviculture

Site studies (silvicultural)

Tree stability

Establishment of amenity plantings

Trials of species for amenity/arboriculture

Arboreta

Arboriculture

Silviculture North

Production and use of planting stock

Site evaluation

Provenance

Choice of species for afforestation

Planting

Forest weed control

Nutrition

Drainage

Cultivation

Tending operations

Artificial regeneration

Natural regeneration

Crop stability

Maximum site amelioration

Site Studies South

Foliar analysis

Soil analysis

Effects of trees on site

Lowland production forest sites

Upland production forest sites

Sites for amenity plantings

Site Studies North

Classification and improvement of upland soil

Site yield guides

Forest Genetics

Testing

Seed production

Seed stands

Biochemical variation

Tree Physiology

Root form, with reference to growth form and survival of tree root systems

Root initiation, with reference to establishment, planting check, etc.

Vegetative propagation

Development of early test, screening procedures for useful tree characteristics

Forest Pathology

Root and butt rot caused by *Fomes annosus*

Armillaria mellea (Honey fungus)

Dutch elm disease caused by *Ceratocystis ulmi*

Beech bark disease

Diseases caused by species of *Phytophthora*

Forest Entomology

Population studies

Host plant susceptibility

Biological control

Chemical control

Elm scolytidae

Taxonomy and collection

Wildlife Management

Management of forest animals and their habitat, and exploitation of wildlife for sporting

Management of deer, squirrel and mammals in general, including birds

Protection against wildlife

Assessment, evaluation and prediction of wildlife damage

Field surveys

Topographic and crop assessment

Site surveys

Measurement

Production forecasting

Elm survey projects

Work Study

Forest management—method study

Harvesting and marketing—method study

Work measurement

Forest machinery

APPENDIX IV

Staff Engaged in Research and Development

As at 31st March 1974

The main centres for research and development are:

FORESTRY COMMISSION RESEARCH STATION

Alice Holt Lodge
Wrecclesham

Farnham, Surrey. Tel. Bentley (Hants) 2255 (STD Code 042 04)

FORESTRY COMMISSION NORTHERN RESEARCH STATION

Roslin
Midlothian

Scotland. Tel. 031-445 2176

Some staff engaged in research and development (or controlled by the Director) are also stationed at:

FORESTRY COMMISSION

25 Savile Row

London W1X 2AY. Tel. 01-734 0221

and

Priestley Road

Basingstoke, Hampshire RG24 9NS. Tel. Basingstoke 3181

Research on timber and other forest products is not carried out by the Forestry Commission but by the Princes Risborough Laboratory of the Department of the Environment's Building Research Establishment, Princes Risborough (Tel. 3101), Aylesbury, Buckinghamshire. The Forestry Commission keeps in close touch with this work, some of which is done jointly by the two organisations.

RESEARCH AND DEVELOPMENT DIVISION

Director	D. R. Johnston, M.A., F.I.For. (<i>Alice Holt</i>)
Administration and Finance Officer	N. E. Stutter, A.M.I.P.M. (<i>Alice Holt</i>)
Director's Secretary	Mrs. V. O. C. Lampard (<i>Alice Holt</i>)

Chief Research Officer (South) D. H. Phillips, M.Sc., Ph.D., F.I.Biol.,
M.I.For. (*Alice Holt*)

(With general responsibilities for research south of the Mersey/Humber line, and with specific responsibilities throughout Britain for research in arboriculture, pathology, entomology and wildlife, in silviculture and site studies in the lowlands, and for seed supply, engineering services and technical advice).

SILVICULTURE (SOUTH) (*Alice Holt*)

J. Jobling, B.Sc.

M. A. Anderson, B.Sc.

R. M. Brown, B.Sc., M.I.For.

J. E. Everard, B.Sc., M.I.For.

A. F. Mitchell, B.A., B.Agric. (For.), V.M.H., M.I.For.

G. J. Mayhead, B.Sc., Ph.D., M.I.For.

Office:

Miss S. B. Page: F. R. W. Stevens (Research Forester):
Mrs. A. Johnston: Mrs. S. A. M. Bridger, Miss J. M. Gay,
Mrs. M. A. MacIntyre

Research Foresters:

		<i>Centre</i>
<i>South East England Region</i>	R. M. Ure, M.I.For.	Alice Holt
South East England Area	P. W. W. Daborn J. B. H. Gardiner, M. L. Pearce: D. W. H. Durrant, P. D. Howard, A. M. Jenkin, P. Marsh, F. S. Smith	Alice Holt
Wareham Area, Dorset	L. A. Howe: G. F. Farrimond	Sugar Hill Nursery, Wareham Forest
Bedgebury Area, Kent	A. W. Westall: M. J. Scott	Bedgebury Pinetum
<i>South West England Region</i>	D. A. Cousins	Westonbirt
South West England Area	K. F. Baker	Exeter
Dean and South Wales Area	F. C. Thompson: K. Broad: T. J. Davies A. J. A. Graver, C. J. Large	Dean Brecon
Westonbirt Area, Gloucestershire	E. Leyshon: P. J. Webb, C. W. Webber	Westonbirt Arboretum
<i>North Wales Region</i>	G. Pringle	Betws-y-Coed
North Wales Area	G. A. Bacon: D. Downs	Betws-y-Coed
Mid-Wales Area	D. G. Tugwell: R. Dean	Knighton, Radnor
<i>East England Region</i>	I. H. Blackmore: P. A. Gregory	Santon Downham, nr. Thetford, Norfolk

SITE STUDIES (SOUTH) (*Alice Holt*)

W. O. Binns, M.A., B.Sc., Ph.D., F.I.For., Head of Branch
R. Carnell
A. Willson, B.Sc., Ph.D.

Research Foresters: D. F. Fourt, L.I.Biol.: I. G. Carolan

Laboratory: Mrs. J. E. Parker, Mrs. S. A. Wright: Miss J. A. Everhard,
Mrs. D. Wild

PATHOLOGY (*Alice Holt*)

D. H. Phillips, M.Sc., Ph.D., F.I.Biol., M.I.For., Head of Branch (acting*)
J. N. Gibbs, M.A., Ph.D.
C. M. Brasier, B.Sc., Ph.D., M.I.Biol.

Research Foresters: C. W. T. Young: B. J. W. Greig: J. E. Pratt, R. G. Strouts,
J. Dickinson, N.D.F.D.

Laboratory: E. J. Parker, M.I.Biol.: Mrs. P. Palmer, A. D. Syred:
M. Awdry, Miss A. Trusler

Office: Mrs. J. G. Anderson (Typist)

Northern Research Station

D. B. Redfern, B.Sc., Ph.D.
S. C. Gregory, M.A., Ph.D.

Research Forester: J. D. Low

Laboratory: A. T. Fairgrieve

*In place of D. A. Burdekin, on a 2-year secondment to the Directorate of Research, Department of the Environment.

ENTOMOLOGY (*Alice Holt*)

D. Bevan, B.Sc., Head of Branch
Miss J. M. Davies, B.Sc.
C. I. Carter, M.Sc., M.I.Biol.

Research Foresters: R. M. Brown, L.I.Biol.: D. J. Billany, C. J. King, C. Walker

Laboratory: T. G. Winter: M. Jukes, L. J. O'Neill

Office: J. Ellison

Northern Research Station

J. T. Stoakley, M.A., M.Sc., D.I.C., F.I.For.

Laboratory: S. G. Heritage: D. A. Barbour

WILDLIFE MANAGEMENT (*Alice Holt*)

Miss J. J. Rowe, B.Sc., Dip.Cons., Head of Branch

Research Foresters: L. A. Tee: R. A. Baldwin (*Bourne, Lincolnshire*), H. W. Pepper, S. J. Petty

Laboratory: B. A. C. Don: Miss C. I. Derrick

Office: Mrs. M. A. McIntyre

SEED (*Alice Holt*)

G. M. Buszewicz, Mgr.Eng.(For.), Head of Branch
A. G. Gordon, B.Sc.Agric., Ph.D.

Laboratory: T. A. Waddell, D. C. Wakeman: Mrs. L. S. Billany, Miss R. E. Crumplin: D. Churchouse, Miss R. McKenzie

Seed Store and Extractory: M. D. Witts (Research Forester): L. Crumplin

Office: Mrs. P. A. M. Pharos: Mrs. M. Greenwood

ENGINEERING SERVICES (*Alice Holt*)

R. E. Stickland
H. G. W. Bodkin, M. F. Johnston, C. H. Bodkin

Northern Research Station

R. McLuckie, H. S. Peaston

TECHNICAL ADVISER (*Alice Holt*)

W. H. Hinson, B.Sc., Ph.D.

Chief Research Officer (North)

B. W. Holtam, B.Sc., F.I.For.
(*Northern Research Station*)

(Administrative head of the Northern Research Station with general responsibilities for research north of the Mersey/Humber line, and with specific responsibilities throughout Britain for research in silviculture and site studies in the uplands and for research in tree physiology and genetics.)

SILVICULTURE (NORTH) (*Northern Research Station*)

R. M. G. Semple, B.Sc., M.I.For., Head of Branch
R. Lines, B.Sc., F.I.For.
A. J. Low, B.Sc., M.Sc.For., Ph.D., M.I.For.
S. A. Neustein, B.Sc., M.I.For.
T. C. Booth, B.Sc., M.I.For.
J. M. Mackenzie, B.Sc., M.I.For.
D. A. Thompson, B.Sc., M.I.For.

		<i>Centre</i>
<i>Research Foresters:</i>	N. P. Danby: A. B. Lewis	Northern Research Station
<i>North Scotland Region</i>	G. Bartlett	Newton, Moray
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