REPORT ON

FOREST RESEARCH

1976

FORESTRY COMMISSION

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Cover picture:

Part of a heavy cone crop on a six-year-old potted Sitka spruce graft induced to flower early and heavily by growing it for 12 months inside a plastic greenhouse (28231).

See Genetics, p. 27.

FORESTRY COMMISSION

REPORT ON FOREST RESEARCH

for the year ended
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The cover picture and Plates 1, 2, and 3 are from the Forestry Commission's Research photographic collection. Plate 4 is from Professor H. E. Street. The diagrams were supplied by the respective authors and prepared for publication by the Commission's Research Photography Section.

INTRODUCTION

By D. R. JOHNSTON
Director of Research and Development

Reorganisation

During the year Planning and Economics, which is not a part of the Research and Development Division, moved from the Alice Holt Research Station to the new Forestry Commission Headquarters in Edinburgh. The Publications Section, which is part of the Communications Branch of the Research and Development Division, was transferred from the London office to Alice Holt.

The Common Market

The Forestry Commission is taking the lead in promoting a Common Market research project on Dutch elm disease. As a first step the Dutch Government, with financial support from the Forestry Commission, has appointed a research worker at the Forest Research Station at Wageningen to work on elm breeding, with a primary object of breeding a strain of elm resistant to Dutch elm disease but similar in appearance to English elm.

Arboriculture

The Department of the Environment has commissioned an arboricultural research contract with the Forestry Commission. The Research and Development Division will establish an arboricultural advisory service based at Alice Holt, and will undertake research into the production and establishment of amenity trees and into the occurrence and control of decay. The first member of the new team, a pathologist, was recruited at the end of the year.

Research Review

A Visiting Group, appointed by the Research Advisory Committee and under the chairmanship of Professor J. P. Hudson, investigated the service branches of the Division. No fundamental changes were proposed but the Committee made a number of suggestions, most of which have now been implemented. The members of the Visiting Group were: Professor J. P. Hudson, formerly Director, Long Ashton Research Station (Chairman); Dr B. M. Freeman, Houghton Poultry Research Station; Mr R. Gardner, Agricultural Development Advisory Service, Ministry of Agriculture, Fisheries and Food; Dr P. G. Jeffery, Warren Spring Laboratory; Dr J. A. Nelder, Rothamsted Experimental Station; and Mr P. J. Rolls, Royal Aircraft Establishment, Farnborough.

Open Days

The Northern Research Station held three Open Days during May 1975, attended by 800 visitors.

Awards to Staff

R. Lines (Principal Scientific Officer, Silviculture (N)) was presented with the Sir George Campbell Memorial Trophy by the Royal Scottish Forestry Society, for the best article of 1975 in *Scottish Forestry*.

Dr D. Wainhouse (Higher Scientific Officer, Entomology) gained a Ph.D. in Applied Entomology, with the thesis "Ecology and behaviour of the carrot fly".

R. G. Strouts (Head Forester, Pathology) was admitted to Associate Membership of the Institute of Linguists, having passed the Institute's Intermediate examination in German.

Visitors

Six hundred and fifty-five people visited Alice Holt Lodge, coming from 31 countries. They included the Ministry of Agriculture, Fisheries and Food Sub-Committee on Poisons, the first workshop of the International Seed Testing Association (ISTA), and a party of forestry lecturers from Iran.

There were 300 overseas visitors to the Northern Research Station, including parties from the German Dendrology Society, International Plant Propagators Society, also physiologists and geneticists attending meetings of the International Union of Forest Research Organisations (IUFRO).

Visits and Conferences

Staff attended 16 conferences overseas (including three Common Market, two OECD and two IUFRO meetings) and 18 in this country. A workshop of the International Seed Testing Association, University of Surrey, was organised by Seed Branch at Alice Holt Lodge in July, 1975.

Staff Changes

A. J. Grayson (Conservator, Planning and Economics) moved to HQ. J. Atterson (Assistant Conservator) was transferred on promotion from North Scotland Conservancy to become Head of Silviculture North in place of R. M. G. Semple, who went to North East England Conservancy. W. O. Wittering was appointed Chief Work Study Officer, in place of I. A. D. Grant who transferred to West Scotland Conservancy. Dr A. G. Gordon was appointed Head of Seed Branch, in place of G. M. Buszewicz who left on a 3-year secondment to Honduras Forestry Corporation. D. A. Burdekin returned as Head of Pathology, after a two-year secondment to the Department of the Environment, Directorate of Research Requirements.

Transfers in: R. O. Smith (District Officer I, Work Study) on promotion from North West England Conservancy. P. N. Edwards (District Officer II, Field Surveys) from South Scotland Conservancy. T. Lees (Executive Officer, Northern Research Station), from Ministry of Agriculture, Fisheries and Food.

New Entrants: D. Lonsdale and P. C. Mercer (Higher Scientific Officers) to Pathology. C. J. Austin (Executive Officer) to Administration and Finance.

Transfers out: D. H. Wallace (District Officer I, Work Study) to Education and Training. G. D. Keighley (District Officer I, Work Study) to South West England Conservancy. P. Wood (Head Forester, Work Study) to South West England Conservancy. J. F. Black (Executive Officer, Northern Research Station) to Headquarters.

Promotions: Miss J. J. Rowe (Wildlife Management) to Principal Scientific Officer. T. C. Booth (Silviculture North) to District Officer I. Mrs J. Birchall (Statistics) to Senior Scientific Officer. G. J. Hall (Statistics) to Higher Scientific Officer. M. R. Jukes (Entomology) to Scientific Officer. Miss M. Hopkin (Typists) to Senior Superintendent.

Resignation: Mrs J. L. Parker (Scientific Officer, Site Studies South).

Retirement: D. W. Brittain (Executive Officer, Work Study).

Deaths: We sadly report the following deaths:
Dr S. Batko, formerly Mycologist, Alice Holt.
F. C. Thompson, Chief Forester, Dean.
D. G. Tugwell, Head Forester, Brecon.
C. H. Bodkin, Engraver, Alice Holt.

PART I

The Work of the Forestry Commission

RESEARCH AND DEVELOPMENT DIVISION

BRANCHES AND THEIR PROJECT GROUPS

Seed

Silviculture South

Silviculture North

Site Studies South

Site Studies North

* No progress is reported during the year.

Forest Genetics

Tree Physiology

Forest Pathology

Forest Entomology

Wildlife Management

Engineering Services

* No progress is reported during the year.

Field Surveys

Work Study

Statistics and Computing

Communications: *Research Information Section*

Photographic Section

Publications Section

* No progress is reported during the year.

SEED

Research

Scots Pine Seed Orchard Extraction and Germination Trial

Further work has confirmed the significant interaction between clones and extraction dates in the ease with which seed is released from the cones. Although clones tended to show the same sort of response from year to year, large variations in total yield mean that no economic method of maximising seed yield can be found. Two years of research have now shown that, although cones from the top of trees are larger than from the bottom, the yield of full and germinable seed per litre is not significantly different.

Pre-chilling of Coniferous Seed

Trials have now been carried out on the moist pre-chilling of seed of Sitka spruce, Lodgepole pine, Douglas fir, Grand fir, Western hemlock and Japanese larch. Naked treatment in the absence of sand has produced more uniform and frequently more complete germination, and invariably more usable seedlings at the end of the season, than controls. In experiments comparing sand with naked pre-treatment, growth after the latter was always as good and often better. No improvement in germination or usable seedlings was produced by a 48-hour seed soak in a 0·5 per cent Thiram suspension before chilling Lodgepole pine, Douglas fir and Sitka spruce seed except when it was infected by cold fungus (*Geniculodendron pyriforme*). It was confirmed that the lethal effects of this fungus, during moist pre-chilling, can be overcome by soaking in the above suspension before chilling. Recommendations to this effect have been issued with all infected seed lots despatched this year. Dressing pre-chilled seed of Western hemlock with 0·5 per cent Thiram dust before sowing has consistently improved germination in the nursery.

Improving Nursery Germination by Irrigation

The results of nursery irrigation experiments have always been inconsistent. Recently no mains operated systems have been available, and "irrigation" treatments have been simulated by a single daily application, when necessary, of a set quantity of water by watering can. Experiments were set up at Headley in 1975 to examine more closely the effect of this irrigation treatment on seedling production. Despite the very dry season, no improvement in germination of Sitka spruce or Japanese larch was produced. However, in the warm sunlight, it was observed that germinating seeds were put under stress by the isolated floods of water, and it was clear that the watering can technique was not a fair assessment of the potential of properly controlled irrigation systems. The only consistent effect produced was in Sitka spruce seedlings, given mains water (at pH 7·3), which were smaller at the end of season than those given rain water (pH 6·2), or no water.

Improving Germination by Better Seed-Soil Contact

Better seed to seedling ratios have been sought by improving seed to soil contact using sand, either alone or followed by a thin layer of grit as seedbed cover. Comparisons have also been made of lightly raking the surface of the seedbed before sowing (a normal research technique) with sowing direct on

to a compacted seedbed (Conservancy practice). The research technique has consistently and often significantly improved germination of Sitka spruce, as has the use of coarse light-coloured sand instead of the normal grit. Contrary to expectations the sand was not blown away by wind, even in the very dry conditions prevailing. A highly significant improvement in Western hemlock germination has been achieved, for two years running, by covering seed with the above sand instead of grit.

Germination Studies Using a Thermo-gradient Bar

By air conditioning the room, and by using a compartmented cover to a thermo-gradient bar made in our own workshop, the uniformity of the micro-climate at the seed surface has been improved. A comparison has been made between germination under routine alternating temperatures of 20°–30°C, and constant temperatures between these, which are easier to produce accurately. A range of Scots pine origins from Turkey to Sweden has been tested. Results have shown that maximum germination can be achieved using constant as well as alternating temperatures.

The Use of Polyethylene Glycol (PEG) to Stimulate Uniform Conifer Seed Germination

PEG stimulation of vegetable seed germination has been recommended in popular and scientific publications recently. Its application to forestry has been studied in laboratory conditions. Results have shown that it cannot be used to overcome conifer seed dormancy, and that in seed lots studied it produces no more uniform germination than can be achieved by normal pre-chilling treatments.

Improving Broadleaved Seed Germination

Most techniques presently used to overcome the deep dormancy of many broadleaved species are out of date, as they still involve use of stratification pits in open nurseries. Methods of improving the germination of seeds of several genera, including *Acer*, *Nothofagus* and *Fraxinus*, have been studied. *Acer* and *Fraxinus* embryos, excised from seed, and grown on germination test papers, have been found to be capable of producing normal and vigorous plants when pricked out into Japanese Paperpots in polyhouses. Home produced *Nothofagus procera* and *obliqua* seed have given improved germination after prolonged periods of pre-chilling (three and six months—normal, one month), but Chilean sources have given better germination without pre-treatment.

International Seed Testing Association

The Branch organised a very successful, week-long, Forest Seed Testing Workshop at the University of Surrey in July 1975. (See Plate 1). It was the first of its kind and attracted over 30 participants from 18 countries as far away as Chile and South Africa. The detailed proceedings will be reported in *Seed Science and Technology* in 1977.

Service

The Branch has continued to provide a forest seed service to Conservancy nurseries and the private trade, as well as carrying out its duties as the Official Forest Seed Testing Station.

Further refinements to the service have been made, following the transfer of responsibility for seed procurement to Forest Management Division. Because of recent increased home seed production from registered seed stands, and decreases in seed usage, surpluses of some seeds have been built up. Very successful attempts have been made to sell these abroad. Forest Management Division have begun to allocate seed for Conservancy nurseries, which has resulted in a more rational use of seed, and the clearance of the increasing number of small lots.

The supply of conifer seed for use within the Commission for the 1976 sowing season was approximately 10 per cent lower than for the 1975 season, but that to the trade approximately 20 per cent lower. Supply of hardwood seed to those private nurserymen requesting it has been continued. The tripling of supplies of broadleaved seed over last year, to both the trade and Commission, compensates for the last poor year, rather than changes of planting policy. These quantities were covered completely by importations.

Good collections of both Corsican pine and Scots pine cones have been made, as well as small collections of Lodgepole pine, Hybrid larch and Douglas fir. There was a near total failure of collectable crops in most other species. However, the present system of registration of stands (which are inspected once collectable crops have been produced) does appear to have improved the supply of home produced seed when available.

It was necessary to import small quantities of the following conifer species to build up at least a three-year supply: European larch, Sudeten larch, Western red cedar, Western hemlock and Long Beach Lodgepole pine. Only a very small quantity of Grand fir was available. This is the only critical species with only a two-year supply remaining.

The tables giving seed procurement and seed supply data which used to be published yearly in this *Report* are no longer given, but details can be obtained from the Principal Seeds Officer.

A. G. GORDON

SILVICULTURE (SOUTH)

Plant Production, Lowland

Seedbed Herbicides (Open Nursery)

Experiments were carried out, at both Alice Holt and the Northern Research Station, on pre-sowing, pre-emergent and post-emergent application of herbicides to seedbeds of Sitka spruce and Lodgepole pine. Herbicides used were:—

Diphenamid—proving to be a safe and satisfactory pre-emergent herbicide.
Trifluralin —Pre-sowing application causes seedling mortality.
Nitrofen —Promising as a pre-emergent herbicide.

Seedbeds sown at low density for under cutting require weed control over two growing seasons. Pre- and post-emergent use of diphenamid followed by a winter application of propyzamide shows promise.

Nutrition of Broadleaved Seedlings (Open Nursery)

The effect of nitrogen fertiliser (Nitrochalk 26 per cent N) was tested on four species of broadleaves. Some increase in growth occurred with pre-emergent applications, but post-emergent applications, at monthly intervals of 5 g element of nitrogen per m^2, gave the optimum result, with increases in both height and diameter at the collar in all species. An increase in the level of nitrogen decreased the number of birch seedlings per plot at germination.

TABLE 1
GROWTH RESPONSES TO POST-EMERGENT APPLICATION OF NITROCHALK

Species	Height (cm)		Collar diameter (mm)	
	No N	N	No N	N
Beech (*Fagus sylvatica*)	13·0	16·1	3·3	3·9
Birch (*Betula pendula*)	2·5	12·2	2·0	3·2
Sycamore (*Acer pseudoplatanus*)	12·3	19·5	5·2	7·2
Sessile oak (*Quercus petraea*)	7·3	8·6	4·3	4·6

Conifer Seedlings in Paperpots (Polythene Greenhouse)

Work on comparison of different composts, size of Paperpot, length of time in the greenhouse and hardening off, continued with Corsican pine. Although the extension into the forest of this experiment is not yet complete, it does show that the regime used by the Conservancy staff at Thetford, of 20 weeks followed by 4 weeks hardening off, is probably the optimum one.

Broadleaved Seedlings in Paperpots and Containers (Polythene Greenhouse)

The raising of broadleaf seedlings in Paperpots in a heated polythene greenhouse, followed by "potting on" into larger pots, and standing outside, produced some promising results. The greenhouse phase lasted 8 to 10 weeks, commencing in March, and the standing out phase for varying periods during the summer, followed by planting in the forest.

TABLE 2
HEIGHT GROWTH OF BROADLEAVED SPECIES RAISED FROM SEED IN POLYTHENE GREENHOUSE

Species	14 weeks cm	20 weeks cm	30 weeks cm	Open Nursery cm
Beech	28	28	42	16
Birch	29	40	122	12
Sycamore	26	35	101	19
Sessile oak	28	28	35	9

This result opens up a field for further development into the rapid production of larger broadleaved planting stock.

W. J. MCCAVISH, P. W. W. DABORN

Plant Production, Arboriculture

Vegetative Propagation

Trials were continued to improve the survival and rate of rooting of softwood cuttings, of eight broadleaf species, under automatic mist. Cuttings were inserted in blocking composts, and substrates composed of vermiculite and peat. Generally, rooting in these materials was poorer than in the control of coarse sand and peat.

Cuttings taken in May and June invariably rooted faster and in greater number than batches of cuttings taken later. Clones of elm showed the greatest reduction in rate of rooting as the season progressed, and Grey poplar, *Populus canescens*, and London plane, *Platanus* × *hispanica*, both ordinarily easy to root from softwood cuttings, the least. Notable progress was achieved with Small-leaved lime, *Tilia cordata*, which had a rooting per cent of 91 in early June, and a rooting per cent of 72 in early July. In the case of this tree only, the cuttings were taken from mature trees some 20 miles away from the Research Station, rather than from specially grown plants nearby in the nursery at Alice Holt. If such satisfactory results are obtained again, the softwood cutting method clearly provides an opportunity to propagate selected, valuable trees of this species.

Further progress was made in evaluating the different clones of Leyland cypress, × *Cupressocyparis leylandii*. At least three little-used clones, namely 'Leighton Green' and the two clones selected at Stapehill Nursery, Ferndown, Dorset, in 1940, root as well as, and sometimes faster and in greater number than, the commonly propagated clone 'Haggerston Grey'. This clone accounts for about 90 per cent of the total production of the hybrid in horticulture, and has a reputation for easy rooting. However, after potting up, or bedding out, it often has a poorer shape and slower growth rate than the other clones.

Cuttings of Leyland cypress root rather less well in substrates of coarse sand and peat, and grit and peat than in vermiculite and peat. There is little variation in response to the substrate from one clone to another.

J. JOBLING

Lowland Silviculture

Establishment and Maintenance of Native Broadleaved Species

In spite of difficulties over obtaining suitable planting stock one experiment comparing the performance of types of oak plant at very wide spacing was planted.

M. L. PEARCE

Establishment of Conifers

Reported under Site Studies (South).

Forest Weed Control

Screening of Herbicides

Propyzamide, screened at 2, 4, and 6 kg a.i./ha on Red oak, beech, Corsican pine, Scots pine, Norway spruce, Sitka spruce, Douglas fir, Hybrid larch and Western hemlock, continued to show good crop tolerance after two growing seasons. Western hemlock and Douglas fir, which showed signs of ill health at the highest rate, recovered well in the second growing season. Other conifer and broadleaved species will be tested.

Atrazine/cyanazine mixture ("Holtox") was screened at 5·4, 8·1 and 10·8 kg a.i./ha on Corsican pine, Lodgepole pine, Sitka spruce, Douglas fir and Japanese larch in March and May. End of season height and health were relatively unaffected.

Control of Grasses and Herbaceous Broadleaved Weeds

"Holtox", an atrazine/cyanazine mixture at 3·8, 5·4 and 8·1 kg a.i./ha, was compared with atrazine alone, at 3·5, 5·0 and 7·5 kg a.i./ha. Applications were made in March and May. Atrazine alone gave slightly better weed control, though that given by atrazine/cyanazine mixture was adequate. March applications seemed marginally better than May applications, for both herbicides.

Neither chemical controlled *Dactylis glomerata* (Cocksfoot) nor *Holcus lanatus* (Yorkshire fog) reinvaded most treatments. It is unlikely that "Holtox" will give more persistent weed control in the second growing season, since cyanazine has a shorter breakdown period in the soil than atrazine.

"Prefix" (chlorthiamid), "Casoron G" (dichlobenil), and "Fydulan" (dichlobenil plus dalapon) granules at 40, 50 and 60 kg product per ha were applied in February and April. Applications were made three weeks after planting. Over five experimental sites, herbicide effectiveness ranged from excellent to not quite adequate, with four sites achieving satisfactory weed control at the end of season, and all sites satisfactory at mid-season.

"Fydulan" gave better weed control than "Prefix" or "Casoron G" on all sites. Weed control generally improved with increase in application rates. Height and health of crop were unaffected by any of the treatments. Survival of Norway spruce, Corsican pine and Sitka spruce was unaffected, while that of Corsican pine was improved, but Douglas fir appeared to be adversely affected, especially by the earlier application in February.

Control of Bracken

Asulam applied at ultra low volume, by incremental spraying, using a controlled droplet applicator, continued to give good control on several sites in the second season of growth control, i.e. three seasons after application.

Control of Woody Broadleaved Weeds

2,4,5-T, as a special controlled droplet formulation, applied at ultra low volume by incremental spraying continued to show promise. Combinations of the special formulation and an additive called "Ulvapron" have been applied to two sites.

W. J. McCavish, F. S. Smith

Arboriculture (on Difficult Man-made Sites)

Industrial Sites

In a species trial planted in 1972 on restored sand and gravel workings at Bramshill Forest (Hampshire and Berkshire), Corsican pine, Leyland cypress and rauli, *Nothofagus procera*, were the most vigorous and tallest trees four years after planting, and Scots pine and Sycamore were the slowest growing and smallest trees at four years of age. Trees planted in cultivated soil were healthier and much more vigorous than trees in the compacted, uncultivated soil, regardless of species, though many trees are showing symptoms of nitrogen

deficiency irrespective of the pre-planting treatment. Further assessments and work are required to determine the extent of the cultivation and manuring needed to ensure sustained fast rates of growth and a healthy crop.

A survey started early in the year of tree plantings on industrial and other difficult man-made sites, in South Wales, was completed, and the information is being prepared for publication.

Margins of Motorways and Trunk Roads

An experiment started at the beginning of the growing season to test the effects, if any, of different mulch materials on recently planted trees, on the margins of the A12 trunk road at Kelvedon, Essex, has proved, in the first year, to be only partially informative. Though some mulches clearly provided benefits, others which were expected to do so did not, and will have to be re-tested.

Worked Peatland

A co-operative trial planting was started with the Wessex Water Authority, on a sedge peat site, presently being excavated at Shapwick Heath, near Glastonbury, Somerset, to test a number of little known amenity trees on this unique lowland soil. Several new clones of White willow, *Salix alba*, a new clone of White poplar, *P. alba*, and Dombey's Southern beech, *Nothofagus dombeyi*, are included in the planting. The trees under trial are in a matrix composed of the indigenous species of birch and Goat willow, *S. caprea*.

J. JOBLING

Arboriculture (Amenity)

Staff recruitment problems have delayed progress on both the contract research for the Department of the Environment and Forestry Commission's own research. An extensive trial of pruning wound treatments has been laid down, using a number of proprietary products. This will provide information on the longer-term aspects of the healing of wounds.

A collection of leaf samples of lime was made for subsequent analysis, with the object of developing this technique to check nutrient requirements of broadleaved species.

J. B. H. GARDINER

A systematic method of recording requests for advice on arboricultural/silvicultural problems has been started to find out the subjects giving rise to the most queries. Main subjects totalling some 200 queries this year have been:

	Per cent
Selection of trees for site	15
Tree maintenance, pruning and surgery	17
Nursery work	20
Other—damage to and by trees establishment of trees abnormal growth stump removal	48

F. R. W. STEVENS

Dendrology and Arboreta

Dendrology

During the year, trees on 89 estates were inspected, identified and measured. In all 3,141 specimens were measured, of which 1,673 were new and 1,468 were re-measurements. Of these trees, 39 are the biggest recorded in both height and diameter of bole; 26 were the tallest alone; and 14 were the biggest in diameter alone. The records now contain 38,657 trees, 23,525 of them conifers and 15,132 broadleaved trees. The species represented number 1,286, of which 276 are conifers. Varieties and cultivars measured number 679.

Westonbirt, Gloucestershire

The revised plans for the Visitor Centre have been accepted, and work will start on the building soon. New stores and office accommodation have been added.

The oak collection has been augmented by planting out many rare species received from Dr H. M. E. Cardwell. The new decorative planting fronting the main road south of the entrance survived the summer drought well, and the improvement is becoming apparent. The gale in January blew down several prominent specimens, and caused much damage generally, entailing some months of work. Leyshon Glade, now 12 years old, is well established as a major feature. It was a remarkable spectacle with the exceptionally good colours of the last autumn. The drought killed a few trees, but serious casualties were reduced by watering.

Bedgebury, Kent

The Juniper collection has been thinned, removing many very spreading forms which were over represented, and allowing the planting of a number of new species. Several new Californian species of cypress were added. A large area of chestnut coppice has been cleared. It has a rich soil, much superior to that of the rest of the Pinetum, and is being planted with the more demanding species.

A. F. MITCHELL

SILVICULTURE (NORTH)

Production of Planting Stock

Seedbed Herbicides

Diphenamid has continued to be a very safe and satisfactory seedbed herbicide in further experiments. It is now recommended for use at 4 kg a.i./ha (active ingredient per hectare) (8 kg product) applied immediately after sowing on Sitka spruce and Lodgepole pine only. Preliminary trials, at Bush Nursery (Lothian), on Japanese larch and various broadleaved trees, indicate that it cannot be used as a pre-emergence herbicide with these species. Experiments are continuing on the use of diphenamid on minor species, and as a post-emergence herbicide.

Trifluralin was tested as a pre-emergence herbicide on seedbeds by spraying at rates between 1 and 3 kg a.i./ha. On Sitka spruce even the low rate resulted in very poor germination, while on Lodgepole pine germination was fairly good but height growth was reduced.

Partial Sterilisation

Several nurseries using dazomet for the 1975 growing season had patches of inhibited growth on Sitka spruce seedbeds. The damage typically appears patchy with yellow- or brown-tipped, stunted seedlings amongst seedlings growing at the increased rate expected of sterilised seedbeds. This problem was first observed in 1975, possibly because the early spring weather was exceptionally wet, inhibiting gas release.

Pre-chilling of Seed

Experiments on Sitka spruce (with and without "cold fungus"), Lodgepole pine and Douglas fir, have confirmed previous results showing that naked pre-chilling for 3 or 4 weeks improves the rate of germination and the number of useable seedlings at the end of the growing season.

Paperpots

Experiments comparing seedlings of different ages have shown after the first growing season, that older seedlings (up to 20 weeks old), when planted out, appear to be better than 16-week-old seedlings on restock sites. A new tool, developed for planting through brash, is being tested with Work Study Branch to assess use in large scale planting.

P. BIGGIN

Arboreta

Eucalyptus

The oldest trials of different *Eucalyptus* species at Kilmun Arboretum (Benmore Forest) on the Holy Loch (Strathclyde Region), were planted in 1949, and some 43 species and varieties have now been tested. Many failed to survive the nursery stage while others show considerable promise. The mean height growth of the tallest plot (*E. urnigera*) has averaged one metre per year for 21 years, while individual trees of *E. nitens*, *E. simmondsii*, *E. cordata*, *E. gigantea* and *E. viminalis*, have averaged more than one metre. Stem form varies considerably; those showing most promise are *E. nitens*, *E. urnigera* and *E. viminalis*.

The rapid early growth of these plots suggested further large-scale trials at sites under less direct maritime influence. The first was planted in nearby Glenbranter Forest on a steep, scrub birch/oak site with a south-east aspect. Growth and survival of 12 species on this site have been affected by both frost and snow. In a later experiment in this forest with a south-west aspect six species were planted, and all had survival percentages exceeding 75 per cent, with *E. simmondsii*, *E. gunnii* and *E. pauciflora* all being more than 4 m tall after six years.

R. LINES

Provenance

Sitka Spruce

Experiments with up to 62 provenances collected by IUFRO, and 12 other seed lots, have now been successfully established on 18 sites, ranging from Cornwall in south-west England to Caithness in north Scotland. Heavy losses have occurred in some of the southern provenances due to frost; failures were replaced but these provenances show repeated frost damage, and their initial stem form will be poor. An analysis of autumn frost damage at Arecleoch Forest (Dumfries and Galloway) showed that distinct provenance groups could be separated, with a curvilinear regression on latitude explaining 91 per cent of the variation.

A report on the patterns of shoot growth and bud set, for 64 of these provenances growing at Bush Nursery (Lothian Region), has been published (Kraus and Lines, 1976).

Lodgepole Pine

Further studies were made on flushing, shoot extension, needle extension and radial increment through the growing season using experiments in North Yorkshire, Dumfries and Galloway, and Grampian Regions in co-operation with Aberdeen University and the University College of North Wales, Bangor. Quite large differences were found in the pattern of radial increment and it is hoped that these can be related to seasonal tracheid formation.

Needle-dry-matter percentage in autumn was assessed on 45 provenances in the Solway Forest (Dumfries and Galloway) experiment planted in 1970, from which shoots were taken for terpene analysis (see p.28). Analyses of dry matter showed highly significant differences between provenance groups and a broad correlation with latitude. Coastal provenances appear to have lower percentages of dry matter than inland ones from the same latitude.

Height assessments after the third growing season in the IUFRO experiments confirm the rapid growth (and poor stem form) of the southern coastal provenances, and suggest that some Vancouver Island provenances may be a better alternative.

Grand Fir

The pattern of height growth, established in the nursery, has continued after the second growing season in the forest, for the 24 provenances planted in 1974. There has been very little frost or winter-browning during the first two winters which were mild.

Red Alder, Alnus rubra

Experiments were planted in early 1976 with nine provenances of *Alnus rubra* and one of *Alnus sinuata* at Shin Forest (Highland Region) and Kielder Forest (Northumberland). Apart from the Alaskan provenance, all grew well in their second year in the nursery, and autumn shoot die-back was minimal, even on the Californian origin. Bacterial nodules had already formed on their roots.

General

International co-operation through the IUFRO Working Parties on Provenance of *Pinus contorta* and Physiology and Genetics continued on an increasing scale in the preparation for the XVIth Congress, and three publications were written.

R. LINES

Species Trials

Mixture Experiments

A co-operative experiment with the Nature Conservancy at Gisburn, Bowland Forest (Lancashire), in 1955 has been assessed after 20 years. The first thinning was carried out in the plots where Scots pine is either pure or in mixture with oak, Common alder or Norway spruce. This experiment provides convincing evidence for the early benefits of raising broadleaved species, particularly oak, in mixture with faster-growing conifers on this kind of low quality site. It also shows the difficult silvicultural and management problems which arise in the later treatment of such mixtures.

Air Pollution

A re-survey of the distribution and health of lichens, around the Invergordon aluminium smelter, was carried out by Dr O. L. Gilbert of Sheffield University. This showed considerable changes in an area within a few miles of the smelter, and pin-pointed some additional sites for collecting conifer foliage samples for fluoride analysis. The results of an extensive foliage survey, made in October 1975, here and near the Fort William smelter, are not yet available, though so far there is little evidence of damage to trees in the Invergordon area. Further samples were also taken near Nigg (Easter Ross, Highland Region), in Blairadam Forest (Fife) and in the southern Pennines, for analysis of sulphur and nitrogen content following the method developed by Malcolm and Garforth. Instruments for monitoring sulphur-dioxide were set up in two sections of Benmore Forest (Strathclyde Region) with the co-operation of the South of Scotland Electricity Board. These will show whether any significant sulphur pollution arises from the power station under construction at Inverkip. Sample plots are also being established in the Forest to monitor growth changes.

Advice was given on air pollution effects in forests to the Natural Environment Research Council, the Department of the Environment, the Central Electricity Generating Board, the Institute of Petroleum, Edinburgh University and Local Authorities.

R. LINES

Drainage

Gleys

Tensiometers have been used on two sites to investigate soil moisture regimes under pine and spruce before and after clear felling. The first is a clear-felled site which is ploughed down the slope at 7–8 m spacing between windrows. The second site has a pole-stage crop.

Results from experiments involving cross-draining during the pole-stage indicate that response rapidly declines with distance from the drain. Since the response depends on three factors, first, the opening in the canopy created when trees were felled prior to draining, second, the drains, and third, spoil from the drains, investigation continues to separate these effects.

Deep Peats

A new plough, the D60/–/t* pulled by one tractor, was developed to provide a furrow 60 cm deep with a planting distance of 2·1 m.

D. A. THOMPSON

Cultivation

Rotary Mouldboard Plough

An extensive trial with three different rotors at Stenton Forest (Borders and Lothian) confirmed the potential of this plough to improve soil mixing above that achieved by a conventional plough. Subsequent trials, on regeneration sites, indicate that the rotary mouldboard plough does not become snagged on stumps and brash any more than the conventional tine plough.

Indurated Gleys

On a regeneration site at Black Isle Forest (Highland), comparisons of Lodgepole pine and low input treatments with Sitka spruce and high input treatments are being made. The treatments include ripping, deep double mouldboard tine plouging (D60/T90/m/I 4·0)*, spaced single mouldboard tine ploughing (S60/T90/m/I 2·0)*, and complete ploughing with the deep single mouldboard plough (S60/T90/m/I 1·0)*.

D. A. THOMPSON

Nutrition

A high demand continues from Forestry Commission and Private Woodland managers for foliage analysis of forest crops. Phosphorus levels are generally well above satisfactory levels in most samples, but pockets of serious P deficiency continue to be revealed in foliage analysis. Large areas of Sitka spruce in heather "check" still exist, and managers must appreciate that more than one application of 2,4–D or nitrogen is often necessary to enable spruce to close canopy on heather sites.

Many new experiments are being laid down in Sitka spruce, and in Lodgepole and Scots pine stands after canopy closure, to determine basal area response to N, P and K. Some of the older establishment-phase nutrition experiments are also being converted to basal area assessments if treatment plot size is large enough (usually 0·05 ha).

G. J. MAYHEAD

Forest Weed Control

Herbicides vary in price and effectiveness, and managers can reduce costs by matching herbicides to the weed spectrum and labour availability. An appreciation of the two main modes of herbicide action should help; i.e. they act by contact with green tissue (e.g. paraquat and glyphosate), or are soil-acting and residual in the short term (e.g. dichlobenil, chlorthiamid and propyzamide).

Tests in winter and spring 1974/75 of five granular herbicides on Sitka spruce in Upland Britain confirmed previous findings that the following could be used safely for weed control in crops of one year old or more; propyzamide (2·0 kg

*This is a new nomenclature intended to order and simplify the classification of ploughs in a logical way. This classification, which incorporates the design specification of each plough, has been published elsewhere (Thompson, 1976).

a.i./ha), chlorthiamid (3·8 kg a.i./ha), dichlobenil (3·8 kg a.i./ha), dichlobenil/dalapon mixture (2·7/4·0 kg a.i./ha), atrazine (5·0 kg a.i./ha). Very few tree deaths occurred at twice the above rates.

Weed control on organic soils continues to be a problem, especially if they are interspersed with non-organic soils: the more reliable herbicides on organic soils are: paraquat, glyphosate, dalapon or dichlobenil/dalapon mixture.

G. J. MAYHEAD, J. H. THOMSON

Crop Stability

Thinning

Two new experiments at Kershope Forest (Cumbria) compare patterns of thinning with a "no thin" control. Thinning took place in October 1975, and the severe gales of January 1976 caused extensive damage in the more exposed experiment. The pattern and extent of damage was similar to that experienced previously, in that the thinned plot (two rows out of six removed) was more badly damaged than the "no thin" control, and damage was mainly in the rows adjacent to the felled rows.

Advisory

The effect of extensive windthrow has to be taken into account in long-term production forecasting. In preparation for the next Forestry Commission production forecast a large proportion of time was spent on advisory work, particularly thin/no thin boundaries using the National Stability Classification (Booth, 1976) as a basis. In West Scotland after the system had proved practical, 30,000 ha were surveyed and zoned by Site Survey Branch.

T. C. BOOTH

Regeneration

Artificial Regeneration on Gley Soils

Ten-year assessments at The Bin, Huntly Forest (Grampian), show the same pattern as at six years (see *Report* for 1972), *viz.* no benefit from single-furrow ploughing or from the addition of phosphate. However, Lodgepole pine and Sitka spruce are growing at General Yield Class 14 compared with General Yield Class 8 of the previous Scots pine crop.

Natural Regeneration

At Forest of Ae (Dumfries and Galloway) a dense crop of naturally regenerated Sitka spruce was reduced to an approximate spacing of 2 m × 2 m two years ago. Height growth on the untouched plot is still as good as the best of the treated plots, although foliage colour is more yellow. Selection of dominant trees has given 0·7 m mean height advantage over a simulated mechanical treatment, and the use of 2,4, 5–T to control regrowth on cut stumps has reduced growth on the remaining trees by 0·5 m.

T. C. BOOTH

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SITE STUDIES (SOUTH)

Foliar Analysis

Broadleaves

The ranges of concentrations of the major nutrients associated with adequate rates of growth are known for several conifers, and standard sampling procedures have been established. Much less is known about broadleaves.

M. J. Rivett, an arboricultural student from Merrist Wood Agricultural College sampled two groups of five oak trees from two different stands at approximately fortnightly intervals over a year, from the resting bud to the senescent leaf. There is no significant difference for the concentrations of N, P, K, Ca, and Mg in the leaves between these two groups, and themean lines are shown in Figure 1.

The curves suggest that in 1974 the period between 7th July and 9th August would have been suitable for sampling for N, P, and K. Magnesium shows no period of steady concentration, and the calcium concentrations vary so widely between trees and between sampling dates for any individual tree that interpretation seems impossible.

Service

The demand for analysis, at 5700 samples, was a little greater than last year, but still appreciably less than in 1973/74.

W. O. BINNS

Soil Analysis

The variation of soil chemical properties is being investigated on an upland brown earth soil at Tywi Forest (Powys and Dyfed). Different sampling intensities have been used and, after chemical analysis, should give an indication of the number of samples needed to characterise a site for the properties being measured.

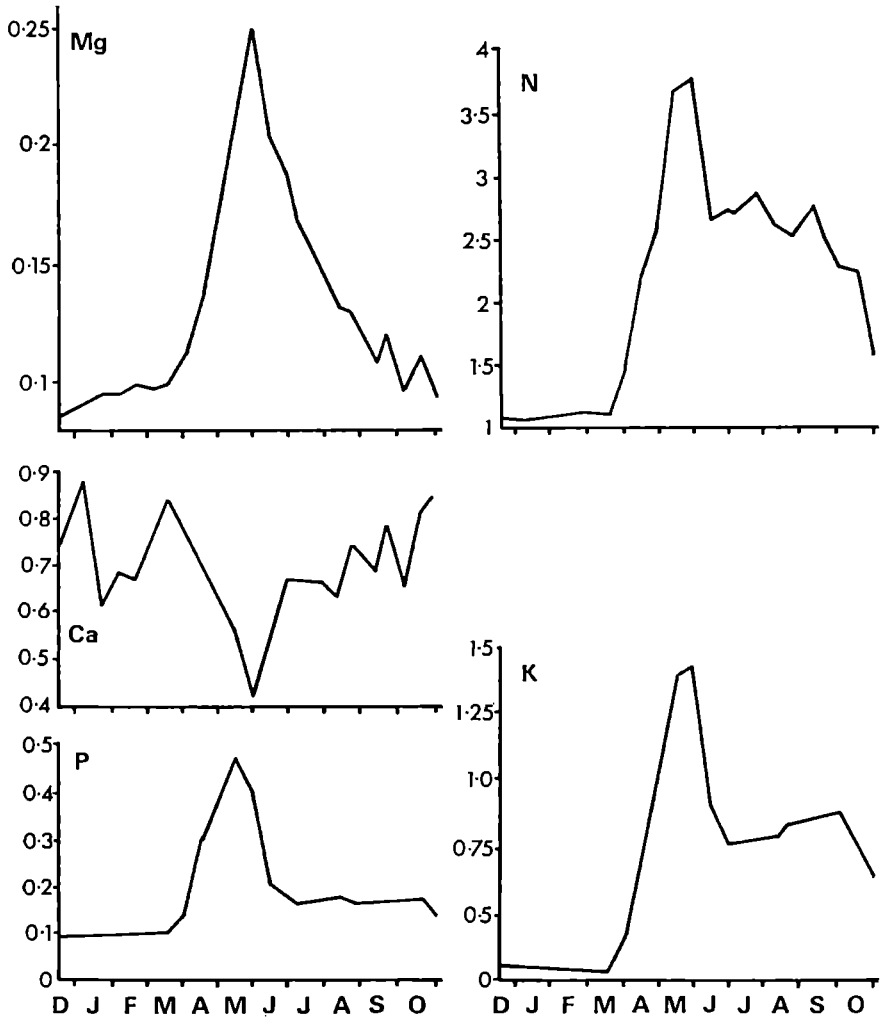

Figure 1: Variation in nutrient concentration of oak leaves over 10½ months, 1973–74. Mean values for ten samples from two populations, as element per cent oven-dry leaves.

The addition of phosphatic fertiliser increases the amount of "available" phosphate (measured by extraction procedures) in a soil. When added as a solution of orthophosphate, the soil completely absorbs the phosphate within a few minutes. Over a period of approximately three hours, the "available" phosphate decreases and the non-labile form increases to levels which remained constant for a period of one month. Grinding of sieved, air-dried soil did not increase the amount of "available" phosphate. This suggests that the "available" phosphate is solely a surface property of the soil and that the soil phosphorus can be represented by the equilibrium:

$$^{P}\text{ solution} \rightleftharpoons {}^{P}\text{ labile} \rightleftharpoons {}^{P}\text{ non-labile} \rightleftharpoons {}^{P}\text{ min}$$

where ^{P} min represents the phosphorus in the mineral lattice comprising the soil.

A. WILLSON

Effects of Trees on Sites

Work has been completed on the re-analysis of mineral soil and vegetation composition in the species plots examined by Ovington in 1953–55, outlined in last year's *Report*. Changes in species composition over the 20-year period show a marked pattern of convergence: variation of ground vegetation from plot to plot is now far less than in 1953. In these lowland areas the effects of climate and underlying soil may begin to override some effects of canopy and the influence of litter as the crop ages. Changes in soil pH, total N and acetic acid-extractable P, Ca, Mg, and Na have been very small and difficult to detect. There has been a marked general convergence in the pH and cation data similar to that in the species composition, although not spatially correlated with it. Extractable Ca and Mg levels are consistently lower than in 1953.

M. A. ANDERSON

Lowland Production Forestry

Gravel Workings

The use of large machines to restore and grade land worked for gravel often causes serious compaction. A new experiment at Bramshill Forest (Hampshire and Berkshire) is testing the effects on survival and growth of Corsican pine and *Pinus muricata*, of tining the sandier type of restored gravel workings at different spacings and depths (see Plate 2.). Nitrogen top dressings are also being tested. Soil physical properties will be measured to quantify the effects of the cultivation and their persistence. Heavier textured soils are also being studied.

Fast-Growing Pines

During 1975 plots of "blue" *Pinus muricata* and *Pinus radiata* were planted in five forests. *Pinus muricata* from Humboldt County, California (its most northerly occurrence), is being compared with the Mendocino origin, imported from Ashley (New Zealand) and with *Pinus radiata* and Corsican pine, in a 6 ha experiment at Newborough (Gwynedd).

Very severe "yellows" developed in *Pinus radiata* during the mild and cloudy winter of 1974/75; in contrast the 1975/76 winter was colder, drier and sunnier and many stands have become greener, though poor needle retention betrays their history. The contrasting seasons are held responsible for these differences.

Seed of *Pinus radiata* should be collected from home grown trees at least 20 years of age which retain at least three years' needles. Stands should be regularly "rogued" to remove poor trees.

Maximum Amelioration and Limiting Factors

Thirteen fully manured species plots were set out in 1970 at Wareham (Dorset). Herbicides and insecticides are used as necessary and nutrient additions are based on annual foliar analysis. Sitka spruce and Western red cedar can make a very rapid start, Corsican pine, Norway spruce and Grand fir need a year or two to settle down, while Noble fir sticks to a slow growth rate for several years (see Figure 2.).

W. O. BINNS, D. F. FOURT

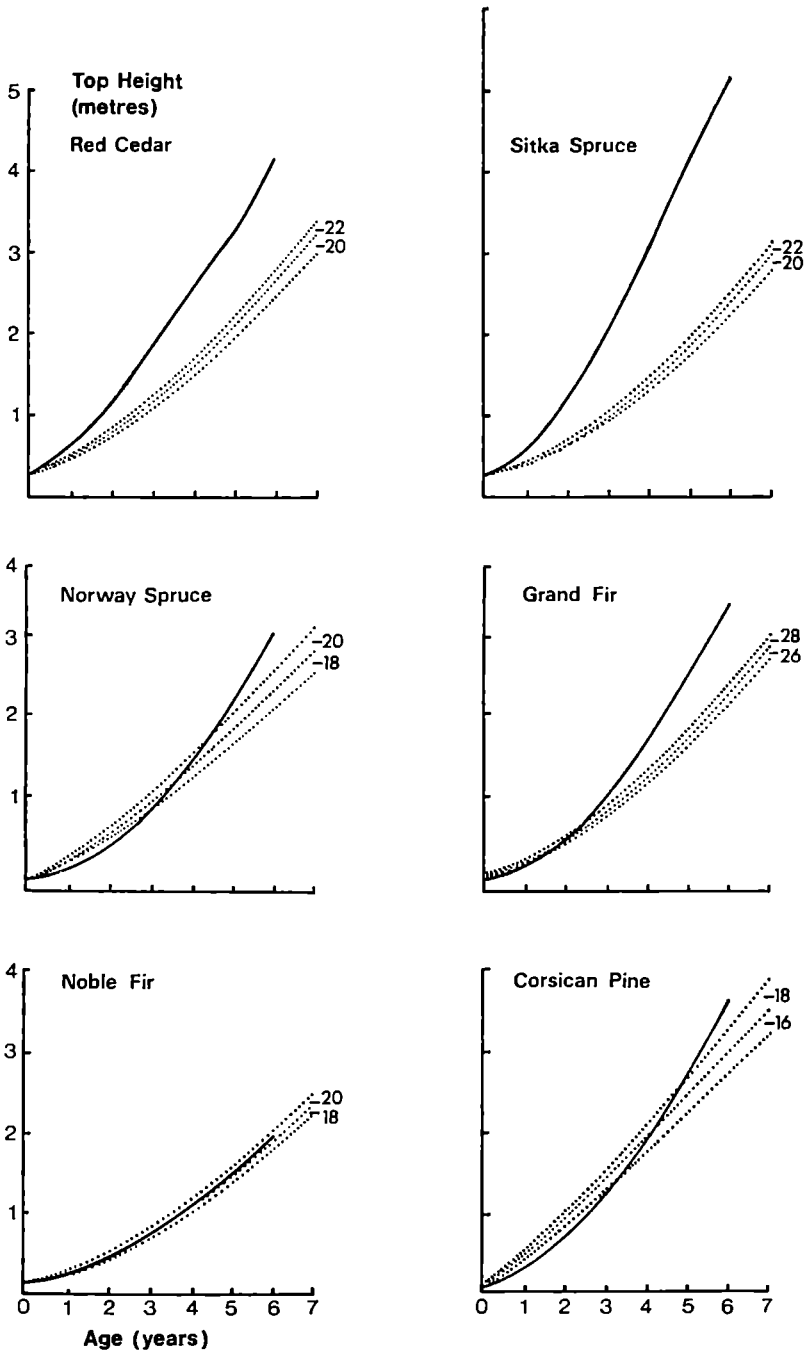

Figure 2: Maximum amelioration at Wareham Forest, Dorset. Height growth of six species compared with expanded management table curves, up to age six. The figures denote metric yield classes.

Lichens and Pollution

Sections of bark bearing the sensitive lichen *Parmelia caperata* were transferred in 1974 from Wareham Forest (Dorset) to Cannock Forest (Staffordshire) and the Forest of Dean (Gloucestershire). By 1976 survival was the same in both forests, but some colonies were expanding at the Dean while at Cannock the best was only holding its own.

The development of naturally occurring colonies of the foliose lichens *Hypogymnia* (*Parmelia*) *physodes* and *Parmelia sulcata* at Cannock Forest was studied by means of annual tracings. Over two years these show a pattern of germination, expansion and disintegration followed either by complete disappearance or the regeneration of the parts remaining. Both techniques appear useful in pollution studies in forests.

K. BROAD

Amenity and Arboriculture

To investigate the nutritional status of lime, an important amenity genus, leaves of three species, *Tilia europea*, *cordata*, and *platyphyllos*, were sampled in August 1975, on a wide range of sites in Southern Britain. No statistical analysis of the nutrient concentrations has yet been made, but the values for N, P, K, Ca, and Mg appear to vary little between regions and most trees sampled seem well supplied with these nutrients.

W. O. BINNS

Meteorology and Phenology

The Branch stores meteorological records for the Division. Outside enquiries included rainfall figures for Headquarters; annual weather summaries for Conservancies; and correlation of long-term drought and heavy rainfall with building foundation failure caused by tree roots.

Great Britain has only one site in the IUFRO international phenology garden project, out of the 1975 European total of 60. An increase in the sites represented is being considered.

M. A. ANDERSON

SITE STUDIES (NORTH)

Classification and Improvement of Upland Soils

Indurated Soils

The important cultivation experiment at Teindland (Speymouth Forest, Grampian Region) planted in 1952 on an ironpan soil with indurated subsoil, is being studied in an attempt to explain why the complete cultivation treatment grew less than the others in the 15–20 years period (Thomson and Neustein, 1973). Soil moisture, rainfall and tree diameter growth have been measured weekly or twice weekly for two growing seasons and less frequently in the winters.

Waterlogging no longer occurs under the trees regardless of the type of cultivation whereas the untouched soil beneath the original heathland vegetation remains wet or waterlogged for most of the year.

Soil dryness has been measured as moisture potential (suction) using tensiometers. In addition to the natural rainfall as the "control" treatment, we have imposed two other moisture regimes using plastic roofs to intercept the rainfall

over small plots and thence to supply it as a bonus to other plots. For Scots and Lodgepole pine, diameter growth over ½-week periods is closely dependent on moisture supplied to the surface soil by rainfall events, and there may be an overall shortage of moisture during the growing season. The diameter growth of Sitka spruce is also affected by the rainfall pattern but the response of the trees is more sluggish.

A dressing of NPK fertiliser has been given to half of the plots to see if the effect of soil moisture variation is also dependent on nutrient supply.

Gleys and Ironpan Soils

The work at Newcastleton Forest (Borders Region) has continued. In addition to the moisture and temperature of the four soil types, the concentrations of oxygen and carbon dioxide in the soil have been measured during the growing season. The extent and duration of near-anaerobic conditions in the surface-water gley and peaty gley and in the ironpan soil *above* the pan was striking. In contrast, generally good aeration prevailed *below* the pan and throughout the brown earth profile. The poor aeration of the gley soils persisted through the two periods of hot, dry weather in 1975 when the water table fell beyond 70 cm depth. The better aeration beneath the ironpan than above it is presumably due to the entry of air into the subsoil through occasional fissures, and perhaps, also, to a lower rate of consumption of oxygen by the fewer roots and organisms present. (See Aeration Status of Upland Soils, p. 56).

Deep Peats

A survey of tree crops on deep peat has shown that the drying and the development of shrinkage cracks are dependent on the original depth of peat, degree of humification, tree species and probably also climate. Lodgepole pine has a much greater drying effect than Scots pine, Japanese larch or Sitka spruce. (See Plate 3). Although the removal of water from different peats may take place at a similar rate under a given species, drying is more intense and cracking more rapid where the peat is relatively shallow (less than 1·5 metres) and well humified than where it is deep and more fibrous.

Nevertheless, under the favourable climate of the lowland bogs near Dumfries, shrinkage cracks have been found under fast growing Lodgepole pine only nine years old in spite of a peat depth greater than three metres.

Work on the classification of deep peats has continued, and it is planned to complete in 1976.

Damage to Soil Caused by Harvesting

There is increasing concern over the effects of modern harvesting methods on various easily damaged soils. A small experiment has been laid down on a gley soil on indurated material at Black Isle Forest (Highland Region). Two degrees of simulated damage with and without remedial cultivation are being compared with the undamaged control in their effects on the soil and the survival and early growth of the new crop.

D. G. PYATT

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FOREST GENETICS

Testing

Pollinations

None of the many Lodgepole pine seed origins under test in Britain combine the highly desirable attributes of vigour and stem-straightness. However, ten-year-old experiments of artificially produced between-provenance hybrids have shown that it is possible to combine these characters to a fairly high degree. In light of this evidence a systematic programme of artificial pollination, between widely separated populations of Lodgepole pine, was started during the year, when south-coastal Washington (Long Beach) and north-coastal Alaskan provenances were hybridised. A single-pair mating scheme was used to make 150 crosses.

Early-tests

At present foresters must assume that natural hybrids occur from seeds collected either from boundary trees of adjacent European and Japanese larch crops, or from orchards containing mixed European and Japanese larch clones. It is also widely assumed that any hybrids which may occur from cross-pollination will show faster growth-rates than plants derived from either of the parent species. In order to test these assumptions seed from two clonal orchards, which had been partially rogued to favour trees with matched flowering periods and good stem-straightness, and three putative hybrid larch seed sources were compared to a bi-parental hybrid of known high merit. Previous glasshouse, nursery and forest-stage progeny tests have shown that it is possible to determine the potential value of larch at a very early stage. Plants were raised in a glasshouse in which a minimum air temperature of 20°C and a day-length of 18 hours were artificially maintained throughout the test. Five months from sowing, when the largest plants were more than 700 mm tall, it was clear that only the material derived from the two clonal seed orchards produced seedlings which were at all comparable, in growth, with those of the known hybrid. All the three seed stands were much poorer, the worst having a mean height of less than half of that of the known hybrid.

Forest Progeny Tests

The first major analysis of height growth from open-pollinated progeny data for 80 selected Sitka spruce trees was possible on the completion of their sixth growing-season. The tests were replicated on eight sites ranging from north Scotland to south-west England. On all sites the same nine progenies had height growths at least 15 per cent better than the commercially obtained Queen Charlotte Island, BC control; three progenies were consistently worse on all eight sites. On the overall evidence from these experiments it has been possible to recommend that test sites be restricted to north Scotland, the English/Scottish borders area, and south-west England.

Seed Production

Plus Tree Selection

In spring 1975 a survey of 20–30 year-old high quality Corsican pine stands of known origin in East Anglia indicated good coning. During the summer

550 selections were made. The main selection criteria were good stem- and crown-form and a crop of at least 100 cones. Cone collections were carried out in November, the seed extracted and tested by X-ray analysis and sown in Japanese Paperpots in a heated plastic-covered house in January.

Flowering Studies (See front cover picture)

A large handicap to the improvement of Sitka spruce is the length of time for a graft or seedling to flower, since this determines the breeding cycle and the number of generations which can be obtained per unit of time. This time interval can vary from ten to thirty or more years.

Nineteen Sitka spruce clones were grafted in 1970, and in 1972 these were potted-on into 33 cm diameter plastic buckets, and left to become established in these containers for a year before beginning a flower induction trial. Twelve well established ramets of each clone were selected for uniformity in spring 1973, to which one of three treatments were applied, namely: (a) severe drought—500 ml of water per week in two application; (b) moderate drought—1000 ml of water per week in two applications; (c) as (b) but grafts also girdled by two half, and slightly overlapping, girdles near to ground level. Plants not subjected to drought or girdling provided a control. The grafts in all treatments were taken into an unheated plastic-covered house on 1st April 1973, and the soil was allowed to dry out, for three weeks, before the watering treatments began; these grafts were transferred out-of-doors in mid-July 1973. Plants in the control treatment remained outside for the entire period.

The grafts in all treatments were taken into the plastic-covered house again at the beginning of April 1974 and remained there for 12 months. The drought and girdling treatments were not re-applied in 1974 but all the indoor plants were given a reduced watering regime.

In 1974 ten of the 19 clones in all treatments produced from 1–141 male flowers, and four of the 19 clones produced from 6–70 female flowers. A total of 261 male and 139 female flowers were produced indoors; the out-of-doors controls produced five and three respectively.

In 1975 all 19 clones inside the plastic-covered house produced male flowers and 17 produced females. A total of 2,772 male flowers and 1,232 females were produced inside (an average of 16·2 and 7·2 respectively), and 10 and 5 flowers out-of-doors. An anlysis of the data showed no significant differences between treatments within the plastic-covered house in either year. This is highly suggestive that temperature, rather than drought, is a main predisposing cause leading to flower initiation in Sitka spruce.

Seed Stands

Six new seed sources totalling 182 ha were registered during the year. One other source was inspected and rejected. Almost 150 ha of the total consisted of very high quality Corsican pine, much of which was coning heavily, and was scheduled for felling.

In the Sitka spruce seed stand flower-induction experiments, referred to in the 1975 *Report*, none of the nitrogen or stem-girdling treatments which were applied to middle-aged crops in March 1974 stimulated flowering.

Biochemical Variations

Completion of the seasonal-variation study of the cortical resin monoterpenes of Sitka spruce of a wide variety of genotypes, showed that in the main stem the composition was constant over the year, while in the shoots significant changes occurred during flushing. The nature of the changes varied between trees.

Studies of the variation between provenances of Lodgepole pine growing at two sites (Bush Estate, Lothian Region, and Solway Forest, Dumfries and Galloway Region) showed that the shoot resin monoterpene composition was correlated with the geographic origin of the seed. Alaskan coastal provenances gave a distinct pattern with little variation, while there was a cline in both the monoterpene composition and its geotype diversity, from the Skeena River BC area, south-eastwards to southern Alberta. In the southern part of the range several regions were characterised by distinct types of monoterpene compsition. In an experiment, in collaboration with the Institute of Terrestrial Ecology, the provenance of a large Lodgepole pine population of uncertain origin was confirmed by the resin monoterpene composition.

In collaboration with Site Studies Branch, analyses indicated that the "blue" and "green" forms of *Pinus muricata* can be easily distinguished by their resin composition.

R. FAULKNER, A. M. FLETCHER, R. C. B. JOHNSTONE, G. I. FORREST

TREE PHYSIOLOGY

Root Form

Previous work on Sitka spruce with divided root systems (*Report* for 1974) has shown that a localised stimulation of root growth is induced by a one-sided application of mineral nutrients. In plants which have an uneven root system it is not known whether a vigorously growing part of the root system might dominate a weaker portion, or whether the weaker root may be stimulated into new activity, when uniform conditions are restored. This problem was investigated using split root Lodgepole pine seedlings, growing in solution culture. The two roots of each seedling were growing under contrasting nutrient regimes until growth differences had developed. On transference to a uniform environment, of optimal mineral nutrients, the smaller slow growing roots, which had previously been subjected to a low level of mineral nutrition, were stimulated into rapid growth (Fig. 3). This occurred even when the low-nutrient roots were dormant when transferred to the optimal conditions.

The results indicate that the root system remains remarkably plastic in its responses to the local environment. The development of the root systems of newly planted trees need not necessarily, therefore, be dominated by the most active roots which develop in the first year. Such roots would be expected to have a competitive advantage over younger or less vigorous roots, but such competitive effects could later be over-ridden by the local changes in soil environment, encountered as the roots grew, or as fertilisers were supplied.

Research on the waterlogging of tree roots has included a study of the responses of dormant roots at 6°C. The roots of cuttings of both Sitka spruce

and Lodgepole pine survived a 30-day flooding treatment at this temperature, and growth resumed from the original tips when the peat was drained. This contrasts with the considerable die-back, especially in Sitka, encountered in previous experiments on actively growing roots, at a summer soil temperature of 15°C.

Experiments are now in progress to separate the effects of dormancy and low temperature in this response.

M. P. COUTTS, J. J. PHILIPSON

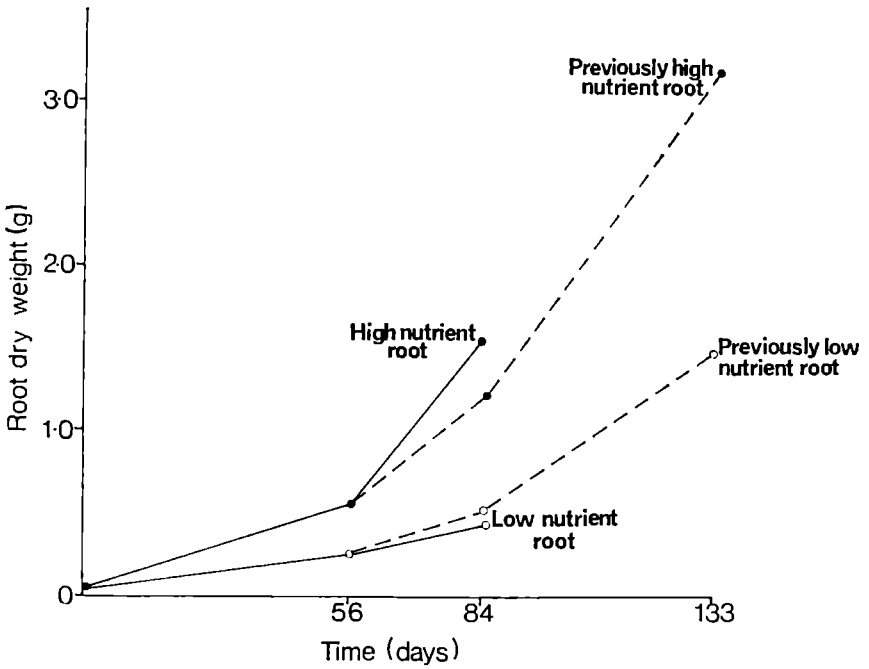


Figure 3: Time course of dry matter accumulation in Lodgepole pine roots. The plants had divided roots growing in either uneven or uniform nutrient concentrations. Certain plants were transferred from the uneven (solid lines) to the uniform high nutrient regime (dashed lines) at 56 days.

Vegetative Propagation

Hybrid Larch

Further studies of summer softwood cuttings of Hybrid larch suggest that these cuttings root best when they are bottom-soaked in an aqueous solution of indole-butyric acid and struck into 25:75 v/v peat:sand mixture as the rooting medium, with the bed temperature of c. 15°C and an air temperature of c. 20°C. A low storage temperature (3 days at 2°C) significantly increased both the number of cuttings rooted and the number of roots formed from each rooted cutting (Table 3).

TABLE 3
ROOTING OF SOFTWOOD HYBRID LARCH CUTTINGS FROM 12-YEAR-OLD PLUS TREES AT TEINDLAND

	Storage at 2°C for			
	16 hours		72 hours	
Propagation Bed Temperature	15°	25°	15°	25°
Rooting %	32·4	27·8	66·9	28·0
Average Number of Roots	2·9	2·2	4·2	2·0

Whereas relatively high levels of rooting have been attained with softwood summer cuttings of hybrid larch, no success has yet been achieved with leafless winter cuttings.

An anatomical investigation of the stages of root development in hybrid larch cuttings has been started.

Sitka Spruce

Further work on Sitka spruce has shown that the proportion of cuttings which root varies with the month of collection, the greatest success being achieved in April. Screening of a number of clones over a three-year period has shown that clones generally retain their characteristic rootability, although in some years certain clones which are normally easy to root may become difficult, and *vice versa.*

Field tests with rooted cuttings of Sitka spruce that were initially plagiotropic have shown that orthotropic growth can be achieved after three to four years. The rapidity of the change from a plagiotropic to an orthotropic habit seems to be related to the vigour and the clonal origin of the cutting.

A. JOHN, J. HOWARTH, J. SIVILL

FOREST PATHOLOGY

Fomes annosus

Butt-rot in Sitka Spruce

Analysis of the data from this project (see *Report* for 1974) indicates that volume losses following rejection of decayed butt lengths average 20 per cent per tree, or 35 per cent following rejection of incipiently-decayed or stained butt lengths. These losses are lower than had been expected. Losses in crops are dependant more on the incidence of diseased trees than on losses per tree. Incidence could not be predicted from data collected in this study.

Preliminary results from the joint study with the Building Research Establishment, Princes Risborough Laboratory (*Report* for 1975), into strength properties of Sitka spruce wood, in various stages of decay caused by *F. annosus*, suggest that loss in strength of incipiently decayed and stained wood is insignificant.

J. E. PRATT, B. J. W. GREIG

TABLE 4
1975 SURVEY RESULTS—ELMS IN THOUSANDS

Location	Total No. of elms	Number slightly affected	Number dying and recently dead	Number long dead
Non-rural	1,900	140	500	240
Rural	10,800	940	2,720	1,420
All non-woodland	12,700	1,080	3,220	1,660

Non-rural elms = elms in gardens, streets and urban parks; Rural elms = elms in hedgerows and rural parks

TABLE 5
ESTIMATES OF NON-RURAL AND RURAL ELM BY COUNTIES IN 1975

Elms in Thousands

County	Proportion of the County Surveyed	Total	Dying and Recently Dead	Long Dead	County	Proportion of the County Surveyed	Total	Dying and Recently Dead	Long Dead
Bedford	All	227	68	13	Monmouth	9/10	97	23	29
Berkshire	All	582	269	25	Norfolk	5/10	356	4	2
Buckingham	All	476	202	7	Northampton	All	224	43	15
Cambridge	All	220	10	1	Oxford	All	453	112	8
Cornwall	3/10	105	10	5	Shropshire	4/10	222	38	70
Devon	4/10	633	64	11	Somerset	All	1538	662	203
Essex	All	866	151	239	Stafford	3/10	68	15	6
Glamorgan	4/10	75	6	0	E. Suffolk	All	1016	58	46
G.L.C.	All	162	36	49	W. Suffolk	All	500	14	0
Gloucester	All	466	113	247	Surrey	All	579	300	140
Hampshire	8/10	379	171	121	E. Sussex	All	103	0	3
Hereford	All	221	43	78	W. Sussex	All	91	38	39
Hertford	All	321	111	5	Warwick	All	647	173	77
Huntingdon	All	239	4	4	Wiltshire	All	925	296	50
Kent	All	458	130	105	Worcester	All	216	43	65
Leicester	All	195	19	1					

Dutch Elm Disease

Survey 1975

As its predecessors have done, the 1975 Dutch elm disease survey of southern Britain concentrated on the rural and non-rural elms, i.e. those in hedgerows, gardens and urban areas, rather than the woodland elms. The figures in Table 4 show that, for these two categories, the number of dead and dying trees totalled 4·9 million, an increase of 1·7 million over 1974. If an allowance is made for disease in woodland, the estimate for dying and dead trees amounts to 5·6 million, in addition to which it is considered that some 1 million diseased trees have been felled since the start of the epidemic in the late 1960s.

The County data (using the boundaries operating before the reorganisation of local government in 1974) are shown in Table 5. The data for small counties, with low elm populations, are necessarily less reliable than those for large counties with high elm populations. If account is taken of trees felled because of the disease since 1972, it is estimated that West Sussex has lost 89 per cent of its non-woodland elm population, Gloucestershire has lost 87 per cent and Hampshire 84 per cent. As noted last year (*Report* for 1975) the disease is still affecting only a small proportion of the elms in some of the counties of East Anglia, notably Norfolk, West Suffolk and Huntingdon. It is in this part of the country that the smooth-leaved elm, rather than the highly susceptible English elm, make up the majority of the population. The level of disease also remains low in East Sussex, where there is a geographically isolated English elm population, and a very vigorous sanitation campaign against the disease is being waged by the local authority.

No quantitative information on the number of trees killed is available for northern Britain. However information on the distribution of the aggressive strain of *Ceratocystis ulmi* is shown in Figure 4. The aggressive strain is widely distributed in north-east England, but does not seem to be so well established in the north-west. The status of the disease in Scotland is described below (p. 35).

J. N. GIBBS

Root Transmission

Studies have shown that rural elm hedgerows arise from sucker or coppice origins, long lengths of such hedgerows have common root systems, and transmission of the aggressive strain of *Ceratocystis ulmi* occurs readily through these roots. It has been observed that all the trees in a hedgerow will die within four years of the initial infection, and that root transmission accounts for about 75 per cent of the deaths. It is estimated that in the current epidemic, about 3 million trees have died as a result of root transmission of elm disease. Root transmission also occurs between trees planted in lines and avenues through grafted roots, especially if the trees are less than 10 m apart.

B. J. W. GREIG

Beech Bark Disease

The Effect of Thinning

An experiment was laid down during the winter of 1970/71 to follow the effects of different thinning regimes, on pole-stage beech, in two southern England forests. There were four treatments, in three randomised blocks, at each site: A, unthinned, B, light thinning (about 30 per cent of stems removed),

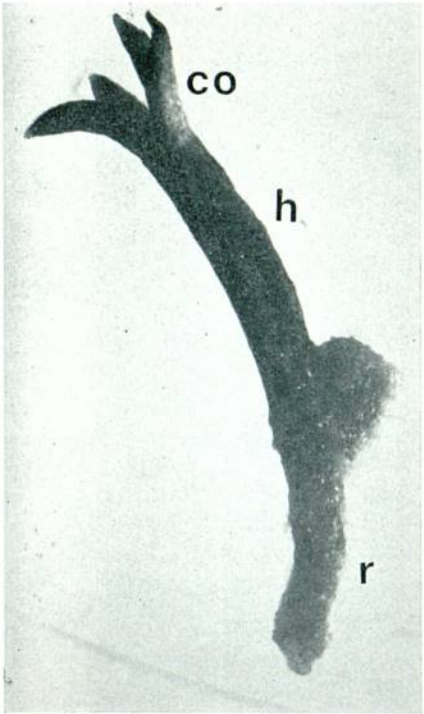
Plate 1—Seed (p. 8).

Members of the International Seed Testing Association Workshop held at Surrey University in July 1975. A. 6088.

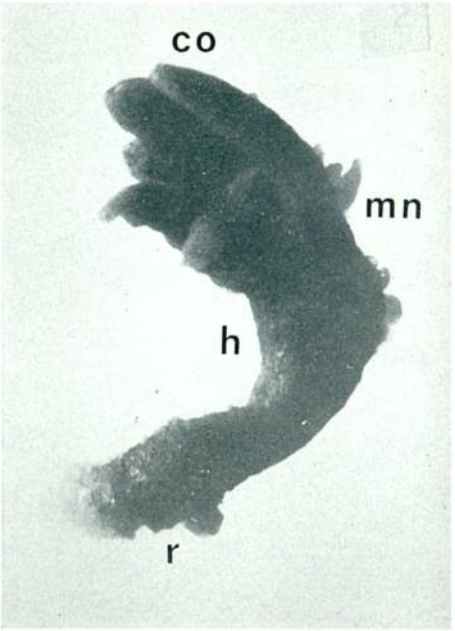
Plate 2—Site Studies South (p. 22).
Gravel workings in Bramshill Forest, Hampshire. (above) Heavy machines used for grading restored land. B. 8776. (right) Multishank adjustable ripper used to relieve compaction by tining to 710 mm depth with a D8K tractor. B. 8777.

Plate 3—Site Studies North (p. 25).

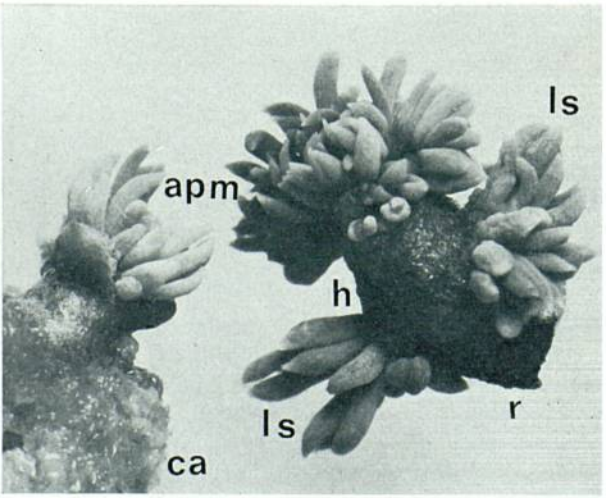
Deep peat, which has grown a crop of Lodgepole pine for 45 years, showing the shrinkage cracks resulting from drying of the peat. The drying appears to be largely irreversible, and the cracks produce a great improvement in the permeability and aeration of the peat. The scale is 50 cm long. Lon Mor, Inchnacardoch Forest, Highland Region. A. 6964.



"Normal" embryo germinations on hormone-free medium.



Embryo maintained in media conducive to "de novo" initiation of meristematic nodules in the hypocotyl.



Embryos showing proliferation of the apical meristem and the outgrowth of the initiated meristematic nodules to leafy shoots on transference to hormone-free medium.
Note the stunted radicle.

Plate 4—Street and Webb (p. 58).
Excised embryos of *Pinus contorta* germinated under sterile conditions.

Legend

apm	apical meristem	ls	leafy shoots
ca	callus	mn	meristematic nodules
co	cotyledons	r	radicle
h	hypocotyl		

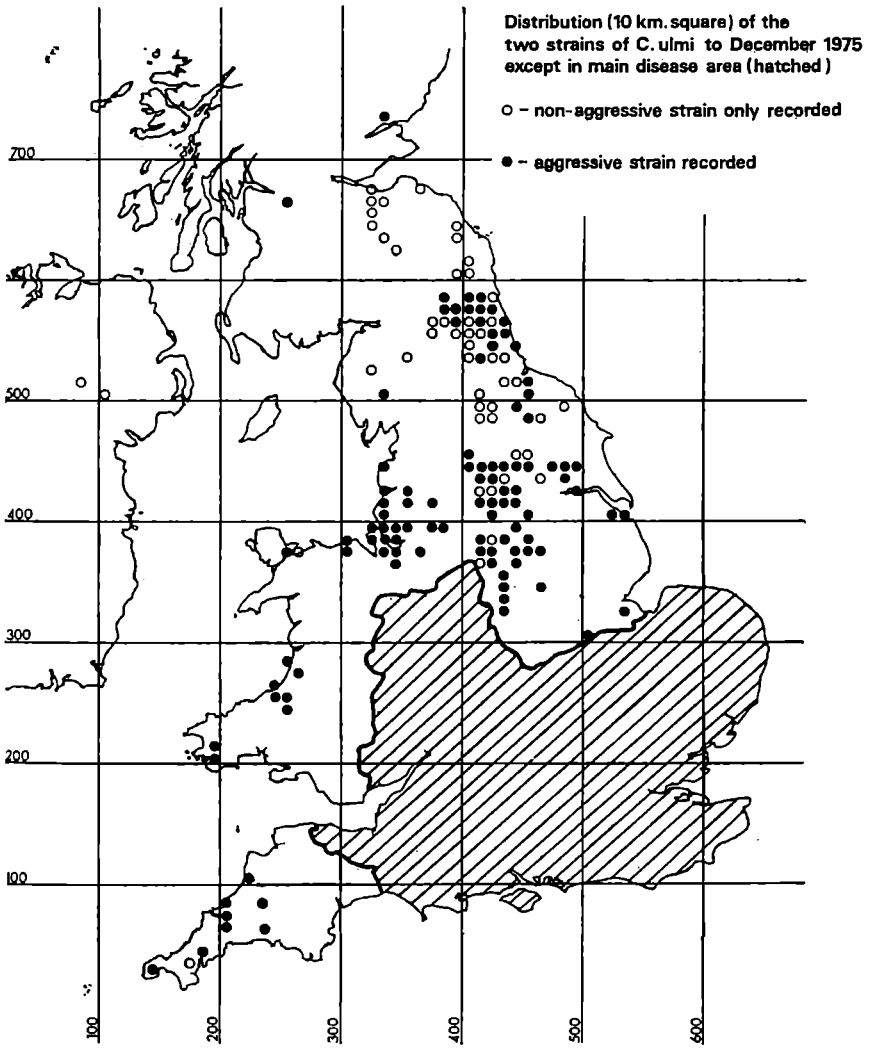


Figure 4: Distribution of Dutch elm disease up to the end of 1975.

C, heavy thinning (about 50 per cent removed), and D, extreme thinning (about 65 per cent removed). Plot size was 35 m square, with an inner assessment area of 30 m square (0·09 ha). The original stand density was about 3,500 stems/ha of trees with diameter over 75 mm at breast height (diam bh).

The degree of infestation by the Felted beech scale, *Cryptococcus fagi*, on each tree was assessed using a score system of 0 to 5, and deaths of trees due to subsequent invasion by *Nectria coccinea* were recorded annually. Diam bh was recorded to calculate annual increment. The data are summarised in Table 6.

There was a significant overall increase in Beech scale infestation in both forests. However, there was no significant relationship between thinning regime and subsequent infestation, although the older crop, at Friston, showed some

TABLE 6
THE RESPONSE OF BEECH TO THINNING

Location		Bedgebury Forest (P.1933) (Friston Section, E. Sussex)				Queen Elizabeth Forest (P.1938) (Hampshire)			
Thinning regime		A	B	C	D	A	B	C	D
Mean diam bh (mm)	1971	150	152	154	158	97	98	101	103
	1975	162	165	169	173	114	112	124	123
Mean Beech scale score	1971	0·59	0·64	0·60	0·72	0·97	1·08	0·84	1·12
	1975	1·91	1·75	1·73	1·55	2·16	2·37	2·71	2·26

tendency for the increase to be less as the intensity of thinning increased, and exposure was greater.

Thus, from this interim evidence, silvicultural thinning (as distinct from sanitation thinning) would seem to have little effect on the course of Beech scale infestation.

E. J. PARKER

Advisory Services

Excluding the many queries on Dutch elm disease in the south, 528 enquiries were received at Alice Holt and 158 at the Northern Research Station.

Alice Holt

In consequence of the growing appreciation of the problem of decay and safety in ornamental trees, the service was expanded to include the identification of wood-rotting fungi in culture, on the basis of M. K. Nobles' (1948) system. Forty-eight identifications covering 15 species were made, the species most frequently encountered being *Armillaria mellea*, *Polyporus giganteus* (mainly on beech), *P. sulphureus* and *Ganoderma applanatum*.

Verticillium dahliae was found killing boughs on a 30-year-old *Aesculus hippocastanum*, apparently the first record on this host in Britain, though not elsewhere.

Phytophthora cryptogea was isolated from dying roots of a 10 ft high *Thuja plicata* in an arboretum, and *P. citricola* from soil around a 45-year-old *T. plicata* screen exhibiting Phytophthora root rot symptoms where numerous trees had died. Hitherto this species had appeared highly resistant to this disease. *Phytophthora hibernalis*, cause of a fruit and foliage disease of *Citrus*, was isolated from soil around dying 10-year-old *Chamaecyparis lawsoniana*—the first record of this fungus in Britain. Surviving plants had dead roots and patches of dead foliage.

Cryptostroma corticale was isolated repeatedly from green and brown streaks, associated with girdling, perennating bark lesions, in bark, cambium and wood of one of several large, dying *Acer pseudoplatanus* in Holland Park, London.

Fomes annosus was found killing a *Ligustrum* hedge and several vigorous, 100 year-old beech trees.

Several large specimens of *Ilex aquifolium* were killed by *Armillaria mellea*. We had long regarded holly as highly resistant to Honey fungus.

Serious *Lophodermium pinastri* defoliation was confirmed in some 12 to 18 year-old *Pinus sylvestris* stands between February and May 1975. The last such outbreak we have documented was in 1954/55.

C. W. T. YOUNG, R. G. STROUTS

Northern Research Station

Dutch elm disease became a major preoccupation for the first time following the discovery of the aggressive strain in Glasgow in mid-summer. Evidence was found that the disease has been present since at least 1947, but probably only the non-aggressive strain was involved before this year. Early in 1976 a tree infected with the aggressive strain was located in Dundee; this is the most northerly record of *Ceratocystis ulmi* in Britain (see Figure 4, p. 33). No other new outbreaks were discovered, although the late summer was notable for the large number of suspected cases reported, mainly from northern England, and the long-standing outbreak area of the Lothians and Borders. Two cases were recorded in the city of Edinburgh.

Excluding elm disease, the most frequently recorded damaging agencies were climate (frost and exposure), cultural malpractice (misuse of chemicals and bad planting), and fungal decay in broadleaved species.

Two of the cases of chemical damage concerned injury to 1-year-old Sitka spruce seedlings by undispersed soil sterilant gases. One case was noteworthy for the early secondary colonisation of damaged seedlings by a *Cladosporium* species.

A striking multi-leadered condition, following a year's loss in apical growth, was reported in Sitka spruce up to 15 m tall from Torrachilty and Naver Forests, Highland Region, and from Glenlivet Forest, Grampian Region. The damage was attributed to early frosts in September 1972 and August 1973. Similar damage to 6 m tall Norway spruce at Kielder Forest, Northumberland, was associated with a late frost in June 1974. Exceptional frosts were again recorded in 1975, for example a grass minimum of −5°C was reported from Achaglachgach Forest, Strathclyde Region, on 3rd June.

Other notable occurrences were *Kabatina thujae* causing dieback of young *Chamaecyparis lawsoniana* in an Aberdeen nursery; road salt damage to several species in a motorway planting by spray from passing traffic, and attack by *Sirococcus strobilinus* on one-year-old Inland Lodgepole pine grown in sterilised beds. Previous records have been on two-year-old plants (*Reports* for 1972 and 1974) but, since plants grown in sterilised ground reach the same size and stage of development (i.e. formation of secondary needles) in one year as seedlings in unsterilised beds do in two years, attack probably begins correspondingly early.

D. B. REDFERN, S. C. GREGORY, J. D. LOW

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FOREST ENTOMOLOGY

Population Studies

The European Spruce Sawfly, Gilpinia hercyniae

In mid-Wales the infestation is more scattered, and noticeable defoliation is encountered in spruce plantations over some 2,000 square miles (5,180 sq. km). The general distribution and pest status in South Wales is not known, but areas proposed for parasite introduction trials have high populations. No parasite complex has been found in any of the infestations. The low incidence of parasites found at Hafren, Powys, was not repeated in 1975, which may be attributed to the regulatory effect of virus on the host population. The Unit of Invertebrate Virology, Natural Environment Research Council, is continuing its programme of research into the successful virus epizootic of *G. hercyniae*.

D. J. BILLANY

The Web-spinning Larch Sawfly, Cephalcia alpina

Existing infestations and new outbreaks increase. New areas were affected at Rheola and Cymer (adjacent to the major infestation at Margam, covering at least 200 ha), Vyrnwy and Penllyn Forests in Wales and Mortimer Forest, Salop. The total area suffering severe defoliation in mid-season is approximately 2,000 ha. Usually the crop regains a second cover of foliage, but not this year at Radnor, Powys, and Mortimer.

R. M. BROWN, D. J. BILLANY

The Larch Bark Beetle, Ips cembrae

Investigation of the biology continued at Dunkeld Forest, Tayside, in conjunction with experiments on insecticidal control, and indicated the unlikelihood of a second generation in Scotland, even in a good beetle season.

J. T. STOAKLEY

The Pine Looper Moth, Bupalus piniarius

The annual survey shows that populations of pupae have increased this season though four units found no pupae. Roseisle, which had the highest number last year, has been halved, having a *maximum compartment* count of 7·6 per m^2 as against Tentsmuir 17·2, Cannock 10·0 and Alltcailleach 9·2. These last three units have approximately doubled their 1975 pupal numbers. While Tentsmuir has this year's highest population, it was greater in both 1957 and 1969. Alltcailleach has not been as high since its first survey in 1954. The *forest average* at Tentsmuir is now 4·2 per m: (last year was 2·0, not 1·88 as recorded in the 1975 *Report*). The greatest rate of increase and of significance is that at Sherwood IV, where the forest average has jumped tenfold from 0·20 in 1975 to 2·16 per m^2.

R. M. BROWN, D. J. BILLANY

Beech Scale, Cryptococcus fagi

A preliminary study of dispersal of first instar larvae of *C. fagi* in unthinned 24 year-old beech at Micheldever Forest, Hampshire, used sticky traps and a suction trap.

Sticky traps were attached to a scaffold tower at heights of 1, 3, 6, 9 and 12·7 m, corresponding to the lower and mid-stem zones, lower and mid-canopy and above the canopy. Catches of larvae on six days in September 1975 showed that densities were highest in the lower and mid-stem zones but the capture of some larvae at 12·7 m suggests that a longer range dispersal above the canopy is possible.

Estimates of aerial density at 1 m by both traps showed good agreement with means for the trapping period of 2·6 (sticky traps) and 1·9 (suction trap) larvae/100 m^3. However, the volume of air sampled by the sticky traps was low, associated with the low wind speeds below the canopy—a mean of 40 cm/sec —and these traps would be unsuitable for a more extensive study of dispersal.

Adults of Cecidomyid collected in August 1975 were identified by K. M. Harris as an undescribed species of the genus *Lestodiplosis*. Their orange coloured larvae are predatory on *C. fagi*.

D. WAINHOUSE

Biology of the Elgin Shoot Moth, Rhyacionia duplana logaea

The biology of *Rhyacionia duplana logaea* Durr. on Lodgepole pine in North East Scotland has been investigated. The adult flight period is in April, earlier than any other British species of shoot moth. Larvae are found from June until August. The early instar larvae construct resin tents from which they mine the needle sheaths of developing needles. On reaching the third instar the larvae tunnel up the shoot and hollow out the terminal bud, before mining back down the shoot. They leave through a hole near the base of the mine. The pupation site has not been discovered in the field, but is believed to be amongst the surface litter, in a grey silk cocoon.

Several parasites have been reared, including an eulophid, *Elachertus isadus* Walker, which frequently kills the host before the terminal bud is attacked.

T. G. WINTER

Host Plant Susceptibility

The Green Spruce Aphid, Elatobium abietinum

Attention has been given to the phenological activity of Sitka spruce, and its relationship to the timing of attacks by the Green spruce aphid, *Elatobium abietinum*.

Observations on field provenance experiments have indicated that plants originating from certain geographical areas are more susceptible in a particular seasonal outbreak. The same origins do not have the same degree of susceptibility at different experimental sites. This may be due to a variety of factors. However, such plants, grown on the same site, have been noticed to switch in susceptibility from year to year, which has emphasised the need for more information.

Small colonies of *E. abietinum* have been confined to shoots of the various provenances of Sitka spruce for brief selected periods coinciding with various phenological stages of the host plant. The aphid performance, as measured by reproduction and growth, has been used as an index of susceptibility of the plant. Results so far show significant differences in aphid performance between certain provenances in the late spring attack.

Foliage samples have been taken from various host plants at certain phenological stages to obtain an amino-acid spectrum and so identify the favourable conditions.

NPK fertilisers have been applied at various rates on 2-year-old Sitka spruce, so altering the host plant nutrition and possibly affecting its period of growth.

C. I. CARTER

Biological Control

The European Spruce Sawfly, Gilpinia hercyniae

A further consignment of 13,000 cocoons of *Gilpinia* spp, estimated to be 14 per cent parasitised, were received from the Commonwealth Institute of Biological Control, Delmont, Switzerland, collected from those regions of Austria found most suitable the previous season. Attempts to increase the number of desirable species of parasites emerging from this material, by breeding up in the laboratory, failed owing to the imbalance of males in some species and females in others, and the prolonged emergence period between the sexes. Maintaining a range of larval instars of the host, *G. hercyniae*, was also difficult because of repeated outbreaks of the larval virus of the sawfly.

Endemic populations in east England were much lower than in previous years and the few larvae collected were not parasitised. Those populations in Wales which previously have yielded the occasional larvae parasitised by a *Gelinae* species were found to be healthy.

C. I. CARTER, N. FIELDING, D. J. BILLANY

The Web-spinning Larch Sawfly, Cephalcia alpina

An ichneumonid parasite of *C. alpina*, *Olesicampe montizada* has been found in the infestation at Margam Forest, Glamorgan. Collections of parasitised overwintering sawflies have been successfully bred through, dispelling any doubts as to *O. martizada's* status as a parasite. This insect appears to be confined to the one forest and its distribution within the host population is very patchy, parasitism ranging between 4 and 64 per cent.

R. M. BROWN, D. J. BILLANY

Chemical Control

The Larch Bark Beetle, Ips cembrae

Two experiments on control of the insect in logs were carried out at Dunkeld Forest, Tayside.

1. Gamma HCH and chlorpyrifos were applied in water at 0·3 and 0·5 per cent concentration, at the rate of 0·7 litre/square metre of superficial stack area, to test their effectiveness in preventing attack by adult beetles. HCH at both levels and chlorpyrifos at the higher level gave very good protection, but chlorpyrifos at 0·3 per cent was not effective.
2. The same insecticides at 0·3 and 0·5 per cent were applied in diesel oil at the rate of one litre/square metre of superficial stack area, to test their effectiveness against a mainly larval population in the logs. Timing of application was based on detailed observations of the progress of attack. All insecticide treatments were moderately effective compared with untreated controls. Statistically, diesel alone appeared to be equally effective; biologically, this seems unlikely.

J. T. STOAKLEY

Hylobius abietis and Hylastes spp.

Root collar swellings with poor development of root systems of Sitka spruce seedlings raised in Japanese Paperpots after drenching with 1·6 per cent gammacol (mentioned in the 1974 *Report*) have been investigated in some detail in glasshouse experiments. Drenching with an emulsifiable concentrate formulation of gamma HCH was shown to have similar effects.

In the forest it was found that although *Hylobius* is normally seen feeding on the thin bark of transplants, young tender plants raised in Japanese Paperpots are also very much at risk.

J. T. STOAKLEY

The systemic insecticide Thimet (phorate) tested on Corsican pine seedlings raised in Japanese Paperpots showed this material to be active in the third summer after application (see *Reports* for 1973, 1974 and 1975). Bioassays showed that both the 1·0 g and 0·5 g active ingredient treatments significantly reduced weevil feeding damage and increased weevil mortality. No significant differences were demonstrated between the two treatments. The reduction in height growth of the treated trees observed in the two previous growing seasons did not occur. In fact, height growth appeared to be enhanced by the treatments in the third year. Final measurements showed no significant differences between treated and control trees.

Transplants of Corsican pine and Sitka spruce treated with Thimet in conventional lines in the forest nursery were planted out on weevil infested sites at Thetford (Norfolk and Suffolk) and Brendon (Somerset). Assessments of weevil damage indicated that uptake of Thimet was extremely erratic, and no significant reduction was observed between treatments and controls.

After a preliminary trial in 1974, with a new carbamate insecticide, seedlings of Corsican pine raised in Japanese Paperpots were sprayed to run-off with a dispersible powder formulation in water at 1·50 and 2·5 per cent active ingredient. After planting out no weevil damage was observed, and comparison of rates was not possible. Height measurements showed no differences between treated and untreated plants.

C. J. KING

Dutch Elm Disease

In certain counties in northern England many new sites of infection seemed closely associated with the importation by sawmills of diseased elm butts infested with Elm bark beetles. Analysis of elm bark samples, taken from sawmills for the presence of Gamma BHC, showed this insecticide to be present in varying quantities in all but one case. The existing legislation on elm timber movements is being reappraised in the light of this information.

C. J. KING

Taxonomy

The Elgin Shoot Moth, Rhyacionia duplana logaea

Larvae of *Rhyacionia duplana logaea* Durr. from Scotland have been taxonomically compared with those of *R. duplana duplana* Hubn. from Europe, and *R. simulata* Hein. from Japan. A significant difference in the number of crochets on the prolegs has been noted between these three groups. Other variations in

the chaetotaxy have been found which separate the species into two groups. A detailed account of these findings and a description of the larva of *R. duplana longaea* is to be published shortly.

T. G. WINTER

Advisory

A large number of enquiries were received last year concerning the browning and premature falling of oak leaves, due to the feeding of the oak leaf aphid, *Phylloxera glabra.*

During the year 61 enquiries were sent to Alice Holt from Forestry Commission staff and 47 to the Northern Research Station. One hundred and three private enquiries were received at Alice Holt and 23 at the Northern Research Station.

WILDLIFE MANAGEMENT

Wildlife Management Techniques

The use of water courses and dry gullies carrying broadleaf or mixed broadleaf conifer groups, interspersed with glades, is being studied. These provide diversity and long-term stability for wildlife conservation management.

Management of Deer, Squirrels and Other Mammals

The annual Squirrel Questionnaire showed that little change had occurred in the range of either species of squirrel. Damage levels for both species were generally slightly higher than in the previous two years. Investigation of the frequency with which damage by grey squirrels is reported on conifer species shows that Scots pine and larch are considerably more vulnerable than any other species, though Lodgepole pine, Norway spruce and Western hemlock can also sustain severe attacks occasionally. Other species, such as Lawson cypress, Corsican pine, Grand fir and Sitka spruce, are attacked very much less frequently than the scale of planting suggests is possible. The use of warfarin poison continues to extend; no reports of secondary effects on non-target species have yet been received. In a bait preference trial, wheat, covered with Chlorozol sky blue FF200 dye, proved more acceptable to caged grey squirrels than red coloured or natural coloured wheat.

Management of Birds

Studies in young lowland plantations using the British Trust for Ornithology mapping census technique, together with nest record details, have indicated that granular herbicide treatment produces a more diverse and successful breeding birdlife than either mechanical or hand weeding methods. Kestrel nest boxes in the upland afforestation area provided barn owls with daytime roosting sites, during winter and early spring, and were also used as perches for other predatory and scavenging species. The provision of carrion for upland predatory and scavenging bird species has suggested that this may directly influence breeding success.

Chemical and Mechanical Repellants

A compound from Armillatox Ltd proved unsatisfactory as a chemical repellant against roe and fallow deer browsing. Ultra low volume application of Aaprotect and Fowikal, to reduce the labour cost and amounts of material used, did not give promising results in the preliminary trial. A trial of Aaprotect against roe deer, rabbit and capercaillie browsing has so far proved inconclusive, as damage levels on both controlled and treated areas have been low.

Preformed spacers have been developed to hold barbed wire at the correct distance from welded mesh in a spring steel fence. The specification was devised for fencing disused mines and quarries, where human access is prevented by using Motto barbed wire over BRC welded mesh fence FC1.

Damage Assessment and Evaluation

The damage assessment sampling technique has been further developed, to enable checks to be made of the accuracy of the sampling, and to define further the patchiness or randomness of the damage within the crop.

J. J. ROWE

ENGINEERING SERVICES

Design and Manufacture of Electro-mechanical Equipment

A prototype Quiz Unit, visual only, has been built that may have applications at Information Centres, camp sites, etc. The Quiz is controlled by the public, and the programme can be quickly changed. The unit can be fixed on a bench or table top, and is housed in a console 1·2 metres wide × 1 metre high with a viewing area 0·4 metres square. On the front are four push buttons, A, B, C, D: a slide is prepared with a question whose answer is either A, B, C, or D. When the appropriate button is pressed the correct answer is shown. An "ADVANCE" button is pressed to move to the next question. The magazine holds up to 120 slides. The Agricultural Show Unit will test the prototype during the 1976 show season.

Two machines have been built to cover seeds, sown in various sizes of containers, with approximately 2·5 mm sand. Both units are now working in North Scotland. A tool to plant container grown trees has been built for the Work Study Branch, and is known as the "Inchnacardoch Planter" (*Work Study Report* 47). Initial tests show promise, and full planting trials, using this tool, are envisaged later this year.

A rotating Drum Dryer has been built to dry seeds after they have been dewinged. The drum is 0·75 metres in diameter and 1·3 metres long, and the hot air enters and leaves through the central hollow shaft. First tests have been carried out, but modifications are necessary before the dryer is satisfactory.

The commercial seven-day event counter has been tested under field conditions but, before being recommended for general purpose use, modifications will be required (e.g. the power supply, 1·5 hr, 12V rechargeable lead acid accumulators with the electrolyte in jelly form, has not proved too satisfactory.

A rotating insect trap was built for the Entomology Branch. Two rotating arms, each approximately 2·5 metres long, rotate and trap the insects in a mesh cone fitted at the end of the arm. The trap is operated from a portable generator.

R. E. STICKLAND

FIELD SURVEYS

Topographical and Crop Assessment

The major part of the year was taken up in data verification for the 1977 valuation and production forecast. Assistance and advice was given to line managers in the preparation of computer documents and in the checking of Yield Classes in a large number of forests.

Nevertheless, new surveys in 13,200 ha and resurveys in 15,500 ha of forest land were completed. Surveys were started on a further 30,000 ha and are continuing on another 37,000 ha.

K. P. THALLON

Site Surveys

It has again proved impossible to maintain the complement of the Section with forester surveyors, and increasing use is being made of graduates and undergraduates on temporary employment.

The following areas were surveyed:

Full survey by Commission staff	18,040 ha
Full survey by non-Commission staff	11,790 ha
Reconnaissance survey by Commission staff	30,000 ha
Total	59,830 ha

Priority is still given to full survey on plantable reserves, although increasingly requests are being made for part or full forest surveys, on areas where crops are exposed to a high windthrow risk, i.e. South and West Scotland. In West Scotland the latter type of survey has been carried out using rapid reconnaissance methods. As the acquisition of land declines, so this survey will become more important.

Soil demonstrations were held for Commission staff and university students in South and East Scotland.

R. D. L. TOLEMAN

Mensuration

January gales caused serious damage to permanent sample plots. Some 54 plots were either totally destroyed or so badly affected that they have had to be abandoned. The bulk of the losses occurred in East Anglia where 27 plots were lost. These include 12 plots comprising an extended cycle thinning experiment, established only two years previously. Other losses occurred in South Wales, the Marches, the North Midlands and Yorkshire. Scottish plots suffered minimal damage.

Further analyses of replicated thinning experiments have been carried out during the year. The best known of these, the Bowmont Norway spruce experiment, is the subject of a special, and probably final, report, due to be published shortly. One aspect of the report shows that there is no significant difference in volume production between C and D, and LC grades of thinning after a period of 44 years. Higher thinning intensities are incorporated in later experiments, and the main interest, in current analyses, is to quantify volume increment losses which are already evident in these more extreme treatments.

G. J. HAMILTON

Special Projects

Discussions were held with Director, Land Use Planning, HQ, concerning the need to revise the 1965 census data. Trials are in hand to devise survey methods which will minimise the use of manpower resources when a general revision is required.

G. M. L. LOCKE

Production Forecasting

The system for calculating forecasts of timber yields from a Sub-Compartment computer file was devised and developed during the year. Computer programming and crop modelling are virtually complete. Explanatory courses for line managers were held in all Conservancies.

Ninety per cent of the basic data is now ready to put into the computer. Trial runs on selected data have proved the system.

Non-standard regimes have been agreed with HQ Divisions, and Conservators are making selections for their particular needs. The development programme is on time.

D. A. COOPER

Central Drawing Office

More Field Survey and Site Survey map work was taken into the Drawing Office in order to increase survey productivity. As a result, work for other divisions has been drastically reduced.

Developments in map reproduction methods, and in the expansion of Drawing Office work in the general survey field, are at the planning stage.

A staff review was made, and a consequential regrading of some posts is proposed.

K. P. THALLON

WORK STUDY

Forest Management: Method Study

Construction of the 6×6 rough terrain ploughing vehicle is nearing completion, in spite of staff shortages and difficulty in obtaining parts. The design has been patented in 14 countries.

The Meri ditcher has been successfully tested in North Wales, but an ideal tractor to power it is still sought.

The Quickwood planter is on trial at Thetford to judge its ability to plant potted plants. A tool (to be known as the *Inchnacardoch Planter*) for planting Paperpots by hand has been developed.

In the weeding field, work on controlled droplet applicators (a new term which includes ultra low volume spraying) is virtually completed.

Forest Management: Servicing

Successful trials of the Holder A55, a small frame-steered tractor, fitted with a hydraulically powered front mounted McConnel flail cutter, demonstrated

once more the need to lay out plantations correctly, if this cheap form of weeding is to be practical. Another flail type cutter, the Willibald SMS 150, was also tested.

A hand operated gravity fed granular herbicide applicator (now named the Huntly) has been produced and patented. It is capable of applying a measured dose of most granular herbicides. The very early "Pepper pot" applicator has been subjected to further trials.

A variety of spray nozzles have been tested to learn more about their distribution patterns.

Forest Management: Work Measurement

An output guide on the use of ultra low volume sprayers in the forest has been produced.

Harvesting and Marketing: Method Study

In normal working in Border conditions, the Pika 52 processor is achieving outputs up to 12 m^3 per hour. Trials were extended to mountain terrain to learn something of the problems of operating large processors there. To operate economically in those conditions, the Pika needs the output of four cable cranes—a difficult organisational problem. To overcome these difficulties, a small delimber from France, known as the Segem, which operates on a hydraulic crane, fitted (in this case) to a Roadless 115 tractor, is being tested.

The Timberjack RW30 harvester has been tried on clear felling and thinning operations where it has shown itself capable of felling, delimbing and stacking trees up to 30 cm butt diameter, and 14 metres top height. Outputs up to 8 m^3 per hour have been achieved. Some butt damage has been caused by the shear.

Commercially available feller bunchers are generally expensive, and attempts are being made to produce a cheaper machine, using a British tractor with an imported felling head. An Ösa 620 felling shear, and an Ösa 640 felling saw, is being tried working on a Roadless 115 tractor fitted with a Cranab 5 tonne-meter crane.

The experimental programme of constructing eight hydrostatic skidders is now complete and the first production machine has been delivered from the assembly line of Roadless Traction Limited. Work on testing large skidders in the Timberjack and Clark ranges has continued. A Ford 5000 has been converted for timber extraction by fitting two radio controlled hydraulic winches and hydraulic front wheel drive.

The Valmet 870CK forwarder has proved very successful in Border conditions, bringing out loads of 6–9 tonnes of shortwood at the rate of 6–10 m^3 per hour. It is shortly to be tested with an Ösa 770 grabsaw, in South Scotland.

A Jensen Type AO chipper has been tested on chipping whole trees and residues. Samples of chips from this and other machines have been supplied to possible users.

Harvesting and Marketing: Servicing

Five new models of chainsaw have been tested during the year.

Harvesting and Marketing: Work Measurement

Four new output guides have been issued during the year, including one on pole length ground skidding by the hydrostatic skidder, and one on clearing windblown pine. Data have also been collected for the production of a number of other guides, including extraction by skyline, and clearing of windblown spruce.

Forest Authority

Studies to find out how long elm trees, which have died as a result of Dutch elm disease, remain saleable as timber while still standing on the stump, showed that a period of two years is likely to be the maximum.

Small-scale trials of applying *Peniophora gigantea* to tree stumps via the chain lubrication system of a chainsaw, during the felling operation (as a protection against *Fomes annosus*), have proved surprisingly successful, and will be extended.

Early trials of a Rapco data recorder, to short circuit the time to carry out time studies, have been promising. Field trials are under way in Wales.

Safety

In January 1976, the post of Safety Officer was transferred to Industrial Establishments Division in the Commission's Headquarters in Edinburgh. What may best be termed "Safety Research" remains with Work Study.

Before that date, two Codes of Practice (*Noise and Hearing Conservation* and *Operating a Clearing Saw*), one Technical Guide (*Noise Levels of Forest Machines* and *Selection of Ear Protection*), and one Technical and Safety Check List (*Operating a Clearing Saw*) were published by the Forestry Safety Council. Others were drafted.

The *ad hoc* FAO Chainsaw Group finalised a document, in agreement with international chainsaw manufacturers, on the design specification for chainsaws and the procedure for testing their safety features. When approved by ILO in mid-1976, this procedure should provide an effective basis for future Health and Safety Executive criteria. This group also made positive recommendations to help prevent the medical condition known as Reynaud's Phenomenon (vibration induced white finger) among chainsaw users.

W. O. WITTERING

STATISTICS AND COMPUTING

Data Preparation and Computing

The regular processing of sample plot, work study, experimental data and library references continued. Major projects were the new Squirrel Questionnaire, the Commission's sales statistics and the fifth Dutch elm disease survey. The ICL card punching equipment (two punches, two verifiers) were replaced by three Kode punch-verifiers, two of which also print.

Statistical Service to Research and Development Projects

Major efforts included services to projects on herbicide testing, conifer heart rot and beech bark disease. A scheme of hazard-zones for exposure in upland forests was constructed. Responsibility for statistical advice for some projects of branches of Headquarters, now stationed in Edinburgh, was passed to the statistician with Planning and Economics Division.

Statistical Service to External Units

Assistance was given to South Scotland Conservancy in planning a deer-damage survey, and to South-East England Conservancy in planning a relatively intensive survey of Dutch elm disease in West Sussex. A study was made of a method of estimating whole-tree specific gravity, from a breast-height boring, for the Home Grown Timber Research Committee.

Programming, Non-mathematical

Preparations were made to set up a new Production Forecasting System on a sub-compartment basis. Substantial progress was also achieved in transferring the sample plot files to magnetic tape. A program was written to interpret and store the output from the Rapco time-recorder.

Programming, Mathematical/Statistical

The development of the DASMA system of statistical programs continued, and new programs were written for partially balanced lattices and lattice squares.

Statistical, Mathematical and Computing Methods

Several members of the branch attended courses on the GENSTAT computing language and have since applied it to research data. A study is being made of tests for non-randomness of point events in mapped data.

Data Capture and Associated Computing

An adaptation to the Swiss-perfo caliper for measuring tree heights was constructed and tested. Trials of the Rapco magnetic-tape time-recorder proved promising, especially for felling and cross-cutting studies. Field trials were also made with two portable magnetic-tape encoders.

D. H. STEWART, R. S. HOWELL

COMMUNICATIONS

The Visiting Group of the Research Advisory Committee inspected the work of the Research Information and Photography Sections. In general they were satisfied that a good service is being given to research staff.

Research Information

Liaison

Annual meetings with professional forest managers in Scotland have, for many years, ensured close contact with the private sector. These meetings have been organised at the Northern Research Station with the Scottish Woodland Owners Association. This year, for the first time, a similar meeting was arranged at Alice Holt for the South, with the Timber Growers' Organisation. Over 60 people attended and it is proposed to make such meetings a regular event.

Library

One hundred and eighty-two new books were acquired, and subscriptions taken out for seven new journals. The number of loans reached a new record of 4,236, with a further 738 items borrowed from other libraries. A total of 2,400 photocopies were provided.

Information Services

For many years machine readable literature references have been the basis of Current Awareness and SDI Services, using the Alice Holt IBM 1130 computer in Statistics and Computing Branch. These are now being accumulated onto a computer data bank for information retrieval. Searches can now be made of the most recent literature references by single subjects, subject areas and combinations of both.

O. N. BLATCHFORD

PHOTOGRAPHY

Slide duplication is again being carried out by the Section, as the quality of the work done by commercial laboratories had become very variable. Also, as original transparencies sent to block-makers for reproduction in publications are often returned in a damaged state, reproduction quality duplicates, made internally, are now sent instead. Originals are no longer lent for any purpose.

Similarly, many more colour prints are being rejected as unsatisfactory, and a limited amount of colour printing by the Section is being considered.

Aerial Photography

Results continue to show that, for most applications, true colour photographs, even at low light levels, yield more information and are easier to interpret than monochrome.

Until the Section can undertake colour printing, however, users will, for reasons of cost, be limited to a choice of three sizes of print (i.e. they will have to select that degree of enlargement which will be nearest to the required scale).

A larger format aerial camera was bought, second-hand, during the year. The object was to reduce, for a given scale, the number of photographs which need to be taken for area coverage. By using a front-surfaced mirror the camera could be mounted in a slightly modified baggage door. On the quality of results the disadvantages (optically, plus difficulties of keeping a larger area of film flat in the film plane) seem to outweigh any advantage gained.

The need for supplementary aerial photography has grown steadily with an additional demand following the gales of January 1976. Any request for aerial photography, other than from R & D Division, should be sent via Field Surveys.

Photographic Library

The storage capacity of the slide collection was again increased, and the existing cabinets modified to reduce ultra-violet emission, which is harmful to transparencies.

I. A. ANDERSON

PUBLICATIONS

The following sixteen new priced publications were issued through Her Majesty's Stationery Office during 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, Alice Holt Lodge, Wrecclesham, Farnham, Surrey.

Reports

Fifty-Fifth Annual Report of the Forestry Commissioners, 1974–75 (£1·65).
Report on Forest Research for year ended 31st March 1975 (£1·85).

Bulletins

No. 53. Production and Use of Tubed Seedlings, by A. J. Low (£1·00).
No. 54. Seed Orchards, edited by R. Faulkner (£2·30).

Booklets

No. 39. Forest Mensuration Handbook, by G. J. Hamilton (£4·00).
No. 40. Chemical Control of Weeds in the Forest, by R. M. Brown (previously Leaflet No. 51). (90p).

Leaflets

No. 61. Tubed Seedlings, by A. J. Low and J. S. Oakley (30p).
No. 62. Ultra Low Volume Herbicide Spraying, by E. V. Rogers (35p).
No. 63. Fertilisers in the Forest: A Guide to Materials, by W. O. Binns (35p).

Forest Records

No. 101. Red Squirrel, by A. M. Tittensor (42p).
No. 102. Three Forest Climbers: Ivy, Old Man's Beard and Honeysuckle, by A. F. Mitchell (23p).
No. 103. Badgers in Woodlands, by Ernest Neal (previously Leaflet No. 34) (30p).
No. 104. Towards Integrated Control of Tree Aphids, by C. I. Carter (50p).
No. 105. Experiments with Insecticides for the Control of Dutch Elm Disease, by T. M. Scott and C. Walker (75p).
No. 107. Mushrooms and Toadstools of Coniferous Forests, by Roy Watling (£1·00).

Guide

Explore the New Forest, edited by D. Small (£1·85).

In addition, fourteen priced publications sold by Her Majesty's Stationery Office were reprinted after varying degrees of revision.

Six further wall charts were produced in the series *Forest Trees in Britain*—Beech, English Elm, European Larch, Sitka Spruce, Sycamore and Corsican Pine.

A Report on the Tenth Commonwealth Forestry Conference held in the United Kingdom in September 1974, was published at £2·50, and the firs two in a pamphlet series for the Forestry Safety Council were produced.

Research and Development Papers

No. 111. Low Pressure Sodium Tube Lights as a Source of Supplementary Lighting for the Improved Growth of Sitka Spruce Seedlings, by R. C. B. Johnstone and W. Brown.

No. 112. Sociological Survey of Border Forest Villages, by F. V. Smith.

These are produced mainly for internal use. Single copies are available from the Publications Section.

H. L. EDLIN

OTHER HEADQUARTER DIVISIONS

PLANNING AND ECONOMICS

General Review

Management guides and information documents issued to Conservancy staff included: revised optimum felling ages for thinned and unthinned conifers; revenue implications of adjustments for landscaping reasons; premature felling in anticipation of windblow; whether to thin and, if so, when; appraisal of beating-up, weeding and cleaning operations; adjustment of cost and prices for inflation; and the recent history of British imports and prices of wood products. Estimates were made of the impact on private woodland owners of a wealth tax, on the basis of the proposals outlined in the Government's 1974 Green Paper (Cmnd 5704) on that subject.

A. J. GRAYSON

Analysis of the Market for Forestry Commission Conifer Sawlogs

Attempts have been made to explain variation in the price of coniferous sawlogs sold by the Forestry Commission in terms of available statistics, reflecting the demand and price situation for sawnwood. Although some initial success was achieved, using a single equation type of model, relating sawlog price to the average price of imported sawn softwood in the previous quarter, this model proved unsatisfactory for forecasting. As attempts to construct a more comprehensive econometric model of the UK sawn softwood market also proved unsatisfactory, the single equation model was modified using prices quoted for specific grades of imported Russian timber. This has given encouraging results in terms of "goodness of fit", short run predictive ability and compliance with theory.

R. J. N. BUSBY, C. M. KELLY

The Influence of Windblow Risk on Thinning and Felling Decision

Given knowledge of the pattern of tree growth throughout a crop's life, the effect of different thinning treatments on the growth pattern and the income which is obtained from thinnings and fellings, it is possible to calculate the optimum age to start thinning, the optimum type of thinning and the optimum time of felling, for different crops, in different situations. These optima are, however, altered if there is a risk of windblow. If this risk, and the associated costs, can be estimated, then it is possible to recalculate the optimum timing, type of thinning and time of felling. Although knowledge of the risk of windblow, at different ages, for different crops, following different treatments, is still limited, calculations of NDR at 5 per cent indicate that, on financial grounds, premature felling by more than 10 years, is seldom justified. Lower yield class crops in unstable areas are best left unthinned. Higher yield class crops should be selectively thinned rather than line thinned.

J. DEWAR

Trend in Recreational Visits

Trends in participation in countryside recreation and the effect of weather on visitor numbers were studied. Data used came from the Department of

Environment, the National Trust, Forestry Commission monitoring of day visitors and Forestry Commission campsites. Use of day visitor sites was found to be extremely weather sensitive, particularly to temperature. All the long-term trend data available showed participation increasing at average annual rates of between 6 and 20 per cent. Day visits in 1974 showed a downward departure from trend partly caused by the weather but, for the Forestry Commission sites, this was reversed in 1975. Regional variations in trends are being investigated.

P. S. COLLINGS

Analysis of Records of Campsite Use

A programme has been developed for the analysis of permits issued to users of Forestry Commission campsites. The system allows valid comparisons to be made, between campsites, about the use of pitches, numbers of people concerned, length of stay distributions, types of camping equipment used, and composition of camping parties. The system is expected to yield suitable data for studies of trend. For 1975, records were processed for 10 campsites. The use of these accounted for some 40 per cent of all camping on Commission land. Bar-chart displays of the data highlight features such as the peaking of use over certain weeks.

R. Q. OAKES

Grizedale Day Visitor Survey

An interview survey was carried out by Conservancy staff at Grizedale, Cumbria, to estimate day visitor use of the Forest Centre in 1974–1975. Visitor origins, length of stay and use of facilities were elicited. High car loadings, a high proportion of holiday makers and long journeys to the site were prominent features of the results. For towns represented by five or more people in the sample interviewed, the following relationship was found between visits and distance:

Visits per 1,000 population $= 10{\cdot}2e^{-0.37d}$, where d equals the road distance (km) of the town from Grizedale. The standard error of the exponent is 0·006. The survey called for 158 man-hours of interviewing, and on the basis of this experience, attention is now being turned to reduction of the time required for such surveys.

P. S. COLLINGS, R. Q. OAKES

Replacement of Unsatisfactory Crops

There is a strong temptation to decide intuitively that an unsatisfactory tree crop should be felled at the earliest opportunity, the site improved by ploughing and/or fertilising and then planted with higher yielding species. However, calculation of cash flows and their discounted value confirms the findings of earlier work, namely that the option of leaving the unsatisfactory crop to mature, a course which involves little or no expenditure and finally produces a small revenue, is often preferable to much reduced revenue from a premature clear felling followed by costly site preparation even although larger revenues will be forthcoming in the future.

R. J. N. BUSBY

TIMBER UTILISATION

The Use of Bark in Horticulture

The new industry concerned in the preparation of pulverised bark for horticulture continued to expand, and a further two units came into operation bringing the total number to eight and increasing the potential production to about 40,000 tonnes per annum.

In the investigation of possible causes of phytotoxicity by fresh bark, further analyses of the volatile oil content were undertaken by gas-liquid chromatography. These have established that the principal monoterpene in *Pinus sylvestris* bark is alpha-pinene, followed by delta-3-carene, and beta-pinene respectively. Beta phellandrene was found to be the main constituent of *Picea sitchensis* bark oil, followed by alpha pinene, beta-pinene and limonene. No work has been carried out on the relative toxicity of these compounds, but growing trials with tomatoes have shown that a high percentage of alpha-pinene (i.e. one ml in 300 ml of potting mixture), can be tolerated without causing death. There were indications, though, that quite small quantities can inhibit height growth.

A full report on the past development work on bark will be published as Forest Record 110, *Conifer Bark: Its properties and uses.*

Fence Post Trials

The final report on this project, which covered assessments of the service life of round fence posts of a number of species with and without preservative treatment, was published as Forest Record 108, *Tests on round timber fence posts.*

J. R. AARON

PART II

Work done for the Forestry Commission by Other Agencies

NUTRITION AND FOREST SOILS

FOREST SOILS AND TREE NUTRITION

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

The Macaulay Institute for Soil Research, Aberdeen

Nutrition of Sitka Spruce

The project to investigate the relationship between tree growth and nutrient cycling in pole-stage Sitka spruce, the plans for which were outlined in the *Report* for 1973, has continued. A fifth experiment in the series has now been established at Kershope Forest, Cumbria, and preparation for the final experiment, to be at Kilmichael Forest, Strathclyde Region, is well advanced. During the year management of existing experiments has given few problems, mainly because of the unfailing attention they receive from local forest management staff at each site.

Growth response at the early experiments had been slow to develop, but by the third year at both Fetteresso, Mearns Forest, Grampian Region, and Leanachan, Highland Region, the early suggestions of responses to nitrogen and potassium fertilisers have given way to a pronounced, and generally linear, response to nitrogen, and a response to high levels of phosphorus and potassium applied together. The most surprising feature is a rapid disappearance of the nitrogen response at heavy rates of phosphorus application.

The accumulated data on amounts of litter fall and rainwater, in the earlier experiments, has shown that the instrumentation used is adequate to yield precise results.

Nutrition of Pines

Examination of the results from the nitrogen fertiliser experiments in pole-stage Corsican pine at Culbin, Laigh of Moray Forest, Grampian Region, (*Reports* for 1965 to 1975) is now virtually complete. Litter fall accounted for nearly all the nitrogen and phosphorus released by these trees. Considerable quantities of potassium, calcium, magnesium and sodium were picked up by rainwater passing over the canopies, but only 30–60 per cent was derived from crown leaching, the remainder being from dirt and impacted aerosols washed from the tree surfaces. Nevertheless, crown leaching represented 89 per cent of the sodium, 48 per cent of the magnesium, 44 per cent of the potassium and 8 per cent of the calcium released by the trees (Miller, Cooper and Miller, 1976). Nitrogen fertiliser had no effect on the net primary production by these trees in the first year of application, although needle retention was increased. However, in the two following years, net primary production was more than doubled due to increases in both photosynthetic area and net assimilation rate Miller and Miller, 1976).

Marked changes in the pattern of growth of unfertilised control trees in the nitrogen fertiliser experiment in old Scots pine at Alltcailleach Forest,

Grampain Region, (*Reports* for 1966, 1968 and 1975) prompted a search for correlations between growth and climatic factors. Three significant and independent climatic factors emerged (multiple correlation coefficient 0·67)—May rain of the same year, annual temperature of the same year and total rain during May-June of the previous year. It was shown that significant regular oscillations, of periods from 4·4 to 42 years, in these climatic parameters were precisely reflected by oscillations in ring width; furthermore, the oscillations in rainfall appear to be limited to the rainshadow of the Grampian Mountains (Miller and Cooper, 1976).

Nitrogen Mineralisation in Peat

Following a comparison of rates of nitrogen mineralisation in different peat types (*Report* for 1975), a study has been made of mineralisation rates in samples taken from peat planted with Lodgepole pine, and from adjacent unplanted areas. The samples, supplied by Site Studies (North), were taken from raised bogs and blanket bogs, flushed and unflushed, in the North of Scotland. Measurements of CO_2 evolution, and rates of nitrogen mineralisation, were made on sub-samples incubated under aerobic conditions. Nitrogen mineralisation was also measured under anaerobic (waterlogged) conditions. The samples were further characterised by chemical analyses. Rates of CO_2 evolution were consistently higher in samples of unplanted peat, whereas the rate of mineral nitrogen production was initially lower in these samples than in the planted peat. This indicates that there was a greater demand for nitrogen in unplanted peat by a rapidly growing aerobic population of micro-organisms, this resulting in a lower net accumulation of mineral nitrogen. The reasons for the lower rate of CO_2 evolution in planted peat are not known, but, compared with unplanted peat, samples from planted sites have less moisture, reduced pH values and lower calcium contents. Greater acidity could account for the lower rate of CO_2 evolution; the decline in moisture and calcium contents would contribute to the fall in pH, and the improved aeration beneath the tree crop could be expected to reduce the amount of readily decomposable substrates in this peat. Further measurements are being made on these samples to investigate more closely the effect of tree growth on nitrogen mineralisation.

Attempts to identify and characterise the organic nitrogen in peat have continued with incubation studies on particle size fractions, isolated from peat by wet sieving (*Report* for 1973). In fractions of a relatively undecomposed *Sphagnum* peat less than 1·0 per cent of the nitrogen in any of the fractions was mineralised, despite a range of nitrogen content from 0·32 per cent of oven-dry matter in coarse plant remains (>5 mm) to 1·36 per cent in fine material (>5 μm). In a well decomposed *Molinia* peat, on the other hand, the nitrogen content of the same size fractions increased from 1·16 to 2·87 per cent and, although the proportion of nitrogen mineralised on incubation varied, it did not parallel the total nitrogen content, being between 4·6 and 6·1 per cent in coarse fractions (>1 mm) and <2·4 per cent in the fine fractions.

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EFFECTS OF SOME ENVIRONMENTAL FACTORS ON TREE SEEDLING GROWTH

By A. E. CANHAM

Applied Research Section, Department of Agriculture and Horticulture, University of Reading

An increase in growth rate in some conifer species when grown in CO_2-enriched atmospheres has been reported by a number of workers (including Hardh, 1966; Funsch *et al.*, 1970; Yeatman, 1970; Alden, 1971; Siren and Alden, 1972; and Tinus, 1972). Others (quoted by Wareing, 1956, and Nitsch, 1957) have observed that long photoperiods promote extension growth in some *Picea* and *Pinus* species.

Since either or both of these techniques could make an important contribution to the productivity of a nursery unit, the responses of three important forest species to these environmental factors were studied during the spring and summer of 1975, in association with staff from Alice Holt Lodge.

Plants of *Picea sitchensis*, *Pinus contorta* and *Pinus nigra* var. *maritima* were raised from seed sown in F508 Paperpots, in a complex experiment involving three CO_2 concentrations, two daylengths, and two levels of nutrition, in a range of six small glasshouses.

The plants were moved to Alice Holt after 16 weeks (*P. contorta*) and 20 weeks (*P. sitchensis* and *P. nigra*) for hardening off prior to planting out for establishment trials and forest performance on appropriate sites. Half of them were transferred to the forests in the autumn and the remainder in the following spring. The *P. contorta* was planted out on a lowland site at Thetford, Norfolk, and the other two species on an upland site in North Wales.

The overall effect of the extended daylength was very small, amounting to an increase of 3·5 per cent in height at the five-week sample, and 7·5 per cent at eight weeks. Thereafter the differences were not significant.

CO_2 enrichment had an appreciable effect which was maximal at week 10. Increases in height at this stage varied from 14 per cent at 1,500 volumes per million (v.p.m.) with Corsican pine to 56 per cent at 3,000 v.p.m. with Sitka spruce, but lack of experimental precision for these comparisons allows only the larger differences to be considered significant. The main result of these increases was that the enriched plants reached a stage suitable for hardening off about 2 weeks earlier than unenriched plants, in the case of Sitka spruce and Lodgepole pine, and from $1\frac{1}{2}$ to 3 weeks earlier with Corsican pine.

Higher rates of top-dressing also increased seedling height but this effect was not detected until week 16 when a 9 per cent increase was recorded.

An increased CO_2 concentration and a higher nutritional level both increased final stem diameter and final dry weight compared on a logarithmic basis as shown in the tables below.

TABLE 7
OVERALL EFFECTS OF CO_2

CO_2 concentration (v.p.m.)	ambient	1500	3000	S.E. of differences
stem diameter (mm)	2·54	2·89	2·95	0·0836
increase over ambient (%)	—	13·7	16·2	—
$\log_e$ dry weight (g)	0·763	0·921	0·984	0·0548
increase over ambient (%)	—	20·7	28·9	—

TABLE 8
OVERALL EFFECTS OF NUTRITION

Nutritional level	Normal	Twice normal	S.E. of difference
stem diameter (mm)	2·75	2·84	0·0576
increase over normal (%)	—	3·5	—
$\log_e$ dry weight (g)	0·840	0·939	0·0166
increase over normal (%)	—	11·8	—

The average percentage survival over the whole experiment was over 99·8 per cent and was unaffected by any of the treatments.

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AERATION STATUS OF UPLAND SOILS

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In contrast with the situation for lowland arable soils used for annual crops, little is known about the soil aeration conditions in upland areas of high rainfall, or about the effect of tree growth, as compared with that of herbaceous plants,

on soil aeration/moisture relationships. Methods originally devised for use in agricultural soils (Dowdell *et al.*, 1972; Smith and Dowdell, 1974) have now been applied to wet upland soils under afforestation. During the period April-October 1975 measurements were made of the concentrations of oxygen and carbon dioxide in the rooting zone of Sitka spruce, at Newcastleton Forest, Borders Region. Gas and water samples were taken by hypodermic syringe from sampling probes at 20, 35 and 50 cm depth, at sites established by the Site Studies Branch (North), on four contrasting soil types: brown earth, ironpan soil, surface-water gley and peaty gley. Soil air samples were analysed directly by gas chromatography; when water samples were obtained during periods of waterlogging, the dissolved gases were extracted by shaking with helium in a sealed vial, after which the helium was injected into the gas chromatograph.

Oxygen levels showed great variability between sites, between individual sampling probes situated a few metres apart at any one site, and with time. Near-anaerobic conditions occurred over prolonged periods in the two gley soils and in the ironpan soil *above* the pan; in contrast, aeration was generally satisfactory in the latter soil *below* the pan and throughout the brown earth profile. At 20 cm depth, both sampling points in the peaty gley and one in the ironpan soil showed very low levels of oxygen, continuously, for eight weeks from late May onwards. One of the two in the surface water gley showed a rapid succession of high and low values. Other probes at this depth showed consistently high levels of oxygen. At 35 cm in the peaty gley, low oxygen levels persisted from April to September. Frequent fluctuations between high and low levels occurred at this depth in the surface water gley, and less rapidly in the ironpan soil. At 50 cm the gley soils showed comparable fluctuations, but the ironpan showed oxygen concentrations always above 15 per cent. Such variations as there were, with time, coincided with those detected in the brown earth. In the latter soil, a low level of oxygen was recorded on only one occasion, when a probe at 50 cm depth was water-filled.

The unusual relationship between oxygen concentration and depth observed in the ironpan soil, i.e. better aeration below than above the pan, is presumably due to the entry of air into the subsoil via occasional fissures, followed by lateral diffusion below the pan.

Carbon dioxide values rose as oxygen levels fell, and vice versa. At all depths in both gleys, above the pan in the ironpan soil, and at 50 cm in the brown earth, roots would have been exposed to concentrations of CO_2 of several per cent for prolonged periods, as well as to very low levels of oxygen. No precise inverse correlation of CO_2 concentration with oxygen deficit is possible, because this depends on the ratio of gas-filled to water-filled pore space at any one time.

Relationship between Aeration and Soil Water

At 20 cm depth, the rapid changes in aeration and the major differences between neighbouring probes may be attributed to the occurrence of intermittent waterlogging. The short diffusion pathway for oxygen from the soil surface would result in a rapid increase in soil oxygen concentrations as soon as the water table dropped. With increasing depth the changes are less rapid, but the data indicate that factors unique to each sampling point can outweigh the effect of depth.

Low oxygen levels were most commonly observed in June and early July—a period when water table depths and moisture tensions were increasing. These

changes in soil water must have increased the permeability to air, thus other factors obviously outweighed them. The likely explanation is the increased respiratory demand for oxygen by the roots as temperatures increased above 5–6°C. This is supported by the experimental evidence from thermistor readings.

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TREE PHYSIOLOGY

APPLICATIONS OF PLANT TISSUE CULTURE IN FORESTRY

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The potential of tissue culture as a means of clonal propagation of coniferous trees is under scrutiny. As indicated in a previous *Report* (1975), work has been mainly (see Plate 4) confined to *Pinus contorta*; experiments with *Picea sitchensis* are still restricted by the poor growth of cultures of this species.

Callus cultures may be initiated from seedling hypocotyls and active shoot meristems of *P. contorta*. Initially healthy cream-yellow callus is obtained which may be capable of sub-culture at monthly intervals. However, these callus cultures and particularly the suspension cultures (derived either from callus or directly from the explant) show varied responses to culture conditions, their growth rates and the periods over which successful serial subculture is possible varying substantially. The cultures, after a variable period in culture, turn brown and become necrotic. The browning is associated with a high content of phenolic acids and their oxidation products in the cells. One particular line, which has been maintained in suspension culture for about two years, has been used in an attempt to study the production of tracheids which are regularly observed in the suspensions. A progressive change has been observed in these cells. The newly initiated suspension exhibited two distinct populations, dead lignified tracheary elements and viable thin walled unlignified "parenchyma" cells. In the older suspension there is a lesser distinction between the two cell types; virtually all the cells have very thick lignified cell walls, though not the characteristic sculpturing typical of tracheids, and the vacuoles of the parenchyma cells often contain osmophilic particles, probably polyphenolic-protein conjugates. The cells in which such lignin production occurs may lose their viability and this can occur to such an extent as to lead to failure of the cultures. We cannot, at present, regulate this lignin production in a reproducible way by changes in culture medium composition. The serially propagated cultures considered above cannot be induced to embark upon morphogenesis.

Although the ultimate objective must be propagation from mature trees, it has been suggested that expression of totipotency in culture is most readily achieved in cultures recently initiated from embryonic material. There is evidence from current work with other gymnosperm species that morphogenesis in culture can be achieved by using explants derived from seedlings (Campbell and Durzan, 1975) or embryos (Sommer and Brown, 1974; Sommer, Brown and Kormanik, 1975). Our exploration of this approach with *Pinus contorta* and *Picea sitchensis* has produced negative results when using hypocotyl segments but work with excised embryos is more encouraging. In a proportion of our cultures, meristematic nodules (up to 30 per explant) have developed from the hypocotyl and cotyledonary regions of the embryos and these have given rise to leafy shoots on transference to hormone-free medium. Current work is directed to increasing the frequency of this shoot bud initiation and to finding conditions conducive to root induction from such shoots. The culture medium used in these studies (as devised by Campbell and Durzan, 1975) has also permitted active growth of shoot tips of *P. contorta* seedlings, and attempts are now being made to induce proliferation of apical meristems of *Picea sitchensis* in similar cultures (by initiation of new growth centres) and to root the growing shoots.

The demonstration that callus can be obtained from mega- and microgametophytes of *Pinus resinosa* (Bonga and Fowler, 1970; Bonga, 1974; Bonga and McInnis, 1975) has led us to explore this approach with *P. contorta* in an attempt to obtain haploid cultures. The callus initiated from megagametophyte material of *P. contorta* is of mixed ploidy; attempts to isolate a haploid cell line from such callus have been unsuccessful. However the callus obtained from microsporangia contains a high proportion of haploid cells and hence was probably of microspore origin. Division of the microspores was enhanced by pre-storage of the material for 14 days at 4°C. The callus obtained could not be serially subcultured. Work with microsporangia and free microspores will be further developed as soon as appropriate material is available once more.

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ENDOGENOUS HORMONES OF SITKA SPRUCE

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A study of the endogenous gibberellins and cytokinins of Sitka spruce has been carried out in relation to the annual cycle of growth and dormancy, and as a basis for studies on the growth responses of this species to nitrogen and phosphorus deficiency. Preliminary studies (Lorenzi *et al.*, 1975) showed that two main gibberellin fractions are present in the needles and buds of Sitka spruce, one fraction (B) being predominant during the period of active growth and a second fraction (A) during winter dormancy. Further studies have now shown that fraction A is the glucosyl ester of gibberellin A_9 (Lorenzi *et al.*, 1976a), while fraction B is a new gibberellin which is an isomer of gibberellin A_9 (Lorenzi *et al.*, 1976b). These results are of interest in relation to the finding that gibberellin A_9 is effective in stimulating flowering in various species of the Pinaceae, and may provide useful information for attempts to induce flowering in Sitka spruce by applied hormones. (See p. 61, for work at Long Ashton).

Parallel studies have also been carried out on variations in the levels of endogenous cytokinins in needles and buds of Sitka spruce. Again two main active fractions were detected, one of which was identified by combined gas chromatography-mass spectrometry as zeatin riboside, and the other appears to be zeatin-9-glucoside (Lorenzi *et al.*, 1976c). This appears to be the first reported positive identification of a cytokinin from a conifer. During the period of active growth, the levels of zeatin riboside are high and those of zeatin-9-glucoside are low, whereas during the winter the position is reversed.

Experiments were carried out with seedlings of Sitka spruce grown in sand culture, to determine the changes in endogenous cytokinins occurring on transfer from an adequate to a nitrogen-deficient regime. In one experiment nitrogen deficiency caused a marked decline in certain cytokinin fractions, but these results were not fully confirmed in a later experiment. Further work is required to elucidate the effect of mineral nutrient deficiency on endogenous hormone levels, and to determine whether the tendency for Sitka spruce to go into "check" on poor sites is due to a disturbance of the hormonal balance in the trees.

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CONTROL OF FLOWERING IN SITKA SPRUCE

By P. B. TOMPSETT

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Flowering in Sitka spruce occurs at irregular intervals under natural conditions; good seed crops are generally separated by periods of several years. The lack of a reliable method for the control of flowering in this species has held up plant breeding programmes. Work aimed at enabling better regulation of flowering and seed production was initiated in 1974; experiments have been set up at Long Ashton and at the Forestry Commission Northern Research Station to investigate the factors controlling flowering, and studies of bud development are being carried out. (See p. 60 for work at University College of Wales).

Bud Development

Knowledge of the pattern of bud development would assist in planning the times when flower-promoting treatments should be applied. Shoot collections were made at frequent intervals throughout 1973 and 1974 from positions on the upper portions of three mature trees where male and female cone buds were likely to develop. Simultaneous collections were made of vegetative shoots from positions in the basal region of the trees, where reproductive buds were not expected. Study of these samples revealed that bud initiation occurs in early April, and that distinct differences between reproductive and vegetative buds first appear in late August. It was concluded that the critical time for flower initiation lies between these two extremes, so that treatments aimed at increasing the amount of flowering should be applied within this period.

Hormonal Induction of Flowering

In the initial year several approaches were explored, the most successful of which involved the application of growth regulating substances. Various combinations of gibberellins, auxins, cytokinins and growth inhibitors were applied to mature-wood branches of plants in pots, in the tree bank and in the forest. Many of these treatments had no effect, or reduced the level of flowering observed. On the other hand, a striking increase in flowering was apparent following treatment with certain gibberellins and application of the cytokinin benzyladenine in combination with gibberellin mixtures further enhanced the response (Table 9). In another experiment, increased flowering was induced by the application of GA_9, and this hormone deserves further investigation (see page 60). Promotion of flowering in the related genus *Pseudotsuga* by gibberellin treatments has been reported recently (Ross and Pharis, 1976).

The results obtained suggest that there is considerable potential for manipulation of flowering in Sitka spruce by the use of growth hormones. Work is in progress to determine the best method for hormone application, the period when hormone applications should be made, and the optimal amounts and combinations of hormones to employ.

TABLE 9

TOTAL NUMBERS OF MALE AND FEMALE FLOWER BUDS IN 1976 INDUCED BY HORMONE TREATMENT OF SITKA SPRUCE MATURE WOOD IN 1975

Seventeen replicate branches per treatment
Experiment carried out at Wauchope Tree Bank (Borders Region)

Hormone treatment	Flowering	
	Male	Female
Gibberellins $A_4 + A_7 + A_3$	53	73
Gibberellins $A_4 + A_7 + A_3$ in combination with benzyladenine	209	80
Control	49	17

REFERENCE

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FOREST ZOOLOGY

REPRODUCTION IN THE GREY SQUIRREL

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Studies on reproduction in the grey squirrel (Dubock and Johnson, 1974 and 1975) have shown that both male and female squirrels exhibit seasonal activity of the gonads, which may be influenced by external factors. In this continuation study the environmental factors which may affect reproduction, in particular, the role of nutrition, will be further investigated. Hormone assays are being developed to determine the levels of circulating progesterone during the female sexual cycle. Such information could lead to experimental trials on the use of progestins as reproductive inhibitors.

Radio Immunoassay for Progesterone

A radio immunoassay for squirrel plasma progesterone has been developed, based on an assay for bovine plasma progesterone (Glencross, Munro, Senior and Pope, 1973). Determinations, using known amounts of progesterone, have shown the method to be accurate and reproducible.

Plasma samples collected from female squirrels caught in the field during 1973 and 1974 have been analysed, using the progesterone assay (Fig. 5). These females were all classed as adult, non-pregnant animals. It is interesting that the highest levels of progesterone were obtained in June/July and December/January and follow closely the ovary and uterine weights previously published (Dubock and Johnson, 1975).

We need to investigate further whether these results indicate that plasma progesterone rises at oestrus or whether the highest values were obtained from females which had ovulated after mating, but were not obviously pregnant.

These values obtained for plasma progesterone are much lower than the values obtained from diagnosed pregnant females captured in the field. Three pregnant females so far analysed had progesterone levels ranging from 3·2 to 9·6 ng/ml.

Assays of progesterone will continue over the summer breeding season.

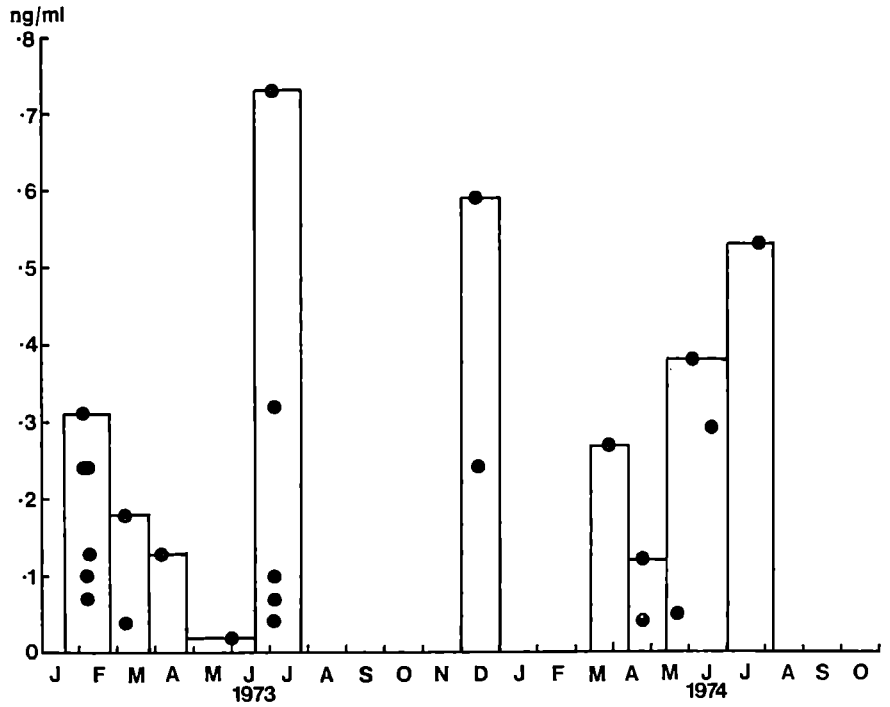

Figure 5: Plasma progesterone levels (nanogram/ml) for individual non-pregnant female squirrels.

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RECREATION

SCOTTISH TOURISM AND RECREATION STUDY

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Data from the 1973 "cordon" and "home interview" surveys of the Scottish Tourism and Recreational Study (STARS) have continued to be analysed (see *Reports* for 1973, 1974 and 1975).

Results of Analysis

Information resulting from the STARS surveys has been available to sponsors as computer output since early 1974. It is produced in three basic formats:

Straightforward Listings of Information. For example, details have been provided of the 100 leading towns in Scotland, according to the number of bednights spent at each by holidaymakers.

Crosstabulations. This is the standard format for information derived from STARS, and is based on a list of several hundred "variables", whereby one category of information—for example, place of residence—can be related to another—for example, region visited. The TRIP system (Tourism and Recreation Information Package) into which STARS data have been input, permits a far greater sophistication of analysis than such two-dimensional crosstabulation; for example, the region visited has been related to home region, in terms of the age group and sex of the respondent, and also the type of holiday group in which he or she was travelling. The TRIP system permits a maximum of 10 such "base" variables to be considered, in addition to the two-dimensional crosstabulation.

Computer Maps. By means of the TRIP system, information can be mapped on a grid square map of Scotland, based on either a 5 × 5 km or a 1 × 1 km grid. Any information which can more readily be understood in map form can be provided—for example, a description of the main roads used by visitors to Scotland, with an indication of how heavily each road is used during a given month in the peak season.

These data have been used by the sponsors to meet their ongoing needs for planning and development, and have been made available, through the newly established TRIP Management Service, to a wider range of national and local bodies such as the Regional Councils. Selected analyses are also being published by the Unit in 1975 and 1976, in a series of STARS reports, each of which has a particular theme.

STARS Reports

TRRU Research Report Number	STARS Series Number	Title	Sponsor
14	1	Survey Description	All
18	2	Summary Report	All
19	3	Holidaymaking in Scotland	Scottish Tourist Board
20	4	The Woodland Visitor	Forestry Commission
25	5	Patterns of Outdoor Recreation in Scotland	Countryside Commission for Scotland
26	6	The Theatregoer in Scotland	Scottish Arts Council
27	7	Tourism in the Highlands and Islands	Highlands and Islands Development Board

STARS Reports Numbers 3 to 7 contain analyses and commentaries reflecting the interests of individual sponsors.

The data from STARS have provided not only valuable information for national and regional planning, but also an impetus for significant further research. Examples of research undertaken by the Unit itself, and made possible by the existence of this body of data, are the development of a physical system analogue, to model patterns of recreational traffic, which will take into account the distinctive nature of recreational travel (sponsored by the Social Science Research Council); and a project on recreation activity substitution (sponsored by the Forestry Commission, the Countryside Commission for Scotland, the Scottish Tourist Board and the Scottish Sports Council) in which relationships between different "life-style" groups and activities are investigated to provide information for future recreational planning in Scotland. In addition, the STARS data are providing a major input into the Scottish Tourism and Recreation Planning Study (STARPS), and other studies being undertaken to improve information on patterns of tourism and recreation in Scotland. A separate report on STARPS is given below.

SCOTTISH TOURISM AND RECREATION PLANNING STUDIES

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The Scottish Tourism and Recreation Planning Studies (STARPS) are sponsored jointly by the Countryside Commission for Scotland, the Scottish Sports Council, the Scottish Tourist Board and the Forestry Commission. The Dartington Amenity Research Trust (DART) have been engaged as consultants for the period March 1975 to March 1977. The purpose of these studies is to assist in the evolution of outline planning strategies for sport, outdoor recreation and tourism for each region and island authority area in Scotland, co-ordinated within a broad national framework.

The background to these studies is the re-organisation of local government in Scotland, by which (from May 1975) a new pattern of regional, island and district authorities came into executive existence with duties and powers relating to tourism, recreation and related matters. The four Government agencies, who themselves have statutory responsibilities in these fields, obviously need to work closely with the new authorities on the essential forward thinking. The studies are therefore aimed directly at assisting and improving the various planning processes, with particular emphasis on the production of Initial Regional Strategies (largely by the local authorities concerned) for each region or island authority.

The work has been divided into two stages. Work on Stage One is complete and is described in this note. Work on Stage Two has commenced recently, and an account of its nature is also given.

Stage One

During the first stage of work, DART's job has been to consolidate a basis of data, planning methods and national policy ideas with which the national sponsors could move, in the second stage, into more formal collaboration with the regional and island authorities. There has been widespread consultation with regional and island authorities regarding their approach to long-term planning and possible ways of assisting them in their strategic thinking, during which the nature and form of Initial Regional Strategies has become more closely defined.

A review of the availability of information on recreation and tourism has been undertaken, together with an investigation into local authority requirements in this respect. A consideration of methodologies available for use in strategic planning took account of the findings of the consultations and availability of information. A significant element in the information has been the results of the Scottish Tourism and Recreation Study, sponsored earlier by the Forestry Commission and others (see *Report* for 1975, p. 63).

Work on national policy ideas has included consultation with national bodies with interests in recreation or tourism, and a review of the policies of the study sponsors, in the light of information on likely future situations supplied by the Scottish Council Research Institute.

Stage Two

In the second stage, DART's role is to assist the national sponsors, and the regional and island authorities, in preparing Initial Regional Strategies relating to recreation and tourism in each region. To this end, as a product of Stage One work, two documents have been prepared, particularly to aid the regional authorities in their work:

Strategic issues (setting out likely future situations and the implications for the regions, of national policies).

Guide to the preparation of initial regional strategies. This guide is in two parts. The first sets out the concept of the Initial Regional Strategy, outlines the thought-process proposed for the preparation of a Strategy, and comments briefly on the subsequent process of adoption. The second

describes in detail the technical work proposed, such as clarification of strategic issues, appraisal of demand and supply and impact, together with formulation of aims, objectives and policies.

The studies are essentially of a "planning" rather than "research" nature, and this is particularly the case in Stage Two, where DART's role will involve assistance and co-ordination in the production of the different strategies.

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

The joint programme has continued, with the Forestry Commission supporting research on home-grown timber at the Princes Risborough Laboratory, to the extent of four man-years of research time during the year.

Evaluation of Forest Management Practices

A non-destructive wood sampling technique offers the possibility of monitoring the effects of forest management practices on wood density and fibre yields. One such sampling technique is the use of a through-tree breast-height boring, and the value of a boring, for estimating selected whole-tree wood properties, has been examined for Sitka spruce. Regression equations, giving whole-tree wood density to two top diameters, have been derived from weighted boring densities, and the effect of sample size on the precision of the estimate examined.

Precision improves significantly as the number of trees sampled increases up to 10 but thereafter, in a between-site comparison, further sampling gives only a minor improvement as random variation between sites limits precision. Nevertheless the technique can be used to distinguish between sites where average wood density differs by 10 kg/m^3 or more. In a comparison of plots within a site, precision is improved by sampling in excess of 10 trees, and differences of only 5 kg/m^3 can be demonstrated. Thus the technique appears specially useful for the examination of the effect on wood density of different management practices within a site. A paper reporting these results is in preparation.

The Simulation of Softwood Sawlog and Sawmilling Conversion Procedures

Development of a computer simulation model for the conversion of softwood sawlogs has continued, and an extensive trial has been carried out in an industrial sawmill.

The model's predictions of how to maximise the sawn yield from individual logs have been shown to be a true representation of what will happen in a real sawmilling situation.

Research has shown that computer-aided conversion techniques improve the volume of the required sawn sizes, obtained from the cant, by at least three per cent and hence maximise the volume of the more valuable structural sized material from particular logs. Although the efficiency of the slab recovery could be improved, the advantages would depend on the value and size of particular markets, and the processing capacity of particular sawmills.

An on-line industrial system which accurately measures individual logs, simulates them and sets them up for cutting, according to computer predictions, is not economically feasible for sawmills within Great Britain. Therefore research is being carried out into combining a log classification system, with a computer aided conversion technique, to maximise the yield of the more valuable material and match it more closely to particular markets.

Using Computer Simulation to assess the Effect of External Features on the Conversion of Sawlogs

Sweep is considered to be the dominant external feature affecting the yield of sawn timber from the core of the log. No information is available on extreme amounts of sweep encountered in softwood plantations in Great Britain, and the first part of this project has been a field study to quantify sweep. The study has been carried out on Lodgepole pine, which is the species exhibiting the most frequent and severe sweep.

Out of a total of 140 measurements, 111 showed sweep exceeding one-third of the under-bark diameter, at the top of the swept length. Severe sweep invariably occurred at the butt, and was contained within 2·5 m to the first natural break.

Future work will use the computer-simulation technique, previously described, to determine limiting values of sweep for logs of 1·8 and 2·5 m in length, and with varying top diameters, to give conversion efficiencies of at least 40 per cent.

Douglas Fir Density Survey

In stress grading studies, Douglas fir, unlike other home-grown timbers, gave low yields when machine graded to the stress levels given in British Standard Code of Practice 112. Doubts have been expressed concerning the representative nature of the graded Douglas fir and, in particular, it is considered it may have been of below average density. To examine this a survey of wood density in Douglas fir, of sawlog size and representative of a range of yield classes, has been made, and the results are being analysed.

Economic Aspects of Slab Recovery

This work has been a continuation of the economic study of chipper canters, which was undertaken during the previous project year. Results indicate that, given a market for the sawn boards recovered, the home sawmiller should endeavour to obtain the maximum proportion of marketable timber from slabs, and should not produce chips at the expense of sawn timber.

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. (1976). Bark industry develops in Britain. *Forestry '76, A Farm Contractor specialist annual*, pp. 12–13.

Outlines the early attempts by the Forestry Commission to develop the use of conifer bark for tanning, and short-lived projects by industry to prepare fuel briquettes from bark.

The steady build-up of a new industry for supplying the horticultural trades with pulverised bark is described, together with the processing needed before it can be used. The properties of bark and peat are compared, and it is concluded that they are best regarded as complementary rather than competitive materials.

The use of bark as litter and for the control of oil pollution is also mentioned.

ATTERSON, J., and BINNS, W. O. (1975). Peat nutrients and tree requirements in Forestry Commission plantations. *Peatland forestry, Proceedings of NERC Symposium*, Edinburgh 1968, pp. 127–137.

A discussion paper dealing with the nutrient reserves of peat, nutrient uptake by and requirements of tree stands, and the long-term changes in peat and in tree requirements. Peat contains large reserves of nitrogen, but relatively small quantities of phosphate and potash. The N is present as organic compounds and until these are broken down is unavailable for plant growth. Experiments are continuing to determine how such breakdown can be accelerated. P and K are now applied by foresters as standard dressings to tree stands on peat based on previous research findings, visual observation and chemical analyses of foliage. The long-term effect of trees on peat are not known, and it is emphasised that the potential benefits of microbiological research on peat, particularly from the point of view of nitrogen availability, are very large as higher-yielding species could then be grown.

(VIEDMA,* M. G. de, and) BEVAN, D. (1975). The evolution of the species *forest entomologist* in different environments. *2nd World Technical Consultation on Forest Diseases and Insects*, New Delhi, India. 7–12 April. FAO/IUFRO/DI/75/18–2.

By analogy with linnean zoological species, three stages in the Forest Entomologist's evolution are described. Brief diagnostic features, a short description of the niche and the major environmental pressures operating within and upon each stage are offered.

Importance is given to the management, coordination and integration of an interdisciplinary team of specialists dealing with the introduction of plans and prescriptions for the management and control of forest insects.

The natural leader of this team should be a Forest Graduate (a generalist) whose specialization in Forest Entomology has been spread over the last stage of his progress through Forestry School.

After Forestry School a further period of formal education is suggested, probably in applied zoology and in-job training at a Forest Research Institute for a period of about two years. The advantages and implications of this type of training are discussed.

(VIEDMA,* M. G. de,) BEVAN, D., (WEDDLE,** A. E., and RAMOS, A.***) (1975). Recommendations for a new Spanish institute of environmental analysis. *Landscape Planning* **2**, 31–36.

The paper gives an outline account of enquiries made and discussions which lead to recommendations for an institute of environmental analysis in Spain. This new venture would be characterised by an applied approach and not restricted to conventional research. Locational criteria and staffing are discussed and the importance attached to project teams clearly emerges. These operational teams would be backed by laboratory services limited

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to two areas. First, a soils laboratory. Second, an air photo laboratory able to offer a very full range of air-photo interpretation and mapping services.

In addition to the Institute's own laboratory services and project teams, full use of specialist services is suggested, drawn from universities, professional consultants and other agencies. The need to build up education services is stressed, both for internal training and as a contribution to the development of inter-disciplinary working in the environmental field.

BINNS, W. O. (1974). Silviculture on drained areas: Fertilisation. *Co-ordinators' Papers and Discussions of the International Symposium on Forest Drainage*, Sept. 1974, Finland, pp. 101–107.

This report summarises six papers given at one session. General conclusions drawn from these six papers were:–

On some peat types, drainage is the limiting factor and without it there is no response to fertiliser. On peatlands nitrogen forms which contain NH_4, or which are converted into NH_4, seem better than forms containing NO_3. Different forms of phosphatic fertiliser seem to have much the same effects over about 15 years. Nitrogen fertilisers for young crops seem best applied spot or in strips, but are better broadcast on older crops. Nitrogen responses seem to last about eight years, phosphorus responses up to 15 years. Evidence was produced that nitrogen may be applied at any time of the year, except when snow is on the ground. Fertilisation should always be delayed until drainage has had an effect. Hardly any of the papers presented described factorial experimental designs, which limited the conclusions which could be drawn.

BINNS, W. O. (1975). Whole-tree utilization: Consequences for soil and environment: Experience and opinion in Britain. *Proceedings of Konferens SK2, Elmia* 75, Jönköping, Sweden, pp. 18–25.

Whole-tree utilisation is likely to increase the nutrient drain between three and five times for spruce and two and three times for pine, depending on the nutrient. There is little direct evidence on effects of increased utilisation on the soil, but a thinning experiment in Norway spruce has shown that increasing thinning intensity reduces the thickness of the litter layer and the weight of nutrient in it per hectare, reduces the C:N ratio, total soil P, and soluble soil Ca, but increases the soluble soil K. Soils under forests generally have higher organic matter and nitrogen contents. Harvesting in British conditions of heavy soil and high rainfall seems to cause some soil damage; brash ought to be left at some stage in the rotation to reduce this soil damage. The consequences of harvesting intensity and the methods used for the next crop should be borne in mind when evaluating harvesting systems.

BINNS, W. O. (1975). *Fertilisers in the forest: A guide to materials.* Forestry Commission Leaflet 63 (HMSO 35p).

The Forestry Commission fertilised 7,200 ha of plantations in 1960–61, 51,000 ha in 1973–74. From 1969 on, roughly two-thirds of the treated area had phosphate alone, one third PK mixture, and less than one per cent had N fertiliser. Rock phosphates from North Africa are the best P fertilisers. The unground form is used for aerial work but is still a dusty material. Potassium chloride (muriate of potash) is the only recommended K fertiliser. A mixture of unground phosphate rock and crude potassium chloride makes an acceptable PK fertiliser for forestry. Urea is the cheapest and most concentrated N fertiliser, but may lose N to the air as ammonia. Ammonium nitrate is more reliable, but less concentrated. Although fertilisers could contaminate surface waters, this should not occur with careful work and, for K and N, spring or summer application. Contamination of ground water is improbable. People working with fertilisers must wear suitable clothing and pay attention to safety measures.

BINNS, W. O., and STICKLAND, R. E. (1975). Measuring tree heights in dense stands with sectional poles and a horizontal arm. *Commonwealth Forestry Review* **54** (3) and (4), 257–266.

Jointed aluminium and bamboo poles, with and without a horizontal arm at the top, were used to estimate the height of Sitka spruce, Corsican pine and Douglas fir 10 to 15 m tall growing in dense stands. Estimates of mean height made with plain poles agreed closely with felled measures. Adding the horizontal arm rendered agreement less close for Sitka spruce and Douglas fir, but not for Corsican pine. In contrast, adding the horizontal arm reduced the *scatter* of measurements for all species with aluminium poles, and for Sitka

spruce and Douglas fir with the bamboo poles also. It is concluded that plain poles are adequate for estimating mean height in dense polestage stands, up to 15 m tall at least, but that the horizontal arm improves precision where increments of individual trees are required.

BLUD, M. (1975/1976). Timberjack skidders. FC/HGTAC Technical Note No. 21. *Forestry and Home Grown Timber* **4** (6), 43–44.

A technical report on the Canadian-made Timberjack 208D, 225D and 360 skidders, with estimated outputs for the 225D.

BOWEN, M. R., HOWARTH, J., and LONGMAN, K. A. (1975). Effects of auxins and other factors on the rooting of *Pinus contorta* Dougl. cuttings. *Annals of Botany* 39, 647–656.

The effects are investigated of application of NAA and IBA upon root number, root type and time to form first roots in cuttings of *Pinus contorta* Dougl. Cuttings treated with NAA generally formed thick, fleshy, unbranched roots, while those receiving IBA produced a thin, finely-divided root system. Both types of roots developed when the two hormones were applied together. The time taken for first roots to form, and the final number of rooted cuttings were also greatly increased when hormones were applied in the range 1–10 μg per cutting. Boric acid applied in combination with hormone treatments increased rooting, but boron alone was ineffective. There were marked differences between clones in their rooting responses to both hormone and boron treatments.

BRADLEY, R. T. (1975). Forestry in West Scotland. *Forestry* **48** (1), 33–50.

After a general description of the topography, climate, soils and natural vegetation of the area, the successive changes in land use are traced from the arrival of Neolithic man to the present-day emphasis on recreation. Tables show the species proportions and average yield class of Forestry Commission plantations, and the potential yield is forecast for the next twenty years. Reference is made to marketing and methods of transport of the felled timber, and to the consequences of the 1968 windblow.

For the future, while recognizing the difficulty of forecasting the rate at which the large reserve of land suitable for forestry will be acquired, the author considers there will be increasing emphasis in this particular region on amenity, recreation and conservation as important objectives for both state and private forestry.

BRASIER, C. M., and GIBBS, J. N. (1975). Highly fertile form of the aggressive strain of *Ceratocystis ulmi*. *Nature* **257** (5522), 128–131.

Most wild isolates of *C. ulmi* may be assigned to either the aggressive or the non-aggressive strain but *c.* 2% have some affinity to the "fluffy" aggressive strain and produce small, black-brown, sclerotium-like bodies throughout the culture. During testing of wild isolates of the aggressive strain for compatibility type, most gave a clear-cut B reaction, forming perithecia only with type A isolates, but a few showed a selfing reaction and produced perithecia as a result of the maturation of the small, black-brown bodies, regarded as protoperithecia, formed at the junction between light and dark coloured colonies. Further tests confirmed that the "proto" or dark sclerotial isolates are highly fertile type A strains which form perithecia when paired with the fluffy B strains, the progeny from which segregate 1:1 for proto and fluffy types. In addition ascospores from selfed perithecia produced by proto isolates alone segregate 1:1 for proto and fluffy. From the available evidence it is suggested that mutation to proto A type occurs in a fluffy B type at a single locus. This postulated locus apparently also has an effect on pathogenicity and growth rate, since wild proto isolates cause significantly less defoliation of inoculated elms than fluffy isolates. These phenomena of pseudoselfing and proto x fluffy outcrossing result in significant variation among progeny and in nature could lead to the appearance of new genotypes which might contribute to a decline in the pathogenicity of the present *C. ulmi* population and thus of the epidemic.

BRASIER, C. M., and GIBBS, J. N. (1975). MBC tolerance in aggressive and non-aggressive isolates of *Ceratocystis ulmi*. *Annals of Applied Biology* **80**, 231–235.

In selection experiments, tolerance to 0.5 ppm methyl benzimidazole-2-ylcarbamate (MBC) occurred at a frequency of *c.* 1 in 1.3×10^8 conidia in both aggressive and non-aggressive isolates of *Ceratocystis ulmi*. The tolerant strains were inhibited by 5 ppm MBC, however, and attempts to select strains tolerant to 10 ppm were unsuccessful. In each of three isolates examined, tolerance remained stable after fifteen successive transfers on fungicide-free medium. Genetic control was nuclear and probably conditioned by a single gene. It is thought unlikely that the appearance of tolerant strains in nature will jeopardize the use of MBC for the control of Dutch elm disease.

BRASIER, C. M., and GIBBS, J. N. (1975). Variation in *Ceratocystis ulmi:* Significance of the aggressive and non-aggressive strains. In *Proceedings of IUFRO Conference on Dutch elm disease*, Minneapolis, St. Paul, USA, 1973. USDA Forest Service, NE Forest Experiment Station, pp. 53–66.

Reviews the history of the disease, the discovery of the aggressive and non-aggressive strains, and the origin of the aggressive strain in the present epidemic on imported timber. Considers the significance of these findings for research on Dutch elm disease including population dynamics, physiology and genetics of host/parasite relations, breeding for disease resistance, and short-term control measures.

(SANSOME, *E.), BRASIER, C. M., and GRIFFIN, M. J. (1975). Chromosome size differences in *Phytophthora palmivora*, a pathogen of cocoa. *Nature* **255** (5511), 704–5.

When 2 isolates from cacao in Nigeria, P131 and P132, were studied, the former was of the A2 mating type and the latter of the A1 type. The sex organs produced in paired culture possessed distinctive nuclei; the large (L) type had a basic number of 5 or 6 comparatively large chromosomes at metaphase, with a multiple association of at least 4 chromosomes, while the other, small (S) chromosome type had a basic number of 9–12 much smaller chromosomes. By pairing P132 with an A2 isolate of *P. drechsleri* it was confirmed that P132 was the L chromosome type and therefore P131 was the S type. When further isolates of *P. palmivora* from cacao in Cameroon, Nigeria and Ghana were examined, 9 of 10 A2 isolates were of the S and the other of the L type, and all 5 A1 isolates were of the L type. Evidently both A1 and A2 compatibility types are present in the L type. On carrot agar L types produced abundant woolly aerial mycelium while S types grew more rapidly and produced less aerial mycelium. The lesions produced by L types on inoculated cacao pods had a diffuse edge while S types produced a faster developing sharp edged lesion. The S and L chromosome types correspond to the cocoa and rubber groups of *P. palmivora* [RAM 8, 526] and in view of the differences in chromosome size and number must be regarded as distinct spp. In a preliminary survey the L type (A1) appeared to be the principal cause of black pod disease in Nigeria while the S type is the only one associated with the disease in Ghana.

BRASIER, C. M., and SANSOME, *Eva (1975). Diploidy and gametangial meiosis in *Phytophthora cinnamomi*, *P. infestans* and *P. drechsleri*. *Transactions of the British Mycological Society* **65** (1), 49–65.

Meiosis was observed in the gametangia of A1 × A2 pairings of *P. cinnamomi* (n=9 or 10), *P. infestans* (n=9 or 10) and *P. drechsleri* (n=9–12). Game-tangial divisions in A2 isolates of the three species which were induced to self by the presence of *Trichoderma* were indistinguishable from those in the pairings. Counts of nuclei in selfed gametangia of *P. cinnamomi* confirmed that the two nuclear divisions occurred. In *P. infestans* an association of six chromosomes indicating chromosomal structural hybridity was observed both in A1 × A2 pairings and in A2 selfed. An association of four chromosomes was observed in A1 × A2 and A2 selfed in *P. drechsleri*. These multiple associations provide conclusive evidence that the divisions are meiotic.

Stages of fertilization were observed in *P. cinnamomi* and *P. infestans*. Differential staining indicated that both A1 and A2 oogonia were produced in the A1 × A2 pairings of *P. drechsleri* and also in *P. cinnamomi*; and that both selfed and hybrid gametangia occurred in *P. cinnamomi*. Single oospore cultures from A2 selfed segregated for cultural characters in *P. drechsleri* but no segregation for compatibility type occurred.

Supporting evidence for diploidy is examined and the significance of a diploid life cycle for *Phytophthora* is discussed.

BROWN, R. M. (1975). *Chemical control of weeds in the forest.* Forestry Commission Booklet 40 (HMSO 90p).

This Booklet gives recommendations on the use of herbicides in British forestry, and replaces Leaflet 51 which bore the same title. In addition to recommendations on the chemicals best suited for controlling the various weed species, information is given on equipment, aerial spraying, costs, safety in use, and sources of supply.

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BROWN, R. M., and THOMSON, J. H. (1975). Trials of ULV applications of herbicides in British forestry. *Commonwealth Forestry Review* **54** (1), 38–44.

Between 1969 and 1973 the Forestry Commission tested the effectiveness of ULV applications of 2,4,5-T for controlling a range of woody broadleaved weeds in coniferous plantations in lowland Britain, and of ULV applications of 2,4-D for controlling heather (*Calluna vulgaris* L.) in upland Britain.

ULV applications of both herbicides caused slightly greater crop damage than the normally recommended LV (mistblower) applications. Control of all weeds considered sensitive or moderately sensitive to these herbicides was as good as that provided by LV applications, but species less easily controlled (including heather) were not quite so well controlled.

Nevertheless, the results suggested that ULV applications may give acceptable results, and it is argued that the future of ULV techniques in British forestry will depend on the frequency and reliability of suitable weather conditions.

CARTER, C. I. (1975). *Towards integrated control of tree aphids.* Forestry Commission Forest Record 104 (HMSO 50p).

Aphid life cycles are of many different types, involving one or more annual migration periods which may or may not be associated with an alteration between different kinds of host plant. Some species seriously reduce or disfigure tree growth and need to be controlled. Others use trees mainly as a place to over-winter and then feed for a relatively short period in the spring before dispersing; such species are usually of little concern to the forester and arboriculturist.

In this paper the example of *Adelges abietis* is taken in which the precise timing of an insecticidal application is shown to be essential in order to achieve control. It is suggested that certain chemical treatments need to be used with caution since they may cause other pests to become troublesome. The point is made that the effect of an insecticidal treatment against aphids is transitory because of the periodic immigration of winged aphids. There is therefore a need to reflect on the factors critical for aphid success in nature. The whole range of control techniques, whether chemical, ecological or managerial, requires to be examined and integrated if effective control is to be assured. In this context it is maintained that host plant physiological condition may be of over-riding importance.

CARTER, C. I. (1975). A gall forming adelgid (*Pineus similis* (Gill.)) new to Britain, with a key to the adelgid galls on Sitka spruce. *Entomologist's Monthly Magazine* **111**, 29–32.

This account constitutes a first record of *Pineus similis* in England, or for that matter anywhere outside North America. The trimorphic first generation on spruce, unique in the family Adelgidae, is compared with other species. *P. similis* forms galls and a key is given for the recognition of all adelgid galls known to occur on Sitka spruce in Britain.

CHARD, R. (1975). A stand of Western white pine (*Pinus monticola* Douglas) at Castle Oer Forest. *Scottish Forestry* **29** (2), 94–101.

Some particulars are given of a small stand of western white pine (*Pinus monticola* Douglas) as further indication that early pruning of five needled pines reduces deaths from white pine blister rust (*Cronartium ribicola* J. C. Fischer). The potential of *P. monticola* for high yields of very stable softwood is indicated.

CHRISTIE, J. M., and LINES, R. (1975). A comparison of forest productivity in Britain and Europe in relation to climatic factors. *Proceedings of 7th International Congress of the International Society for Biometeorology* August, Maryland, USA.

Using national yield tables as a basis, the growth of Scots pine, Lodgepole pine, Norway spruce and Sitka spruce has been compared. From the trends of height growth with age and the levels of total volume production, the paper attempts to relate the differences in growth in various countries to climatic factors.

CLARKE, J. C., and BOSWELL, R. C. (1976). *Tests on round timber fence posts*, Forestry Commission Forest Record 108 (HMSO £1.70).

The results of annual tests applied over a total of fifteen years on treated and untreated hardwood and softwood fence posts are assessed in relation to the normal service life of fence posts of given species, the effect of creosote and of a water-borne preservative treatment applied by the hot and cold open tank technique, and the influence of the site on these results.

COUTTS, M. P., and PHILIPSON, J. J. (1975). The influence of mineral nutrition on development of individual roots of Sitka spruce. *Arboricultural Journal* **2** (9), 406–410.

Sitka spruce seedlings were grown with their root systems divided between two contrasting nutrient regimes. One half of the root system was supplied with a solution containing N, P and K at a range of concentrations, while the untreated half received water only. High nutrient treatments induced two flushes of shoot growth resulting in a large shoot system, whereas plants in the low nutrient treatments flushed once only and showed symptoms of nutrient deficiency.

Root growth, assessed in terms of dry weight, was stimulated only in the roots to which the nutrients were actually applied; the untreated roots on treated plants grew no more than plants receiving water alone. However, internal nutrient concentrations on *both* sides of the root systems were related to the concentrations applied to the treated roots, though to a slightly lesser extent in the untreated roots. Thus, the nutrients which had been internally translocated to the untreated roots had little effect on their growth.

The physiological mechanisms involved in these responses and the practical aspects of the work are discussed.

DANBY, N. P. (1975). A study tour in Western Norway. *Scottish Forestry* **29** (3), 167–185.

Natural forests of Scots pine and Norway spruce and areas of planted exotics, mostly Sitka spruce, were seen in the characteristically windy maritime climate of Western Norway. Wind effects on the forest were much less than expected, especially away from the coast. The differences in the climate, the more dramatic topography, better soils, more natural silviculture and the generally slower growth all contribute to the greater stability of this region compared to the windthrow problem areas of upland Britain.

DAVIES, GERAINT, (1975). Line thinning. *Forestry and Home Grown Timber* **4** (2), 22–24.

The object of thinning is to increase the profitability of a forest crop by obtaining revenue before the end of a rotation, and to concentrate growth onto a smaller number of trees. To justify the thinning operation, the return it brings should be greater than its cost.

Line thinning is a system which can reduce the costs of brashing, marking, felling and extraction operations, when compared with the more conventional selective thinning at first or second thinning stage, while selective thinning during the later life of the crop is not precluded.

EDLIN, H. L. (1975). *The observer's book of trees.* 191 pp., 51 colour illustrations, 58 photos, 35 line drawings. London: Frederick Warne & Co. (75p).

This volume contains illustrations which will enable readers to name and appreciate the 74 kinds of trees most commonly found in the British Isles. Text relates the progress of each tree through its seasonal changes, together with its patterns of flowering and fruiting. Uses of wood and maximum sizes by height and girth are given for each kind. There is an account of each tree's history whether native or introduced, and its value for ornament or forest timber production.

EVANS, J. D. (1976). Amenity trees. *The Garden* **101** (1), 57–58.

Covers the Forestry Commission's interest in arboriculture, and comments on the lines that research is likely to take.

FAULKNER, R. (1975). *Seed orchards.* Forestry Commission Bulletin 54 (HMSO £2.30).

A joint production by specialist members of the International Union of Forest Research Organizations Working Party on Seed Orchards, which deals authoritatively with history; planning and strategy; designs; vegetative propagation; location establishment and management; protection flowering and seed production; pollination, pollen management; cone and seed harvesting; inbreeding; advanced-generation orchards; broadleaved orchards; and seed certification.

FAULKNER, R. (1976). Timber trees. In *Evolution of crop plants* (ed. N. W. Simmonds), pp. 298–300. London: Longman.

A short paper describing the main uses and groups of timber trees and their cytotaxonomic background, together with a potted historical review of forest exploitation and the development of afforestation and breeding programmes. A forecast is given of likely future developments in tree improvement work.

FAULKNER, R. (1976). Breeding conifers. *Arboricultural Journal* **2** (10), 434–443.

A general review of variation with particular reference to vigour, stem and crown form, foliage and resistance to adverse climate, pests and diseases. Breeding for ornamental and commercial forestry purposes are dealt with in some detail.

FLETCHER, J. R., INGOLDBY, M. J. R., and WALLACE, D. H. (1975). Ösa 705 processor. FC/HGTAC Technical Note No. 20. *Forestry and Home Grown Timber* **4** (5), 41–42.

A technical report on this Swedish-built machine which delimbs and crosscuts felled trees. Outputs up to 900 m^3 per 40-hour week have been achieved.

FOOT, D. L. (1975). Forest management at Craik. *Scottish Forestry* **29** (2), 129–34.

This is a discussion paper written for the Royal Scottish Forestry Society's 1975 Annual Excursion, which included a visit to Craik Forest, South Scotland. Here the theme was environmental influences on forest management with special reference to windblow. This paper describes the forest in the context of Border conditions, and the particular tactics and techniques being introduced to meet the challenge of wind.

FORREST, G. I., (and SMITH, R. A. H.)* (1975). The productivity of a range of blanket bog vegetation types in the northern Pennines. *Journal of Ecology* **63**, 173–202.

Total and component net production of seven blanket bog sites in the northern Pennines, representing a range of variation in floristic composition, was estimated. There was a two-fold variation in production between sites (481–868 g $m^{-2}yr^{-1}$), the mean total annual net production for all seven sites studied being 659 ± 53 g $m^{-2}yr^{-1}$. Between-year variation was relatively small in comparison to that between sites. The sites with the highest production were those which had been recently burnt. For the remaining sites, assumed to be in a steady state situation, there was a trend of decreasing production with increasing wetness, reflecting decreasing contribution of *Calluna* and *Eriophorum vaginatum* only partly replaced by increased *Sphagnum* growth on the wetter sites.

Mean production per growing season day for the four Calluneto-Eriophoretum sites was 1.98 g m^{-2} day^{-1}. The total production of the 1215 ha of blanket bog within the Moor House National Nature Reserve was estimated as 7.67×10^6 kg yr^{-1}.

GIBBS, J. N., BRASIER, C. M., (McNABB, H. S.,† and HEYBROEK, H. M.**) (1975). Further studies on pathogenicity in *Ceratocystis ulmi*. *European Journal of Forest Pathology* **5** (3), 161–174.

Nine "fluffy" isolates of *Ceratocystis ulmi* from England, USA, Canada, The Netherlands and Iran and seven "waxy" isolates from England, USA, France and The Netherlands were inoculated into 5-year-old *Ulmus procera* at Alice Holt. Isolates in the "fluffy" group caused between 56 and 100% stem dieback at 16 weeks, isolates in the "waxy" group between 0 and 3%. A similar separation of the two groups was found in experiments at Ames on *U. glabra* and *U. pumila*. At Ames inoculations made by cutting into the main stem resulted in more disease than "pinprick" inoculations in the 2-year-old twigs.

Severe disease developed in many clones from the elm breeding programme in The Netherlands inoculated with "fluffy" aggressive isolates at Wageningen. Mean crown symptoms at 14 weeks ranged from 30–100%. Only *U. japonica* 685 was unaffected. Of the remainder, the best clones seemed to be 454, 494 and 496. "Waxy" non-aggressive isolates caused very little disease except on *U.* × *hollandica* 'Belgica'. Similar results were obtained in inoculations at Alice Holt and at Ames. The most resistant elms seemed to be selections of *U. pumila*, *U. pumila* × 148 and Christine Buisman 24. *U. americana* showed its usual very high susceptibility to both aggressive and non-aggressive isolates.

GIBBS, J. N., and DICKINSON, J. (1975). Fungicide injection for the control of Dutch elm disease. *Forestry* **48** (2), 165–176.

The superiority of the benzimidazole fungicides, and in particular of carbendazim (MBC), over other fungicides was shown by injection experiments on both artificially inoculated and naturally infected young elm. With carbendazim the degree of control depended in great measure on the formulation, and some evidence was obtained that the commercial formulation

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of carbendazim hydrochloride (Lignasan) produced in 1974 was less effective than an experimental formulation of the same chemical. Benefits from injection with Lignasan were most marked on trees below 25 m in height. The effects of various factors such as time of day, season, weather conditions and tree size on the rate of fungicide uptake are considered.

GREIG, B. J. W. (1975). Biological control of *Fomes annosus* by *Peniophora gigantea*. *2nd World Technical Consultation on Forest Diseases and Insects*, New Delhi, India, 7–12 April 1975. FAO/IUFRO/DI/75/12-1.

Fomes annosus is the most important disease affecting British forests. It is often checked in pine crops when stumps are naturally colonised by *Peniophora gigantea*. Inoculation of stumps with *P. gigantea* was as effective as chemicals in controlling *F. annosus* in first rotation crops. In diseased pine crops *P. gigantea* reduced but did not eliminate *F. annosus*. *P. gigantea* is available commercially in Britain and is used in about 30 forests.

GREIG, B. J. W., and LOW, J. D. (1975). An experiment to control *Fomes annosus* in second rotation pine crops. *Forestry* **48** (2), 147–163.

Stump removal was found to significantly reduce killing by *Fomes annosus* in second rotation crops of pine. Poisoning and girdling of trees prior to felling and also stump poisoning failed to control the disease. In this experiment no significant differences were detected in the susceptibility of Scots and Corsican pine to attack. Increasing periods of delay before replanting resulted in less mortality. An equation is presented, based on factors of the first rotation crop, which may be used to predict losses likely to occur when a site is replanted. Root attack by *F. annosus* results in reduced growth and yield as well as mortality.

The results from the experiment are discussed in terms of the management of pine crops attacked by *F. annosus* in Thetford Chase.

GREIG, B. J. W., (and McNABB, H. S., Jr.*) (1976). Management of *Fomes annosus* root rot disease in pine crops in Britain. *Iowa State Journal of Research* **50** (3), 287–292.

Fomes annosus, the most important forest disease organism in Britain, causes decay and mortality. The fungus infects stumps by airborne spores and then spreads to adjacent trees by root contact. Control can be achieved in first rotation crops by chemical and biological stump protection. The disease is a serious problem in the pine forest of Thetford Chase, where experiments have shown that stump removal is an efficient control method. Stump removal also gives benefits through increased yields and revenues. Management of the disease involves study of soil data and surveys to identify the infected crops. Current stump removal methods are described. Preliminary cost/benefit estimates of disease control are presented. The implications of root disease for intensive culture systems are discussed.

HAMILTON, G. J. (1975). *Forest mensuration handbook*. Forestry Commission Booklet 39 (HMSO £4).

Provides detailed procedures for various methods of measurement of standing and felled timber including, for example, measurement of stacked timber and measurement by weight. All necessary tables are appended. Miscellaneous aspects of measurement included are: sampling, plot sizes, height measurement, the use of relascopes, conversion factors etc.

HAMILTON, G. J. (Editor), (1976). *Aspects of thinning*. Forestry Commission Bulletin 55 (HMSO £2.50).

Contains the papers presented at a meeting of IUFRO Project Group p 4.02 "Economics and Harvesting of Thinning", held in Edinburgh from 30 September to 2 October 1974. Papers include yield aspects of thinning, methods of harvesting, and the damage caused to site and stand by harvesting operations.

HAMILTON, G. J. (1976). Effects of line thinning on increment. In *Aspects of thinning*, Forestry Commission Bulletin 55 (ed. G. J. Hamilton), pp. 37–45. London: HMSO.

The results from five experiments involving line thinning treatments show that:

—A loss of volume production is associated with the neutral thinning type implicit in line thinning;

*Professor of Forest Pathology, Iowa State University, USA.

—the zone of influence of line thinning is largely confined to the rows immediately adjacent to those removed;
—the response of outside rows rises markedly as the number of adjacent rows removed increases; and
—greater losses in volume production are associated with greater numbers of adjacent rows removed.

HOLMES, G. D. (1975). History of forestry and forest management. A discussion on forests and forestry in Britain. *Philosophical Transactions of the Royal Society of London.* B. **271**, 69–80.

Britain possesses a forest area which is one of the smallest in Europe, in relation to its population and land area. In the past, forests have been felled to make way for farming and to supply timber for ships, houses, fuel and metal smelting. Timber was a key to sea power, and repeatedly the availability of home timber supplies has proved crucial in time of war.

The nation's dwindling reserves of timber have been a source of anxiety since Tudor times and periodic surges of planting for timber production by private landowners took place until about 1850. Thereafter, interest faded with the advent of the iron ship, the Industrial Revolution and the availability of cheap timber imports. Government activity was minimal until a national forest authority was formed in 1919 to create a strategic timber reserve. Since 1958 there have been frequent policy reviews to assess the changing needs of the nation for timber and the new values associated with the social and environmental benefits of forests.

HOWELL, W. (1974/75). Management of wildlife within a commercial forest. *Y Coedwigwr* **27**, 42–45.

The wildlife management of any woodland will vary depending on the factors affecting the area. The more complex the biological diversity, the more difficult it will become to maintain a balance of species within the communities, whether it be fauna or flora. This is especially so when it happens to be an artificially created forest of mainly coniferous species managed primarily for the production of wood.

This paper describes briefly the methods of wildlife management on one of the largest of our coniferous forests, the Border Forests of Northumberland. This is a compact area of some 1,000 square kilometres, created and managed by the Forestry Commission, consisting of semi-mature crops intermixed with young re-afforested areas and bordered by high unplanted moorlands.

INGOLDBY, M. J. R. (1975). The Finn Forester planting machine. FC/HGTAC Technical Note No. 18. *Forestry and Home Grown Timber* **4** (2), 47.

A technical report on this Finnish tree planting machine, both in planting conventional stock and used with potted plants.

JOHNSTON, D. R. (1975). Tree growth and wood production in Britain. *Philosophical Transactions of the Royal Society of London.* B. **271**, 101–114.

Trees are measured in cubic metres. By convention the measurement is usually over bark and to a top diameter limit. Crop growth is classified in Britain by mean annual increment classes, the classes being separated by steps of 2 m^3/ha. Thus a crop of yield class 12 will produce an average yield of 12 $m^3\ ha^{-1}\ year^{-1}$ on the rotation of maximum volume production. Yield class depends upon species, soil, climate and treatment.

The actual production of a crop depends upon yield class, initial spacing, thinning treatment and age of felling. Various characteristics of wood quality may be influenced by treatment.

The average yield class of all hardwoods in Britain is about 5 and of conifers about 10. The conifer value compares with about 3 in Scandinavia and about 18 in New Zealand.

Current annual production in Britain is 3.75×10^6 m^3. This will rise to about 8.7×10^6 m^3 by the year 2000.

JOHNSTONE, R. C. B., and BROWN, W. (1976). *Low pressure sodium (SOX) tube lights as a source of supplementary lighting for the improved growth of Sitka spruce seedlings.* Forestry Commission Research and Development Paper 111.

The reasons for the choice of the low-pressure sodium (SOX) tube light as a source of supplementary lighting for use within the Sitka spruce progeny testing programme are described. Details are given of the type of installation and lighting regime required to produce a tree in six months on which vigour, stem-straightness and branching characteristics can

readily be measured. Experiment results show that under low-pressure sodium lighting, as a supplement to natural daylight, Sitka spruce seedlings will grow normally but the plant produced will be twice as large as that produced without supplementary lighting. The costs of a lighting scheme are calculated.

(LAWS,* R. M., PARKER,** I. S. C., and) JOHNSTONE, R. C. B. (1975). *The ecology of elephants in North Bunyoro, Uganda.* Oxford: Clarendon Press.

Following a description of the history of the region and man's use of it, details are given of the flora and fauna of the area. There are accounts of the growth, nutrition, habits, reproduction, age structure and behaviour of the elephant populations, and the changes in habitat associated with past management, including the cropping programmes involving both elephant and hippo. Recommendations are put forward based on an analysis of the ecological factors involved, and recognising aesthetic and cultural considerations. These recommendations regard economic considerations of over-riding importance in the management of the elephant population.

JONES, A. T. (1976). Drainage work: A look at developments and machines in forestry drainage. *Forestry '76, a Farm Contractor specialist annual*, pp. 10–11.

The need is discussed for the development of mechanical methods of forest drainage in view of rising labour costs.

KEIGHLEY, G. D. (1975). Chainsaw vibration: White finger risk reduced? *Forestry and Home Grown Timber* **4** (3), 25.

Vibration-induced white finger (VWF) was an occupational risk for full-time chainsaw operators in the 1960s. The development, by saw manufacturers, of systems to overcome this problem is discussed.

KEIGHLEY, G. D. (1975). The logging scene at Elmia. *Forestry and Home Grown Timber* **4** (4), 18–19.

A review of the equipment exhibited at the Elmia forestry show, Sweden, in 1975.

KEIGHLEY, G. D. (1976). The advent of the Forestry Safety Council. *Forestry '76, a Farm Contractor specialist annual*, p. 53.

The formation and aims of the Safety Council are discussed.

KING, C. J., and SCOTT, T. M. (1975). Control of the Large pine weevil and Bark beetles of the genus *Hylastes*. *Forestry* **48** (1), 87–97.

Since 1968 a water-based formulation of gamma BHC (Gammacol) has largely replaced DDT as a plant-dipping treatment against the Large pine weevil *Hylobius abietis* L. and *Hylastes* spp. beetles.

With Sitka spruce in high rainfall areas, BHC at 1.6 per cent is as effective as DDT at 2.5 per cent in controlling these insects. Neither chemical has proved adequate where exceptionally high populations of *Hylobius* occurred, though control of *Hylastes* has been very good.

Plants were dipped in Gammacol, and then stored in sealed polythene bags for 28 days. Provided that the plants were dried sufficiently before storing, they subsequently suffered only a slight reduction in height-growth but received adequate protection against beetles. This technique should enable forest nurseries to supply ready-treated planting stock. Chlorpyrifos (Dursban) may prove a useful alternative to BHC.

KING, C. J., and SCOTT, T. M. (1975). Testing dosage rates of methoxychlor applied by helicopter for control of Dutch elm disease. *Forestry* **48** (2), 177–181.

During April 1973, various doses and concentrations of methoxychlor were applied to healthy elms by helicopter on farmland near Warwick. Bioassays showed that only the highest rate, five gallons of 6 per cent methoxychlor per tree, achieved good control of maturation feeding by *Scolytus scolytus* (Fab.) for six weeks after spraying. The bioassays indicated that the efficacy of this treatment declined markedly between six and ten weeks after spraying. None of the treatments prevented beetle-borne infection of the treated test elms, though trees sprayed with five gallons of 6 per cent methoxychlor showed the least amount of Dutch elm disease at the end of the summer.

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*British Antarctic Survey, Cambridge.
**Wildlife Services Ltd, Nairobi, Kenya.

Separate tests of aerial spray deposits using a standard quantity of methoxychlor at varying dilutions in water showed that tree coverage was generally good,though none of these treatments satisfactorily controlled elm beetle maturation feeding. Residue analyses of methoxychlor deposits indicate that the original residues declined by about 50 per cent thirteen weeks after spraying.

LOW, A. J. (1975). *Production and use of tubed seedlings.* Forestry Commission Bulletin 53 (HMSO £1).

The production and use of tubed conifer seedlings in Britain have been studied between 1968 and 1973 in an extensive research and development programme based initially on Canadian practice. Results from the many nursery and forest experiments are described and form the basis for practical recommendations on raising and planting tubed seedlings.

LOW, A. J., and OAKLEY, J. S. (1975). *Tubed seedlings.* Forestry Commission Leaflet 61 (HMSO 30p).

Eight-week-old conifer seedlings raised intensively in small plastic tubes are capable of high survival and vigorous growth when step planted on ploughed peatland. The effective planting season is from April to August, and very high planting rates are possible with a special tool. Current recommendations are given for the production and use of Lodgepole pine and Sitka spruce tubed seedlings.

MITCHELL, A. F. (1975). The Monteviot Pinery. *Scottish Forestry* **29** (3), 189–190.

Describes, with measurements, some especially interesting specimens in this small collection near Jedburgh, in the Borders Region of Scotland.

MITCHELL, A. F. (1975). Conifers at Cragside. *Quarterly Journal of Forestry* **69** (2), 84–87.

Cragside in Northumberland was planted in around 1860 with a good selection of western North American conifers. They have grown here with the vigour which these trees show in north and western Scotland and many are exceptionally tall trees. Some of the trees were previously measured in 1958 and the dimensions then and now show the good growth being maintained.

MITCHELL, A. F. (1975). The conifers at Wisley. *The Garden* **100** (7), 276–277.

A survey of the exceptionally wide range of conifers in the RHS Garden, both in the Pinetum and in other parts. The dimensions of many outstanding specimens are given, and those which show good growth are compared with their dimensions some years ago. There is almost no information in the archives of the early plantings, so the ages of most of the trees are not known. Particular note is made of the metasequoias (tallest in Britain), Leyland cypress (earliest planting of two clones adjacent) and some very rare pines.

MITCHELL, A. F. (1975). *Three forest climbers: Ivy, Old man's beard and honeysuckle.* Forestry Commission Forest Record 102 (HMSO 23p).

Brief descriptions of honeysuckle, ivy and Wild clematis are illustrated by line drawings. The importance of each in forest crops as a pest is balanced by an account of their place in the ecology and how they support wildlife.

MITCHELL, A. F. (1976). Tree genera. 4. The walnut family. *Arboricultural Journal* **2** (10), 457–461.

Description of Juglandaceae, giving both salient botanical features to aid recognition and details of tree size of outstanding specimens in Britain.

PARKER, E. J. (1975). Some investigations with Beech bark disease *Nectria* in southern England. *European Journal of Forest Pathology*, **5**, 118–124.

Ascospores of the *Nectria* sp. causing necrosis of beech bark were trapped throughout the year, and their discharge was associated with prevailing wet weather.

Nectria isolates only infected the bark of forest and potted beech through wounds. Inoculations were most successful during dormancy of the host. Small cankers were formed but were soon delimited by callus production. Relatively larger cankers were formed when the supply of water to the host was restricted.

Perithecia were produced *in vitro* by mated cultures of isolates from opposite compatibility types. Characteristics of *Nectria* associated with Beech bark disease agreed with those of *N. coccinea sensulato*. Substantial growth of the fungus occurred at 5°C.

PARKER, E. J. (1975). The problem of Beech bark disease. *Arboricultural Journal*, **2** (8), 332–5.

The symptoms of Beech bark disease, including details of the Beech scale and of *Nectria coccinea* which are jointly held responsible for the disease, are described. Recommendations are given for the control of the disease under forest conditions by sanitation thinning. In addition, the use of insecticides is considered for control on specimen trees of high value.

REDFERN, D. B. (1975). The influence of food base on rhizomorph growth and pathogenicity of *Armillaria mellea* isolates. In *Biology and control of soil-borne plant pathogens* (ed. G. W. Bruehl), pp. 69–73. St Paul, Minnesota, USA: The American Phytopathological Society.

In Britain, killing by *Armillaria mellea* (Vahl ex Fries) Kummer is a frequent cause of loss in young conifer plantations established on sites formerly occupied either by pure broadleaved forest or by a mixture of coniferous and broadleaved species. Attacks occasionally occur on sites without a broadleaved association, but they are rare. In order to compare the value of broadleaved and conifer roots as food bases for *A. mellea*, Sitka spruce (*Picea sitchensis*) seedlings (20–25 cm tall) were inoculated with segments of sycamore (*Acer pseudoplatanus*) and Scots pine (*Pinus sylvestris*) roots colonised by four isolates of *A. mellea*. After 20 months, differences between the proportions of trees killed by each isolate were striking and varied from less than 2% to more than 60%. Rhizomorph production also varied, and the results suggested that there was an inverse relationship between rhizomorph production and pathogenicity. The effect of substrate was smaller but in general fewer trees were killed by pine inocula than by sycamore inocula, although the reverse was true for one isolate. These results are discussed with particular reference to the spread of *A. mellea* in conifer plantations.

ROGERS, E. V. (1975). *Ultra low volume herbicide spraying*. Forestry Commission Leaflet 62 (HMSO 35p).

Explains Controlled Droplet Application with the Micron ULVA and ULVA 8 for the control of woody broadleaves, heather and bracken.

ROGERS, E. V. (1976). System for grass weed control. *Forestry '76, a Farm Contractor specialist annual*, pp. 26–27.

The control of grasses in young plantations using the flowable formulation of atrazine, and the Micron HERBI rotary atomiser to apply it, is described. A total of 10-14 litres of herbicide plus diluent is required per hectare of plantation. The Herbi is described together with details on calibration, protective clothing, time of application, species susceptibility, costs and outputs.

ROGERS, E. V. (1976). Calibration of knapsack sprayers for forest weeding. *Forestry and Home Grown Timber* **5** (1), 22–23.

Describes the method of calibrating a knapsack sprayer in order to achieve the recommended rate of application of herbicide in forest weeding, and checking that the rate is being accurately carried out.

ROSS, R. B. (1975). Specialised vehicles for forestry operations. *Proceedings, 4th International Fluid Power Symposium, Institute of Mechanical Engineers*, London, pp. 151–162.

The requirements of specialized vehicles for forest use are discussed, together with an outline of the use of hydrostatic transmissions.

SAWYER, T. R. (1976). Sport integrated forestry. *Forestry '76, a Farm Contractor specialist annual*, pp. 28–29.

Fishing can provide revenue to forestry, and ways and means of achieving this are discussed.

SCOTT, T. M., and WALKER, C. (1975). *Experiments with insecticides for the control of Dutch elm disease.* Forestry Commission Forest Record 105 (HMSO 70p).

In 1972 a series of experiments was carried out in an attempt to assess the place for prophylactic insecticide sprays in the fight against elm disease.

The conclusion was drawn that, whilst insecticide spraying is possible and may be of use in some circumstances, it cannot be recommended for general use.

THOMPSON, D. A. (1974). A brief review of drainage in deep peat in the Forestry Commission. *Proceedings, International Symposium on Forest Drainage,* Finland, Sept. 1974, pp. 253–259.

Considers early height measurement from drainage experiments on deep peat (*Sphagnum-Eriophorum-Calluna*), and discusses implication for forest management in decisions on the afforestation of these sites in Britain.

WAKEMAN, D. C. (1975). Seed colorant for hand sowing. *Gardeners Chronicle* **178** (11), 35.

WALKER, C. (1975). *Restricting the movement of elm infected with Dutch elm disease: A working guide to the* 1974 *Order.* Forestry Commission Miscellaneous Publication.

WALKER, C., (and ROSS,* RUTH) (1975). A comparison of maturation feeding of the Elm bark beetles *Scolytus scolytus* (F.) and *S. multistriatus* (Marsh.) on English elm (*Ulmus procera* Salisb.) and six other elm taxa. *Plant Pathology* **24**, 187–191.

In laboratory experiments Elm bark beetles (*Scolytus scolytus* and *S. multistriatus*) were allowed to choose between English elm and one of six other taxa (Smooth-leaved, Wheatley, Wych, Huntingdon, Commelin 274 and Cornish) for maturation feeding. Preference was sometimes shown for English elm over Huntingdon and Commelin elms and, on one occasion, Wheatley elm was fed on more than English. However, there was no consistent pattern. Sufficient feeding occurred on all taxa to enable spores of the Dutch elm disease fungus (*Ceratocystis ulmi*) to be introduced to the twigs.

WALLACE, D. H. (1976). Buyers guide: Cross-country vehicles. *Forestry* '76, *A Farm Contractor specialist annual,* pp. 20–21.

The uses for cross-country vehicles are outlined and a buyers guide to vehicles currently available is given.

WHAYMAN, A. (1975). The Pika 52 processor. FC/HGTAC Technical Note No. 19. *Forestry and Home Grown Timber* **4** (4), 29.

A technical note on this Finnish machine which delimbs and crosscuts felled trees. Outputs of over 12 m^3 per hour have been obtained.

WHAYMAN, A. (1976). Holder Cultitrac A55 F forestry tractor. FC/HGTAC Technical Note No. 22. *Forestry and Home Grown Timber* **5** (1), 35.

A technical report on this German-built, narrow (1.5 m) extraction machine. Outputs of up to 9.5 m^3 per hour have been obtained.

WINTER, T. G. (1976). Notes and observations: *Diarsia dahlii* (Hübner) (Lep. Noctuidae) in Surrey. *Entomologist's Gazette* **27** (1), 12.

A new county record.

WITTERING, W. O. (1975). Work study aids British forestry. *Work Study and Management Services* **19** (4), 130–133.

Some of the problems of British forestry are described, together with the solutions found by the Work Study Branch.

WITTERING, W. O. (1975). The hydrostatic skidder. *Proceedings, IUFRO Division* 3, *Forest Harvesting Mechanisation and Automation,* pp. 533-542.

This paper gives briefly the development of the Commission's hydrostatic skidder, an indication of its performance, and the arrangements made for its manufacture on a commercial scale.

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*Department of Biology, Liverpool Polytechnic.

WITTERING, W. O. (1975/1976). Work study for foresters. *Forestry and Home Grown Timber*: 1. **4** (4), 38–39; 2. **4** (5), 27–28; 3. Time Study, **4** (6), 40–41.

The first three articles in a series explaining work study techniques, and the application of work study data to forest management.

WITTERING, W. O. (1975/1976). Philately for foresters. *Forestry and Home Grown Timber* **4** (2–6), and **5** (1).

A continuation of a regular series of short snippets for readers who are interested in philately. The topics covered bear a relation to forestry, forestry industries and kindred subjects.

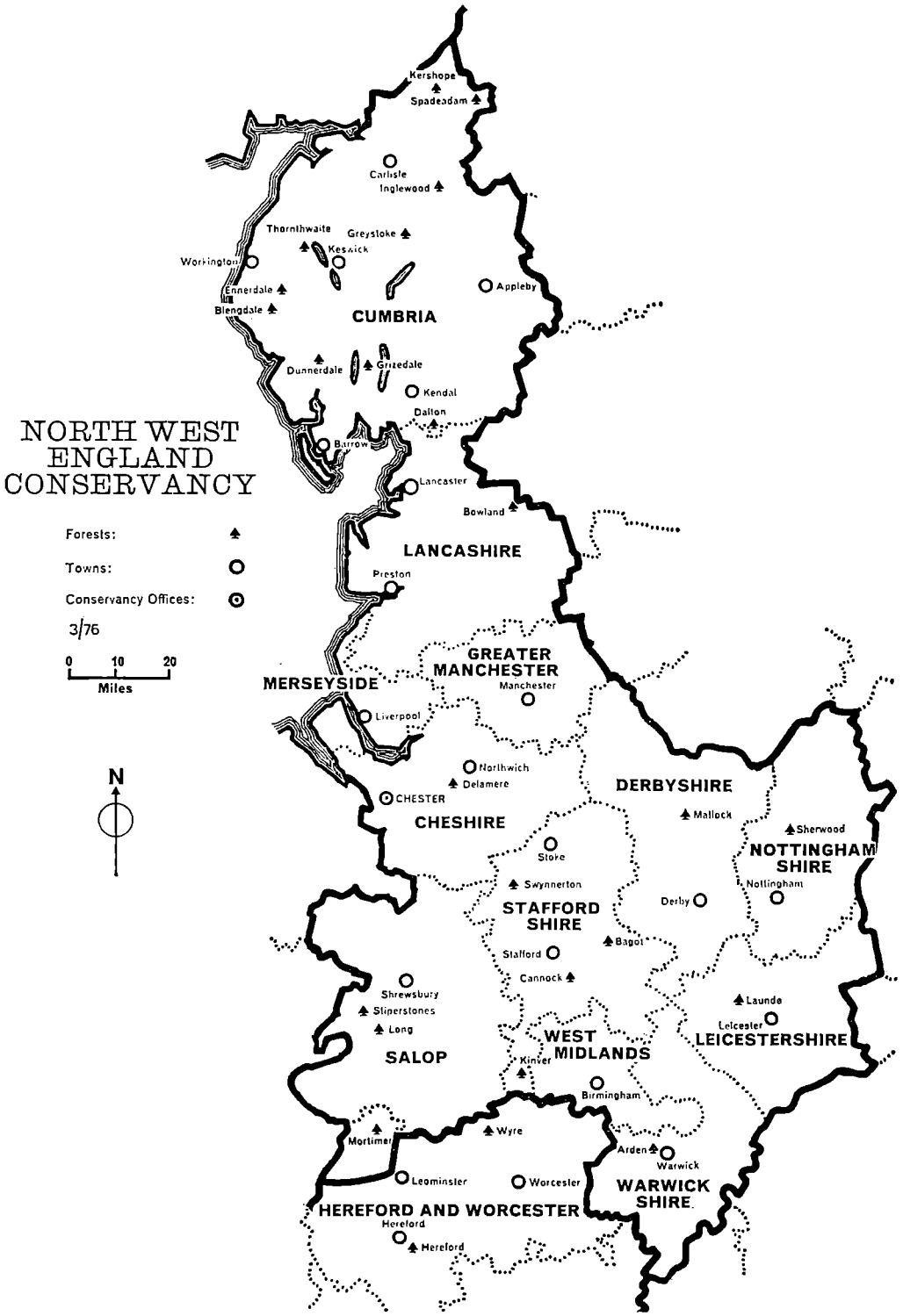
WITTERING, W. O. (1976). Weed control: What's new in weeding machinery? *Forestry '76, A Farm Contractor specialist annual*, pp. 24–25.

Forest weeding by tractor is one of the cheapest ways of doing the job, and equipment suitable for mounting on a tractor is discussed. New developments in portable brushcutters are also outlined.

APPENDIX II

Forest Maps

Maps showing the situation of the Commission Forests and the boundaries of the Conservancies as at 31 March 1976 follow overleaf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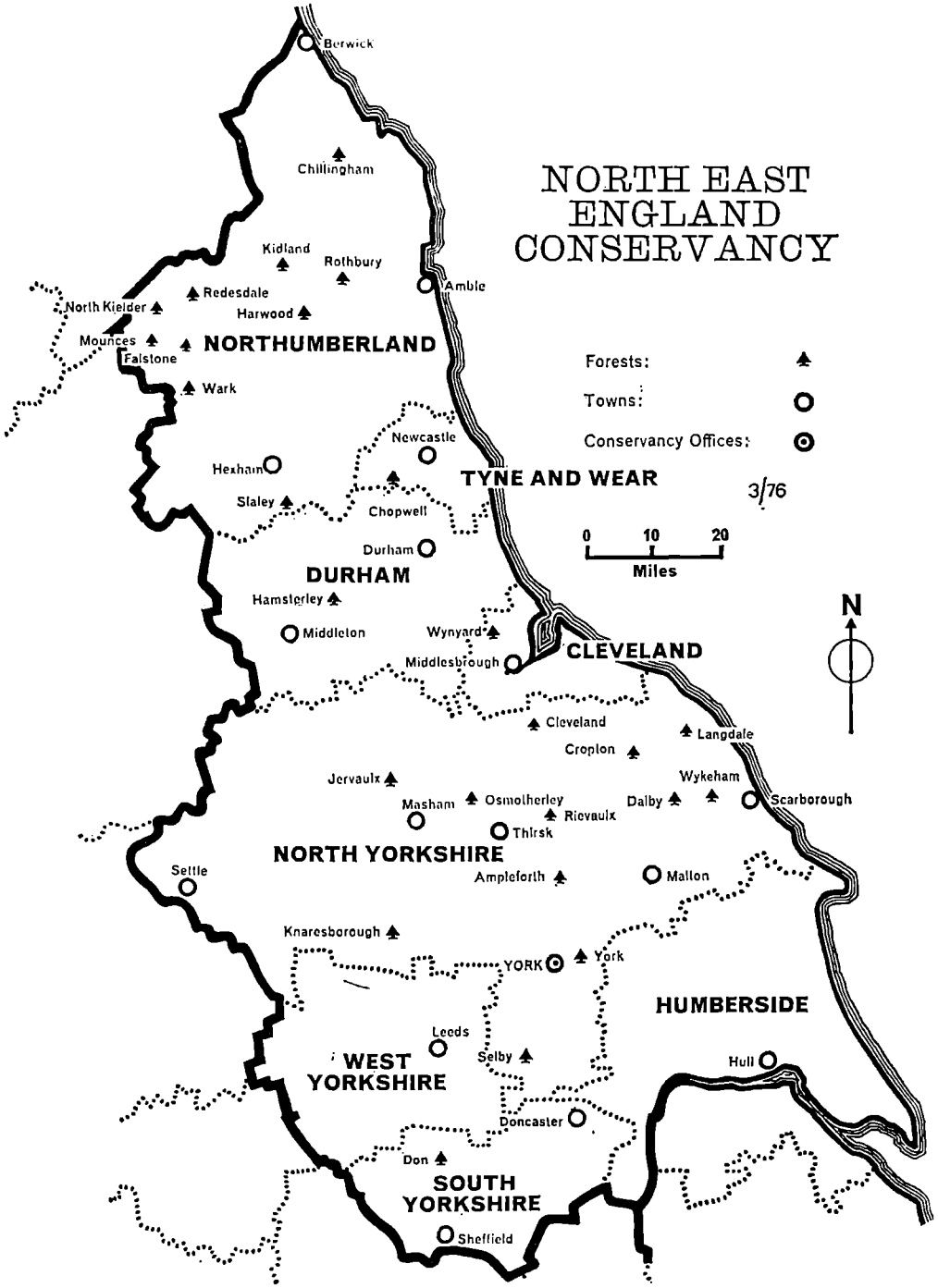
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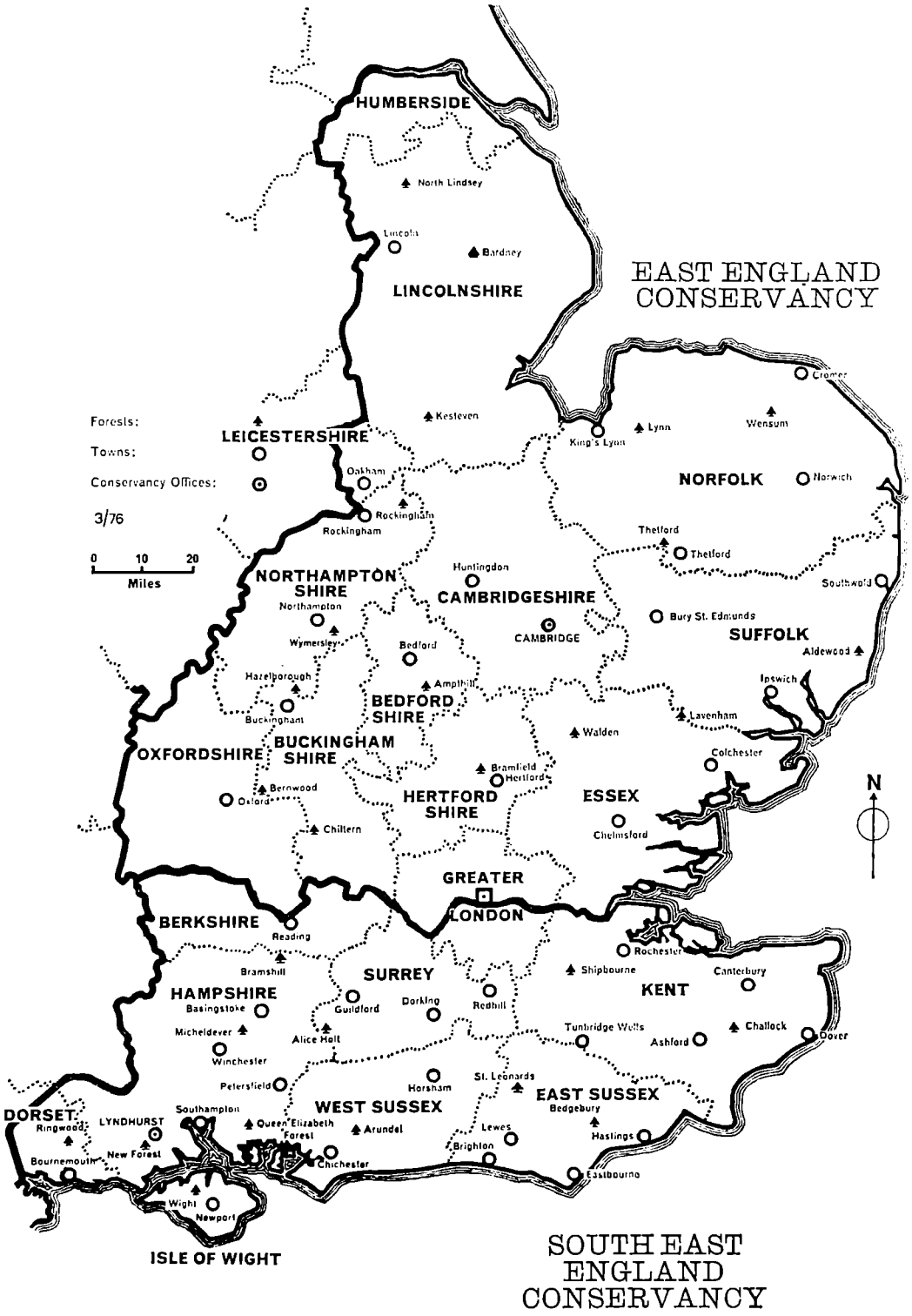
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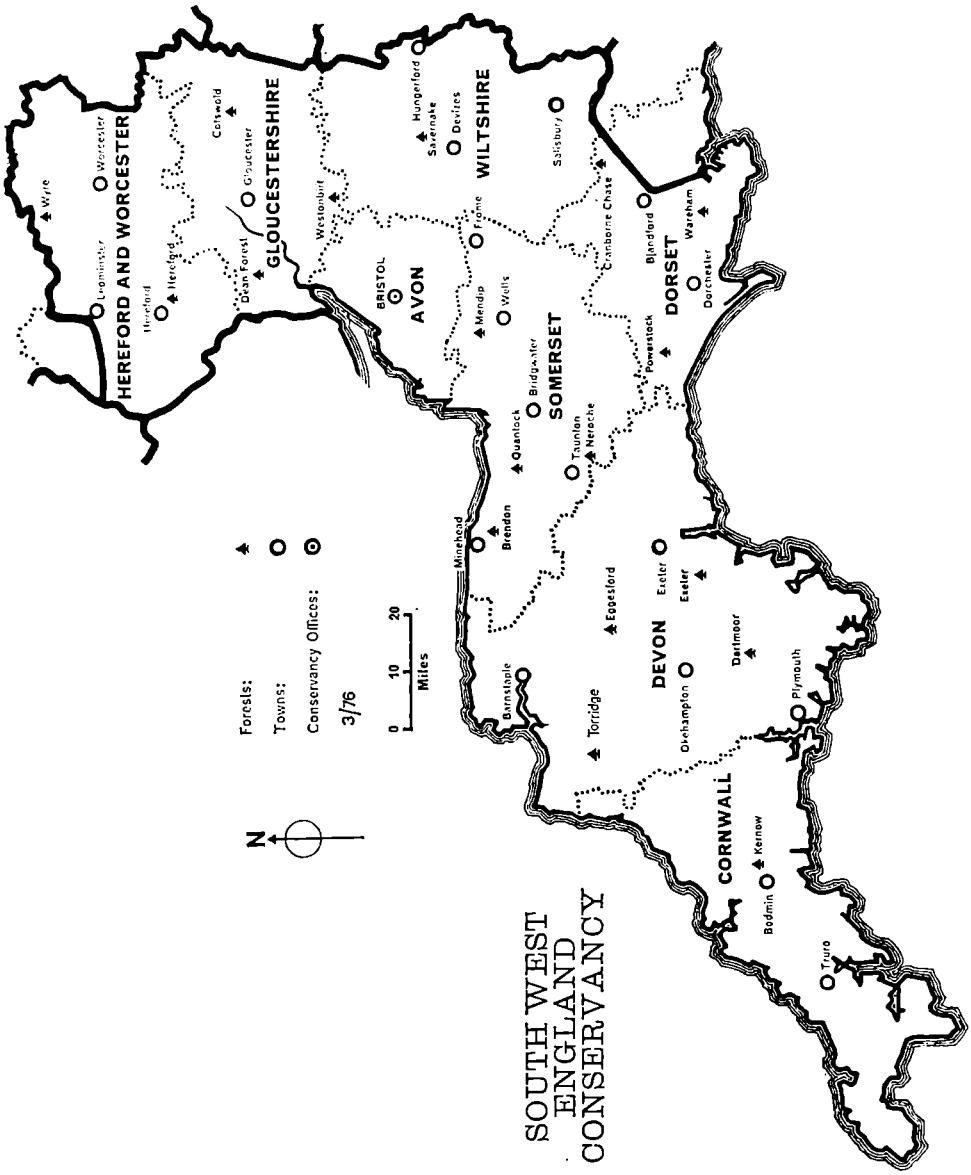
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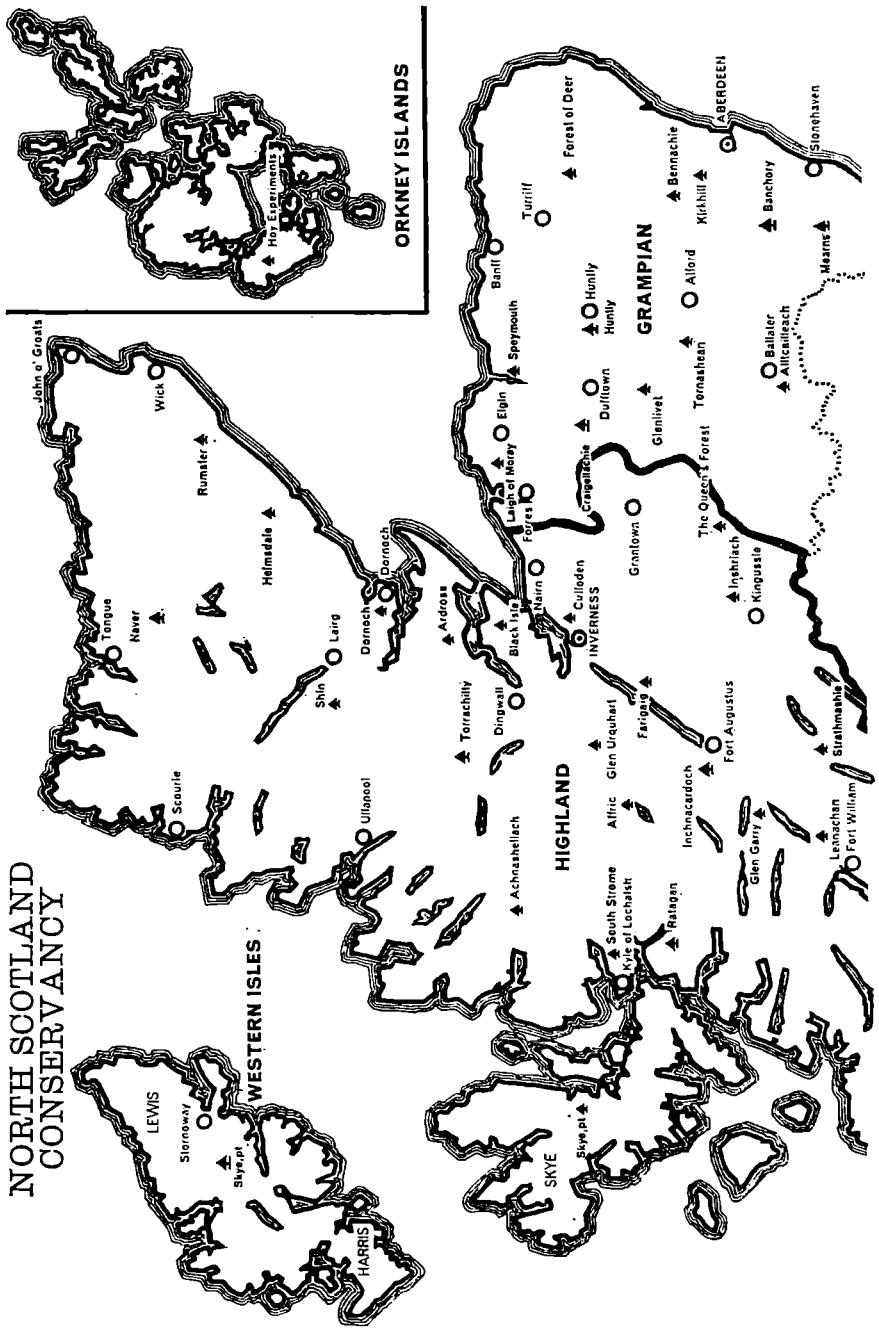
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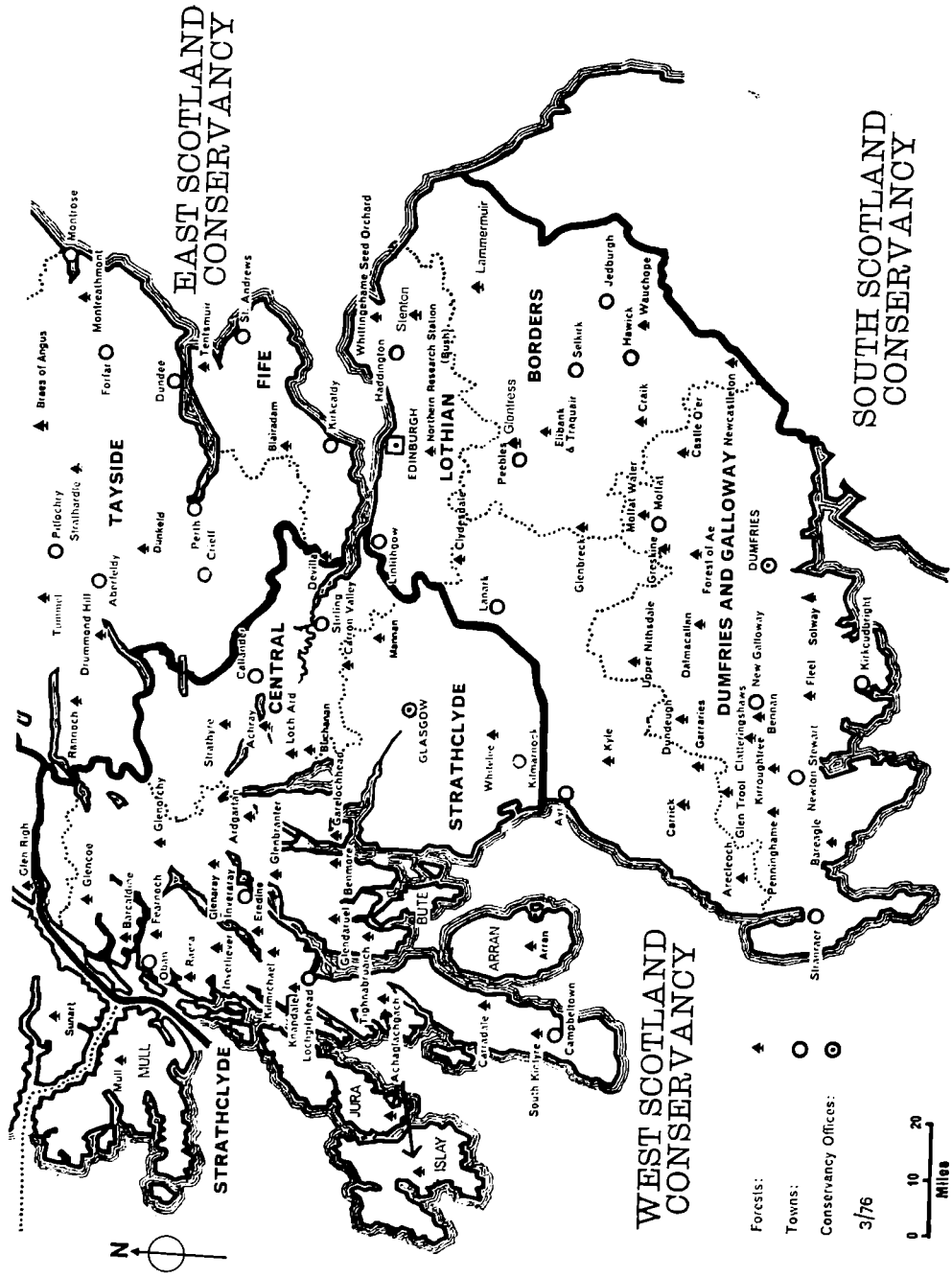
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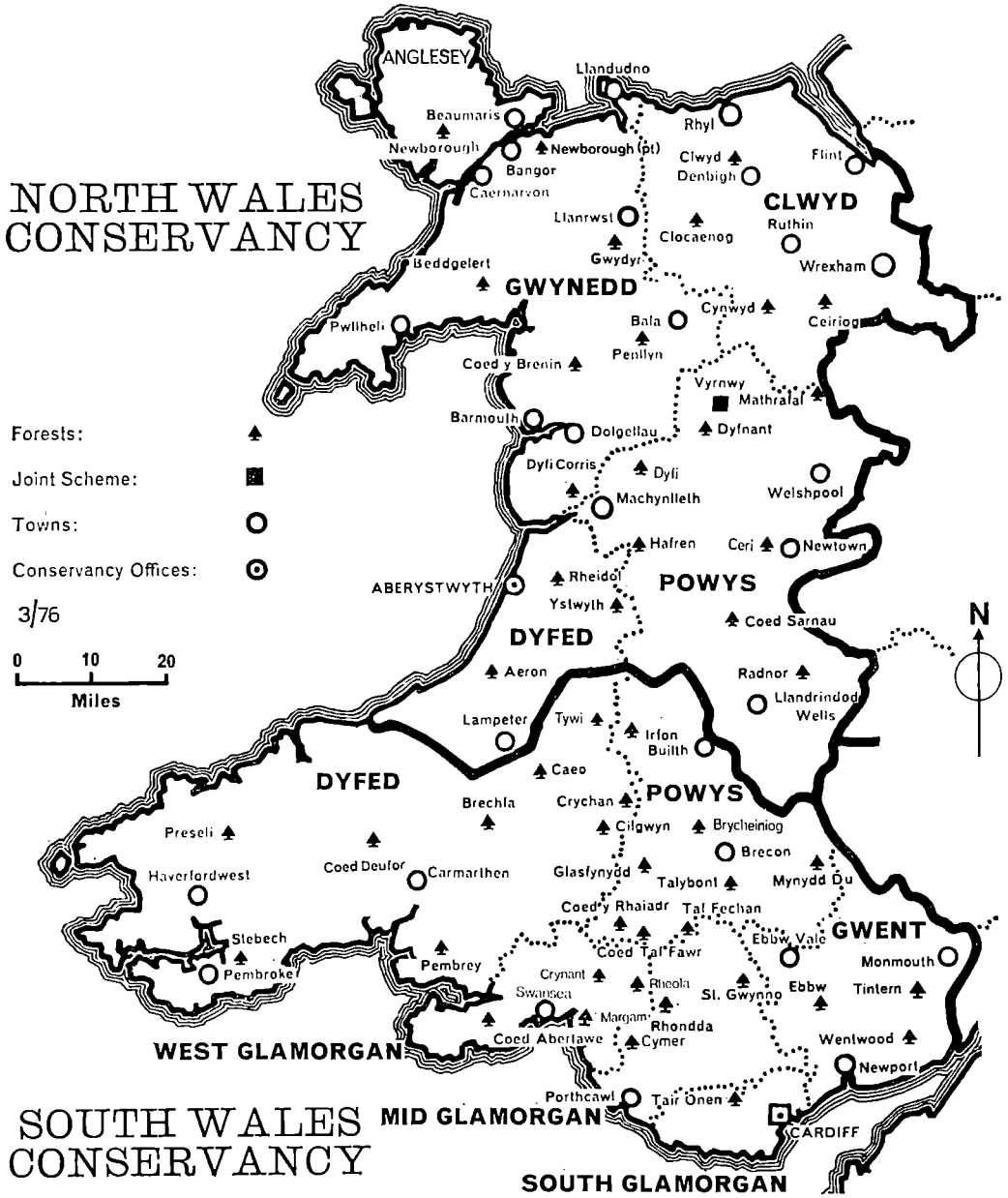
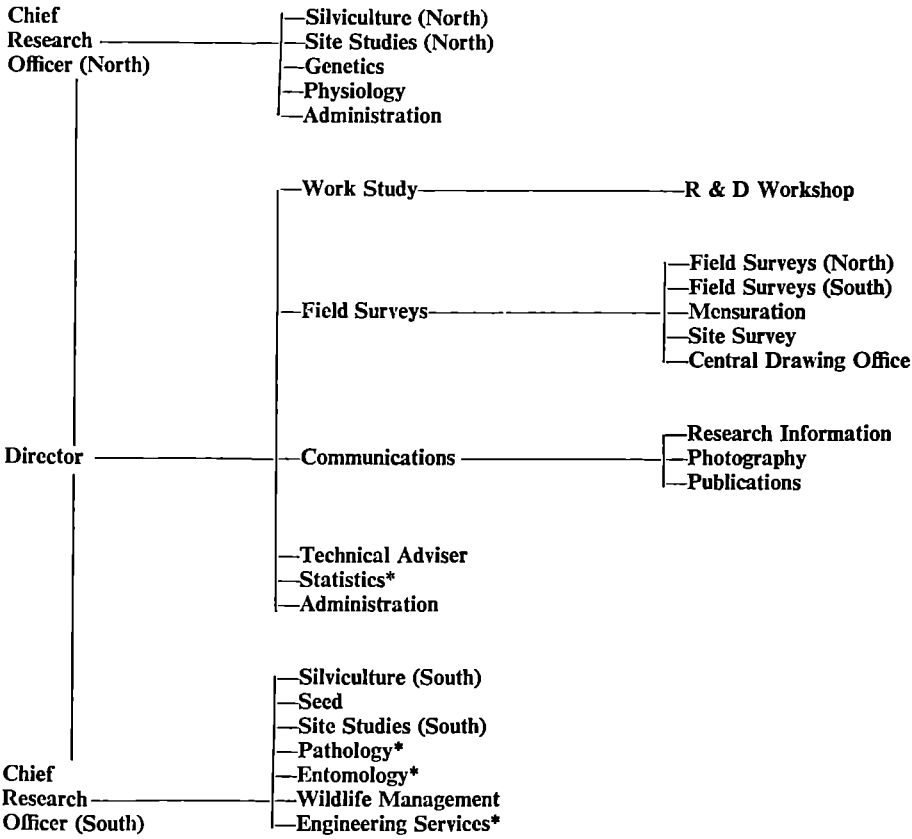
Forests:
Towns:
Conservancy Offices:
3/76
Miles
N


NORTH WALES CONSERVANCY
SOUTH WALES CONSERVANCY
Forests:
Joint Scheme:
Towns:
Conservancy Offices:
3/76
0 10 20
Miles
N
ANGLESEY
Llandudno
Beaumaris
Newborough
Newborough (pl)
Bangor
Caernarvon
Rhyl
Clwyd
Denbigh
Flint
CLWYD
Ruthin
Wrexham
Llanrwst
Clocaenog
Gwydyr
Beddgelert
GWYNEDD
Pwllheli
Bala
Cynwyd
Ceiriog
Penllyn
Coed y Brenin
Vyrnwy
Mathrafal
Barmouth
Dolgellau
Dyfnant
Dyfi Corris
Dyfi
Machynlleth
Welshpool
Hafren
Ceri
Newtown
ABERYSTWYTH
Rheidol
POWYS
Ystwyth
Coed Sarnau
DYFED
Aeron
Radnor
Llandrindod Wells
Lampeter
Tywi
Irfon
Builth
Caeo
DYFED
POWYS
Brechfa
Crychan
Preseli
Cilgwyn
Brycheiniog
Brecon
Haverfordwest
Coed Deufor
Carmarthen
Glasfynydd
Talybont
Mynydd Du
Coed y Rhaiadr
Tal Fechan
Ebbw Vale
GWENT
Stebech
Pembroke
Pembrey
Coed Taf Fawr
Monmouth
Crynant
Rheola
Ebbw
Tintern
Swansea
Margam
Sl. Gwynno
Rhondda
Coed Aberlawe
Cymer
Wentwood
Newport
WEST GLAMORGAN
Porthcawl
Tair Onen
MID GLAMORGAN
CARDIFF
SOUTH GLAMORGAN

APPENDIX III

Research and Development Divisional Organisation



*Branches with sections at the Northern Research Station.

APPENDIX IV

Staff Engaged in Research and Development

As at 31st March 1976

The main centres for research and development are:

FORESTRY COMMISSION RESEARCH STATION

Alice Holt Lodge
Wrecclesham
Farnham, Surrey GU10 4LH. Tel. Bentley (Hants) 2255 (STD Code 042 04)

FORESTRY COMMISSION NORTHERN RESEARCH STATION

Roslin
Lothian EH25 9SY
Scotland. Tel. 031-445 2176

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

FORESTRY COMMISSION HEADQUARTERS

231 Corstorphine Road
Edinburgh EH12 7AT. Tel. 031-334 0303

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, STD Code 0844 4), 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. (*Alice Holt*)
Administration and Finance Officer . N. E. Stutter, M.I.P.M. (*Alice Holt*)
Director's Secretary . . . Mrs V. O. C. Lampard (*Alice Holt*)

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, seed, 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*)

R. E. Crowther, B.Sc., M.I.For., Head of Branch
J. Jobling, B.Sc., A. F. Mitchell, B.A., B.Agric. (For.), V.M.H., M.I.For., W. J. McCavish, B.Sc., M.I.For., J. D. Evans, B.Sc., Ph.D., M.I.For.*

Office: Miss S. B. Page: Miss J. M. Gay, B.Sc., G. T. Mellor

---

*On unpaid leave, lecturing in forestry at the University of Papua.

Research Foresters:		*Centre*
South East England Region	R. M. Ure, M.I.For.	Alice Holt
South East England Area	P. W. W. Daborn	Alice Holt
	J. B. H. Gardiner, M. L. Pearce: P. D. Howard, A. M. Jenkin, F. S. Smith, F. R. W. Stevens	Alice Holt
Wareham Area, Dorset	L. A. Howe	Sugar Hill Nursery, Wareham Forest
Bedgebury Area, Kent	A. W. Westall: M. J. Scott	Bedgebury Pinetum
South West England Region	D. A. Cousins	Westonbirt
South West England Area	K. F. Baker: D. W. H. Durrant	Exeter
Dean Area	K. Broad: T. J. Davies	Dean
Westonbirt Area, Gloucestershire	P. J. Webb, C. W. Webber, J. E. J. White, E. Leyshon	Westonbirt Arboretum
East England Region	I. H. Blackmore: P. A. Gregory	Santon Downham, Brandon, Suffolk

SITE STUDIES (SOUTH) (*Alice Holt*)

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M. A. Anderson, B.Sc., R. Carnell, A. Willson, B.Sc., Ph.D.

Research Foresters:	D. F. Fourt, L. I. Biol.: I. G. Carolan, P. Marsh.
Laboratory:	Mrs S. A. Wright: D. M. Ashdown, J. Dedman, Miss P. H. Sones, Mrs D. A. Waddell

PATHOLOGY

D. A. Burdekin, B.A., Dip. Ag.Sci., M.I.Biol., Head of Branch
J. N. Gibbs, M.A., Ph.D.: C. M. Brasier, B.Sc., Ph.D., M.I.Biol.: D. Lonsdale, B.Sc., Ph.D., P. Mercer, B.A., Ph.D., D.I.C., E. J. Parker, Ph.D., M.I.Biol.†

Research Foresters:	C. W. T. Young: B. J. W. Greig, R. G. Strouts: J. E. Pratt, J. Dickinson, N.D.F.
Laboratory:	Miss B. J. Brindley, Mrs. C. C. Gulliver: M. J. S. Awdry, A. Jeeves
Office:	J. Empson: Mrs. J. G. Anderson (Typist)

Northern Research Station
PATHOLOGY

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

Research Forester:	J. D. Low
Laboratory:	Miss H. Amos

ENTOMOLOGY (*Alice Holt*)

D. Bevan, B.Sc., Head of Branch
Miss J. M. Davies, B.Sc., C. I. Carter, M.Sc., M.I.Biol., D. Wainhouse, M.Sc., Ph.D.: T. G. Winter

Research Foresters:	R. M. Brown, L.I.Biol.: D. J. Billany, C. J. King, C. Walker, B.A.‡
Laboratory:	M. Jukes, L.I.Biol.: N. J. Fielding, Mrs. V. Rex
Office:	J. Ellison

Northern Research Station
ENTOMOLOGY

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

Laboratory:	S. G. Heritage, M.I.Biol., F.R.E.S.: D. A. Barbour, B.Sc.

†On 3-year secondment to the Tree Improvement Research Centre at Kitwe, Zambia.
‡On unpaid leave, attending a Ph.D. course at Iowa State University, USA.

WILDLIFE MANAGEMENT (*Alice Holt*)

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

Research Foresters:	L. A. Tee: F. A. Currie, H. W. Pepper, S. J. Petty
Laboratory:	B. A. C. Don: Miss C. I. Derrick, A. R. Hall
Office:	Mrs. A. Bowcock

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Seed Store and Extractory:	T. A. Waddell: L. H. Crumplin, P. Groves-Hambidge
Office:	Mrs. M. Greenwood: Mrs. M. Foster

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H. G. W. Bodkin, R. D. Butt, M. F. Johnston, G. J. Keens

Northern Research Station
R. McLuckie, T. Stewart

Chief Research Officer (North) . . . D. T. Seal, B.Sc., M.I.For. (*Northern Research Station*)

(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*)

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R. Lines, B.Sc., F.I.For., P. Biggin, B.Sc., T. C. Booth, B.Sc., M.I.For., G. J. Mayhead, B.Sc., Ph.D., M.I.For., D. A. Thompson, B.Sc., M.I.For.

		Centre
Research Foresters:	N. P. Danby: A. B. Lewis	Northern Research Station
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North East Scotland Area	W. G. Paterson: J. E. Kirby, N. Mackell	Lairg, Highland Region
East Scotland Area	A. L. Sharpe: W. J. P. Dyce, A. M. Walker, A. W. F. Watson	Newton, Grampian Region
Central Scotland Region	J. H. Thomson	Northern Research Station
Central Scotland Area	M. Rodgers, J. D. Lindsay	Perth, Tayside Region
South East Scotland Area	A. H. Reid: J. B. McNeill	Northern Research Station
West Scotland Area	A. R. Mair: E. A. Crofts	Kilmun, by Dunoon, Strathclyde Region
Borders and North England Region	E. Baldwin	Mabie, Dumfries and Galloway Region

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Borders Area	G. S. Forbes: P. Priestley, D. L. Willmott	Kielder by Hexham, Northumberland
South West Scotland Area	W. R. Kinsey, J. D. McNeill	Mabie, Dumfries and Galloway Region
Wales Region	G. Pringle	Betws-y-Coed
North Wales Area	G. A. Bacon: D. Downs	Betws-y-Coed
South Wales Area	A. J. A. Graver, C. J. Large	Brecon

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W. S. Mackenzie, M. Turner

*On a 3-year secondment to the Federal Department of Forest Research, Ibadan, Nigeria.

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