REPORT ON

FOREST RESEARCH

1978

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Cover picture:

Collecting samples from the crown of a Lime tree for foliar analysis in connection with arboricultural research. (*7995*) (p. 12).

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REPORT ON FOREST RESEARCH

for the year ended
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INTRODUCTION

By D. R. JOHNSTON
Director of Research and Development

Tree Breeding

The first of a series of Sitka spruce clonal seed orchards was planted in Wales and is an important landmark in the breeding of this species. The component clones have all been progeny-tested and shown to have valuable inherent qualities. New impetus has been given to the Lodgepole pine breeding programme following clear indications from earlier work that certain between-provenance hybrids are capable of growing vigorously with a much higher degree of resistance to wind- and snow-sway damage than the commonly planted South Coastal origins. Over 300 artificial crosses were made between individual trees from South and North Coastal American sources and interior British Columbia origins. These will provide plants for more exhaustive progeny tests and seedling orchards.

Weed Control

Collaboration has continued with the Weed Research Organisation and research has been concentrated on the identification and testing of safer and more effective herbicides for use in the forest. Glyphosate, for example, is likely to replace paraquat for grass control and some other more toxic chemicals for the control of broadleaved species.

Tree Pests and Diseases

Studies aimed at the control of the European spruce sawfly *Gilpinia hercyniae* and the web-spinning larch sawfly *Cephalcia lariciphila*, which for some years have been causing defoliation of spruce and larch crops in Wales, have continued. The possibilities of biological control by parasites and predators are being examined. At the same time, in related investigations, staff of the Unit of Invertebrate Virology (UIV) of the Natural Environment Research Council are studying insect viruses that might be used to control these infestations. In a joint study with the Forestry Commission they are also examining a virus that destroys the Fox-coloured Pine sawfly (the Lesser pine sawfly) *Neodiprion sertifer*.

More recently a devastating outbreak of the Pine beauty moth *Panolis flammea* has killed some 240 ha of Lodgepole pine in Caithness, in the north of Scotland, and is threatening a further area of about 5,000 ha. Work on the control of this pest is therefore being carried out.

Plant Health

Work on the drafting of new plant health legislation covering forest trees, and stemming from the EEC Plant Health Directive (77/93/EEC), is proceeding. Close contacts are being maintained with the agricultural authorities, who are producing parallel legislation concerning agricultural and horticultural crops.

Meanwhile discussions continue in Brussels to clarify some points and to make final minor adjustments to the text of the Directive. Members of our staff are taking part in these discussions.

Losses in Broadleaved Trees

Serious losses in broadleaved trees, particularly of beech in southern England, were reported during the year. In the majority of cases, the trees were seriously weakened during the 1976 drought and finally died a year or so later. Suggestions that a new epidemic disease of beech might be responsible for these deaths were not substantiated. Considerable efforts were made by the Forestry Commission to give a balanced view of the importance of tree diseases and disorders in order to allay fears that devastating problems were likely to occur on a wide range of broadleaved trees.

Contracts

In addition to the existing arboricultural work two new contracts were arranged.

A one-year contract from the Energy Technical Support Unit of the Department of Energy was started. This study will evaluate the possibilities of using coppice crops as a means of tapping solar energy, and will include poplar and other species on very short rotations as well as orthodox coppice crops.

A one-year contract to examine the problems of establishing trees on deep colliery spoil in England was completed for the Department of the Environment and this has now been followed up with a further contract involving field trials. Drafts for publication were prepared both for this work and for an earlier project involving coal tips and other derelict land in South Wales.

International Exchanges

Professor J. H. Borden from Simon Fraser University, Vancouver, returned home after a year with the Entomology Branch studying the pheromone chemistry of *Scolytus scolytus*, a vector of Dutch elm disease.

Dr J. N. Gibbs (Pathology) returned from 12 months at the North Central Forest Experiment Station at St. Paul, Minnesota, studying oak wilt.

Dr C. M. Brasier (Pathology) spent 3 months at the Research Institute of Forests and Range Lands at Teheran, Iran, studying Dutch elm disease in Iran under the auspices of the British Council.

A. I. D. Horne (Field Surveys) left in January to spend a year in the Netherlands at the National Institute for Aerial Survey and Earth Sciences, studying aerial photo interpretation.

Awards to Staff

D. G. Pyatt (Site Studies North) received his Ph.D. (Aberdeen University). Dr D. B. Redfern (Pathology North) was awarded the Sir George Campbell Memorial Trophy by the Royal Scottish Forestry Society for his article entitled "Dutch Elm Disease in Scotland", printed in the April 1977 issue of Scottish Forestry. P. N. Edwards (Mensuration) received his M.A. (Oxford University). J. M. Christie (Mensuration) was appointed J.P. to the Alton Bench.

Visitors

A total of 530 professional visitors came to Alice Holt Lodge including Professor D. M. Griffin from Canberra; Mr W. H. Van der Merwe, Pretoria, South Africa; Professor T. U. T. Kallio from Finland; and Dr H. Kramer, Göttingen University, who brought a party of 50 students from Göttingen University Forestry Department.

Other parties included a Research Management Conference (IUFRO Group S6.06); the HGTAC Technical Sub Committee, and a Japanese Forest Protection Team.

Visitors to the Northern Research Station numbered 34.

On 13 July 1977 a Tree Nutrition Seminar was held at Alice Holt Lodge to which a number of outside experts were invited and contributed. This assisted with the formulation of policy for future nutrition research.

Visits and Conferences

Staff made 13 visits to research organisations overseas and attended 9 conferences abroad and 16 conferences in this country.

Staff Changes

Transfers in: A. I. D. Horne (District Officer I, Field Surveys) from South East England Conservancy; M. N. Haworth (District Officer II, Work Study) from North West England Conservancy; R. Mackintosh (District Officer II) from South Scotland Conservancy; C. H. Blackwood (Head Forester, Silviculture North) on promotion from North West England Conservancy; Mrs D. R. Harper (Higher Executive Officer, Finance); F. W. C. McLauchlan (Higher Executive Officer, N.R.S.) and S. Hankin (Executive Officer, Statistics); the last 3 from Headquarters.

Transfers out: W. O. Wittering (Principal, Work Study) to East England Conservancy; A. Ray (District Officer I, Work Study) to South East England Conservancy; R. C. B. Johnstone (District Officer I, Genetics) to North East England Conservancy; J. Dickinson (Head Forester, Pathology) to East England Conservancy; D. Fraser (Head Forester, Work Study) to East Scotland Conservancy; and A. B. Lewis (Head Forester, Silviculture North) to North Scotland Conservancy.

Promotions: A. J. G. Hughes (Work Study) to Assistant Conservator, to become Chief Work Study Officer; C. I. Carter (Entomology) to Principal Scientific Officer; Mrs M. M. Craven (Site Studies) to Scientific Officer; S. C. Gregory (Pathology) to Senior Scientific Officer; and D. C. Wakeman (Seed) to Higher Scientific Officer.

Retirements: P. Hunter (Higher Executive Officer, Northern Research Station) who had been with the research staff in the North for twenty-five years, and P. Mayne (Executive Officer, Publications).

Deaths: D. H. Jackson (Forester, Silviculture South) and H. Farr (Leading Research Worker, Silviculture South), the latter after more than thirty years at Alice Holt Lodge.

PART I

The Work of the Forestry Commission

RESEARCH AND DEVELOPMENT DIVISION

BRANCHES AND THEIR PROJECT GROUPS

Tree Physiology

Forest Pathology

Forest Entomology

Wildlife Management

Engineering Services

Field Surveys

Field Survey Section

Site Survey Section

Mensuration Section

Drawing Office

*No progress is reported during the year.

Work Study

Statistics and Computing

Communications:

Research Information Section

Photography Section

Publications Section

OTHER HEADQUARTER DIVISIONS

Planning and Economics

Timber Utilisation

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*No progress is reported during the year.

SEED

Research

Nursery Experiments on Conifers

Similar experiments to those spoilt by the drought in 1976 were repeated again in 1977. Because of installation delays irrigation was not applied until after the normal period for germination. Sowings were carried out in very wet conditions, but were followed almost at once by one month's drought. The conclusions must again be open to question.

In experiments comparing research and conservancy sowing techniques, germination of Sitka spruce and Lodgepole pine was initially faster under the conservancy technique. During the drought the germination in research sowings overtook the germination in conservancy sowings. These results suggest that the condition of the seedbed at actual time of sowing and the depth to which the seeds sink in the seedbed are more critical than have been appreciated.

The work on seedbed covering materials for small seeded species was extended to Western red cedar and Lawson cypress. Germination was greater and more uniform under sand than under grit, even though the sand used was a builder's sand and not the ideal coarse silver sand.

The relationship between laboratory germination (with and without prechill) and field germination (with and without naked cold pretreatment) was studied. It was not possible to predict with any accuracy the relative success of the two treatments in the field on Sitka spruce and Lodgepole pine germination. These results suggest that seed vigour rather than absolute germination levels may be more important.

The field trials with polyethylene glycol (PEG), referred to in last year's *Report*, showed that overall PEG did not improve field germination beyond that obtained by a routine naked prechilling of seed. The treatments and seed lots used were those in which PEG had been found to give more rapid germination in the laboratory. In the field there were no differences in the germination of one lot of Scots pine and one of Norway spruce; in two other lots of Scots pine, a PEG treatment gave more rapid germination; and in one lot of Sitka spruce and one of Lodgepole pine naked prechill gave more rapid germination. It was interesting to note that one of the two Scots pine seed lots that gave a positive response originated in Sweden. There the immature embryos in northern origins of seed have been found to mature during PEG treatment leading to complete germination.

Broadleaved Seed Pretreatment

A project was begun to look at methods of improving the predictability of germination of the most important broadleaved species used in Britain. Many of these species have naturally deep dormancy requiring combined or lengthy pretreatments. Eight species have been chosen to study in depth; *Acer campestre*, *A. platanoides*, *A. pseudoplatanus*, *Carpinus betulus*, *Crataegus monogyna*, *Nothofagus obliqua*, *N. procera* and *Tilia platyphyllos*. Existing treatments are being compared for another 15 species.

The plentiful supply of seed enabled the above species of *Nothofagus* to be studied in detail for the first time. Prechilling in sand and "naked" for 3 and 6 weeks, plus soaking in 2 concentrations of Gibberellic acid (GA_3), found to be

very effective in the greenhouse and laboratory (see *Report* for 1977, page 8) were tried. Best germination was obtained from 6 weeks prechill, with no consistent difference between sand and naked. These were significantly better than the 3 weeks prechilling or GA_3 treatments which were delayed in germination by the drought. These last were both better than the control sowings which yielded very few seedlings until much later in the year. Subsequent laboratory experiments with a thermo-gradient bar showed that GA_3 is only effective at temperatures above 15°C. Further experiments have suggested that another Gibberellin ($GA_{4/7}$) will continue to stimulate germination of *N. obliqua* to a lower temperature than does GA_3. It would seem that lengthy prechilling and sowing in well irrigated seedbeds is the best method of ensuring nursery germination of dormant and even non-dormant *Nothofagus* seeds.

International Seed Testing Association

Dr A. G. Gordon attended the 18th ISTA Congress in Madrid in May 1977 and was elected Chairman of the Forest Tree Seed Committee. Three discussion papers have since been issued to the Committee. The laboratory has participated in the Working Groups on tetrazolium, X-ray and abnormal seedling evaluation, and has organised the first Association-wide referee testing exercise on tree seed using *Pinus sylvestris.*

Service

The Branch has continued to provide all its normal services. It has also listed a fairly comprehensive range of minor broadleaved species in its catalogue for the first time. The response to this has been much greater than anticipated.

After the heavy flowering in 1976, there was a poor crop of nearly every species in 1977. Small collections of Lodgepole, Corsican and Scots pine, Hybrid larch, Sitka spruce and Douglas fir were made. Apart from one small collection from a beech seed orchard, there was a total failure of all major broadleaved species in Britain. A limited amount of minor broadleaved seed was also collected.

To compensate for poor home collections it was necessary to turn to importations for the balance of supplies. Crop failure on the Continent also in oak and beech and some minor broad leaved species combined with a late harvest, resulted in acute shortages. Because of greater competition for seed, more precise information on the suitability of origins for British conditions and only an average crop in North America, not all requirements of conifer seed from that area were met.

Sales of conifer seed to the trade have increased by about 50 per cent in the last year. This was partly due to the cessation of business by the only other long established British tree seed supplier. There has been a large increase in the amount of Sitka and Norway spruce seed sold, the latter probably reflecting the shortage of planting stock for Christmas trees. Supplies of conifer seed to the Forestry Commission have increased slightly to compensate for the shortage of planting stock following two difficult years in the nurseries. Some seeds of origins unsuitable for Britain were again exported.

A. G. GORDON, D. C. WAKEMAN

SILVICULTURE (SOUTH)

Plant Production

Seedbed Covers

Xiro film covering of seedbeds produced a 65 per cent and 10 per cent increase in height of Corsican pine and Japanese larch seedlings respectively.

Conifers in Paperpots (Polythene Greenhouse)

Lodgepole pine, Sitka spruce and Corsican pine showed no preference between argon and low pressure sodium lighting, underheating and no underheating, or the Levington C4 compost and Irish moss peat regimes for raising seedlings.

Broadleaved Species in Paperpots and Containers (Polythene Greenhouse)

Nothofagus obliqua preferred Irish moss peat without vermiculite and double the normal rate of magnesian limestone (2 × 3 kg per m^3).

Reducing the rate of "Osmocote" fertiliser in the Paperpot from 2 kg to 1 kg per m^3 of medium gave reductions in height growth of 10 per cent and 20 per cent for beech and oak respectively, even when grown-on in "Rosepots" with 2 kg per m^3 of "Osmocote".

Applications of GA_3 (gibberellic acid) solution to the leading shoot gave 10 per cent and 8 per cent height increases in beech and oak respectively. Only the response of oak to GA_3 when grown under low pressure sodium lighting was significant statistically.

Underheating was ineffective and there was no difference between plants grown under low pressure sodium or argon lighting in the three species.

Broadleaved Species in Containers

Oak, beech, sycamore and birch were extended to the forest in Paperpots, and in 0·75 litre and 4·0 litre "Whalehide" pots. Survival of plants extended in Paperpots was generally poorer than those in either "Whalehide" pot. The 0·75 litre pot gave good growth performance in the forest and occupies less space on standout ground.

W. J. McCAVISH

Vegetative Propagation

Eight small propagation benches were installed during the year by Engineering Services Branch in a glasshouse previously used for progeny testing. Since the benches are separately controlled for soil temperature, overhead mist irrigation and weaning, valuable experimental work can now be conducted on different aspects of propagation from cuttings. High rooting per cents of softwood cuttings of a wide range of ornamental deciduous species and cultivars between May and September suggest that good environmental control can be achieved with these units.

J. JOBLING

Lowland Silviculture

Nothofagus (Plate 1)

Over 20 seed lots of both major species were germinated in the Seed Laboratory at Alice Holt in January/February 1977 and pricked out in Japanese Paperpots.

The plants were grown with artificial heat and light during the spring and hardened off prior to lining out in early June. This intensive technique maximises the number of plants from very small seed lots. At the end of the growing season the mean height of *N. procera* varied from 24–69 cm and of *N. obliqua* from 28–107 cm.

Eighteen seed origins of *N. procera* and 9 of *N. obliqua* were sown at Fleet (Dumfries and Galloway) and Headley (Hampshire) nurseries. Although each plot was sown with the same number of viable seeds, germination varied markedly (from 3–90 per cent) averaging 33 per cent at Fleet and 41 per cent at Headley. There were large differences in the rate of emergence of seedlings and, in general, those which germinated rapidly were the tallest at the end of the season. All home collected seed and some of the Chilean *N. procera* were slow to germinate.

Results from the intensive technique suggest that seed lots of *N. procera* from the lower slopes of the Chilean Andes may grow better in the nursery than those from the coastal range of mountains. Some of the seed lots which grew well under the intensive technique were slow to germinate in the nursery. The two seed lots from the central province of Cautin grew well in both of the nursery experiments but were only moderate in the intensive experiment. In England the three seed lots from the northern province of Nuble grew well but were only moderate in Scotland. These northern seed lots may be more susceptible to damage by spring frosts. No seed from the northern part of the natural range of *N. obliqua* was available, but the growth from seed lots collected below 700 m were the best, and most of the Chilean lots were better than home collected seed.

A number of other *Nothofagus* species have been raised by the intensive methods used on *N. procera* and *N. obliqua*, to see if they have any potential in this country. The evergreen Chilean species (*N. dombeyi*, *N. nitida* and *N. betuloides*) grew rapidly in late summer but have been damaged by the frosts in late February. The evergreen species from New Zealand and Tasmania (*N. menziesii*, *N. solandri*, *N. fusca* and *N. cunninghamii*) grew more slowly. The two deciduous species with very limited distribution in the northern part of central Chile (*N. alessandrii* and *N. glauca*) grew rapidly in early summer but ceased growth early. Several seed origins of *N. antarctica* grew rapidly, as expected, but *N. pumilio* was much slower.

It remains to be seen whether these growth differences will be sustained when planted out in the forest and whether they will be repeated in the nursery in subsequent seasons.

G. TULEY, R. LINES

Provenance of Douglas Fir

The IUFRO collection of Douglas fir provenances (46 origins of *Pseudotsuga menziesii* from the North American continent) has reached the sixth year of establishment on 5 experiments in the southern lowlands. Data show a strong correlation between height growth and origin, confirming the suitability of traditional seed sources of the Washington coastal plains (Olympic peninsula) and coastal Oregon. At Bodmin (Cornwall) there is a correlation between aspect and height growth, where east, south and north facing slopes have produced (in that order) decreasing vigour.

M. L. PEARCE

Forest Weed Control

Herbicide Screening in the Nursery

Glyphosate at 0·5, 1·0 and 1·5 kg acid equivalent per hectare was applied in March, June and August to Corsican pine, Lodgepole pine, Sitka spruce, Norway spruce, Douglas fir and Japanese larch during 1976. At the end of 1977 Japanese larch had unacceptable loss of height growth following treatments in June and August, and poor survival following June applications when treated at the 0·5 kg acid equivalent per hectare rate (which is now the recommended rate for grass control in lowland Britain for Sitka spruce, Norway spruce, Corsican pine and Lodgepole pine). Douglas fir continued with poor growth following the application of 0·5 kg acid equivalent per hectare in March, but survival was unaffected. Only summer applications are recommended for Douglas fir.

Hexazinone ("Velpar") a grass herbicide, was screened at 1, 2 and 4 kg product/ha. Applications were made in March, May and July. Japanese larch was severely damaged at all dates tested. May treatments severely affected the health and survival of Douglas fir, Sitka spruce, Western hemlock, Norway spruce and Lodgepole pine. The health of Douglas fir, Western hemlock and Norway spruce was affected by all of the dates of application especially at the higher rates. Corsican pine and Scots pine were not seriously affected.

Triclopyr ("Garlon") a herbicide for controlling woody weeds, was screened at 1·25, 2·50 and 5·00 kg acid equivalent per hectare. Treatments were applied in July and August and showed the tolerance of Sitka spruce, Lodgepole pine, Corsican pine and Douglas fir. Height and survival were unaffected but the health of Japanese larch was seriously affected by the herbicide at all rates and both dates.

Control of Bracken

Asulam at 2·0 kg active ingredient per hectare, glyphosate at 0·75 kg acid equivalent per hectare and "Krenite" at 2·0 kg active ingredient per hectare gave adequate control when applied in early August, and inadequate control when applied in late August. Glyphosate gave better control at both sites.

Control of Woody Weeds

"Silvapron T" (2, 4, 5-T) at 2·1 kg acid equivalent per hectare; glyphosate at 1·0 kg acid equivalent per hectare; "Krenite" at 2 kg active ingredient per hectare; hexazinone ("Velpar") at 2 kg active ingredient per hectare; triclopyr amine at 2·5 kg acid equivalent per hectare; and triclopyr ester at 2·4 kg acid equivalent per hectare were tested. Applications were made in late August and late September. September applications were less successful. Glyphosate gave the best control of the widest range of weed species including oak, birch, blackthorn, hawthorn, briar, hazel and bramble.

Control of Grasses and Herbaceous Broadleaved Weeds

Glyphosate at 0·5 and 1·0 kg acid equivalent per hectare applied in early spring and mid-summer 1976 continued to give some weed control in 1977.

Glyphosate was re-tested at three sites with five conifer species using rates of 0·2, 0·4 and 0·6 or 0·4, 0·6 and 0·8 kg acid equivalent per hectare in early spring, repeated in late summer. Indications are that repeated doses in one season

cause reduced height growth and survival and poorer crop health, but adequate weed control can be achieved on coarse grasses with 0·2 plus 0·2 kg and 0·4 plus 0·4 acid equivalent per hectare. The tree crop was only seriously affected by the higher rates of application.

Hexazinone ("Velpar") was tested at 1, 2 and 3 kg product per hectare and applied in March, May and June. Health of the Norway spruce, Sitka spruce and Corsican pine treated was not affected at any rate or date, in contrast to the result obtained in the screening trial. Treated Sitka spruce grew taller especially after the March application and Corsican pine survival was particularly improved by the March application. 2 kg product per hectare gave adequate control of *Dactylis glomerata* and *Arrhenatherum elatius*, while *Deschampsia caespitosa* required 3 kg product per hectare to achieve adequate control.

W. J. McCAVISH

Arboriculture—Department of the Environment Contracts

Nutrition of Amenity Trees

Foliar sampling of limes carried out in July and August 1975 (front cover) showed no evidence of difference in nutrient status between trees growing in rural and urban sites. This work has been extended to obtain information on the normal range of foliar macronutrient (N, P, K, Ca and Mg) levels present in a number of amenity tree species and during 1977 sampling included hawthorns, *Sorbus* spp. and *Malus* spp. Within season variation of foliar macronutrients was monitored from May to October 1977 using an avenue of common limes at Avington Hall (Hampshire).

Motorway Planting

Experiments to compare survival and early growth of bare root transplants and Japanese Paperpot grown stock, using beech, sycamore, birch and *Nothofagus obliqua*, were established on roadside cuttings and embankments on the M.11 in Essex, A.45 trunk road in Suffolk and A.3 Esher by-pass in Surrey. Season of planting is also being tested at Esher using transplants and Japanese Paperpot grown birch. The effect of incorporating peat compost in the planting backfill at varying rates is the subject of an experiment beside the A.38 trunk road in Devon.

Urban Planting

The testing of container grown and bare root stock was extended in 1977 to include a topsoil covered concrete rubble site at St Georges Barracks, Sutton Coldfield. The effect of root and shoot pruning on survival and early growth of small-leaved lime and London plane standards is being investigated in an experiment at Tern Hill (Shropshire).

Production of Amenity Stock

A trial of Ethrel R as a defoliant for hardy nursery stock was carried out during October and November 1977 in Hilliers' Nurseries at Ampfield and Romsey (Hampshire). Response varied considerably between species. Hawthorn, Common alder and Norway maple showed no response 23 days after spraying, while *Nothofagus obliqua*, London plane and Turkey oak, sprayed with 2 and 4

per cent solutions of Ethrel R showed significant loss of leaves compared with controls sprayed with water and wetting agent only.

A large amount of sampling was done on hardwood transplants delivered for motorway planting during December 1977 and January 1978 so that the condition of the plants on delivery could be determined.

H. INSLEY, J. B. H. GARDINER

Advisory and Information Service

The number of enquirers using the service rose during the year to 1,120 covering some 2,000 topics. Following the dry seasons of 1975 and 1976 the problems of "tree injury", the spread of roots and damage to buildings continued to be areas of concern especially to the public. Questions relating to the management of mature trees also reflected seasonal weather, especially gale damage resulting in uprooted trees. Practitioners showed a growing awareness of the potential uses of herbicides, but the enquiries suggested that there was a lack of available information on this subject.

During the year an "Assistance with Arboricultural Reading" service and "Arboricultural Research Notes" service were introduced. These are intended to help the arboricultural practitioner to maintain an up-to-date knowledge of the literature and research findings.

D. PATCH, F. R. W. STEVENS

Coal Tip Review

A survey of colliery spoil heap reclamation was concluded at the end of September 1977. The work was carried out over a 12-month period primarily to study the establishment of trees and other woody vegetation on regraded wastes from deep mining. The problems and practices peculiar to revegetated pit heaps, and the relevant research, are discussed in a report to be published in 1978.

J. JOBLING, F. R. W. STEVENS

Short Rotation Coppice—Department of Energy Contract

A conceptual study of the potential dry matter yield from short rotation coppice is currently being undertaken for the Department of Energy, as part of their much wider examination of alternative biological energy sources.

M. L. PEARCE

Arboriculture—Other

Difficult Man-made Sites

A survey of restored opencast coal sites in South and West Yorkshire, Derbyshire, Nottinghamshire, Staffordshire and Clwyd was carried out under contract to the Opencast Executive of the National Coal Board. Particular attention was paid to choice of tree species and cultural practices required to secure tree establishment.

The revegetation of many other types of industrial and despoiled land was also considered. Although sand and gravel workings and domestic refuse disposal led to the greatest effort, heavy metal spoils, chalk quarries and industrial refuse received attention as well.

J. JOBLING

Dendrology and Arboreta

One hundred estates and collections were visited, 53 for the first time and 47 to remeasure trees. Altogether 4,105 trees were measured, 2,782 were new to the records bringing the total of trees in the register to 43,580. These are comprised of 1,307 species and 722 varieties and cultivars. Conifers extend their lead in number of specimens, now 26,645 compared with 16,935 broadleaves. Of 2,444 specimen trees given in Elwes and Henry and included so far in the register, with dimensions taken between 1902 and 1911, 831 have been found and remeasured, although a few of these have since died. 4,545 trees recorded for the Conifer Conference of 1931 are on the register and 2,592 of these have been found and remeasured. The above records include trees in Northern Ireland and the Republic of Ireland.

Westonbirt Arboretum

January gales did much damage and a few fine specimens were lost. Additions were made to the Native Species Glade and the Hillier Cherry Glade which now has 60 of the Japanese cultivars and needs only a few more to have a complete collection of them. Trees whose measurements are kept now total 2,070 specimens of 508 species and 191 cultivars.

The Visitor Centre was opened on 17 May 1978. The surroundings are being landscaped and planted.

Bedgebury Arboretum

Damage from gales was fortunately confined to a few of the plots which have long been unstable. Several collections have been thinned, removing some of the well duplicated common forms to allow the remainder to grow full crowns and to make room for additional forms. The collection of cultivars of Lawson cypress is still being extended.

The old kennels have been completely renovated as an exhibition and lecture room for schoolchildren in wet weather. Exhibits are now being assembled and the room will be ready for use during the summer. A study of flowering times of a wide array of conifers and the relationship with temperature has been made and is being written up.

Eleven plots were thinned. Exactly half the 132 plots now contain sample plots.

A. F. MITCHELL

SILVICULTURE (NORTH)

Production of Planting Stock

Seedbed Herbicides

Diphenamid, nitrofen and RH2915 were tested as pre-emergent herbicides on seedbeds of Sitka spruce, Lodgepole, pine, Japanese larch and Hybrid larch, and performed satisfactorily. Crop damage was minimal at rates up to 12 kg active ingredient diphenamid per ha, 12 kg ai nitrofen per ha and 1·2 kg ai RH2915 per ha. RH2915 did slow rate of germination but not enough to affect

the number of usable seedlings at the end of the year. Weed control was good with all three herbicides.

Herbicides on Transplants

Work with propyzamide has been discontinued after damage was observed on Sitka spruce transplants at Newton (Laigh of Moray Forest, Grampian) in July 1977 following a 2 kg ai/ha application in October 1976. The plants were slightly yellow, growth was poor, and there were some deaths.

Preliminary trials with glyphosate are continuing. Lodgepole pine transplants appear to be sensitive even when dormant, whilst Sitka spruce shows some temporary damage at rates up to 2·0 kg ai/ha applied in September, but recovers fully.

Diphenamid and nitrofen were compared with simazine on transplant lines. Both diphenamid and nitrofen gave good weed control though not as effective or as long lasting as simazine.

Seedbed Cloches

A further experiment at Newton confirmed that seedlings large enough for lining-out could be grown successfully under cloches with buried edges on unsterilised ground in one year. Scots and Lodgepole pines germinate and grow well under the cloches, while Japanese larch and Douglas fir germinate well, but once germinated there is some loss of numbers while subsequent height growth is good. Sitka spruce does respond in height growth but numbers are seriously reduced by the high temperatures.

Seedbed Grit

Experiments, at Bush (Midlothian) in 1976 and at Newton in 1977 have shown that pale-coloured material and a coarse sand texture (0·5–1·0 mm) gives considerably better germination than darker-coloured material or a coarse grit texture (2·0–5·0 mm).

Partial Sterilisation

A trial at Fleet (Dumfries and Galloway) showed that the date of application of dazomet is critical. Late August treatment gave the best seedlings and weed control. Early August treatment gave poorer seedling growth and poor weed control. Mid-September and mid-October gave poorer seedling growth but weed control was good.

Vegetative Propagation

Experiments have shown that rooting of Hybrid larch and Sitka spruce cuttings taken from young plants (less than two year old) is easily done by insertion into a grit medium with overhead mist irrigation in a polythene greenhouse. Hormones and nutrition treatments have been of little value, and neither artificial light nor heat appears to be necessary. The optimum insertion time for Sitka spruce appears to be mid-March, and for Hybrid larch early July. The main problem with Sitka spruce has been *Botrytis* which tends to attack young needles just as the bud scales are being shed. Soft Hybrid larch cuttings must be handled very carefully. After insertion active and upright growth must be maintained if a plagiotropic growth habit is to be avoided. Larch cuttings

transplanted into the open nursery have shown a good recovery from a plagiotropic habit after one year and a series of field experiments comparing these with transplants has been established.

P. BIGGIN

Planting

Visual inspection of planting stock can give a misleading impression, especially with cold-stored plants. A sample of transplants destined for planting was grown in a greenhouse in peat in containers designed to observe root growth. Growth was accelerated by using greenhouse conditions. After four days with an 18 hour day-length, trees adversely affected by previous treatments could be identified by their inability to produce new active roots. This technique of growing a sample of trees in warm, moist conditions for a short time could be used to categorise the vitality of plants about to be planted. It is hoped to refine and simplify the technique.

D. A. THOMPSON, P. BIGGIN

Species Trials

Seed Origin

Sitka spruce. The experiment at Glendaruel Forest (Strathclyde) see (*Report* for 1975 p. 17) was assessed for height at ten years. It had been expected that the southern origins would have overtaken those from British Columbia by this stage, yet the tallest were from British Columbia. A younger experiment at Shin Forest (Highland) contains ten Alaskan origins, collected by the Icelandic Forest Service, and a control origin from the Queen Charlotte Islands BC. The latter was badly frosted in August 1973 and August 1974, when grass minimum temperatures of −7·6° and −5·7°C were recorded, while the Alaskan lots were unharmed. Female cones were produced on four of the Alaskan seed origins in 1976 or 1977, thus offering some confirmation of the hypothesis on the precocity of these origins from the far northwest of the range put forward earlier (Lines, 1977).

The IUFRO seed collection contains several seed lots from the Skeena and Nass Rivers, BC. Some of these may show introgression with White spruce (*Picea glauca* (Moench) Voss), which has a different shape of needle from Sitka spruce. Samples were taken from two experiments and the dimensions of needle transverse sections (Figure 1) measured on a projector microscope. A seed origin from Kitwanga (IUFRO No. 3032) showed most White spruce genetic influence, and is one of the least vigorous in the IUFRO collection. This contrasts markedly with the rapid growth of artificially created hybrids of the two species.

Abies species. The silvicultural performance, including variation due to seed origin, of the main species in this genus has been reviewed (Lines, 1978). The early results from the IUFRO seed collection and other experiments have confirmed that Grand fir (*Abies grandis*) shows differences of 10 Yield Classes between the most and the least vigorous origins. Since many existing stands are of sources at the poorer end of the range, a reassessment of the potential of this species is necessary. Trials with *Abies alba* have confirmed the slow initial growth, which appears to be inherent in this species, even under favourable conditions. The tallest seed sources after ten years were from such divergent areas as Calabria (Italy), Czechoslovakia and the Swiss Juras (Plate 2).

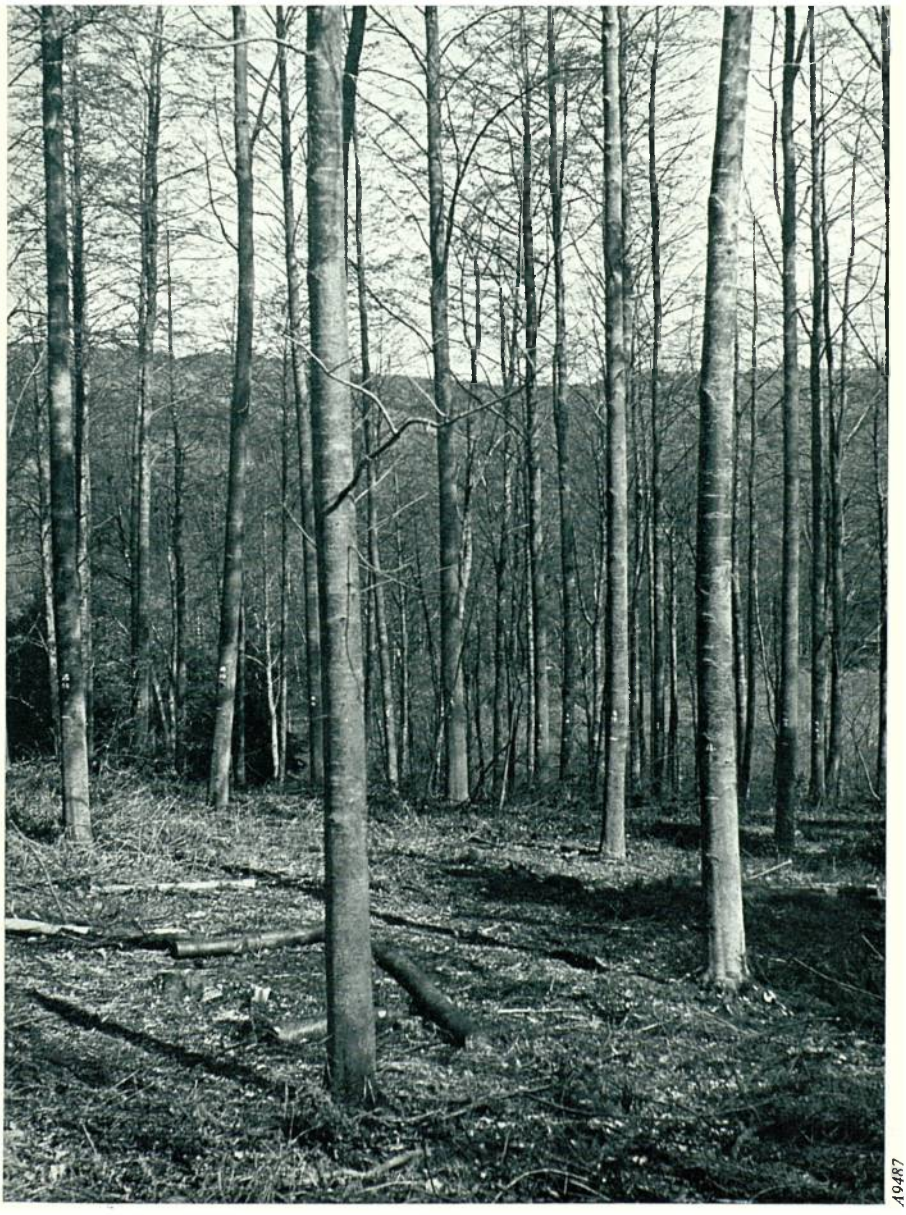

Plate 1

Nothofagus procera planted in 1956 at Flaxley, Forest of Dean, Gloucestershire. Thinned in February 1977. Top height 18·2 m. Standing Volume 152·5 cu m/ha. (p. 9)

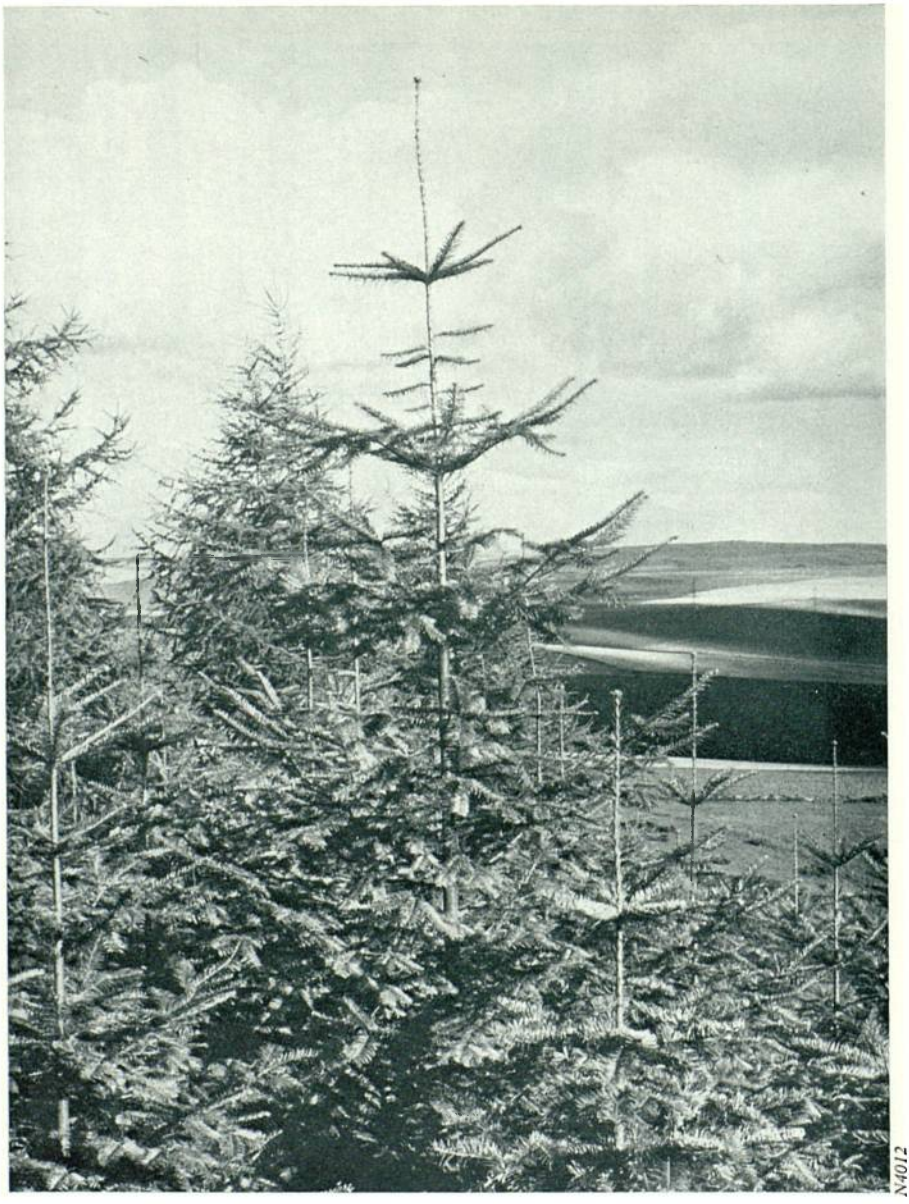

Plate 2

Ten year old Grand fir in a seed origin experiment at Mearns Forest, Grampian Region. Trees in the foreground are from the east side of the Cascade Mountains, Washington; height is equivalent to Yield Class 14. Trees behind, from Darrington on the west slopes of the Cascade Mountains are the equivalent of Yield Class 24. (p. 16)

Plate 3

Winged sock attachment to one of the three ripper shanks fitted to a caterpillar D8 tractor. Working depths of tip, 750 mm. Wing width, 600 mm. (p. 24)

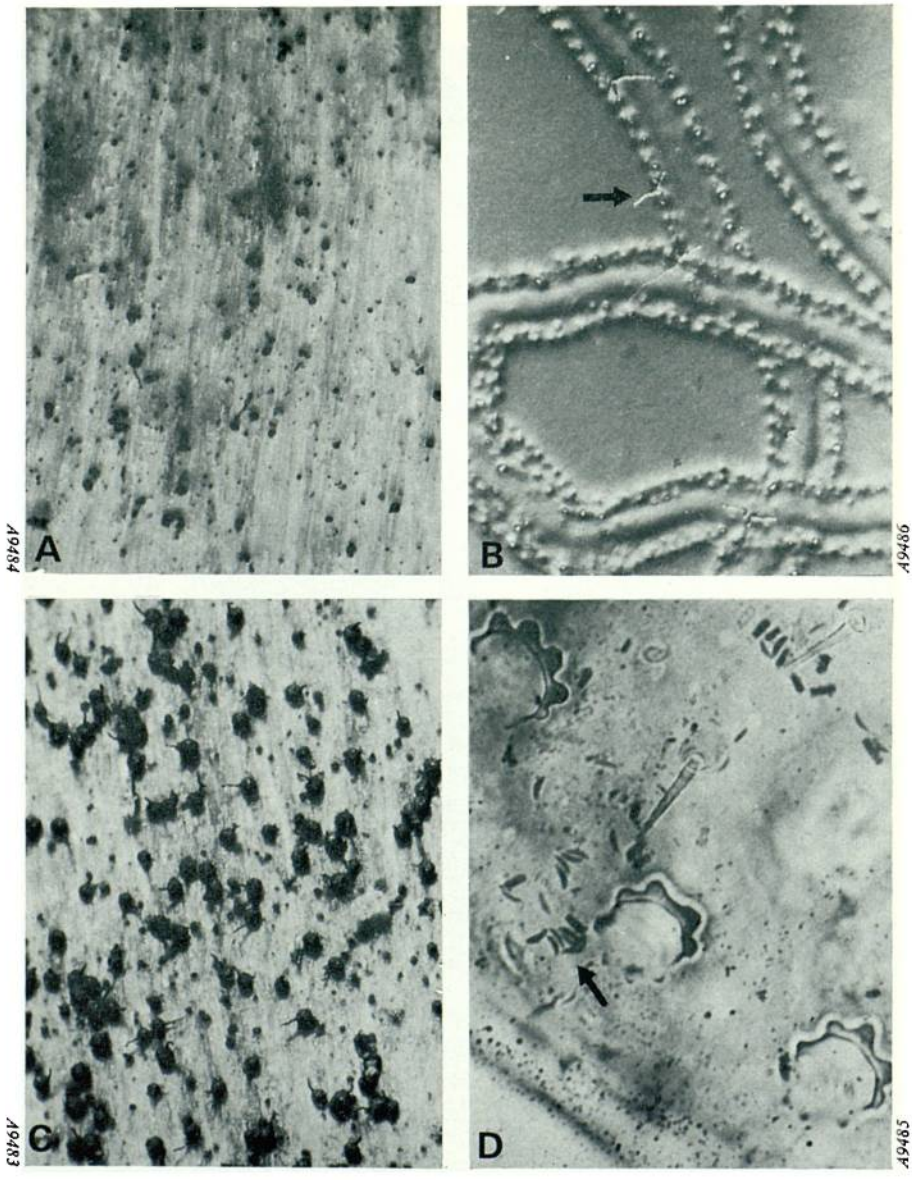

Plate 4

Transmission of spores of *Ceratocystis ulmi* by mites. (pp. 31, 32)

A. Unfertilised protoperithecia (♀) of the aggressive strain of *C. ulmi* on an elm twig. These have failed to be fertilised by mites carrying spores of a non-aggressive isolate of opposite mating type.

B. Trail on malt agar of a mite from diseased elm bark in nature, showing germinating spores of *C. ulmi* (arrowed) associated with the 'mite footprints'.

C. Perithecia of the aggressive strain of *C. ulmi* (on an elm twig) resulting from fertilisation by mites carrying spores of an aggressive isolate of opposite mating type.

D. Enlargement of dorsal surface of a mite from diseased elm bark in nature, showing probable ascospores and conidia of *C. ulmi* (arrowed).

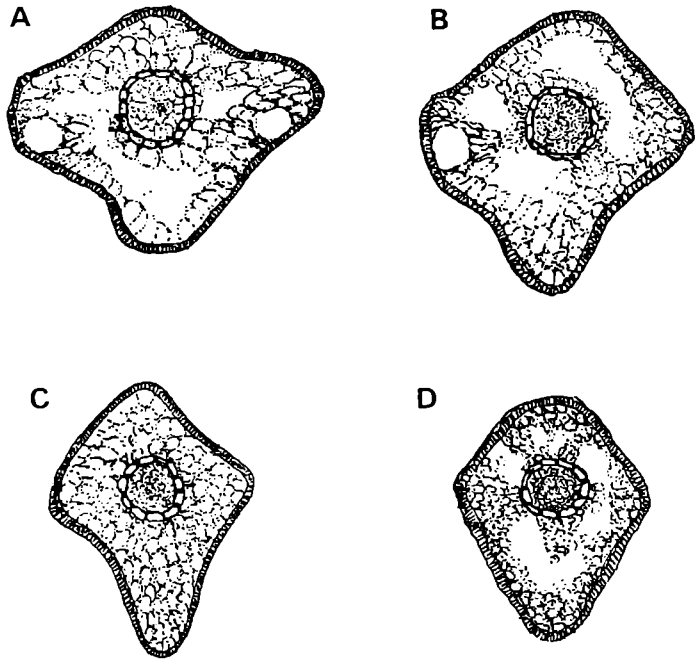

Figure 1: Ratio of height to diameter in transverse sections of Sitka spruce needles. (A) IUFRO No. 3070 Dinan Bay, Queen Charlotte Islands, Ratio 75 per cent. (B) IUFRO No. 3026 Derrick Lake, Nass River, Ratio 94 per cent. (C) IUFRO No. 3032 Kitwanga, Skeena River, Ratio 103 per cent. (D) IUFRO No. 3032 Kitwanga, Skeena River (i.e. as (C)) Ratio 123 per cent.

Species Trials on Poor Peat

As large-scale afforestation of poor peatlands increased in the 1960's it was felt that more information was needed on species for amenity use as well as alternatives for commercial use on these difficult sites. In 1968, 18 species were planted at Shin Forest (Highland) on a poor deep-peat site, followed in 1969 and 1970 by eight more. At ten years the best of the broadleaved species was *Betula pendula* (4·5 m tall). *Alnus incana* was 2·9 m and in poor condition, while *A. rubra*, after exceeding 2 m in height in three years, failed after being repeatedly frosted. The tallest conifer was Hybrid larch (4·5 m) followed by *Larix laricina* (3·9 m) which has very spindly and twisted form. Among the spruces, *Picea x lutzii* was outstanding at 3·1 m.

Polluted Sites

In July 1977 browning of foliage was noticed on Sitka and Norway spruces growing at the mouth of Glen Nevis only 1·5 km from the aluminium smelter near Fort William. Douglas fir and Western hemlock growing alongside were unaffected. The symptoms are of the kind associated with injury from fluorine. The incident is being investigated jointly with the British Aluminium Company and analyses for F are being checked with the Government Chemist. In June

there was an unusual number of days with calm or slightly northerly winds at Fort William which might have interfered with normal dispersion of pollution.

R. LINES

Cultivation (Including Drainage)

Deep Peats

The new plough (D60/–/t) developed in conjunction with Work Study Branch has been rapidly introduced into normal forestry practice on these soils. This rapid acceptance is based partly on higher outputs and lower costs which have been obtained and partly on the theoretical advantages of increasing stability and maintaining currently accepted rates of growth. Nevertheless, the theoretical advantages have to be confirmed as quickly as possible and to this end a new experiment has been established in Shin Forest. Various forms of double mouldboard ploughing, D25/–/t, D60/–/t, D60/T90/t, and D90/–/t are compared with single mouldboard ploughing S60/–/t.

Gley Soils

A large group, probably amounting to one-third, of the total gley soils planted and being planted by the Forestry Commission, cannot be easily classified into clayey or indurated (Fragogley) classes. A general name of 'loamy gley' has been adopted for this category. Broadly, their texture and structure suggest that the loamy gleys should be relatively permeable down the profile, but the presence of gleying indicates that for various reasons, anaerobic conditions do prevail at some time during the year. Since most of these soils appear to be associated with Western Upland Britain it is believed that the commonest cause of gleying is simply that rainfall rate overwhelms the drainage capability of the loamy soil. However, examples of loamy gleys have been found with rainfalls as low as 1,000 mm. As loamy gleys occur normally in a mosaic with other soil types, experimentation on them is difficult. Nevertheless, an experiment has been established to compare two forms of ploughing on loamy gley soils (D60/–/t and S60/T90/t) at Glenorchy Forest (Strathclyde).

Reploughing Restocking Sites

A new experiment established jointly with Silviculture (S) Branch at Exeter Forest (Devon) examines the various ways of cultivating a restocking site previously carrying a poor stand of pine. The soils are compacted with layers of clay and cherts at various depths below the surface.

The cost of ploughing small restocking areas with recommended equipment can be exceedingly high and this experiment attempts to compare less intensive cultivations done with relatively cheap equipment with the expensive but recommended methods of bringing about site changes. Intensive cultivations were to 0·6 m depth with single and double mouldboard ploughs and to 0·75 m with a rotary mouldboard plough. The "cheaper" less intense cultivations were to 0·45 m depth with single and double mouldboard ploughs.

D. A. THOMPSON

Nutrition

An investigation of the foliage nutrient levels of Sitka spruce over 4·5 m mean height was started in autumn 1976 and extended to cover Lodgepole and Scots

pines in 1977. The primary shoots of the first to sixth whorls were sampled and analysed separately for N, P, K, Ca and Mg. A sample of five dominant or co-dominant trees per 0·05 ha plot was demonstrated to be adequate. At present it has been found that in Sitka spruce N levels remain constant down the crown whereas P and K levels tend to decline from the top to the bottom. The evidence suggests that the absolute levels of N, P, and K and the rate of decline in P and K down the crown should be of value in quantifying stand responses to applications of fertiliser. It has been decided to discontinue analysis for Ca and Mg.

It is becoming obvious that biennial breast height basal area (BA) assessments of pole-stage nutrition experiments do not always produce adequate information. In some experiments BA increment is influenced as much by minor differences ($\pm$2–3 m²/ha) in standing BA as by fertiliser thus necessitating covariance analysis. Experience is thus confirming that the fertiliser, standing BA/ha and thinning interaction has to be examined very carefully. Another approach is to examine retrospective measurements of volume and stem shape changes in selected older nutrition experiments. This study was started in late 1977 but is laborious and only worthwhile where fertilisers were applied at least 4 or 5 years earlier.

A review of ammonium nitrate/urea comparisons in five establishment-stage and three pole-stage stands demonstrated that both sources of nitrogen produce responses; price and convenience suggest urea is the better choice.

Nutrition experiments on reputedly better soils reveal that on some of these sites Sitka spruce may respond to fertiliser, e.g. to phosphorus on some surface water gleys on the Ordovician-Silurian lithology of south Scotland and the brown earths on the Basalt of north Scotland.

G. J. MAYHEAD

Forest Weed Control

Adequate control of heather (*Calluna vulgaris*) by controlled droplet application (CDA) is based on a droplet size of around 80–100 μm using 4 kg acid equivalent 2, 4-D iso-octyl ester in 10 litre refined mineral oil/ha. Considerable drift of herbicide using this method is a disadvantage and the use of a larger droplet would be preferable and might allow an increase in the length of the CDA season by reducing tree damage. Provisional results indicate that a droplet size of around 300 μm can kill heather but less effectively than the smaller droplets. Higher rates and a change in time of application are being investigated as a method of achieving acceptable control.

Experiments have been conducted with hexazinone ("Velpar") for heather control; provisional results indicate that satisfactory control may be achievable at 8–12 kg active ingredient/ha, a rate that is unfortunately likely to be prohibitively expensive of chemical.

Some experiments with Sitka spruce planted in 1973 and 1974 have shown substantial height responses to 100 per cent weed control maintained for 3–4 years. A herbicide/fertiliser interaction was also demonstrated. New work is proceeding on the effect on Sitka spruce growth of different levels of chemical weeding, such as comparisons of control in spots of different sizes, strips and overall. It is desirable to standardise on herbicides in such an investigation and glyphosate, propyzamide and dichlobenil-dalapon mix have been selected as being suitable.

G. J. MAYHEAD, J. H. THOMSON

Wind

Wind Flow Over Topography

Collection of field data from the experiment at Wauchope Forest (Borders) reported on last year was completed during the winter. There had been sufficient variation in the direction of strong winds during the period under study for relative figures to be available for seven out of eight sectors of the wind rose.

Provisional testing of the models in the wind tunnel has already shown that a model without vertical exaggeration produces a laminar wind flow, giving no variation in wind speed over large areas of the model. This scale of model will therefore only be fully tested with surface aluminium oxide crystals used to promote roughness.

Assessment of Exposure

For Windthrow Hazard Classification, as it is necessary to have a quick survey method for assessing exposure that could be applied nationally, the system known as "TOPEX" (Pyatt, 1977) or "Geomorphic Shelter" (Howell and Neustein, 1965) was examined in detail. The method has been in use in a restricted way by the Forestry Commission Site Survey in South Scotland and NE England Conservancies and in Wales, but not in areas of rough, more complex topography. Two areas of doubt existed: (i) the practicalities of measuring and mapping "Topex", and (ii) the relationship of the results obtained to actual wind-flow. Site Survey staff attempted the assessment and mapping of "Topex" for two sites in West Scotland Conservancy, at Achaglachgach and Raera Forests (Strathclyde). Site Survey staff found that it was practical to produce broad zonation "Topex" maps even in very complex topographic areas. Silviculture staff modelled the Raera site and carried out a wind flow test at the Northern Research Station. Results from this test, plus evidence from previous comparisons made by Forestry Commission staff and students from the Soil Science Department of Aberdeen University, showed that "Topex" gave reliable local relationships. The conclusions of the exercise were: that "Topex" maps could be produced as standard in upland areas, and that to make comparisons on a national scale using "Topex" is only valid when account is taken of regional variation in windiness.

T. C. BOOTH

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SITE STUDIES (SOUTH)

Foliar Analysis

Research

Samples of phloem at breast height were taken from a number of pole-stage Sitka spruce experiments, which were being studied for variation in nutrient concentration in the foliage down the crown. A nitrogen experiment on *Pinus radiata* has also been sampled in the same way. As mentioned in the *Report* for 1977, it is hoped that the phloem may prove a useful and more convenient substitute for foliage from the top of the crown, for assessing the nutrient status of pole-stage crops. It also appears that for potassium the lower crown may show deficiency when foliage in the upper crown is still well supplied with this nutrient.

Service

In spite of efforts to reduce the load, the number of samples received rose from about 6500 in the previous year to over 12,000. Omitting determinations of calcium and magnesium, except where essential, has helped to ease the strain on the laboratory staff.

Methods of Analysis

Because of the increasing demand for elements other than nitrogen, phosphorus and potassium, and also to help speed up the determination of several elements from one digest of foliage, a "Spectrascan" plasma echelle grating emission spectrometer is being purchased.

W. O. BINNS

Soil Analysis

Chemical Variability of Forest Soils

Sixty cores were taken from each plot of a pole-stage Sitka spruce trial, with three rates of applied phosphorus fertiliser, in Clocaenog Forest (Clwyd). Results indicated that there was no advantage in analysing each sample more than once. The analysis of variance for the individual elements (Table A) indicates that phosphorus and calcium are the most variable elements, 400 and 300 cores respectively being required to reduce the coefficient of variation to 5 per cent, 60 cores being sufficient for the other elements.

TABLE A

MEAN, STANDARD ERROR AND COEFFICIENT OF VARIATION FOR INDIVIDUAL SOIL ELEMENTS

Element	Mean	Standard error	Coefficient of variation, per cent
N	0·809	0·045	5·6
P	2·095	0·277	13·2
K	83·85	4·26	5·1
Ca	229·0	28·32	12·4
Mg	69·55	4·11	5·9
Fe	245·8	16·40	6·7
Al	18·78	1·33	7·1

Soil Phosphorus

No correlation could be found between tree growth and the level of extractable phosphorus in establishment and pole-stage experiments which have shown responses to phosphorus. Addition of phosphate (up to 30 ppm P) in solution to the soils increased the levels of available phosphorus by a fixed amount, typically from 2 to 2·5 ppm. The larger part of the phosphorus is fixed strongly by the soil, the extractable phosphorus being a transient species. This suggests that measurement of only the quantities of the different forms of phosphorus and other elements will not help in understanding forest soils. Efforts are being made to determine the rates of transformation of phosphorus and to quantify the rate of supply to the tree crop.

A. WILLSON, D. A. WADDELL

Upland Production Forestry

Phosphorus Nutrition of Lodgepole Pine (Pinus contorta)

Using water culture techniques, the growth of Lodgepole pine was found to be related to the origin. Seedlings were germinated under nutrient deficient conditions before being placed in the culture media; no deficiency symptoms were observed even at the lowest concentration of phosphate. Differences between the origins in shoot length, wet and dry weight of the shoot, and wet weight of the roots were all significant at the 0·1 per cent level and in root dry weight at the 5 per cent level.

Varying the level of phosphate in the nutrient solutions (with constant amount of other nutrients) affected the size of plants (Figure 2) and also the amount of other nutrients in the roots and shoots but there was no interaction between phosphate and origin. Above 2 ppm, little change was observed in any of the parameters measured, indicating a tolerance to a wide range of phosphate concentration.

TABLE B

AVERAGE VALUES OF ROOT-SHOOT RATIOS AND SHOOT LENGTH OF LODGEPOLE PINE OF FOUR ORIGINS

Origin	Assignment	Shoot length mm	Root-shoot ratio, dry weight
Skeena River	N. interior	55·1	0·465
Mount Ida	S. interior	54·6	0·481
Long Beach	S. coastal	43·2	0·380
Vancouver Island	S. coastal	51·0	0·383

The root-shoot ratio (Table B) shows that the south coastal origins have the lowest values which parallels their poor root development in plantations. The Mount Ida origin produced a shoot comparable in weight and length to the two south coastal origins but had a much larger rooting system, while the north interior origin had a long shoot of low weight. This suggests that the Mount Ida origin might yield well with comparatively good stability compared to the three other origins studied. The results demonstrate the importance of knowing the origin when considering the appearance of the trees in relation to the need for fertiliser.

A. WILLSON

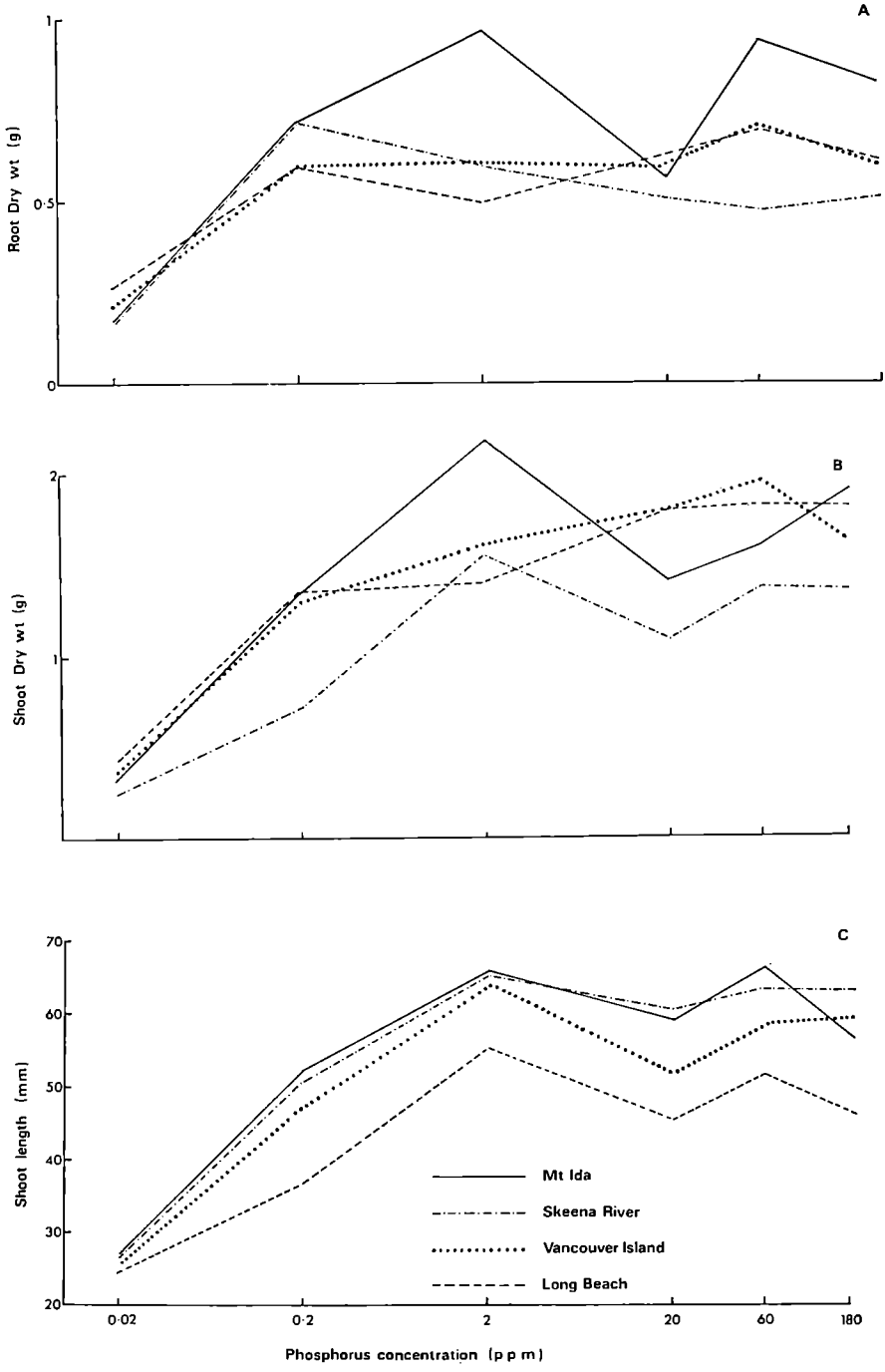

Figure 2: Variation of (A) root dry weight, (B) shoot dry weight, and (C) shoot length with phosphorus concentration in the nutrient medium for four origins of *Pinus contorta*.

Effects of Trees and Sites

Species, Thinning and Spacing Trials

Studies of soil development under contrasted upland crops has continued. Samples were collected from one Welsh experiment to compare the effects of Sitka spruce and Lodgepole pine on soil nutrient status, and also from two experiments contrasting a wide range of Sitka spruce thinning and spacing regimes. Analysis of the soils is in progress.

Whole-tree Harvesting of Sitka Spruce

Analysis has continued on samples collected in 1976 (see *Report* for 1977). The aim has been to determine the increased nutrient loss from high yield class sites if forest residues are harvested as well as the stem. Early results suggest that whole-tree harvesting of Yield Class 17 Sitka spruce could remove four times as much phosphorus compared with harvesting stems only. The proportional loss may be higher in crops of lower yield class.

M. A. ANDERSON

Lowland Production Forestry

Restoration of Spoils

Further experience has been gained in handling restored sites preparatory to replanting. Progress has also been made in persuading gravel operators to provide more topography, both for improving run-off and covering silt beds. On most restored sites, compaction must be reduced before attention is paid to nitrogen nutrition. Supplies of phosphorus and potassium are usually adequate.

A three-tine unit fitted to a Caterpillar D8 tractor relieves compaction effectively, but needs two passes for complete disruption of the soil mass (see *Report* for 1976). Lateral wings have now been fitted to each of the tine shanks, to lift the soil mass between the rip lines, which results in complete disruption at a single pass (see Plate 3). We acknowledge with gratitude the help of Mr G. Spoor, of the National College of Agricultural Engineering, Silsoe, Bedford, in this development.

Replanting after Fire

At Ringwood Forest (Hants) on sites with huge numbers of *Rhizina undulata* fruit bodies, *Pinus radiata* and *muricata* (Japanese Paperpot stock) and Corsican pine (1 + 1 stock) have survived reasonably well. Direct sowing of these species in drills has also been successful, except on the driest sites.

D. F. FOURT

Amenity and Arboriculture

A small amount of work has been done on roadside plantings on heavy soils in conjunction with Silviculture (South) Branch. Again, machine compaction can be a limiting factor unless it is relieved before planting.

Considerable laboratory time has been spent on analysis of foliage from broadleaved trees in connection with both the Commission's own programme and contracts from the Department of the Environment.

W. O. BINNS, D. F. FOURT

Meteorology and Phenology

Site Studies (South) have taken over full responsibility for the meteorological observations at Alice Holt. The run of phenology data for the last seven years is being analysed in an attempt to see whether more appropriate meteorological measurements could be made when relating climate to plant performance.

M. A. ANDERSON

Advisory Work

A larger than usual number of enquiries of water use by trees and effects of drought were received, following the aftermath of the dry summer of 1976. Enquiries suggest that, on restored sites, neither root growth nor wetting and drying cycles are likely to relieve the compaction produced by heavy machinery.

W. O. BINNS, D. F. FOURT

SITE STUDIES (NORTH)

Classification and Improvement of Upland Soils

Indurated Soils and Loamy Gleys

At Teindland (Speymouth Forest, Grampian) tensiometers were used to compare the moisture regimes of podzol, gley and ironpan soils, all with indurated material. Under pine plantations the gley soil had a shallow water table throughout the winter. The podzol was not affected by the water table, except for a few weeks, at depths greater than 100 cm. In the ironpan soil there was no waterlogging at any depth.

Outside the plantations, under the semi-natural heathland vegetation, the ironpan soil had a "perched" water table for most of the year. Beneath the ironpan and underlying indurated layer the soil was not waterlogged.

The depths from which moisture was extracted by the trees during the summer were always greater than 100 cm, in spite of rooting being restricted by the indurated material to less than 50 cm depth. This indicates that the indurated material has quite good conductivity to capillary water, and suggests that on these soils the benefits from deep cultivation to provide greater rooting depth may be represented by improved crop stability rather than yield (Pyatt, 1978).

Gleys and Ironpan Soils

At Newcastleton Forest (Borders) the study of the physical properties of four soil types under pole stage spruce was supplemented by sampling the root distribution by depth. Eight cores around each of three Sitka spruce trees on each soil resulted in 350 sections of core, when cut up according to soil horizons. Separation of roots is not yet complete, but results to date indicate that mean maximum rooting depths are:

Brown earth	85 cm
Ironpan soil	75 cm (ironpan itself is at 35 cm)
Peaty gley	30 cm (peat thickness is 40 cm)

These results relate closely with the maximum depths from which moisture was extracted, as assessed by tensiometers during the previous three years.

Deep Peats

The experiments at Naver Forest (Highland) on the irreversible drying of blanket peat under conifer plantations, were partly destroyed by Pine Beauty moth. Assessments of the moisture relations of the peat will continue in areas felled before defoliation of the Lodgepole pine, and also under the surviving stands of larch and spruce.

Work on the classification of peats according to physical and chemical properties continued. Sampling was completed and analysis is in progress.

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FOREST GENETICS

Testing

Pollinations

The single-pair mating programme between widely separated populations of Lodgepole pine continued and 122 crosses between Alaskan and Oregon origins and 202 crosses between South Coastal Washington, and Skeena River, British Columbia origins were made. Further hybrid larch families were created by crossing 26 Japanese larch clones with a European larch plus tree pollen mixture, and 36 European larch clones crossed with a Japanese larch plus tree pollen mixture. Sitka spruce pollinations continued in the Wauchope (Borders) tree bank with 182 previously untested clones being pollinated with a plus tree pollen mixture. A late-frost destroyed 59 per cent of the 10,000 isolated female flowers, and also resulted in low seed-yields in those developing cones which survived. Many of these crosses will have to be repeated.

Forest Progeny Tests

Almost 350 families of selected individuals from five high-quality Sitka spruce stands were planted in forest tests on up to three sites throughout Britain. In addition, Lodgepole pine families from a factorial crossing experiment, involving 42 females each crossed with up to four males of widely separated origins, were planted on up to three sites in north and east Scotland. The crossing pattern is designed to give estimates of both the general and specific combining-abilities of the parents and to indicate the mode of inheritance of vigour and stem straightness.

Experiments at Shin (Highland), and Aultmore (Grampian), containing the earliest specific crosses between Sitka spruce and *Picea glauca* are now four years old. Recent assessments show that on both sites all the hybrids appear to be more frost tolerant and taller than the commercially obtained Sitka spruce from

Queen Charlotte Islands, British Columbia, used as a control. The height difference was in excess of 30 per cent in some cases.

Height data from the first six annual assessments of the Sitka spruce population study (see 1970 *Report* p. 110 and 1973 *Report* p. 85) progeny tests, which are located on three sites, have been analysed. Many changes in rank among overall family means were particularly prominent before the fourth season, and families from sub-dominant parent trees ranked among the tallest in all years. Significant differences between sites from the fourth year onwards were not detected by an analysis of variance and the sites x families interaction also was not significant after the fourth year. Estimates of narrow-sense heritability for height over the first six years were:

Year	1	2	3	4	5	6
Heritability	0·30	0·16	0·14	0·19	0·24	0·27

These results have an important influence on the phenotypic selection of potential breeding trees, the early evaluation of progeny tests, and genetic gain predictions in Sitka spruce breeding plans.

Seed Production

Plus Tree Selection

Flowering on Sitka spruce was generally poor except in some stands in north-east Scotland. One particular stand in the Forest of Deer (Grampian), which had been surveyed previously for plus trees, flowered well. Six trees were selected in 1968 and established in half-sib progeny tests; of these two produced progenies well above the average and have since been used in recent production clonal seed orchards. Because of the high breeding value of two of the original selections it was decided to increase the number of plus trees for testing. As a result 45 further selections were made and cones collected.

Flowering Studies

Flowering studies in Sitka spruce in conjunction with the Long Ashton Research Station (see page 55) were continued. Previous studies have shown that a combination of heat and drought treatments in a plastic covered house could produce large increases in the amounts of flowering (see 1976 *Report* p. 25–26). A continuation of this study showed that the high temperature and drought treatments need only be applied over a four or six week period commencing at about the time of cessation of shoot growth. Flowering decreased when material was left in the plastic house for longer periods and especially during the period before shoot growth ceased.

Growth hormone studies were continued and the period of application was shown to be critical. Applications of $GA_{4/7}$ were made in mid-June, mid-July and mid-August either as one, two, or three applications and at varying concentrations. The mid-June treatment was not so effective in promoting flowering as applications made on the other two dates but it did produce significant increases over the untreated controls.

Seed Orchards

Part of Slebech (Dyfed) nursery and an adjoining 27-years-old larch plantation were cleared and prepared for the establishment of the first section of a 17 ha

Sitka spruce commercial seed orchard complex which will be established during the next 10–15 years. This first section contains 29 clones of proven good general combining-ability for rate-of-growth and form in several progeny tests, and good flowering ability and high seed yields as grafted plants. A permutated neighbourhood design (see 1977 *Report* p. 26) with irregular numbers of ramets per clone provides an isolation barrier of at least 36 grafts of other clones to each ramet.

Plans were made for the development of the orchard programme over the next 10 years. These require 105 ha of ground of which 32 ha have been established already. A further 45 ha of suitable ground are currently held in reserve. The deficit of 28 ha will have to be obtained specially during the period 1982–85.

Seed Stands

An additional 139 ha of new seed sources were added to the National Register during the year. These consisted of a Scots pine orchard; four Sitka spruce, four Corsican pine, five Pedunculate oak, two Douglas fir and two Scots pine stands. Thirty-two hectares of previously registered sources were removed from the Register on account of wind-throw, fellings, or proven unsuitability of progenies. Eight applications for the registration of new sources were refused on the grounds of quality or serious risk of contamination by pollen from nearby unsuitable stands of the same or compatible species.

Biochemical Variation

Analysis of the monoterpene composition of Lodgepole pine shoot cortical resin has been extended to include further origins. On the basis of the results, the natural range of the species has been subdivided into some 15 regions which are biochemically distinct from each other. These regions are closely associated with the ecological and physiographical divisions of the natural range. In the central parts of the range, trees from a given origin yield a relatively complex assortment of monoterpene patterns. Generally the peripheral regions give more highly specific and less variable patterns, with the exception of populations in north-eastern British Columbia and western Alberta where the natural range is still extending and the influence of natural hybridisation and introgression with *Pinus banksiana* is apparent. The method is now used as a practical tool for the identification of populations of unrecorded origin.

An experiment to define the nature of any changes in monoterpene composition which occur during the early years of growth of several Lodgepole pine and Sitka spruce origins was begun during the year.

R. FAULKNER, A. M. FLETCHER, G. I. FORREST, J. G. S. GILL, C. J. SAMUEL

TREE PHYSIOLOGY

Root Growth and Form

Responses of Sitka spruce seedlings to waterlogging of the soil

Growth room studies showed that dormant 1 + 1 year transplants survived a 28 day period of waterlogging at 15°C, whereas this treatment killed actively growing plants. Visible symptoms in active plants were variable, but usually included yellowing of current foliage, and browning of young, sub-apical leaves. Death and browning of the cambium progressed upwards from the roots into the stem, and brown deposits developed in the transfusion tissue of needles of affected plants. Draining of the soil, after a lethal period of waterlogging, accelerated the death of the plants.

The roots of dormant plants were prevented from growing by waterlogging, but the shoots flushed and elongated, although the shoots and needles extended less than those of freely drained controls. Root growth of active plants stopped after the soil was waterlogged, and shoot growth stopped after about 14 days.

The transpiration rate of dormant plants decreased to a very low level during the days following waterlogging, while that of plants waterlogged when in an active condition followed a characteristic pattern, i.e. there was a rapid decrease for two days, followed by an increase which continued over a period of 10–14 days. The transpiration rate then declined and visible symptoms appeared in the leaves.

The leaf water potential of waterlogged dormant plants (−15 bars) showed that they were stressed more than the controls (−10 bars) throughout the period of waterlogging. In plants waterlogged when actively growing there was often a brief period of water stress about one day after waterlogging, coinciding with the initial drop in transpiration rate, and sometimes accompanied by temporary wilting of the shoots. The plants then recovered their moisture status, with leaf water potential at −12 bars as symptoms of senesence became noticeable in the leaves. When senesence of the leaf and cambium had become well advanced, increased resistance to water flow was observed in the xylem of stem and hypocotyl, and a water potential of −30 bars was often observed in the leaves.

The observations indicate that death of shoot tissues under waterlogged conditions is not primarily due to water stress, although water stress may build up and kill the already senescing plant. The symptoms in plants waterlogged when in an active state suggested a toxic effect, probably caused by substances from the waterlogged soil. Transpiration is maintained at quite a high rate by water absorbtion by roots which are dead. The relative tolerance of dormant plants is due partly to the lower sensitivity of the root to anaerobic conditions, but could also depend upon the slower uptake of toxic substances from waterlogged soil as a result of greatly reduced transpiration.

M. P. COUTTS

The Effect of growth regulators on secondary growth

An investigation into the roles of plant hormones in secondary growth has been carried out to aid our understanding of the processes which control the development of the structural root systems of trees. The hormones indole-acetic acid (IAA) and gibberellic acid (GA_3) and the cytokinin 6-benzylaminopurine (BAP) were applied factorially in lanolin to the roots and stems of 3-year-old Sitka spruce seedlings in controlled experiments.

All the treatments applied, with the exception of GA_3 alone, stimulated the growth of the xylem, phloem and tissues exterior to the phloem, in both roots and stems. The stimulation was confined to the point of hormone application with no evidence for basipetal or acropetal transmission.

In the roots, in both the xylem and phloem, the greatest stimulation was observed with a combination of GA_3 and BAP. GA_3 appeared to enhance the effect of BAP. This is an interesting finding since GA_3 alone had no effect. In the root tissues exterior to the phloem, growth was stimulated in all treatments except GA_3 alone, although the effect of BAP was confined to the parenchymatous cells of the pericycle.

In the stems similar responses were observed to those reported for the roots, although the greatest stimulation of all tissues occurred with the combination of IAA and BAP. The tissues exterior to the phloem consist of the cortical parenchyma and periderm and, as in the roots, the effect of BAP alone was confined to the parenchymatous cells with no stimulation of the periderm.

In addition, BAP affected the differentiation of the initials of the vascular cambium so that in both roots and stems the proportion of ray parenchyma was abnormally high in the xylem. In the BAP treatment the proportion of ray tissues by volume in the xylem was 31 per cent in the stems and 34 per cent in the roots, whereas in the lanolin control plants there was only 6 per cent ray tissue in the stems and 10 per cent in the roots.

The results of this work are being applied in an attempt to improve the success of grafting in Sitka spruce.

J. J. PHILIPSON

Vegetative Propagation

Experiments have demonstrated that leafy cuttings from Hybrid larch ortets less than three-years old can be propagated vegetatively without hormone pre-treatment. Rooting levels were generally greater than 90 per cent.

It would be preferable to use leafless cuttings since handling problems are virtually eliminated. Leafless cuttings can be callused and rooted by damp storage in polythene bags in the dark at 20°. However, even though 100 per cent callusing has been achieved, survival and rooting after transfer to mist conditions has been poor. The highest levels of rooting with leafless cuttings (circa 80 per cent) have been attained under mist after nine weeks storage at 2° where no callusing occurred.

Leafless cuttings of Hybrid larch have also been rooted out of doors during the winter, with the cutting bases heated and the tops exposed to the cold conditions. The rooting levels achieved were low (20 per cent).

A. JOHN, J. SIVILL

FOREST PATHOLOGY

Fomes annosus

Species susceptibility

In a premature felling of a species susceptibility trial, the following incidence of stem decay caused by *F. annosus* was found in 16-year-old trees; Western hemlock (21 per cent), Leyland cypress (19 per cent), Douglas fir (11 per cent), Western red cedar (7 per cent), Noble fir (2 per cent), Lawson cypress (2 per

cent), Omorika spruce (1 per cent), but no infection was recorded in Norway spruce, *Abies concolor* or *A. homolepis*. The maximum vertical extent of decay was 1·1 m.

Although there is little data on the relationship between disease incidence and age, a recent study in a 26 year-old stand in the Forest of Dean has shown that infection in Western hemlock increased from 14 per cent at 19 years to 62 per cent at 26 years. In comparable Grand fir only 4 per cent were infected in the later assessment, confirming the relative resistance of young Grand fir.

B. J. W. GREIG

Decay in Sitka spruce

In 1971 *Fomes annosus* was introduced into three previously unthinned, first rotation, pole stage crops of Lodgepole pine and Sitka spruce in mixture by inoculating the stumps of 40 freshly-felled Lodgepole pine. One of the crops inoculated in this way was growing on a gleyed, sandy, mineral soil of pH 4·6 which had previously been cultivated for agricultural use. The other two crops were growing on deep peats of pH 3·5 (approximately). Six years after inoculation, surrounding live Sitka spruce were excavated and examined for infections. Infected trees were felled and sectioned to determine the extent of *F. annosus* in the stem. On the mineral soil 26 trees were killed and 92 were infected but remained alive. *F. annosus* invaded the latter to a mean height of 0·91 m with a maximum in one tree of 2·85 m. No trees were killed on the peat soils but 36 and 23 became infected. The mean and maximum figures for growth of *F. annosus* were 1·45 m and 2·75 m and 1·43 m and 3·65 m respectively.

D. B. REDFERN

Dutch Elm Disease

Research on Ceratocystis ulmi

Millions of young root suckers of English elm (*Ulmus procera*) are now developing in the original outbreak areas and have the potential to form replacement trees. However they are no more resistant to the disease than their parent trees, and when they are large enough to support beetle breeding the disease may return to destroy them. This in turn depends greatly upon the future of the aggressive strain: whether it will die out in the face of a declining host and beetle population, or whether it will survive. At present there appear to be three possibilities for decline of the aggressive strain: direct replacement by the non-aggressive strain; hybridisation with the non-aggressive strain to give rise to intermediates (Brasier and Gibbs, 1976); or decline through internal genetic processes to a less pathogenic form.

Previous work indicated that a mechanism existed which might inhibit hybridisation of the two strains (Brasier, 1977). This possibility has been tested experimentally. To test cross-fertilisation under as natural conditions as possible, mites were used to carry spores from one strain of the fungus to the other. Abundant perithecia (the sexual stage) were produced only when the aggressive strain was fertilised by spores of a compatible aggressive isolate, but none when the spores were of a compatible non-aggressive isolate (Plate 4AC). This confirms the existence of a mechanism inhibiting hybridisation of the two strains. Such hybrids are therefore unlikely to contribute to a decline of the present epidemic (Brasier, 1978).

Mites from diseased elm bark in nature were found to be carrying numerous

spores of *C. ulmi* (Plate 4BD) and are thought to be the main agency of fertilisation of *C. ulmi* in nature, and to be important in distributing the fungus in the beetle galleries (Brasier, 1978).

The centres of origin of the aggressive and non-aggressive strains are being investigated experimentally and geographically. In October 1977, a survey was conducted in the Caspian Forests of Iran which showed that the aggressive strain occurred from Astara on the Russian border in the west to Chachkam 600 km further east. Only the non-aggressive strain was found at Golestan in the extreme east of the region. The data suggest that the aggressive strain entered Iran only recently from the Russian border area at Astara, and was probably responsible for the serious disease outbreak in this area of Iran in 1971. The outbreaks of the disease which occurred in the Volga region of Russia at the northern end of the Caspian Sea in 1968–70 (Kryukova, 1972) could well be related. From an interpretation of Kryukova's (1972) data it is likely that both strains are present in this part of Russia (Brasier and Afsharpour, in press).

C. M. BRASIER

Spread of the Disease

Dutch elm disease continued to spread in Britain in 1977 and, although no survey was undertaken, it is estimated that about 50 per cent (approximately 11 million trees) of the elms in southern England have now been killed. The disease is now fairly widespread in nothern England, and in Scotland several thousand trees were diseased. The aggressive strain of the fungus was also confirmed from Ireland and Guernsey.

The hot, dry summer of 1976 provided very favourable breeding conditions for elm bark beetles, which subsequently emerged in 1977, thus partially accounting for the increase in infections reported from many previously lightly affected areas.

B. J. W. GREIG

Beech Bark Disease

In Britain, the Continent and North America a "mid-slope" concentration of disease symptoms has been reported. Most British observations come from chalk downland where nutritional conditions may be involved. Nutrition may interact with other factors on these sites. A suggested causal factor common to slopes irrespective of soil type is the topographically influenced dispersal of the pathogens. An attempt to detect this effect consisted of surveys of early *Cryptococcus fagi* infestation on two non-calcareous slopes in Tintern Forest, Gwent. The distribution of trees with moderate and heavy infestation showed no concentration at any points along the slope profiles.

A complementary study of the effects of nutrition on disease incidence has become possible due to the occurrence in an unthinned stand in Arundel Forest, W. Sussex, of a distinct spatial separation of trees with and without nutritionally induced foliar chlorosis. Ground surveys showed this separation to be related to ancient land use.

The results of wound-inoculating *C. fagi*-infested trees with *Nectria coccinea* (Figure 3) indicate that cankering is most severe on heavily infested trees and that the role of *C. fagi* in this disease is not limited to facilitating initial entry of

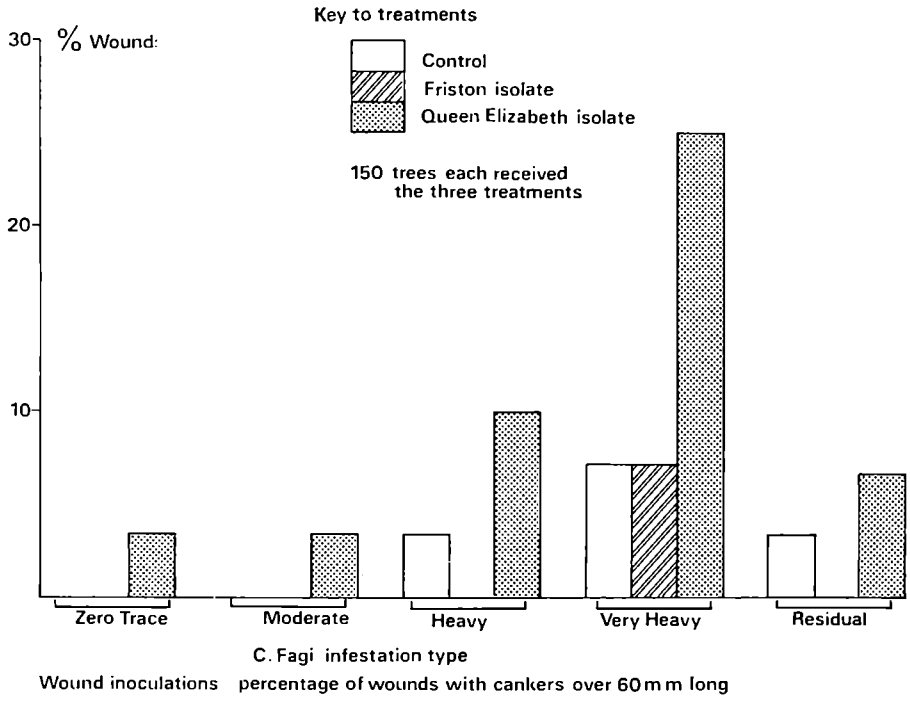

Figure 3: Wound inoculating *Cryptococcus fagi*-infested trees with *Nectria coccinea*.

the fungus. Some natural infection occurred as evidenced by the results for the "controls".

D. LONSDALE

Advisory Services

Alice Holt Lodge

Seven hundred and thirty inquiries were received excluding those on Dutch elm disease. Consequences of the hot dry summer of 1976 (*Report* for 1977) accounted for many of these: bark necrosis of beech, birch and sycamore became increasingly apparent, and many affected trees, especially beech, died; the Sooty bark disease of sycamore epidemic continued; *Rhizina undulata* developed abundantly on the sites of forest fires in the New Forest, Hampshire, and there were many cases of possibly drought-linked premature loss of older foliage of X *Cupressocyparis leylandii* 'Haggerston Grey'.

Numerous cases of Phytophthora root rot, mainly on Sweet chestnut and Lawson cypress, were probably consequent on very wet conditions in September 1976. Four cases of Beech seedling blight—an infrequent disease in Britain—were apparently associated with wet periods in the spring and early summer of 1977. *Phytophthora cactorum* is usually the cause, but in one case we found *P. citricola.*

Venturia tremulae was recorded causing spotting, blotching and complete blackening of leaves and death of shoots on several *Populus tremula* in Surrey; apparently there is only one previous record of this fungus in England (Peace, 1962).

Collybia fusipes, a fungus scarcely mentioned in the literature as a parasite, was isolated from diseased roots of several large, dying *Quercus robur* and one dying *Q. borealis*.

Stereum purpureum was observed fruiting on dead parts of live *Sorbus aucuparia* and *Acer saccharinum* in circumstances suggesting a causal relationship.

Conspicuous white patches of *Athelia arachnoidea*, a fungal parasite of lichen, developed on the trunks and boughs of many broadleaved trees in the autumn and caused needless alarm in the south.

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

Northern Research Station

Two hundred and eighty-seven enquiries were received during the year. One hundred and forty-seven of these concerned Dutch elm disease which continued to spread in Scotland and North England. It was recorded for the first time in the Dumfries area of Dumfries and Galloway Region and on Deeside in Grampian Region.

As in previous years the most frequently recorded damaging agencies other than Dutch elm disease were cultural malpractice (planting failure and misuse of chemicals) and climate (drought). Failure at planting was notably more serious than usual and the 1976 drought resulted in widespread death and dieback of large beech.

Dothiorella ulmi Verral and May was associated with cankers and dieback on Wych elm (*Ulmus glabra*) throughout eastern Scotland and north-east England. Wound inoculation in February 1977 of one-year-old shoots on trees 5 m tall resulted in dieback or caused the formation of typical cankers at the point of inoculation by the following June. *D. ulmi* was recovered from shoots with both symptoms. This is the first record of this disease in Britain. *D. ulmi* was also isolated from similar cankers on a lime tree in Edinburgh.

Death of one and two-year-old Lodgepole pine seedlings in a nursery at the Northern Research Station was associated with a fungus showing many of the characters of *Phytophthora cactorum*.

Several cases of death and dieback of large sycamores have been reported in the last few years. Investigation of one occurrence on an estate in Cumbria revealed numerous perennating cankers on the mainstems of many trees. Various fungi were isolated from the bark and wood of these cankers and work is continuing. In another report, wilt and dieback of branches was associated with *Nectria cinnabarina* lesions.

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

Arboriculture, Department of the Environment Contract

Decay in Amenity Trees

A pulsed electric current meter (Shigometer) has been tested for its use in decay detection in standing trees. It is proving to be a useful research tool, and decay assessments have been successfully incorporated in three-dimensional mapping of stain and decay columns. It is used routinely for the assessment of decay in pruning-wound experiments.

Quick laboratory tests have been devised for testing the phyto- and fungitoxic effects of various proprietary sealing and fungicidal products. These are also being tested on pruning wounds of beech. Although sealants restrict the number

of fungi found in wounds up to 18 months after pruning, the wounds appear more deeply stained than untreated wounds and contain more bacteria. The long-term implications of this are being studied.

Antagonism trials on agar in Petri dishes, using the fungi most commonly isolated from beech pruning wounds, have suggested *Cryptosporiopsis fasiculata* and *Fusarium lateritium* as possible agents in biological control. Further trials on wood-strips and in the field are planned.

The culture collection of fungi associated with pruning wounds and decay is being expanded; detailed records and descriptions are filed for easy access, the basidiomycete section being on punch-cards. Initial attempts to use serology and immuno-fluorescence as an aid to basidiomycete identification have had some success in the genus *Stereum*.

P. C. MERCER

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FOREST ENTOMOLOGY

Population Studies

The Green Spruce Aphid, Elatobium abietinum

Studies on the effect of subzero temperatures on aphid survival have been resumed. Previously, temperatures of −8°C or lower have been observed to cause a significant mortality. Such losses were thought to occur particularly during frosty periods when superficial moisture is deposited on aphids and foliage, first as dew, and then as ice crystals. Laboratory simulation of similar conditions have provided evidence that this is a direct cause of mortality.

D. BEVAN, C. I. CARTER

Cephalcia lariciphila (= *C. alpina*) *The Web-spinning Larch Sawfly*

Twenty forests are affected by this pest in Wales and the West Midlands. In most of the infestations, annual defoliation is severe and the area has increased from approximately 1,500 ha in 1976 to 2,500 ha in 1977.

Damage was most extensive in the South Wales Conservancy in 1977, covering 1,700 ha which represents 14 per cent of the total larch under plantation.

The Unit of Invertebrate Virology sampled all the infestations during 1977 for the presence of an epizootic of *C. lariciphila*. The results of this survey will not be available until larvae of *C. lariciphila* are obtained in 1978 for infectivity tests.

D. J. BILLANY

Gilpinia hercyniae. The European Spruce Sawfly

During 1977 populations of this pest reached a damaging level in some of the areas seriously affected in mid-Wales during the period 1968 to 1971. Damage is notably confined to the spruce at higher elevations over a forest area of 130 km^2. Overwintering populations of forty cocoons per m^2 were found in the defoliated areas.

The Unit of Invertebrate Virology has continued research into the virus epizootic of *G. hercyniae* and in promoting its applied use for the future, should the infestation continue unchecked.

D. J. BILLANY

Beech Scale, Cryptococcus fagi

In a study of dispersal, the deposition of first instar larvae onto uninfested trees was examined using sticky bands placed around the boles at different heights. Significantly more larvae were deposited per unit area on trees of small diameter (7–10 cm) than on larger trees (diameter 15–20 cm), with most larvae trapped on the lower part of the trunk.

The number of larvae deposited on lightly infested trees from which the adults had been removed and which were distributed around a heavily infested source tree, was proportional to the diameter of the tree and its distance from the source. The number of larvae deposited on these trees appeared to be unrelated to the number of adults previously present. Some trees with high immigrant populations of larvae had low adult populations, suggesting they may be less susceptible to attack.

D. WAINHOUSE

The Pine Looper Moth, Bupalus piniaria—Annual Pupal Survey

Last year only Tentsmuir (Fife) returned a compartment mean in excess of 20 pupae per m^2 (69·6). This year three units have done so—Cannock doubled to 34·8, Sherwood IV a seven-fold jump to 27·2 and Langdale with a 50 per cent increase to 21·6 per m^2. This winter, increases of population are greater than the decreases except at Tentsmuir (now 6·4) One hundred and two ha were sprayed with an insecticide (see section on chemical control).

R. M. BROWN, D. J. BILLANY

Torymus druparum—The Wild Service Seed Wasp

It was found that *Torymus druparum* (Hymenoptera) infested 80 per cent of the seeds of *Sorbus torminalis* which are used for amenity planting. This insect also occurs in the seeds of other *Sorbus* and *Malus* species. An exploratory survey made in the autumn of 1977 showed that three quarters of the trees in Southern

England were affected. In the Midland and Eastern counties 15 per cent of the *S. torminalis* were infected but at much lower levels than in the South.

T. G. WINTER, M. R. JUKES

Host Plant Susceptibility

The Green Spruce Aphid, Elatobium abietinum

Studies on the seasonal changes in the amino-acid spectrum in the foliage of various Sitka spruce provenances and the periods of susceptibility to *E. abietinum* have continued. Application of selected fertiliser formulations to the trees were found to alter the periods of growth and thus their susceptibility.

C. I. CARTER

Other Aphids

Certain groups of broadleaved and ornamental trees are being screened for differences in susceptibility to aphid attack. Particularly included are the species and hybrids of Lime (*Tilia*) of which one (*T. x euchlora*), is reputed to show some resistance to the Lime Aphid (*Eucallipterus tiliae*) and hence the honeydew problem.

C. I. CARTER

Biological Control

Pine Beauty Moth, Panolis flammea

The very high population at Rimsdale, Naver Forest (Highland), in 1976 continued in 1977. Aerial application of a preparation of *Bacillus thuringiensis* proved unsuccessful. The material is a stomach poison but it was found that, on Lodgepole pine, the larvae feed within young needles for several weeks and so do not ingest treated foliage.

A second outbreak area was found during the year, also in Naver Forest, bringing the total area killed by defoliation to 240 ha. A pupal survey of all Lodgepole pine areas in Caithness and Sutherland during the autumn indicated that 4,600 ha were at risk and would require treatment in 1978.

J. T. STOAKLEY

Cephalcia lariciphila

The larval parasite of *C. lariciphila*, *Olesicampe monticola*, is having a controlling effect locally at Margam Forest (West and Mid-Glamorgan). This parasite has been found in the other eight infestations in South Wales, but has not yet reached an effective level. The parasite's status is not known in the other infestations.

The role chemicals (kairomones) play in the host/parasite relationship and their applied use for managing the parasite as an effective pest control measure is being studied with the Insect Chemistry Unit, Southampton University.

D. J. BILLANY

Cephalcia lariciphila—Pheromone response and sexual behaviour

Trapping experiments and observations of sexual behaviour were made on *Cephalcia lariciphila* in infested larch in May 1977. The results indicated that

virgin females and dichloromethane extract of virgin females were highly attractive to males. Males responded to females throughout the warmest part of the day. Females became unattractive to males within 10 minutes after mating. There was no evidence of an anti-attractive pheromone or pheromone mask. The preferred flight level for males is near the ground. A few males were captured dispersing from infested larch. Horizontal board traps were found to be superior to the other three types of trap assessed. The observations and results suggest that the best applied uses of *C. lariciphila* pheromone would be in survey and detection, and male disruption techniques. Research along these lines is projected for 1978. The significance of pheromones in this pest is also being studied in conjunction with the Insect Chemistry Unit, Southampton University.

*J. H. BORDEN, D. J. BILLANY

Gilpinia hercyniae

A consignment of parasites specific to *G. hercyniae* larvae was received from the Commonwealth Institute of Biological Control during 1977. These were released at Rheidol (Dyfed) and Coed Sarnau (Powys) Forests, both against natural populations and in cages containing spruce artificially infested with larvae of *G. hercyniae*.

A larval parasite, *Lamachus marginatus*, Ichneumonidae, was found occurring naturally during 1977 at Ystwyth and Rheidol (Dyfed) and Coed Sarnau and Hafren (Powys) Forests. The significance of this parasite is being studied.

D. J. BILLANY, C. I. CARTER

Bupalus piniaria

At Tentsmuir (Fife), one compartment with high numbers was left unsprayed in the chemical control operation for the purpose of carrying out a study of the natural development of the *Bupalus* population. Survival was good up as far as the fourth instar larva. Then in late October-November the population declined sharply from 221 larvae per m^2 to 7·4 pupae per m^2. The parasite *Campoplex oxyacanthae* was one important factor accounting for approximately 70 per cent of the *Bupalus* larval population. (See section on chemical control).

D. A. BARBOUR

Chemical Control

Bupalus piniaria—Pine Looper Moth

Following the very high pupal numbers recorded in last year's survey at Tentsmuir Forest (Fife), egg counts were carried out in July and August to assess the progress of the population. In the ten highest compartments a mean of 1,926 eggs per tree was found. This fell below the criterion of 3,000 eggs per tree regarded in the past as being the figure likely to result in severe defoliation. However, East Scotland Conservancy decided to carry out aerial spraying against larvae partly in the light of the amenity value of the area which is close to the popular Kinshaldy Beach picnic site. On 24–25 August, 102 ha were sprayed by helicopter with the organophosphorus insecticide tetrachlorvinphos at 0·56 grams ai per ha. At the time, counts of dead larvae falling from the

*Dr J. H. Borden, visiting scientist from Simon Fraser University, British Columbia, Canada, in 1976/1977.

trees indicated that a high percentage kill had been achieved. In the 1977/78 pupal survey populations range from 0·0 to 2·0 per m^2 in the sprayed area.

R. M. BROWN, D. A. BARBOUR

Hylobius abietis

The three field trials established in 1976 to evaluate the insecticide Thimet (phorate) were assessed during the year (see 1977 *Report*). The two rates of application to Japanese Paperpot planting stock showed good control of *Hylobius*, both in the field and in laboratory bioassays. The higher rate of 0·75 grams ai per plant being marginally better. Due to high planting losses, occasioned by the extreme drought of 1976, these trials will now be concluded in late autumn 1978.

C. J. KING, S. G. HERITAGE

Elm Scolytids

Scolytus scolytus

Studies of the behaviour and pheromone chemistry of *S. scolytus* were continued during the year in co-operation with the Unit of Invertebrate Chemistry and Physiology of the Agricultural Research Council.

Field experiments, using virgin beetles boring into English elm billets placed inside sticky-mesh traps, were established in late May and June 1977. The traps, containing males only, females only, males with females, and elm billets only, were exposed to a natural population of flying beetles. Results show that the male *S. scolytus* produces the aggregation pheromone.

Investigations into chemical compounds showed that virgin males produce large quantities of 4-methyl-3-heptanol, whilst the females produce mostly multistriatin alpha cubebene, a host plant volatile was released by both sexes. Further field trials using these compounds separately and in combination as bait in sticky-traps, showed cubebene to synergise 4-methyl-3-heptanol thus enhancing its attractiveness to *S. scolytus*. Multistriatin appeared to act as an antiattractant when added to the other two compounds.

Future work will aim to determine the most active isomers of the pheromone constituents and the activity of some terpenes and sesquiterpenes produced by the host plant.

*J. H. BORDEN, C. J. KING

Advisory Services

At Alice Holt, 109 enquiries were received from Forestry Commission staff and 35 at the Northern Research Station. The number of private enquiries received at Alice Holt was 145, while at the Northern Research Station there were 16.

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WILDLIFE MANAGEMENT

Management of Deer, Squirrels and Other Mammals

Examination of material from the red deer hinds culled from stocks resident in forests suggested that reproductive performance is considerably higher than in open hill stocks. A high proportion of pregnant yearlings and a very low incidence of yeld hinds occurred. Work has also been done on roe deer performance in the Border Forests in comparison with data from Powerstock Forest (Dorset), and forests in south Scotland.

The annual Squirrel Questionnaire showed that grey squirrel damage levels had not altered significantly nor had range and abundance of either species changed. Breeding in spring 1978 appeared to be low and patchy. Two large enclosures in which it is hoped that mating will take place were completed.

Chemical and Mechanical Repellants

Investigation of possible alternatives to the standard 31 mm hexagonal mesh netting against rabbits showed that a rectangular welded mesh 50 × 25 mm is a potential candidate. While 75 × 25 mm mesh stopped rabbits it is likely that in the light gauge required for fencing large areas a break-down of one mesh would leave a gap large enough for rabbits to penetrate. However, this size is useful for individual tree protection where the guards can be almost self-supporting. The light-degradable polythene net tube under trial against deer and rabbit browsing has given satisfactory protection to the leading shoots for two winters. No new chemical repellant candidates turned up from this season's trials.

Damage Assessment and Evaluation

Development of new methods of damage assessment has made it considerably easier and quicker to get an objective measurement of damage occurring over a large area. A comparison of the amount of grey squirrel damage occurring in pure beech and mixed beech/conifer crops suggested that the mixtures were not significantly more prone to damage than were pure crops. However, the reduction in numbers of broadleaved stems on the ground left fewer silvicultural options open for future treatment of mixtures.

J. J. ROWE

ENGINEERING SERVICES

Design and Manufacture of Equipment

The Rotating Drum Dryer, built for the Seed Branch, has been modified and now operates satisfactorily. A Macerator was built and tested which removes the outer pulp from the fruit of some hardwood species.

Four Inductive Loop Detectors have been installed in the New Forest, Hampshire to monitor vehicle traffic. Each detector is connected to a battery operated 7-day event recorder.

A Post Jig, to cut a groove in round posts, was made. Following field trials the jig was considered unsafe for forest use and withdrawn. Another design has been made and is awaiting trials.

An experimental model of a linear measuring machine was constructed to test the procedures necessary to measure such things as tree discs, cores, etc. Initial tests were satisfactory and a production machine will be built.

A caliper was designed to measure the upper diameter of trees in dense stands (up to approximately 12 m high) without climbing the trees. A prototype was built and is undergoing trials with the Field Surveys Branch.

A method of setting up insect traps at tree height (approximately 12 m) was evolved, using a crossbow to fire a light line across the top of the tree. This enables a heavier line to be erected from tree top to tree top, approximately 200 m long. Further work is progressing to adapt this method to tree climbing.

Maintenance of Electro-mechanical Services

An experimental safety light was installed in the main building. Two ventilation fans and aspirated screen were installed in the 80 ft Polytunnel. Alloy benching was erected in the Crittall greenhouse. Drying frames, to allow air drying of sacks of cones, were erected in an open-fronted shed.

Maintenance of Existing Equipment

An extractor fan was fitted to the mixing machine in the potting shed. The soft water supply fitted in the seed germination room has been successful. Only minimum maintenance has been given to the germination tanks, particularly since level detectors were fitted to the water tanks.

Engraving Service

An engraving machine and accessories were purchased for Westonbirt Arboretum.

R. E. STICKLAND

FIELD SURVEYS BRANCH

FIELD SURVEY SECTION

Surveys

Aerial survey was adopted as the principal method of mapping during the year. Staff training in the uses of this method is well advanced and two courses in the field completion of maps were conducted by the Ordnance Survey. Investigations

are in progress into the extension of aerial photography to the crop assessment phase of surveys.

The shortage of surveyors has led to a continuing slippage in the survey programme. Forty-three thousand ha were completely surveyed against a desirable programme of some 65,000 ha. Agreement was reached during the year concerning the employment of non-forester grades as survey assistants, and arrangements for recruitment are now in hand. It is clear, that with more staff and faster survey methods a substantial improvement in the rate of progress will be achieved within the next year.

Production Forecasting

The production forecast for the 1977 quinquennial valuation under the new system was completed on time. Arrangements for annually updating the Sub-compartment Data Base are well advanced.

Further developments in the use of the Data Base as a management information system has progressed more slowly than was originally planned due principally to a shortage of experienced computer programmers.

Census

Development work into the use of aerial photography in a general census of trees and woodlands has progressed to a point where the design of survey systems for the census is nearing completion.

Other Projects

The Elm Disease Survey was extended into Scotland on a reconnaissance basis but no survey was conducted in England and Wales.

Some assistance was given for the survey of Pine Beauty moth damage in North Scotland.

SITE SURVEYS SECTION

Work in Scotland concentrated on surveys of the plantable reserve with a small amount in established forests. With the increased incidence of windthrow during the past few years, demand is rapidly developing for site information in established forests. It is apparent therefore that the assumption that Site Surveys in Wales and western England were virtually complete requires a thorough re-examination. An extension of surveys into the upland forests generally will require substantial increases in manpower.

MENSURATION SECTION

Seminars were held in a number of Conservancies to bring local management up-to-date in developments and to stimulate interest in the services offered by this Section. As a result, the number of enquiries, particularly concerning the tariff system, has increased.

The Section is now fully up to complement and progress with development work is regaining momentum. In particular, the assortment forecasting service which has been promised for some time should now be available in 1978.

The establishment of the detailed sample plot data bank has been given high priority and work is progressing well. This phase of the project should be

completed during 1978/79. It is evident, however, that greater computer programming power will be required if full advantage is to be taken of this new facility.

DRAWING OFFICE

The preparation of draft maps from aerial photography is now well established, and the necessary reorganisation of the office is complete. Consequential training plans for Cartographic staff have been agreed and courses to cover immediate needs have been arranged.

K. P. THALLON

WORK STUDY

Forest Management: Method Study

An examination of respacing of both naturally regenerated and planted crops was completed.

Weeding developments include the modification of the Herbi to give a fixed dose spot treatment and continued involvement in tractor mounted controlled droplet applicators. A Lockinge Ulvamast capable of both placed and drift spray has been on trial. A tractor mounted CDA sprayer developed in East England Conservancy reached the finals of a BP/Big Farm Management competition.

Ploughing trials continue in North Scotland on both gleys and peats and a lightweight plough developed from the D60 plough shows promise on the very soft peats.

Forest Management: Servicing

Trials of the Holder A55 frame steered tractor continued but fitted with a front mounted Shaw weeding flail. This combination showed some potential as a narrow gauge, tractor powered inter-row weeding machine.

Extended trials with the Scrubmaster 66 brushcutter were completed.

Generally, liaison with chemical, spraying and protective clothing firms has been maintained and several new ideas in these fields are under active review.

Forest Management: Work Measurement

An Output Guide for tractor mounted controlled droplet applicators was prepared and one for the Herbi is in the course of production.

Harvesting and Marketing: Method Study

A major investigation into Brandon Central Depot was carried out. The subsequent recommendations included a revised layout incorporating new peeling and conversion units, a new road system and improved office, staff and workshop facilities. An increased throughput of 40 per cent (over the present 50,000 m^3/year) was predicted with reduced unit treatment costs and the elimination, where possible, of the existing costly waste disposal systems. Safety, environmental and staffing factors were also stressed.

The Bray front end loader continued trials in East England Conservancy after factory modifications.

An examination of whole tree chipping in the forest was carried out in North Scotland Conservancy. Continued contact with potential customers regarding chips from stumpwood and lop and top as well as conventional chips was maintained. The market for such material at the moment is very limited and without obvious prospect for improvement.

Studies were carried out to determine what time saving could be achieved by the use of a radio for double drum winch control. The results indicated savings on terminal time of about 19 per cent.

Extraction trials in the south of England compared the frame steered Holder A55 tractor to the Ford 4000, working with hydratongs. While the Ford was capable of overall greater load size, the Holder showed promise in extremely restricted and difficult areas.

Comparative work on two grapple cranes (HAP 216 and HIAB 560) was carried out.

A study of the Timberjack 360 skidder on a variety of terrain types and under differing crop conditions was completed.

The Sifer delimber was subjected to trials in most of the major species and under differing conditions. The complete method of its use, including preparatory felling and subsequent extraction, was examined.

An exercise in the comparison of cable crane systems and their possible application in the Commission was carried out. The evaluation of the Trailer Alp continued including work on line thinning in West Scotland Conservancy. Also the Forestry Commission mounted Alp was studied on clear fellings in North Scotland Conservancy as a basis for a subsequent comparison with the Trailer Alp.

A start has been made on the examination of aid tools used throughout the Commission.

A trial of the Husqvarna SP26 delimber mounted on a Gremo TT12C forwarder is ongoing. The delimbing head is very effective working faster than the Sifer, due largely to electro-magnetic controls. Feeding of the head is carried out by an hydraulic crane, which also clears away lop and top and loads the produce on to the forwarder/trailer.

A report on the TGT forwarder was prepared.

Harvesting and Marketing: Servicing

A method of shortwood working extensively used in Sweden was investigated. The results showed that basic times are very similar to those for the conventional method but it does offer very considerable advantages to the operator by virtue of a reduction in effort and improved working posture.

Six models of chainsaw were tested during the year.

Harvesting and Marketing: Work Measurement

Four new or revised standard time tables and output guides were issued during the year covering peeling by Cundey peeler, crosscutting at roadside using a chainsaw, loading, carriage and unloading lorries and clearfelling Sitka spruce using the Work Bench method.

Tables under preparation and to be issued shortly include clearfelling of Scots and Corsican pine and Sifer delimbing in all major species.

Forest Authority

The Rapco data recorder has been introduced into full field usage and the total holding has been increased to four machines. The advantages of increased accuracy and fast collation of data are striking, especially as operators become fluent in the use of the machines.

Safety

Trials of alternative protective clothing for use in herbicide application have commenced and noise and vibration levels of chainsaws have been measured as part of routine trials.

The draft Safety Guides have been monitored and recommendations made to the Forestry Safety Council regarding their content.

Regular regional meetings of Work Study, Safety Officer and Education and Training Branch have taken place to co-ordinate the approach of the Branches towards ensuring the application of safe techniques in forestry operations.

Training of Forestry Commission Staff

Work Study Branch members conducted a series of Work Study Appreciation courses for forest workers in all Conservancies.

A. J. G. HUGHES

STATISTICS AND COMPUTING

Data Preparation and Computing

Punching of the older sample plot data at the PMA bureau, Horley, continues, and the largest task this year has been the validation and correction of these files. Loading of all sample plot files to the Rutherford Laboratory IBM 360/195 system has started with the help of staff at the MAFF computer centre at Guildford.

Genetics branch have instigated work on a data-base for tree breeding.

Statistical Service to Research and Development Projects

Advice on experiment and survey design, analysis and the interpretation of results continued to take up most of the statisticians' time. Special mention can be made of surveys of Pine Beauty pupae in some Scottish Lodgepole pine forests, and experiments in urban arboriculture and decay in amenity trees.

Statistical Service to External Units

Help was given to South Scotland Conservancy in planning another survey of deer damage in Galloway, and to the Department of Agriculture of Jersey in planning and analysing a survey of the distribution of their trees. A striking result was that it appeared that over 40 per cent of the trees in Jersey are elms!

Programming Service, General

A summary program was written to access the sub-compartment data-base and produce an area analysis of the present state of all crops. This consisted of a

breakdown by species, planting year and yield class for pure and mixed crops separately, with the addition of an analysis of mixture types and a combined summary. Preparations were made to update and expand the data-base, to increase the number of species recognised, and to provide for the inclusion of all land and its legal status.

Programs were written to analyse the data of the pilot and main surveys for the West Sussex census of woodlands in preparation for the proposed new national census.

Many other miscellaneous programs have been written such as one to facilitate weekly updating of germination counts; one to draw 3-D histograms in perspective on the IBM 1130; and one to calculate estimates of deer populations in forests based on field data.

Programming Service, Mathematical/Statistical/Technical

A general FORTRAN program was developed to produce "neighbourhood" seed-orchard designs. A user's manual and a paper for publication are in preparation.

When a plane Poisson process is sampled by a random plot the expected nearest neighbour distance is a function of the plot size and shape. A program was written to calculate this effect for circular plots by numerical quadrature. A program to compare results for square plots with Persson's simulation study is being developed.

Statistical, Mathematical and Computing Methods

A study has been made of methods for fitting the distribution of dispersal from a point source. The usual regression methods have been compared with that of maximum likelihood for a more general model. Some theoretical work has been done on soft-core competition processes in the plane. Several short courses on elementary mathematics, statistics, data analysis and computing have been conducted for various groups of R and D Division staff.

Data Capture and Associated Computing

A Racal Termicette magnetic tape drive was bought, primarily to allow Rapco tapes (see 1977 *Report*) to be read without having to use the transcription service kindly given us by the Road Research Laboratory, Bracknell. Later, trials showed that the Termicette could also efficiently receive data over the public telephone system from a MSI 77 hand-held terminal. In agreement with Field Surveys Branch, three MSI 77 devices have been ordered for extensive trials to assess methods of recording field measurements of research data directly into a solid-state memory device.

D. H. STEWART, R. S. HOWELL

COMMUNICATIONS

RESEARCH INFORMATION

Library

One hundred and seventy new books were acquired and subscriptions taken out for six new journals. Loans from library stock were 4,343, with a further 751 items borrowed from other libraries. Approximately 2,000 photocopies were sent out instead of library loans. During the year the library Catalogue of Books was revised to December 1976 and published. The list of Periodicals and Serials holding was revised and issued to staff. It revealed that there are over a thousand titles.

Information Services

The Lockheed DIALOG service is now being used, giving "on-line" access to more than sixty databases by telephone. Those found to be most useful are "CAB Abstracts", "AGRICOLA" (the database of the National Agricultural Library of USA) and "CRIS" (Current Research Information system). The last is a database of research project descriptions of most of the publicly supported agricultural and forestry research in the USA.

O. N. BLATCHFORD

PHOTOGRAPHY

The Section continues to provide a general photographic service to the Research and Development Division but this is becoming increasingly limited and basic due to lack of staff. Colour processing equipment has been installed and trials of various film/paper/chemical combinations are being made to find that best suited to the needs for aerial photography.

Aerial Photography

The demand for aerial photography continues to grow. The programme has to be drawn up and priorities agreed early in the year before the start of the flying season. All requests have to be routed via the Chief Field Surveys Officer who acts as co-ordinator.

Though once-only survey flights are likely to continue to be the main requirement, requests to monitor specific forest or urban areas at yearly (or shorter) intervals is increasing. The design of a twin-Hasselblad camera mount for use in Cessna 172 aircraft has been finalised and construction is well-advanced.

Photographic Library

Most existing photographs have now been incorporated into the collection, but there is growing concern about the low rate at which new material is currently being added.

I. A. ANDERSON

PUBLICATIONS

New editions of the Forestry Commission Catalogue of Publications and of the Library Catalogue were published this year. The section prepared for in-house

printing and publication two consultative papers "*Wood Production Outlook in Britain*" (£2·00) and "*The Place of Forestry in England and Wales*".

The ten new priced publications issued through Her Majesty's Stationery Office were:

Reports

Fifty-seventh Annual Report of the Forestry Commissioners, 1976–77 (£2·25).
Report on Forest Research 1977 (£1·90).

Bulletins

No. 57. The Safety of the Herbicides 2,4-D and 2,4,5-T, by D. J. Turner (£1·20).

Forest Records

No. 111. Some Important Foreign Diseases of Broadleaved Trees, by D. A. Burdekin and D. H. Phillips (40p).
No. 112. Monitoring Day Visitor Use of Recreational Areas, by P. S. Collings and A. J. Grayson (65p).
No. 113. Free Growth of Oak, by J. Jobling and M. L. Pearce (50p).
No. 114. Terrain Classification, by A. A. Rowan (70p).
No. 115. Dutch Elm Disease, by J. N. Gibbs, D. A. Burdekin and C. M. Brasier (50p).

Leaflets

No. 69. Starling Roost Dispersal from Woodlands, by F. A. Currie, D. Elgy and S. J. Petty (50p).

Research and Development Papers

No. 116. Impact of Green Spruce Aphid on Growth, by C. I. Carter.
No. 117. Tied Houses in British Forestry, by B. L. Irving and E. L. Holgendorf (60p).
No. 118. Population Aggregation of *Scolytus scolytus*, by J. H. Borden and C. J. King (20p).

Guides

Forests of North-East Scotland, edited by H. L. Edlin (£1·35).

Arboricultural Leaflets

The Stationery Office also published for the Department of the Environment the first of a new series some of which are being prepared by the Forestry Commission in connection with its arboricultural research programme:

No. 1. External Signs of Decay in Tree, by C. W. T. Young (40p).

Posters

Four posters were produced in collaboration with E.P. Publications Ltd to complete the present series of "Forest Trees in Britain", the species being ash, lime, Norway spruce and Sweet chestnut. All the posters have been produced from paintings by Christine Darter.

Other Publications

A pamphlet *The Marketing of Forest Tree Seed and Plants within the EEC* was published to explain the latest Community Regulations which were effective from 1 July 1977.

In addition, revised editions of Forest Record 69, Leaflets 3 and 20, were prepared and published.

K. W. WILSON

OTHER HEADQUARTER DIVISIONS

PLANNING AND ECONOMICS

Forest Policy

Wood Production Outlook in the 21st Century

Contributions were made to the report of the above title (Forestry Commission, 1978) on forecasts of future demand for wood products for the world and for Britain, prospects for increased world supply of roundwood, the profitability of wood growing in Britain under various assumptions and labour and investment requirements associated with different planting programmes.

Quinquennial Financial Review

The Commission's 57th Annual Report for 1976–77 (Forestry Commission, 1978, pp. 8, 29–31, 94–98) reports on the financial performance of the State Forestry Enterprise over the quinquennium 1972 to 1977. The unit cost and price weights assumed in 1972 and expressed in £ of 1977 value were applied to future programmes of work and timber output forecast on the estate existing at the end of 1976–77, in order to calculate the change in asset values over the previous 5 years. This change was then compared with the increase in liabilities accruing at 3 per cent in real terms. Certain accounting changes and other adjustments have led to the adoption of slightly revised cost and price assumptions in calculating an updated asset value as at 1 April 1977 and planting subsidies for the next quinquennium to allow performance over the period 1977–82 to be assessed.

A. J. GRAYSON

Forest Operations

Analysis of Changes in Direct Costs of Operations

As part of studies aimed at the analysis of variations in cost over time, and in different places, an analysis has been made of the causes of changes in the unit direct cost of Forestry Commission operations over the past 7 years. For each element of total cost (labour, machinery, other inputs) the following have been calculated:

(a) change in output per unit of input
(b) change in cost per unit of input, and hence
(c) change in cost of input per unit of output.

The last measure when weighted by the proportion that each element of cost contributes to total expenditure, and summed over all input, gives a result which checks with the observed change in total real costs per unit of output.

A. J. GRAYSON

Financial Control

The system of financial control introduced in 1970–71 (see *Report on Forest Research*, 1971) has been modified in the light of recommendations of a Working Party. One of the principal shortcomings of the original system was that by summarising data by the main operational groups, middle managers had insufficient information for effective control. This was consistent with the principle of management by exception, but this principle did not appear to work efficiently in practice. The Working Party recommended a revision of the district level manager's report so that he could in future receive information on expenditure by resource (labour, materials, machines, etc) for each operation or treatment type within an operation. A booklet has been produced outlining the principles of the revised system and the linkages with investment appraisal and planning.

Price-size Data for Standing Sales

Data on standing sales of Forestry Commission timber have been stored on computer since the end of 1974. A simple program has been written to plot price in updated £s against mean tree volume by species group and by region.

R. J. N. BUSBY

The Influence of Windthrow Risk on Thinning Decisions

Comparisons have been made of NDR at 5 per cent for different thinning options allowing for the risk of windthrow. Because of the uncertainties associated with wind damage, assumptions have to be made on the probability of windthrow occurring throughout a crop's life depending on whether or not the crop

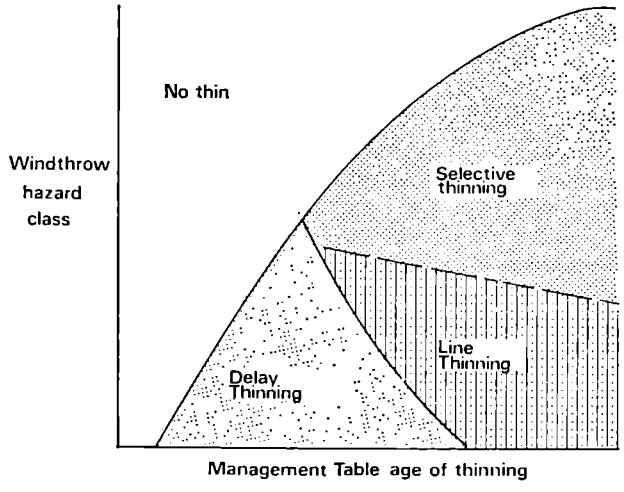

Figure 4: Desirable thinning practice in relation to yield class and windthrow hazard class.

is to be thinned and, if thinned, the timing and type of thinning practised. Only experience will show how realistic the probabilities used in the calculations are, but some useful results have been obtained on how the optimum thinning regime is likely to vary depending on the growth of the crop and windiness of the site. This is illustrated graphically in Figure 4. No values have been inserted on the axes since the position of the boundaries between the different thinning regimes will vary depending not only on wood prices, roading cost and other expenditures associated with each option but also with the probabilities of windthrow for given hazard classes.

J. DEWAR

Recreation

National Day Visitor Survey

A survey of day-visits to Forestry Commission land was carried out during the summer of 1977. It is estimated that for the 4 month season of the survey, assuming an average of 3 persons per car, almost 9 million visits were made to Forestry Commission car parks and about 6 million visits were made by people whose cars were parked at the roadside. This implies a total in a full year of approximately 24 million visits to Forestry Commission woodland.

Following the survey, a study was made of a sample of car parks and their costs in relation to use. The average cost (capital + capitalised maintenance) per visitor-hour is about 2p at 1977 prices. However, there is a very wide variation about this figure for individual car parks. No patterns emerge from a review of relationships between cost and size of car park, use and size of car park, or use and location.

Index of Recreation Potential

This Division, in association with Forest Management Division, has produced a set of indices of informal recreation potential as an objective guide to the allocation of the budget for informal recreation facilities. The relevant factors on the demand side were taken to be population, car ownership and distance between town and forests, with allowance made for demand by tourists. On the supply side two factors were taken into account, namely forest area and road frontage. Expenditures in recent years are generally well correlated with the resulting indices and particularly with those giving greater weight to road frontage than to total forest area.

R. Q. OAKES

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TIMBER UTILISATION

Spruce Power Transmission Poles

Despite wide use on the Continent, spruces have never been favoured for poles in Britain. This has been mainly on account of their impermeability to wood preservatives, and also because of lower strength properties than Scots pine. Following exploratory discussions with the Electricity Council, a study visit was made to the Irish Republic by representatives of electricity distribution industry, the home timber trade, pole importers and the Forestry Commission, to study recent development work on the improvement of the permeability of spruce.

As a result a project has been set up under the guidance of a Panel which incorporates members from the Area Electricity Boards, the Forestry Commission, the Building Research Establishment and the Timber Research and Development Association. Poles of Norway and Sitka spruce have been selected from Dartmoor (Devon), Dyfi (Powys), Kershope (Cumbria), Kielder (Northumberland), Loch Ard (Central) and Solway forests (Dumfries and Galloway), and delivered to a pole importers yard in Gloucestershire for spray treatment. The effect of this treatment is to stimulate bacterial activity which renders the sapwood permeable to wood preservatives. The bacterial activity is being monitored at Aston University.

To compensate for the lower strength properties of spruce, the pole diameters are 5–15 mm larger than specified by the appropriate British Standard.

Utilisation of Bark

The steady growth of the horticultural bark industry continued. A further three manufacturing units came into production, and two more organisations began to market the product.

Trials on the use of composted Sweet chestnut bark, mainly for mulching, have started at the East Malling Research Station.

An Agrément Board Certificate was awarded to a company making bark-based building blocks.

J. R. AARON

PART II

Work done for the Forestry Commission by Other Agencies

FOREST SOILS

NUTRITION AND FOREST SOILS

By H. G. MILLER

The Macaulay Institute for Soil Research, Aberdeen

The six experiments designed to investigate the relationship between tree growth and nutrient cycling in pole-stage Sitka spruce (*Report* for 1973) have continued. It is now five years since the first two experiments in this series were fertilized and both have shown remarkably similar response patterns to the applied nutrients (Figure 5). Basal area growth responded when high rates of phosphorus and potassium were applied together, and when nitrogen was applied alone, but this nitrogen response was reduced or eliminated in the presence of applied phosphorus. At Fetteresso (Grampian), a significant response first appeared in the third year after application and has remained significant during the fourth and fifth years. At Leanachan (Highland), on the other hand, the response was significant only in the second, third and fourth years. Both these experiments are on brown, forest soils. The newer experiments, however, are on peats and peaty-gley soils, and early indications are that the response patterns will be somewhat different, maximum response so far being to high levels of phosphorus plus potassium applied in the presence of moderate to high levels of nitrogen.

Examination and publication of earlier results for pine continues. It has been shown that growth of mature Scots pine on a terrace of the river Dee suffers both from nitrogen deficiency and from early spring drought, the severity of which varies cyclically. Climate affected growth directly through May rainfall and indirectly through an influence of June rainfall on nitrogen uptake (Miller, Miller and Binns, 1977). At Culbin forest (Grampian), association-analyses of the ground vegetation in two nitrogen-fertiliser experiments suggested that

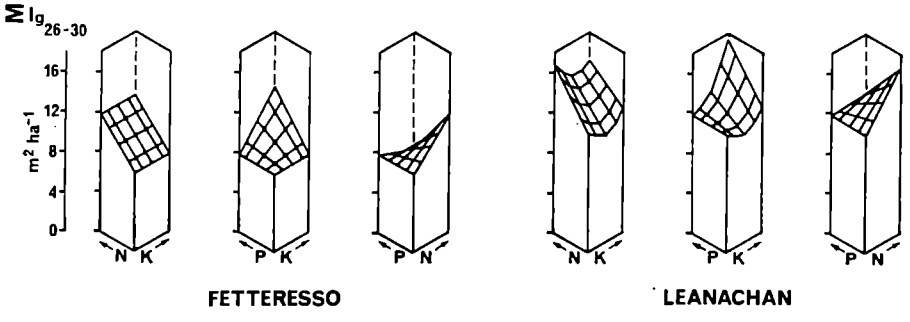

Figure 5: Response surfaces fitted to five years basal area growth in central-composite-rotatable experiments at Fetteresso ($r = 0{\cdot}73$, $P < 0{\cdot}01$) and Leanachan ($r = 0{\cdot}83$, $P < 0{\cdot}01$) forests. Rates of application were 0, 78, 200, 322 and 400 kg N ha^{-1}, 0, 39, 100, 161 and 200 kg P ha^{-1} and 0, 58, 150, 242 and 300 kg K ha^{-1}.

improving nitrogen status is reflected in the progressive appearance of a number of indicator species. In the forest as a whole, the occurrence of these species was found to correlate both with tree growth and concentration of nitrogen in the humus.

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TREE PHYSIOLOGY

APPLICATIONS OF PLANT TISSUE CULTURE IN FORESTRY

By K. JUDITH WEBB*

Botanical Laboratories, University of Leicester

The potential of the application of tissue culture techniques to the clonal propagation of the gymnosperm species *Pinus contorta* and *Picea sitchensis* has been partially realised. Adventitious buds have been initiated on juvenile explants such as excised embryos and germinated seedlings of both species, and on excised shoot meristems of 2 year old seedlings of *P. sitchensis.* Under appropriate conditions, these buds can be stimulated to extend, and individual shoots have been dissected out and rooted by traditional silvicultural techniques. The cytokinins employed to induce morphogenesis in excised embryos of *P. sitchensis* were found to influence the rate of extension growth and the subsequent rooting performance of the regenerated shoots. In contrast to buds induced on media containing benzylaminopurine, those initiated on either kinetin or dimethylallyl aminopurine extended, whilst still on the initiation media. On transfer to a diluted hormone-free medium, approximately 5 per cent of these shoots rooted. It would appear that a combination of cytokinins may be required to optimise adventitious bud production and extension growth, and the subsequent rooting of the regenerated shoots in culture.

In principle, these techniques offer a feasible method of obtaining clonal plants from juvenile material, and perhaps ultimately from mature trees. However, the induction of embryogenesis, in either callus or suspension cultures, would have many advantages over such techniques, including the presence of the potential root meristem of the embryoid. This would possibly avoid the problems encountered in the rooting of regenerated shoots. Two suspension culture lines initiated from seedling hypocotyl of *P. contorta* have been studied in detail over at least 12 months. In neither of these culture lines were structures resembling embryoids observed. However, a proportion of the cells were capable of differentiation. In the stock cultures, cells were observed to differentiate into

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dead, lignified tracheary elements, the percentage of these cells present in the cultures reaching a peak after several passages from initiation of the cultures. The expression of the embryogenic potential of suspension cultures of *Daucus carota* shows a similar pattern with time in culture (Reinert *et al.*, 1971; Smith and Street, 1974). The withdrawal of the trace element boron from the culture medium of one of these cell lines resulted in the altered cytodifferentiation of the culture. Light and electron microscopic examination revealed that whilst tracheid production was inhibited under these conditions, cells with ultrastructural features characteristic of phloem elements in *Pinus* spp. were present. Thus, although these cultures were not embryogenic, the cells had retained their ability to differentiate. Further work may eventually result in the definition of conditions conducive to somatic embryogenesis from similar gymnosperm cultures.

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SMITH, S. M. and STREET, H. E. (1974). The decline of embryogenic potential as callus and suspension cultures of carrot (*Daucus carota* L.) are serially subcultured. *Annals of Botany* **38**, 223–241.

FLOWERING PHYSIOLOGY OF SITKA SPRUCE

By P. B. TOMPSETT

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Applications of growth regulators, such as gibberellin $A_{4/7}$ and benzyl adenine mixtures, can enhance the flowering of mature scions of Sitka spruce (Tompsett, 1977); this work has been continued and extended to include a study of bud growth rates on mature trees.

Growth regulator treatments

When growth promoters were applied during different periods it was found that treatment in the middle of the growing season produced more strobili than at the end of the season. In another experiment, treatment early gave more flowering than in mid-season, but the difference was not statistically significant. Treatment in two or three periods always gave more flowering than treatment in one period only.

A second type of experiment tested increasing concentrations of gibberellin on male flowering. Strobilus numbers increased with concentration to an optimum (5 mg per branch in 0·24 ml of solution); greater concentrations decreased flowering. However, the optimum may be different in other years, so further work is required before responses can be predicted from dosages given.

Gibberellin has been applied through 1 cm long cuts in the branch or by microsyringe directly to the buds, both of which gave good results. Applying

through the roots from soil drenches, or spraying aqueous solutions on the foliage, however, did not increase flowering.

Gibberellin treatments increased not only the numbers of strobili but also the numbers of viable seeds in 1976 (from 16 seeds per branch in controls to 188) and in 1977 (from none in controls to 94 seeds per branch).

Bud growth rate study

Knowing what induces flowering in nature might make it easier to control flowering artificially. Bud growth rates were therefore studied and showed that, during the period of growth before buds become morphologically distinguishable, apical meristem growth rates differ in different parts of the tree. They were fastest in parts most likely to form female buds, intermediate in parts likely to form male buds and slowest in the base of the crown where no strobili are formed. The reasoning is complex, but this finding has led to the proposition that the early growth rate of an apical meristem may determine the type of bud which is formed later (Tompsett, 1978).

REFERENCES

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TOMPSETT, P. B. (1978). Studies of growth and flowering in *Picea sitchensis* (Bong.) Carr. 2. Initiation and development of male, female and vegetative buds. *Annals of Botany* **42**, 889–900.

HERBICIDES

HERBICIDE EVALUATION FOR FORESTRY USES

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Evaluation of herbicides on pot-grown crop and weed species has continued. This work constitutes the first stage of a research programme aimed at developing new methods of controlling weeds in forestry situations. Follow-on field experiments, reported elsewhere, are being conducted by the Forestry Commission Research and Development Division.

Studies relevant to seedbed weed control

More than 50 compounds were applied pre-emergence to Sitka spruce, Corsican pine, Lodgepole pine, Douglas fir, beech, oak and gorse. Several herbicides which control important seedbed weeds were tolerated by some or all of the crop species. Herbicides selected for further study include hexazinone, chlornitrofen, oxyfluorfen, K 1441, trifop-methyl, butam, terbuthylazine, prodiamine,

napropamide and ethofumesate. The compounds K 1441 and trifop-methyl are of particular interest as they will probably provide up to six month's control of grass seedlings. They have had no measurable effect on any crop species or on broadleaved weeds; in practice they are most likely to be used in mixtures. Hexazinone and terbuthylazine are also relatively inactive against many crop species but toxic to important weeds. Apart from commonly encountered seedbed weeds, terbuthylazine controls gorse (*Ulex* spp).

Studies relevant to transplant lines and plantations

About 25 compounds were applied post-emergence, to 2–4 year old Sitka spruce, Corsican pine, Lodgepole pine, Douglas fir, beech and oak. Treatments were also applied to pot-grown heather (*Calluna vulgaris*), and to three atrazine-resistant grasses: *Molinia caerulea*, *Deschampsia caespitosa* and *Calamagrostis epigejos*. Trifop-methyl again had no visible effect on any crop species but was active against all three grasses. Other herbicides which have shown potential for selective grass control in plantations include hexazinone, terbuthylazine and glyphosate. The former is very active against *Molinia* while glyphosate and terbuthylazine may provide better control of *Deschampsia* and *Calamagrostis*.

A triazine herbicide, cyprazine, effectively controlled heather without injuring most tree species. With spruce, there is likely to be ample selectivity between weed and crop. Unfortunately, cyprazine has been withdrawn by its manufacturers. However, higher doses of some related triazines have been found to have similar selectivity. Work with these alternative products continues. At present, most attention is being given to atrazine and terbuthylazine. For heather control, mixtures of MCPA-salt with ammonium sulphate are also being investigated. These are cheaper and perhaps more effective than the standard treatment with 2·4-D ester.

Some newer herbicides, including glyphosate, hexazinone and triclopyr may be useful for selectively controlling broadleaved woody weeds in conifers. The last named, triclopyr, is perhaps of greatest interest, because of its activity towards species not readily controlled with phenoxy herbicides, including oak, ash and hawthorn. In the USA its main use is for non-selective woody plant control. Moderate doses, however, may kill broadleaves without injuring conifers.

FOREST ZOOLOGY

LONG-HAIRED FALLOW DEER

By R. H. SMITH, ELIZABETH JOHNSON, JANET HORNBY and ELIZABETH HOLT

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Inheritance

Of the crosses set up in September 1976 (Smith, Johnson, Hornby and Holt, 1977), only one produced a fawn in June 1977. This was a long-haired buck (L12) mated with a short-haired doe (L5) and the buck fawn produced was short-haired.

More crosses were set up in enclosures during September 1977. The table shows the phenotypes of the deer together with a code used to refer to individual deer. Some of the deer are classified as intermediate, although it is not yet clear whether intermediate is a separate category, or represents variable expression of long hair.

Enclosure	1	2	4
Buck	L11 Short	L9 Long	L12 Long
Does	L14 Short L1 Long	L16 Short L15 Intermediate L18 Long	L5 Short L8 Intermediate L7 Long

Unfortunately the deer in enclosure 4 were attacked by poachers in November 1977 and all but L8 were killed. The fawn from the cross L12 × L5 was also killed. Additional crosses will be set up in September 1978 to replace those lost.

Hand-reared does

Studies of the coat changes in the hand-reared does (Smith *et al.*, 1977) were continued until January 1978, and a detailed study will be published. These deer will shortly be returned to the Mortimer Forest (Shropshire) enclosures for further controlled crosses.

It is well known that fallow are the most difficult of deer to handle, and, having had previous experience with hand-reared roe deer, we would confirm this. We have not yet overcome the problems of fitting harnesses to the deer, for the attachment of transmitters for long term monitoring of heart rate and temperature. We propose hand rearing another long-haired and normal fawn this summer, and training them to the wearing of a harness from birth. We hope to telemeter various physiological parameters during the autumn of 1978.

From April 1978 the investigations will be continued by Robert Smith and Elizabeth Johnson.

REFERENCE

SMITH, R. H., JOHNSON, E., HORNBY, J. and HOLT, E. (1977). Long-haired fallow deer. *Forestry Commission Report on Forest Research* 1977, 56–57.

REPRODUCTION IN THE GREY SQUIRREL

By ELIZABETH JOHNSON

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Since 1972 we have studied various aspects of the reproduction of the grey squirrel (*Sciurus carolinensis*). With Adrian Dubock we first established a reliable method for ageing squirrels, using eye lens weight combined with degree of epiphyseal fusion in the wrist. The epiphyses do not fuse until sexual maturity, so that it has been possible to separate juvenile from adult animals by means of

X-ray techniques. This successfully enabled detailed studies to be made of the histological changes in the gonads of male and female squirrels at different ages, and established that male squirrels, as well as female squirrels have periods of gonad regression (Dubock and Johnson, 1974). Female squirrels do not have regular oestrous cycles in captivity, even when in the presence of males, so that it has been necessary to make all observations on animals trapped in the field.

More recently, with Alex Tait, we have measured the levels of plasma progesterone throughout the female sexual cycle and pregnancy (Tait and Johnson, 1976; 1977). This established that the female squirrel has very low levels of plasma progesterone except during pregnancy.

During pregnancy the corpora lutea of the ovaries, which in many mammals are the source of the progesterone of pregnancy, regress in size before the maximum levels of plasma progesterone are obtained. Our evidence suggests that the placenta is the main source of plasma progesterone during the second half of pregnancy in the grey squirrel.

In male squirrels the cycle of sperm production has been elucidated, and the use of histochemical techniques previously reported (Tait and Johnson, 1977) suggests that androgen production falls prior to the arrest of spermatogenesis in regressing testes.

We now have sufficient information for a practical study to investigate the possibility of control of the grey squirrel, using reproductive inhibitors. The woodland enclosure for squirrels, which is now available at Alice Holt Forest, will provide a field laboratory for the proposed investigation. Control of reproduction cannot lead to eradication of the grey squirrel, but it could be successful in establishing smaller non-breeding populations in or near susceptible plantations.

A problem which requires further study is an investigation into the factors which determine the period of sexual activity in the grey squirrel. Regression of the gonads may occur throughout a population of grey squirrels at various times of the year, so that the sexual period is unlikely to be controlled by simple environmental cues, such as day length. We hope to be able to investigate the possibility of interaction between male and female squirrels, in determining the period of sexual activity.

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DUBOCK, A. and JOHNSON, E. (1974). *Forestry Commission Report on Forest Research* 1974, 67–68.

TAIT, A. and JOHNSON, E. (1976 and 1977). *Forestry Commission Report on Forest Research* 1976, 62–73; 1977, 58–59.

RECREATION

SCOTTISH TOURISM AND RECREATION PLANNING STUDIES

By P. DOWNING

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The object of the STARPS programme was to assist in the evolution of initial strategies for tourism and recreation in each of the 12 Regions or Islands Authority areas of Scotland, co-ordinated within a broad national framework and related to the work of planning authorities. During the first stage of the work (March 1975 to March 1976) DART prepared a basis of data, planning methods and strategic issues so that the national sponsors could move, in the second stage, into more formal collaboration with the local authorities. This basis is expressed in two reports published by the sponsors and widely circulated to local authorities and others:

1. *Strategic Issues.*
2. *A Guide to the Preparation of Initial Regional Strategies.* (DART publications Nos. 27 and 28).

From April 1976, the second stage of work focussed on the production—by the local authorities, with help from the national agencies and from DART—of initial regional strategies for sport, outdoor recreation and tourism. The purpose of these strategies was seen to be:

(a) to clarify the aims and objectives relating to sport, outdoor recreation and tourism in each region and in Scotland as a whole;

(b) to clarify the policies which should be pursued by the local authorities, national agencies and other bodies in order to meet these aims and objectives;

(c) thus, to provide a basis for incorporating agreed policies on sport, outdoor recreation and tourism in the work of the national agencies and in the corporate and physical planning activity of the local authorities.

To this work, DART's contributions fell under six headings:

(a) assisting the design of (and later adjustment to) the planning processes used;

(b) persuasion of the regional and island authorities to follow the agreed methodology;

(c) providing technical advice and guidance, including the preparation of information sheets and data collection forms;

(d) undertaking specific technical work for certain authorities, including data analysis and preparation of "model" papers;

(e) co-ordinating the sponsors' contributions, with particular reference to sub-contracted related work and the TRIP Service available through the Tourism and Recreation Research Unit at Edinburgh University.

DART's involvement in these studies was completed in February 1978, with a report on the project as a whole (which is to be published by the sponsors) but work continues under a team of officers provided by the sponsors.

TIMBER UTILISATION

JOINT RESEARCH PROGRAMME ON BRITISH-GROWN TIMBER

By T. HARDING

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

Comparison of the Effect of Rectangular Spacing on Wood Properties

Rectangular spacing trials were set up for a range of species on a number of different sites in East Scotland Conservancy between 1955 and 1957. In the first instance, that at Weem Wood, Drummond Hill (Tayside), where Sitka spruce was planted at 3 × 12 ft, 4 × 9 ft and 6 × 6 ft, is being examined. Wood samples have been taken at proportional heights in each tree and growth increments are being examined in line with and at right angles to the planting rows, and on the axis of maximum eccentricity. Should rectangular plantings result in an increase in eccentric growth, the effect on compression wood development and incidence of spiral grain will be assessed. In addition, knot size, number and distribution about the stem, relative to the planting pattern, are being examined at nodes above and below the proportional sampling positions, to examine eccentricity of crown development.

The Effects of Fertiliser Application on Wood Quality

Work has continued on the effects of fertiliser treatment on the character of the wood produced, and the distribution of the added increment in the tree. The results are being analysed.

Machine Stress Grading Larger Sections of Timber

Stress grading studies have shown that improved yields at higher grade levels are normally obtained when timber is machine graded, rather than visually graded. This is particularly significant for British-grown Sitka spruce.

The machine stress grading of timber is currently limited to section sizes generally not greater than 50 × 200 mm. Although this covers most structural uses there is, nevertheless, a need to extend the scope of machine grading to cover the full range of structural timber species and sizes up to 75 × 300 mm. However, since machine stress grading depends on establishing relations between the indicating parameter of the machine and the strength properties of timber, extending its scope requires extensive testing. To test samples of the various species in sections up to 75 × 300 mm would be very costly, and so an alternative co-ordinated approach was devised by PRL to minimise the work involved.

Financial and other support to enable the work to be carried out was given by the following organisations: The Forestry Commission, PRL, TRADA, The

Home Timber Merchants' Association of England and Wales, The Home Timber Merchants' Association of Scotland, Council of Forest Industries of British Columbia and the Swedish Forest Products Laboratory (SFPL). The test work was carried out by PRL, TRADA and SFPL. PRL had overall control of the project, and undertook the analysis of the test results.

The work has been completed, and a pattern for the change in grading machine limits, associated with changes in width and thickness, and which appears to be independent of species, has been established. Using this pattern a list of new grade limits for the complete range of sizes up to 75 × 300 mm has been produced for European redwood/whitewood, Canadian hem-fir and British grown Sitka spruce.

Some alterations to the existing limits will occur and these will cause some grade yields to increase or decrease slightly depending on grade, species and size, but the most significant change will be the increase in yields of the higher grades of British-grown Sitka spruce. Analysis is now being carried out to apply the pattern to other British grown species, for which small amounts of data are available, viz Scots pine, Douglas fir and Corsican pine.

Computer-aided Log Conversion for the British Softwood Sawmilling Industry

Economic analyses based upon varying levels of computer aid applied to two basic sawmill models have been carried out in order to establish a theoretically viable computer-aided conversion system, with potential application in many existing British softwood sawmills. This work has produced a system which is capable of being used in mills having a single headsaw using a cant conversion process, and in mills having a double bandsaw as the primary breakdown machine.

As an initial constraint, studies are being confined to systems which, in a medium sized mill, should be capable of paying for themselves over a relatively short time span (about two years).

Work is now proceeding with the development of the log measuring equipment and computer programs required to implement and prove this system in a sawmill, in such a way that the log intake rate is not reduced and the mill layout does not need to be changed. Laser scanning equipment has been developed which enables the cross-section, profile and bow of logs and cants to be recorded. Current research is proceeding with this equipment, initially to compare a sawmill's normal performance with the theoretically computer-optimised performance and subsequently to develop and evaluate the computer-aided conversion system as a practical tool in a sawmill.

The Evaluation of Specific Items of Sawmilling Equipment

A further stage of this project has just commenced, aimed at bandsaw technology. The objectives are: to review the developments in bandsaw technology and to evaluate the potential improvement in performance over existing installed machines in Britain; to assess the level of performance being achieved with existing bandsaws and provide guidance on how to optimise this performance.

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. (1977). Wood chips for animal litter. *Forestry and British Timber* **6** (3), 36–37.

There has been increased interest in the use of wood products as litter resulting from occasional shortages of straw. The qualitative litter requirements of dairy cattle, beef cattle, and poultry are described, together with the effect of wood flake manure on yields of hay.

AARON, J. R. (1977). United Kingdom experience in the use of bark. *Suppl. to Vol. XXIV of the Timber Bulletin for Europe.* ECE Symposium Paper "UK experience in the use of bark", Geneva 1977.

A new and expanding industry for the preparation and supply of bark for horticulture has appeared as a result of recent development work by the British Forestry Commission. While there is scope for further research especially in the fields of using bark for long term soil improvement, and in assessing the effect of the individual components of the volatile oil found in bark on plant growth, sufficient applications already exist to utilise the whole of the United Kingdom production of conifer bark; and these markets can be expected to expand as reserves of peat become exhausted and as the costs of imports rise.

Other uses for bark, although technically feasible, are economically unattractive. Regrettable though it may seem, the extractive-rich conifer barks are unlikely to be required as a source of tannin for the leather industry; this is mainly because the harvesting and preparation of tan bark is labour intensive in that it must be hand-peeled and air-dried, a factor which also makes it a poor competitor against other tannin materials. Similarly the intermittent seasonal demand militates against its use as domestic or industrial fuel.

AARON, J. R. (1977). The use of residues in the Home timber industry. *Recycling and Waste Disposal* **2** (4), 91–94.

The nature and incidence of residues in the forest and at sawmill are outlined. Current and possible future uses for tops, branches, foliage, bark, roots, stumps, sawdust, slabs and offcuts are described. It is concluded that most of the residues arising during the processing of wood find markets. Those which remain unsold are either produced in remote areas or are too contaminated for use. The only major scope for increased utilisation of residues lies in harvesting a larger part of the forest biomass.

BILLANY, D. J. and BROWN, R. M. (1977). The geographical distribution of *Gilpinia hercyniae* Hymenoptera: Diprionidae in the United Kingdom. *Forestry* **50** (2), 155–160.

Since 1960 when the European spruce sawfly, *Gilpinia hercyniae* (Hartig), was first recorded in Britain, in the New Forest, Hampshire, the species has spread into 18 counties in England and Wales. In 1970–74 it achieved pest status in mid-Wales, but has remained at an endemic level elsewhere. *G. hercyniae* has not become well established in northern England and has not yet been found in the extensive spruce plantations in Scotland.

(MILLER, H. G.,* MILLER, J. D.*) and BINNS, W. O. (1977). Growth of Scots pine under nutritional and climatic stress. *Plant and Soil* **48**, 103–114.

A stand of mature *Pinus sylvestris L.* within the rain-shadow of the Grampian Mountains was found to be suffering both from nitrogen deficiency and from early spring drought, the severity of which varied cyclically. Climate affected growth directly through May rainfall and indirectly through an influence of June rainfall on nitrogen uptake. Sectional area growth responded linearly to fertiliser nitrogen at rates up to 234 kg N ha^{-1}, this effect being independent of and additive to climate-induced changes; except for the large trees, the response was

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*The Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen.

more pronounced at 7·6 m up the stem than at breast height. As growth increased, irrespective of cause, early wood percentage rose to a maximum and then declined.

BLATCHFORD, O. N. (1977). The Forestry Commission Library. *State Librarian* **25** (2), 19.

A brief description of the Forestry Commission Library and information services, and the users.

BOOTH, T. C. (1975). A review of the pinewoods managed by the Forestry Commission. In *Native Pinewoods of Scotland* (Ed. R. G. H. Bunce and J. N. R. Jeffers) (1977). [Institute of Terrestrial Ecology]. Proceedings of Aviemore Symposium, 1975. 112–115.

A summary of the organisation, staffing and policy of the Forestry Commission, and changes in these as they relate to the native pinewoods. This is followed by a listing and review of the management of the remnants under Forestry Commission ownership.

BORDEN, J. H. and KING, C. J. (1977). *Population aggregation of Scolytus scolytus.* Forestry Commission Research and Development Paper 118.

Response of natural populations of *Scolytus scolytus* to sticky, wire mesh traps baited with infested *Ulmus procera* logs was investigated in May-June 1977. The highest response (88·3 per cent of 460 beetles captured) was to traps baited with male-infested logs. No apparent response occurred to traps baited with female-infested logs, but a possible trace response occurred to traps baited with logs infested by both sexes. The results strongly indicate that male beetles produce the population aggregation pheromone component of secondary attraction in *S. scolytus.*

BORDEN, J. H. and BILLANY, D. J. (1978). Pheromone response and sexual behaviour of *Cephalcia lariciphila* Wachtl. (Hymenoptera: pamphiliidae). *Ecological Entomology* **3**, 13–23.

1. Trapping experiments and observations of sexual behaviour were made on *Cephalcia lariciphila* in infested larch forests in Hereford and Worcester and mid-Glamorgan in early May 1977.

2. The results indicated that virgin females and dichloromethane extract of crushed virgin females were highly attractive to males.

3. On 17 May males responded to females throughout the warmest part of the day. First response occurred before 09.00 hrs, the last after 17.00 hrs, and peak activity was from 11.00 to 14.00 hrs.

4. Mated females became unattractive to males within 10 min after mating. When mated females or males were paired with virgin females there was no evidence of an anti-attractive pheromone or pheromone mask.

5. A few males dispersed out of larch into adjacent spruce forests and were captured in virgin female-baited traps up to 135 m distant from infested larch. Virgin female-baited traps at 0–0·5 m from the ground captured over seven times the number of males as traps at 1, 2 or 4 m, supporting visual observations that the preferred flight level for males is very near the ground.

6. Horizontal board traps with an acetate surface coated with "Stikem Special" were superior to Pherocon IC, vertical board and gypsy moth traps in that order.

7. The observations and results suggest that the best applied uses of *C. lariciphila* pheromone would be in survey and detection, and male disruption techniques.

BOWEN, M. R. (1975). Preliminary results on the germination, drying and storage of seeds and fruits of *Triplochiton scleroxylon K.* Schum. *Proceedings of the Symposium on Variations in Breeding Systems of T. scleroxylon.* Federal Department for Forest Research, Ibadan. 74–85.

An examination was made of the factors affecting the short-term storage of green fruits of *Triplochiton scleroxylon* K. Schum., the drying of these fruits, and the conditions required for their long-term storage. Increasing the storage temperature of the green fruits progressively from 0° to 40°C sharply decreased the longevity of the seed. Mature fruits were dried to a moisture content around 12 per cent without appreciable loss of viability; immature fruits did not dry successfully. Rapid drying of the fruits caused a loss of viability. A temperature around 6°C and a moisture content between 12 per cent and 25 per cent appears to be necessary for long-term storage. Some seeds remained viable for up to 22 months. Fruits from a single

collection were dried to a wide range of moisture contents, and sown in damp sand. Optimum germination was obtained when the fruits contained between 115 per cent and 190 per cent moisture, few undried fruits (288 per cent) moisture) germinated, as did fruits containing below 45 per cent moisture. However, fruits from two further collections gave 52 per cent and 77 per cent germination at 11 per cent moisture content, while the undried fruits again germinated properly.

BOWEN, M. R. (1975). Studies on the growth patterns of *Triplochiton scleroxylon* K. Schum. *Proceedings of the Symposium on Variations in Breeding Systems of T. scleroxylon.* Federal Department for Forest Research, Ibadan. 130–134.

Measurements from three-year-old provenance and progeny trials of *Triplochiton scleroxylon* K. Schum are recorded, together with a technique for progeny testing using clonal stock.

(HOWLAND, P. and) BOWEN, M. R. (1978). *Triplochiton scleroxylon* K. Schum and other West African tropical hardwoods. *Ministry of Overseas Development Report*, 1–109.

The economic importance of the timber of *T. scleroxylon* (Obeche) is described. Studies on the species distribution range were made and factors influencing its flowering and fruiting carried out. Successful techniques for both seedling and vegetative propagation were developed and tested under field conditions. The genetic variation within its species was studied, mainly by use of clonal cuttings, and probable methods of field establishment were developed. The results of vegetative propagation trials using 11 other tropical timber species are presented briefly.

BRASIER, C. M. (1978). Mites and reproduction in *Ceratocystis ulmi* and other fungi. *Transactions of the British Mycological Society* **70** (1), 81–89.

Adults of the mite *Tyrophagus putrescentiae* were isolated from diseased elm bark and maintained on agar cultures of the aggressive or non-aggressive strains of *Ceratocystis ulmi*. *T. putrescentiae* was used in fertilisation experiments to carry spores from aggressive or non-aggressive isolates of B mating-type growing on elm bark pieces to the protoperithecia (♀) of an aggressive A-type on adjacent elm twigs. Numerous perithecia developed on the twigs in the aggressive (twig) × aggressive (bark) combinations but very few in the aggressive (twig) × non-aggressive (bark). This confirms the existence of a mechanism inhibiting hybridisation between the aggressive and non-aggressive strains of *C. ulmi*.

T. putrescentiae ate the mycelium of *C. ulmi* leaving the protoperithecia and perithecia untouched, suggesting that these and similar structures of other fungi may be tough and pigmented to deter predation.

Over 90 per cent of mites from diseased elm bark in nature were found to be carrying *C. ulmi* when plated on a medium selective for the fungus. Microscopic examination revealed probable ascospores as well as mycelial and synnematal conidia of *C. ulmi* on their surfaces. It is suggested that *C. ulmi* is commonly fertilised by mites in nature, and that mites disperse genetic variants of *C. ulmi* within bark and introduce potential antagonists of *C. ulmi* from without. Mites from outer elm bark and others from beech bark were found to be carrying a variety of fungal spore types. The potential role of mites in the dispersal, fertilisation and adaptation of fungal fruiting structures is discussed.

BURDEKIN, D. A. (1977). Gale damage to amenity trees. *Arboricultural Journal* **3** (3), 181–189.

A sample survey of trees in rural areas which were blown down or broken during the gale of January 1976 was undertaken in the autumn of 1976 and records were made of factors likely to contribute to windblow or breakage in four species; oak, ash, elm and beech. Decay was the most important factor associated with gale damaged trees and it was found in 60 per cent of the trees in the survey. The fruiting bodies of nine different fungi were often found associated with the decay. Restriction of rooting, caused by poor drainage, mechanical disturbance or a rocky substrate, was a fairly common feature of uprooted trees. The uprooted oak and beech tended to be large trees, ash and elm were smaller. Stems of oak and beech frequently broke at the base whereas ash and elm stems broke elsewhere. Boughs were sometimes broken as a result of neighbouring trees falling on them.

BURDEKIN, D. A. (1977). Drought—not disease—has killed the beeches. *Forestry and British Timber*, **6** (6), 24.

Drought has played a major role in the dieback of beech, now apparent in various parts of Britain. Suggestions that a new disease has broken out are wholly without foundation.

BURDEKIN, D. A. and PHILLIPS, D. H. (1977). *Some important foreign diseases of broad-leaved trees.* Forestry Commission Forest Record 111.

Four important foreign tree diseases are briefly described and illustrated: Oak wilt (caused by *Ceratocystis fagacearum*), Chestnut blight (caused by *Endothia parasitica*), Elm phloem necrosis (caused by a mycoplasma) and Vascular mycosis of oak (allegedly caused by *Ophiostoma roboris*). Information is given to help appreciate the nature of these diseases and the possible threat they make to trees in Britain. The leaflet may also help inspectors called upon to examine imported material of oak, Sweet chestnut and elm in connection with these disorders and to explain some of the reasons for our plant health legislation.

BURDEKIN, D. A. (1977). After the elms—will we have to take the axe to the beeches? *The Times*, 3 December, p. 14.

The effect of the 1975 and 1976 droughts on beech trees is discussed. Some of the symptoms on drought damaged trees are similar to those caused by Beech bark disease and research is being undertaken to throw more light on this subject. The effects of the drought continued in 1977 and a hypothesis based on the severe exhaustion of food reserves is put forward to explain this phenomenon.

BURDEKIN, D. A. (1977). After Dutch elm disease, could our other trees be at risk? *The Times*, 3 August, p. 14.

The devastating effects of Dutch elm disease are recognised and the possible significance of other tree diseases such as Beech bark disease and Sooty bark disease of sycamore is discussed. The influence on disease epidemics of various factors including climate, movement of diseased material and public awareness is discussed. Dutch elm disease is considered to be by far the most serious tree disease occurring in Britain.

CARTER, C. I. (1977). Limes and Honey bees. *Arboricultural Association Newsletter* No. 13, p. 2.

Suggests that the exceptionally dry weather during the summer of 1976 may have played a major part in causing bee paralysis. In dry conditions the sugars (other than glucose and fructose) present in nectar of lime flowers occur in larger amounts than usual and may accumulate in the bee's bloodstream, causing a metabolic blockage.

CARTER, C. I. (1977). *Impact of Green spruce aphid on growth.* Forestry Commission Research and Development Paper 116, April.

Attack by the Green spruce aphid (*Elatobium abietinum*) on *Picea sitchensis* results in discolouration and defoliation of old needles. Trees are seldom if ever killed by the insect but annual rings formed in years of defoliation are conspicuously narrow. There are obvious physical problems general to all investigations aimed at quantifying the growth changes occurring in forest trees. Furthermore, forest mensuration techniques often used in order to communicate with the practising forester are not always biologically meaningful, since the objectives of this kind of investigation are usually simply to approximate variation in wood yield. It would, however, normally be difficult to measure increment losses by aphids in the forest. Firstly because these insects tend to be relatively homogeneously distributed within a given area, and secondly uninfested individuals for comparison are, at the most, very rare and almost impossible to arrange artificially.

Some of these difficulties may be overcome by appropriate experimental design and sampling, once it is known where the principal effects of aphid attack occur. Nevertheless as ring width in itself is a very imperfect measure of increment, the investigator could often be faced with the formidable task of harvesting whole trees, if, for example, he required information on dry weight losses.

CARTER, C. I. (and COLE, JANICE*) (1977). Flight regulation in the Green spruce aphid (*Elatobium abietinum*). *Annals of Applied Biology* **86**, 137–151.

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In Britain the flight of alate parthenogenetic viviparae of *Elatobium abietinum* was found to occur only in early summer. Data for this study were extracted from suction trap catches and weather records obtained from meteorological stations adjacent to the traps.

The duration of the flight period increased with latitude. At 51° N 95 per cent of the trap catch was taken in 24 days and at 55° N in 32 days. A flight threshold temperature of 12–13°C was deduced from trap catches taken within the forest crop. Displacements in median flight days at various sites in Britain could be related to values of accumulated day-degrees but not to differences in photoperiod. The median flight day can be predicted empirically by accumulating day-degree values over 8°C from 1 January up to a total of 115 day-degrees.

The implications of seasonal flight activity on crop reinvasion is discussed.

COLLINGS, P. S. and GRAYSON, A. J. (1977). *Monitoring day visitor use of recreational areas.* Forestry Commission Forest Record 112.

Traffic counters have been used to monitor vehicle movements at informal Forestry Commission sites.

Patterns of use through the week are amenable to study, but seasonal patterns less so. The importance of Sundays as a proportion of total use is the major factor in comparisons between weekly patterns for different data sets. Sites have much the same seasonal and weekly patterns in different years.

In the design of surveys the proportions of the sample allocated to Sundays and weekdays should depend on the type of site, with Sundays usually having a higher sampling intensity than weekdays, and this difference being greater at sites dominated by day visitors from home than at tourist sites. A useful rule of thumb might be to allocate one seventh of the sample to Sundays at predominantly tourist sites, one half at day visitor from home sites and one third at mixed sites. Sampling intensity should not vary greatly through the season.

COUTTS, M. P. and PHILIPSON, J. J. (1978). Tolerance of tree roots to waterlogging. I. Survival of Sitka spruce and Lodgepole pine. *New Phytologist* **80,** 63–69.

Rooted cuttings of Sitka spruce and Lodgepole pine were grown in Perspex tubes of peat and the lower portion of the root systems was flooded, while either active or dormant, and at 6° and 15°C. Root survival was assessed after draining the tubes.

Root elongation in both species stopped within a few days of flooding, during which the oxygen flux in the peat had declined to zero. Actively growing root tips were more susceptible to waterlogging than the region behind the tip and the latter region remained alive for up to 90 cm below the water-table in certain treatments.

Growing roots of pine were more tolerant to waterlogging than spruce, when assessed in terms of the survival of both the tip and the basal region of the root. By contrast, dormant roots of both species were so tolerant to waterlogging that the tips remained alive and rapid regrowth took place after the soil was drained.

COUTTS, M. P. and PHILIPSON, J. J. (1978). Tolerance of tree roots to waterlogging. II. Adaptation of Sitka spruce and Lodgepole pine to waterlogged soil. *New Phytologist* **80,** 71–77.

A study is presented of the growth of rooted cuttings of Lodgepole pine and Sitka spruce into waterlogged soil. Lodgepole pine roots penetrated to depths of 29 cm at 10°C in soil devoid of oxygen, whereas Sitka spruce made only shallow growth into the water-table. The growth rate of the pine roots decreased with depth below the water-table and penetration was greater at 10°C than at 20°C. Large gas-filled cavities were found in the stele of the pine roots that penetrated the water-table but were absent from the spruce. When pine roots were allowed to grow into a water-table for 2 cm, and were subsequently inundated to a depth of 10 cm, root tip survival was much better than where non-acclimatised roots were flooded.

The results suggest that the deeper penetration of waterlogged soils by Lodgepole pine than Sitka spruce is due to internal oxygen transport in the pine roots; oxygen transport and other possible mechanisms for growth and survival of roots in waterlogged soil are discussed.

COUTTS, M. P. and PHILIPSON, J. J. (1978). The tolerance of tree roots to waterlogging. III. Oxygen transport in Lodgepole pine and Sitka spruce roots of primary structure. *New Phytologist* **80,** 341–349.

Seedling root systems, or individual roots of cuttings, were submerged in reduced indigo-carmine solution so that only the seedling shoot, or basal part of the cutting root, was exposed

to air or oxygen. Oxygen diffusing out of the roots produced a localised blue colouration of the previously clear reduced dye; this process was employed to study internal oxygen movement.

Using plants grown in freely drained soil it was evident that seedlings of the flood-tolerant species, Lodgepole pine, had a greater capacity for oxygen transport than the flood-intolerant Sitka spruce. Oxygen diffusion was also observed in roots detached from Lodgepole pine cuttings and was greatly enhanced in plants which had grown in waterlogged conditions; in the latter plants oxygen diffusion was detected from the root tips after a short exposure of the basal region of the root to oxygen, whereas roots from plants grown in freely drained soil showed diffusion of oxygen only from the upper submerged portion during the same treatment period. Oxygen diffusion over distances of more than 30 cm was detected in certain experiments.

Observations on the movement of gas supplied under pressure to Lodgepole pine root segments showed that the rate of gas flow was much greater in roots grown in waterlogged soil than in those grown in freely drained soil and that the gas movement occurred in the stelar tissues. The regions of oxygen entry included the needles, and lenticels on the roots.

CROWTHER, R. E. (1977). Short-rotation coppice—time for a revival. *Forestry and British Timber* **6** (4), 42–43.

Outlines the possibilities of wood production from coppice on rotations as low as 1 to 5 years.

CURRIE, F. A., ELGY, D. and PETTY, S. J. (1977). *Starling roost dispersal from woodlands.* Forestry Commission Leaflet 69.

Describes methods of dispersing starlings from woodland roosts and gives details of suitable equipment.

DAVIES, E. J. M., GARFORTH, M. F. and McINTOSH, R. (1978). New prospects in forest fertilisation. *Scottish Forestry* **32** (1), 37–40.

Following experience by the Forestry Commission of aerial fertiliser application of N, P, and K in South Scotland, it is concluded that Sitka spruce on brown earths is responsive to 375 kg/ha of unground rock phosphate; some crops respond to P on surface water gleys; and that Sitka spruce is more responsive than Lodgepole pine in LP/SS Mixtures.

DAVIES, E. J. M. (1977). Red deer in Galloway. *Scottish Forestry* **31** (3), 165–169.

During the course of the last 30 years red deer have re-established themselves in Galloway and have increased in numbers to such an extent that serious damage has been done to pine and spruce plantations. Attempts have been made since 1965 to limit their increase, restrict their range and reduce the damage.

DAVIES, E. J. M. (1977). Along the Queen's Way (Forestry Commission area in Galloway), South Scotland Conservancy. *Country Life*, 21 July, p. 175.

Briefly mentions the history of the road over the Galloway Hills from St. John's Town of Dalry to Newton Stewart. Goes on to describe in detail the landscaping of the area by the Forestry Commission in their attempts to provide as scenic a route as possible.

DAVIES, J. M. and KING, C. J. (1977). *Pine shoot beetles.* Forestry Commission Leaflet 3.

Two pine shoot beetles of the genus *Tomicus* (Syn. *Myelophilus*, *Blastophagus*) occur in Britain and cause damage to British pinewoods. By far the more common of the two is *T. piniperda* L., found throughout the British Isles. *T. Minor* Htg., rare by comparison, occurs chiefly in Scotland and is also known to occur in Dorset. Both species breed beneath the bark of felled, windblown, burnt or sickly pines. The adult beetles bore in the centre of pine twigs on healthy, vigorous trees thus killing or weakening the shoots sufficiently for them to break off. This activity, if prolonged, can cause severe deformation of pine crowns and subsequent loss of form and vigour. Pine shoot beetles can also degrade pine sawlogs by introducing blue staining fungi in their breeding gallery systems. Pine shoot beetles should not be confused with Black Pine Beetles (*Hylastes* spp.) or with the Large Pine Weevil (*Hylobius abietis* L.) which are described in Forestry Commission Leaflet 58.

EDLIN, H. L. (Editor) (1976). *Forests of North-East Scotland.* Forestry Commission Guide.

Replaces the 1963 edition and includes chapters on the evolution of the forests in the landscape, their history and antiquities, as well as the flora and fauna they contain. Recreational facilities are listed and maps and photographs of the area included.

EVANS, J. (1976). Arbor-vitae, or reconciling long-term benefits from forestry with short-term national objectives. *Commonwealth Forestry Review* **56** (1), 33–37.

Discusses the basic incompatibility of forestry and short-term national objectives, suggesting that fundamental changes of attitude, both by the forester and the public, are necessary to ensure the long-term prosperity of forestry.

FAULKNER, R. (1977). The gene-pool of Caledonian Scots pine—its conservation and uses. In *Native Pinewoods of Scotland* (Eds. R. G. H. Bunce and J. N. R. Jeffers) (1977) [Institute of Terrestrial Ecology]. Proceedings of Aviemore Symposium, 1975, 96–99.

A discussion paper containing a brief historical review of the Caledonian pinewoods and their value for commercial forestry. Reasons for conserving them include their unique geographical position in relation to the natural range of the species, the known adaptability of their progenies and high content of unusual variants. Suggestions are made for priorities for population conservation. Methods of gene conservation are given under the headings of: pollen; seed; vegetative propagation; clonal seed orchards; natural regeneration; artificial pollinations; and special seed plantations.

(TOMPSETT, P. B. and) FLETCHER, A. M. (1977). Increased flowering of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) in a polythene house. *Silvae Genetica* **26** (2–3) 84–86.

The effect on flowering of keeping 4-year-old grafted plants of mature Sitka spruce (*Picea sitchensis* (Bong.) Carr.) in a plastic covered greenhouse for long periods was assessed in three successive years: overall mean increases of 15-fold in numbers of male strobili over untreated controls were observed. This response was associated with large increases in day temperatures inside the house during the months preceding the differentiation of distinct reproductive and vegetative buds. The implications of these findings for tree breeding and seed production are discussed.

FOREST, G. I. (1977). Geographical variation in the monoterpenes of the resin of *Pinus contorta*. In *EEC Symposium on Forest Tree Biochemistry*, EUR 5885, 55–71. Commission of the European Communities.

The percentage monoterpene composition of the shoot cortical resin of Lodgepole pine has been studied by gas-liquid chromatography, using material from several different sites in Britain grown from seed collected from a large number of provenances in north-west America. The objective was to assess the degree of biochemical variation occurring within and between provenances.

Variations between replicate plots and between different sites in Britain were small, and the results showed that resin analysis of a sample of 25 trees was usually sufficient to allocate that sample to a provenance or a provenance group on the basis of the monoterpene composition.

(SMITH, R. A. H. and) FORREST, G. I. (1977). Field estimates of primary production. In *Production Ecology of British Moors and Montane Grasslands*. Ecological Studies 27, 17–37, Heidelberg.

Production values from a range of *Calluneto-Eriophoretum* blanket bog sites at Moor House in the north Pennines are compared. Figures are given for average net production of *Sphagnum rubellum* at three sites, and for variation in total net production of blanket bog. The conclusion is reached that, though nutrient and microclimatic variation is probably unimportant in affecting the total production of the blanket bog vegetation, the production of individual species on a particular site is probably largely limited by climatic factors and by interaction between species. The "strategy" of the two main bog species, *Calluna vulgaris* and *Eriophorum vaginatum* is compared, and figures given for the percentage of photosynthetically active solar radiation in the growing season which is converted to plant production.

(ROBERTS, J.*) and FOURT, D. F. (1977). A small pressure chamber for use with plant leaves of small size. *Plant and Soil* **48**, 545–546.

A description of a pressure chamber for use with individual small needles or leaves, e.g. from spruce or heather, constructed out of commercially available parts.

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FRANCIS, G. (1977). Developing British wood markets. *Forestry & British Timber* **6** (3), 22–23.

Discusses the probable increases in requirements for, and production of, wood in Britain during the next decade. Concludes by stressing the high degree of co-operation needed between grower and consumer to ensure a reliable supply of wood in the quantities required.

GIBBS, J. N. (1978). Development of the Dutch elm disease epidemic in southern England 1971–6. *Annals of Applied Biology* **88**, 219–228.

In five plots in the west Midlands, 95 per cent of individual English hedgerow elms died between May 1972 and September 1975, with an average infection rate (r) of 1·35 when the proportion of disease, x, increased from 0·16 to 0·42. In 234 plots of a survey of non-woodland elms in southern England the average infection rate was 0·65 and the cumulative loss increased from 6 to 62 per cent between 1971 and 1976. The course of the epidemic was not apparently influenced by variations in the weather. These infection rates are as high as those recorded in Dutch elm disease epidemics elsewhere in the world. The infection rate in English elm was higher than in the wych elm or "smooth-leaved elm". In English elm in four geographical areas of southern Britain there was an initial drop in infection rate until $x = 0{\cdot}12$, when a steady infection rate obtained in all four areas, ranging from 0·56 in the Midlands to 0·76 in the south-east. The epidemic is likely to continue at a high rate until most non-woodland elm have died, with most survivors being smooth-leaved elms in East Anglia.

Data from sanitation control programmes in East Sussex and Brighton are analysed and the effect on disease progress discussed.

GIBBS, J. N. and GULLIVER, C. CLARE (1977). Fungal decay of dead elms. *European Journal of Forest Pathology* 7 (4), 193–200.

The pattern of decay developing in *Ulmus procera* killed by *Ceratocystis ulmi* was examined. *Flammulina velutipes* had caused some decay and discolouration in most trees which had been dead for more than two years. Decay caused by *Pleurotus sapidus* was less common. *Pleurotus palmatus* was frequently isolated from wood in the upper trunk showing no visible deterioration. Trees should be felled within two years of death in order to retain the value of their timber.

GIBBS, J. N. and GREIG, B. J. W. (1977). Some consequences of the 1975–1976 drought for Dutch elm disease in southern England. *Forestry* **50** (2), 145–154.

During the exceptionally hot, dry summer of 1976 the large elm bark beetle, *Scolytus scolytus*, was able to invade and successfully breed in apparently healthy, undiseased elms. A conspicuous feature was the clustering of wasps, bees and ladybirds on the stems, attracted by sap exudation. The trees were probably suffering from drought, although many showed no symptoms. The phenomenon occurred mainly on shallow soils over limestone; trees on chalk were not generally affected.

In 1976, and to some extent in 1975, the downward development of *Ceratocystis ulmi* through the tree was less than in previous years, and only a low proportion of the numerous maturation feeding wounds became infected. However, the drought does not appear to have significantly influenced the course of the epidemic.

The attacks by *S. scolytus* on undiseased trees are discussed in respect of 19th Century reports of attacks on elms, and it is concluded that the ability of *S. scolytus* to assume a more primary role may have been underestimated.

GIBBS, J. N., BURDEKIN, D. A. and BRASIER, C. M. (1977). *Dutch elm disease.* Forestry Commission Forest Record 115.

This is a new Forest Record which gives a detailed description of the biology of Dutch elm disease and of measures taken to spread the control of the disease.

GORDON, A. G. (1977). Tree seed sources. Broadleaved seed supply in Britain. *GC & HTJ* **182** (17) and *Forestry & British Timber* **7** (1), 1978.

Concern is expressed over the quality and origin of broadleaved seed being imported into Britain. Some advice is offered on the safeguards to be requested when buying seeds. The Forestry Commission's service in supply of conifer and broadleaved seed is described.

GORDON, A. G. (Editor) (1977). Report of the International Forest Tree Seed Testing Workshop, Guildford, England, 1975. *Seed Science and Technology* **5** (4), 771–825.

The planning and programme of the first ever Tree Seed Testing Workshop to be arranged by the International Seed Testing Association and sponsored by the Forestry Commission are described. The workers responsible for each part of the programme—sampling and purity, germination, tetrazolium, excised embryo, moisture content and X-ray—present reports and conclusions.

GORDON, A. G. (1977). Raising *Nothofagus* from seed. *Forestry & British Timber* **6** (3).

A brief review is given of the reasons for the chronic lack of seed and of the poor nursery productivity over the last 30 years. Initial results of experiments to improve the productivity, including the results of Gibberellic acid treatment, are described.

GRAYSON, A. J. (1977). Factors influencing forestry investment in Great Britain. In *Forest policies for stimulating investment in developing countries.* Proceedings of IUFRO Working Group 4.06.2, ed. H.-J. von Maydell.

Experience in Britain is that it is difficult to explain variations in one major field of private forestry investment, namely planting, either in absolute terms or relative to the total of all private investment.

Among the factors likely to assist in generating confidence and establishing the desired investment rate, fuller information about the prospects for future returns from investment may be of limited use. Advice on matters in the technical field is likely to be of more value than forecasts on such economic topics as expectations about future prices. Tax regimes which give preferential treatment have their place but more emphasis should, it is suggested, be given to the promotion of stability of future tax burdens and this it is difficult to assure. Methods of government assistance which deserve the fullest consideration include the various schemes of State aid through grant or loan which are operated in so many countries.

GREGORY, S. C. (1977). The effect of *Peridermium pini* (Pers.) Lev. on water conduction in *Pinus sylvestris* L. *European Journal of Forest Pathology* **7** (6), 328–338.

The effect of the stem disease caused by *Peridermium pini* (Pers.) Lev. on the water relations of *Pinus sylvestris* L. was investigated by comparing the permeability to water of wood from healthy and diseased stems. It was found that affected wood becomes impermeable and that severe infections cause complete loss of conducting ability in the stem. The impermeable wood is both resinous and dry; the importance of these features in causing the loss of permeability is discussed in relation to this and some other diseases.

GREGORY, S. C. (1977). A simple technique for measuring the permeability of coniferous wood and its application to the study of water conduction in living trees. *European Journal of Forest Pathology* **7** (6), 321–328.

A method is described for measuring the permeability to water of fresh coniferous wood samples in accordance with the provisions of Darcy's Law describing fluid flow through porous media. Departures from this law are also described and briefly discussed.

HEWITT, R. M. (1977). Forestry in Northumberland. *Forestry* **50** (1), 21–26.

Describes the topography, climate, geology and soils of the area, before tracing the history and development of public and private forestry since 1920.

HOLMES, G. D. (1978). National planting and production goals. *Timber Grower* 66, January, 18–25.

Outlines past planting by the Forestry Commission and private woodland owners. Gives details of likely available land, the possible planting programme for the rest of the present century, as well as timber production forecasts to the year 2050.

INSLEY, H. (1977). An estimate of the population density of the Red fox (*Vulpes vulpes*) in the New Forest, Hants. *Journal of Zoology* **183**, 549–553.

Describes a survey of breeding dens made over a 20 per cent sample of the 271 square kilometres of land managed by the Forestry Commission. A population density of $2{\cdot}18 \pm 0{\cdot}45$ foxes per square kilometre was estimated.

INSLEY, H. (1977). British Deer Society Wessex Branch roe survey. *Deer* **4** (4), 212–214.

Presents the results of a distribution survey carried out on the basis of tetrad (2 × 2 km) squares.

JOBLING, J. and PEARCE, M. L. (1977). *Free growth of oak.* Forest Record 113.

Discusses the improvements in rate of radial growth and in crown development of selected trees in young oak crops, achieved by frequent, heavy thinning to give open conditions for vigorous crown extension. Data are presented from three experiments started in 1950 in 20 year-old oak stands, and yield models are shown for "free growth" thinning in plantations.

JOHN, A. (1977). Vegetative propagation of Hybrid larch (*Larix* × *eurolepis* Henry) in Scotland. In *Vegetative propagation of forest trees—physiology and practice.* Lectures from a symposium in Uppsala, Sweden, 16–17 February. The Institute for Forest Improvement and the Department of Forest Genetics, College of Forestry, the Swedish University of Agricultural Sciences, 129–136.

The propagation of both summer softwood leafy cuttings and winter hardwood leafless cuttings, from different ages of ortet, and the effect of hormonal and environmental factors on rooting are described. The possible application of the methods to large scale propagation is discussed.

JOHNSTON, D. R. (1977). Arboricultural research in the Forestry Commission. *Arboricultural Journal* **3** (2), 74–78.

Describes arboricultural research in the Forestry Commission rising from the initiative of three organisations. The Forestry Commission, originally as a byproduct from its forestry research; the Arboricultural Association, which set up an Arboricultural Research Working Party in 1972; and the Department of the Environment, which has sponsored special arboricultural research projects.

JUKES, M. R. (1977). Extraction of sawfly cocoons from samples of soil and surface litter. *Annals of Applied Biology* **85**, 399–401.

A non-destructive, wet technique to extract sawfly cocoons from a variety of soil and surface litter types is described. The system, involving a pair of tilting, curved sieves, was originally developed to extract cocoons of the European spruce sawfly (*Gilpinia hercyniae*).

(CUNLIFFE, C.,*) LONSDALE, D. (and EPTON, H. A. S.*) (1977). Transmission of *Phytophthora erythroseptica* on stored potatoes. *Transactions of the British Mycological Society* **69** (1), 27–30.

After eye inoculation of potato tubers with a suspension of zoospores of *Phytophthora erythroseptica*, oospores were observed in the surface tissues of the tubers. These tubers did not all rot during prolonged storage at 20°C. During storage under high humidity at 9°, *P. erythroseptica* grew from rotting, wound-inoculated tubers to the surface tissues of adjacent tubers in which oospores were formed. The latter tubers did not rot in storage but many produced rotting daughter tubers when grown. Superficial contamination of tuber eyes with *P. erythroseptica* oospores and mycelium led to pink rot in daughter tubers.

This suggests a mechanism whereby *P. erythroseptica*, well-known as a soil-borne pathogen, can apparently cause pink rot in crops grown on previously uninfested land.

McCAVISH, W. J. (1978). Selection and use of herbicides. *Forestry* '78, *a Farm Contractor Specialist Annual*, 18–19.

A brief account of the selection of herbicides with particular reference to those most commonly used in both the nursery and woodland situation by the Forestry Commission.

MACKENZIE, J. M. (1977). Living with deer in the re-afforestation phase. *Scottish Forestry* **31** (3), 170–175.

Describes the type and degree of damage caused by deer during replanting in three areas, and concludes that more information is required about deer populations before control can be successful. Suggests that where damage has been reduced to an acceptable level the deer should be managed as a natural resource to produce revenue.

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MITCHELL, A. F. (1977). How does climate affect tree shape? *Garden* **102** (12), 504.

The well known change of habit of Incense cedar from level-branched open crowns in native stands to densely fastigiate in England is part of a far more complex phenomenon.

(1) Incense cedars in W. Britain and Ireland are broader and bushy, in Eastern US they are similar; north of their range, in Washington States they have big upright branches.

(2) Most Western US *Cupressaceae* behave similarly—notably *C. macrocarpa, C. goveniana* and Leyland cypress too.

(3) Only *C. lawsoniana, nootkatensis* and *Thuja plicata* are less affected, but they are much broader in Ireland than in England.

Many possible factors have been considered but none, nor any combination of them, fits the observations.

PARKER, E. J. (1977). Viability tests for the biological control fungus *Peniophora gigantea* (Fr.) Mass. *European Journal of Forest Pathology* **44**, 251–253.

Peniophora gigantea (Fr.) Mass. is now widely used in Great Britain in the treatment of pine stumps against *Heterobasidion annosum* (Fr.) Bref. Spore suspensions of P. gigantea are supplied commercially in sachets. The Forestry Commission Research Station at Alice Holt Lodge is responsible for testing the viability of the suspension at different stages of manufacture and while it is in use at a forest. Details are given of the sequential sampling scheme employed.

PARSONS, D. and EVANS, J. (1977). Forest fire protection in the Neath District of S. Wales. *Quarterly Journal of Forestry* **LXXI** (4), 186–198.

Neath District suffers more forest fires than elsewhere in Britain. This problem arises mostly from the young plantations in *Molinia* dominated hill land near to large urban populations; arson is definitely increasing.

Fixed protection defences, e.g. fire-breaks, rides and brashed belts are widely used and larch is planted where possible. Liaison with Fire Service includes equipment development, exchange of technical information and, with serious situations, joint manning of the forest fire control centre. In fire-fighting great importance is placed on the senior officer present assessing the whole situation before deciding the plan of attack. Successful fire suppression depends on strategic deployment of men, combining methods of control such as beaters and water, and keeping access routes unobstructed. Efficient radio communication enables large areas to be effectively protected by few men. Fire danger assessment relies on local experience, using weather information from a nearby meteorological station and the pattern of build-up in the numbers of fires.

PEPPER, H. W. (1977). Protection of trees, shrubs and garden plants from deer. *Deer* **4** (3), July, 150–152.

Describes methods of protecting small areas from deer and gives specification for suitable fences, individual tree guards and chemical repellants.

PYATT, D. G. (1977). *Guide to site types in forests of North and Mid Wales.* Forestry Commission Forest Record 69.

The site classification is applicable to a region comprising slatey rocks of the Cambrian, Ordovician, Silurian and Devonian systems. This region encompasses some 110,000 hectares of Forestry Commission land. The site classification is based on soil types, and is presented in the form of three tables. Table 1 lists the soil, topographic and vegetation characteristics of each site type. In the assessment of windthrow hazard pertaining to each site type (Table 2) consideration is given to soil depth and drainage status, and to the degree of topographic exposure of the site. On the most hazardous sites (high hazard) windthrow is expected to be a serious management problem before crops reach 18 metres top height. Table 3 rationalises for each site type the best current practices for cultivation, drainage, choice of species, fertilisation at planting and as later top-dressing and treatment of weeds. There are 12 colour plates of soil profiles, enlarged from the first edition.

PYATT, D. G. (1978). *Physical properties of soils with indurated material.* Ph.D. Thesis, Aberdeen University, February.

Review of literature: indurated materials in Britain are compared with fragipans abroad. The main aim of the project is to measure physical properties of indurated material and look

for inter-relationships. Thirty profiles are examined. Macromorphology: indurated material is described in terms of the sequence of horizons of the profile, depth, thickness, colour, structure and presence of silty cappings on stones. Bulk density and pore space: measured with either excavation method or gamma-ray transmission to depths of at least 1 m. Dry bulk density of fine earth component and air-filled pore space are calculated.

Particle size analysis: separation is made into 7 B.S. size fractions. Indurated materials have 3–15 per cent clay.

Mechanical properties: hardness is assessed by consistence (subjective) and penetrometer measurements. Cementation is assessed by a slaking test. Some indurated materials resist slaking.

Micromorphology: 10 × 5 cm thin sections of several horizons of 11 profiles are examined for microstructural features such as vesicles, cutans, fabric and silty cappings.

Moisture regime: for 6 sites on ORS borehole water level and tensiometer data are related to weekly rainfall and predicted soil moisture deficit.

Discussion and conclusions.

RAY, A. (1978). Testing chainsaws for vibration and noise. *Forestry & British Timber* **7** (1), 20–21.

This article describes the equipment and methods used to measure the vibration and noise levels of chainsaws by the Work Study Branch of the Forestry Commission. It shows how the data are presented in order to draw conclusions and make recommendations.

REDFERN, D. B. (1978). Dutch elm disease in Scotland. *Scottish Forestry* **31** (2), 105–109.

Until 1975 Dutch elm disease was confined to the Lothian and Border Regions and involved only the non-aggressive strain of *Ceratocystis ulmi*. During 1975 and 1976 outbreaks of the aggressive strain were discovered in Strathclyde, Tayside, Central and Fife Regions. Factors affecting the spread of the disease are discussed.

ROWAN, A. A. (1977). *Terrain classification.* Forest Record 114.

Describes the British system of terrain classification, devised in 1974 and based on the Scandinavian one. Deals with the application of the system in the field and its use in choosing machinery in relation to terrain.

SEAL, D. T. (1977). *EEC Symposium on forest tree biochemistry—Chairman's Report.* Commission of the European Communities, pp. 7–15.

The origin, purpose and composition of the symposium are explained. The methods of biochemical analysis of terpenes, iso-enzymes, polyphenols and other substances are briefly described and their potential applications considered. Recommendations are made for future development in EEC. The Report, in English, French and German, prefaces symposium papers.

STEWART, G. G. (1977). The development of recreation in privately owned woodlands. *Timber Grower* **65**, September, 21–24.

The object of this brief paper is no more than to try to stimulate thoughts about ways in which recreation might be developed in privately owned woodlands.

STOAKLEY, J. T. (1977). A severe outbreak of the Pine Beauty Moth on Lodgepole pine in Sutherland. *Scottish Forestry* **31** (2). April, 113–125.

The life history of the Pine Beauty is given and the severe defoliation of 120 ha of Lodgepole pine at Naver Forest, Sutherland, in 1976 is described. A pupal survey was carried out on 16 ha of the affected block in autumn 1976. This study area, chosen because of an apparent gradation from severe to slight defoliation, was found to consist of two distinct zones in respect of defoliation and pupal weights; in the less defoliated area these variables were well correlated. There was much variation in numbers of pupae per unit area, probably due to use of a small sampling unit but, in general, extremely large numbers of pupae were present and even in the less defoliated area pupal density was very high. Incidence of diseased pupae was not density dependent. The distribution of the pest and its parasites within the block is discussed. An appraisal is made of the possible financial loss and of justifiable expenditure on preventative measures. Development of suitable methods for monitoring populations is proposed.

THOMPSON, D. A. (1977). Northumberland contrasts. *Forestry & British Timber* **6** (6), 26–27.

A report on I.F.G.B.'s study tour in the forests of Northumberland.

TULEY, G. (1977). Forestry in Denmark—notes on the study tour of April 1977. *Arbor* **6** (2), 12–15.

Notes on the Aberdeen University forestry students' visit to Denmark in April 1977, by the Forestry Commission guest who accompanied the party.

WAINHOUSE, D. (1977). Rhythmic activity of the adult Carrot fly, *Psila rosae*. *Physiological Entomology* **2**, 323–329.

In a laboratory study of adult carrot fly activity, observations were made on caged populations and on individuals isolated in actographs. In cages in LD 12:12, feeding, oviposition, flight and possibly mating were all rhythmic. Peak feeding occurred within 1 h from lights-on and oviposition and flight 10–12 h later. Mating frequency increased slightly in the latter half of the light phase. In actographs in LD 12:12, peak activity also occurred 10–12 h after lights-on. Activity increased with age up to at least 5 days old, independently of the effects of starvation, and by day 5 males were approximately 3 times and females 8 times more active than on the day of emergence. Overall, males were approximately 1·4 times more active than females. Females isolated in actographs for 4 days in continuous dim light showed peaks of activity at intervals of approximately 22·5 h, and activity therefore appears to be a true circadian rhythm. In continuous bright light the activity of females became arrhythmic.

(BENSON, J. F.* and) WALKER, C. (1974). Abundance of *Odinia meijerei* Collin (Deipt., Odiniidae). *Entomologist's Monthly Magazine* **110**, January/February/March, p. 50.

Odinia meijerei Collin is found on diseased elm trees (*Ulmus*), and its occurrence in abundance at the present time is therefore of some interest. We have bred specimens from elm logs infested with *Scolytus scolytus* (F) and *S. multistriatus* (Marsh.), obtaining most specimens from two areas where Dutch elm disease is particularly severe. It seems certain that the present abundance of the fly is due to the dramatic increase in the numbers of diseased and dying elms caused by the current epidemic of Dutch elm disease.

(WAY, M. J.† and) BEVAN, D. (1977). Dilemmas in forest pest and disease management. *Ecological Effects of Pesticides* edited by F. H. Perring and K. Mellanby (Linnean Society Symposium Series No. 5, 1977), 95–110.

Difficulties in estimating the economics of commercial timber production and relevant protection from pests create an obscure background for assessing the other forestry "values". Such values include those related to the often conflicting requirements of watersheds, recreation and wildlife conservation. The frequent complexity of uses greatly complicates judgements on validity of pesticide application in forestry. In North America, large scale campaigns against some destructive species are therefore being severely criticised.

Examples are given of some of the dilemmas in forest pest control and of situations where pesticides should, or should not, be used as components of good pest management practices. Special attention is given to the population dynamics of spruce budworm, *Choristoneura fumiferana*, in North America, larch budmoth, *Zeiraphera diniana*, in Switzerland, and pine looper, *Bupalus piniaria*, in Britain in relation to chemical control. Distinctions are made between the justifiably greater use of pesticides in seed orchards and forest nurseries than in established timber plantations. Attention is drawn to limited work in Great Britain on the dynamics of forest pests or potential pests, especially in view of the possibility that pest problems may increase as the relatively young British plantations age.

WHAYMAN, A. and WITTERING, W. O. (1978). Mini harvesters and processors. *Forestry & British Timber* **7** (3), 19–22, 24.

Details are given for five harvesters or processors costing less than £60,000 including the power unit. In addition, there is a table showing a full list of all small delimbing machines (including harvesters and processors) currently available.

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*Department of Forestry, Oxford.
†Imperial College Field Station, Silwood Park, Ascot, Berkshire.

WILSON, K. W. (1977). *Trees please.* Booklet for Blue Circle Group & Tree Council. 14pp.

A brief why, when, how and where of tree planting and maintenance to promote and encourage these activities in rural and urban residential areas.

WINTER, T. G. and SCOTT, T. M. (1977). Chemical control of the Pine shoot moth, *Rhyacionia buoliana* (Denis and Schiffermüller) (Lepidoptera:Tortricidae) in seed orchards in Britain. *Forestry* **50** (2), 161–164.

In 1970 and 1971 a high population of *Rhyacionia buoliana* (Denis and Schiffermüller), the Pine shoot moth, appeared in a seed orchard of *Pinus contorta* Douglas ex Loud. in Wiltshire. The opportunity was taken to compare several alternative insecticides with DDT. Field trials in March and August showed that fenitrothion can be used as a alternative to DDT to control the Pine shoot moth.

WITTERING, W. O. (1977). Harvesting forest residues. *Forestry & British Timber* **6** (2), 31–32.

The article examines the potential for utilisation of stumpwood and lop and top material which is normally left in the wood. Such residues amount to about 45 per cent of the whole tree and the author considers that up to 25 per cent of this total could be utilised nationally. An account of trials with the Karhula 312CS chipper is given and a resume of current interest in chipping in Europe and America is included.

WITTERING, W. O. (1977). Elmia 77. *Forestry & British Timber* **6** (4), 889.

A description of the equipment and machinery on show at Sweden's premier forestry trade fair is given.

WITTERING, W. O. (1977). What's happening at Ösa? *Forestry & British Timber* **6** (5), 28–30.

A full description of the range of machines supplied by Ösa (mainly for timber harvesting) is provided with the emphasis on the developments undertaken since 1975 when Ösa broke its marketing arrangement with Volvo. The training facilities available at the firm's own training centre include courses for operators, fitters and supervisors.

WITTERING, W. O. (1977). Harvesting and utilising stumps. *Forestry & British Timber* **6** (6), 28–29.

A review of the current attitudes to stump harvesting is given. The case is made for a more positive approach to residue utilisation and details are given of the Scandinavian stumpwood harvesting programme. A description of the Pallari Stumparvester is included as are photographs of its operation.

WITTERING, W. O. and SAWYER, T. R. (1977). Time study since the stopwatch. *Management Services* **21** (12), 18–19.

A description of the RAPCO automatic data logger is given and its advantages over conventional stopwatch studies by virtue of increased accuracy and reduced data transcription are stressed. The Forestry Commission Work Study Branch are extending the range of operations where RAPCO studies are used and further machines have been ordered.

WOOD, J. H. and BARDY, D. A. (1977). Protective and safety clothing—Forestry Commission approach. *Forestry & British Timber* **6** (2), 18–20.

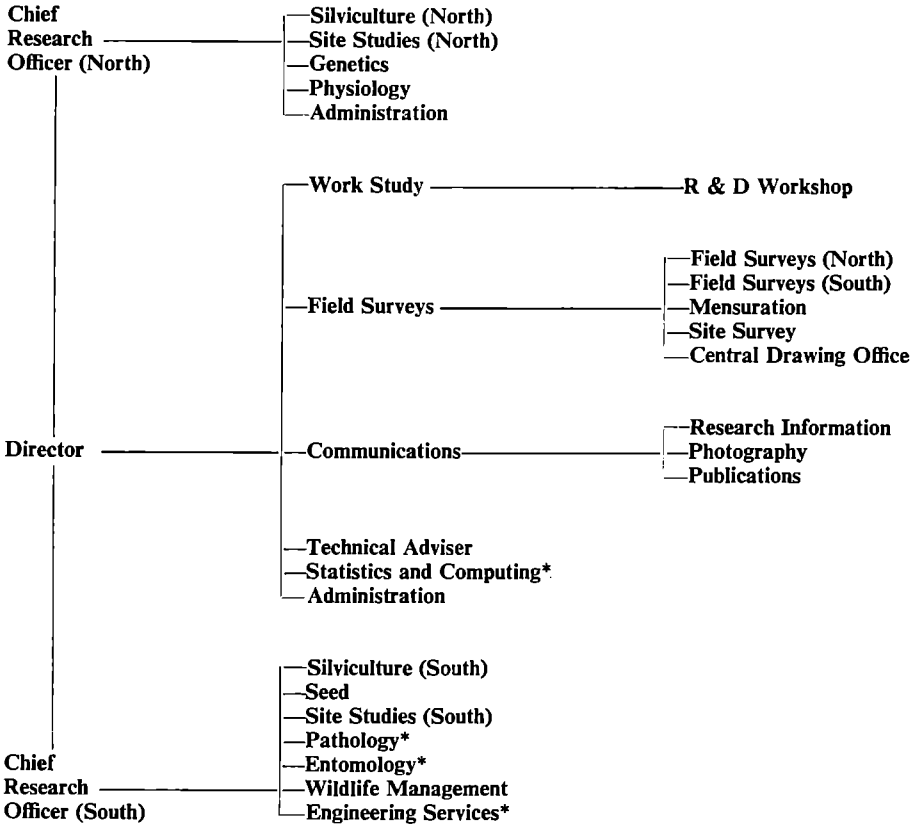
Describes a range of protective and safety clothing introduced by the Forestry Commission since 1975.

YOUNG, C. W. T. (1977). *External signs of decay in trees.* Arboricultural Leaflet 1. Prepared for Department of the Environment by the Forestry Commission.

Describes the signs of decay to be looked for when trees are examined visually in connection with their safety or preservation.

APPENDIX II

Research and Development Divisional Organisation



*Branches with sections at the Northern Research Station.

APPENDIX III

Staff Engaged in Research and Development

As at 31 March 1978

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
Midlothian 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 aspects of legislation relating to plant health).

SILVICULTURE (SOUTH) (*Alice Holt*)

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

ARBORICULTURAL ADVISORY SERVICE (Department of the Environment)

D. Patch, B.Sc., M.I.For., N.D. Arb.

Office: Miss K. A. Rhodes

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

Research Foresters:		*Centre*
South East England Region	P. W. W. Daborn	Alice Holt
South East England Area	D. Elgy, J. B. H. Gardiner	Alice Holt
	M. L. Pearce, M.I.For:	Alice Holt
	P. D. Howard, P. Marsh,	
	C. W. Shanks, F. R. W. Stevens	
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	T. J. Davis	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*)

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

Research Foresters:	D. F. Fourt, L.I.Biol.: I. G. Carolan, K. G. Shuker
Laboratory:	Mrs S. A. Wright: A. Bonner, D. Goddard, Miss C. A. Howard, Mrs D. A. Waddell

PATHOLOGY (*Alice Holt*)

D. A. Burdekin, B.A., Dip. Ag. Sci., 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, M.I.For., R. G. Strouts: J. E. Pratt, P. G. Risby
Laboratory:	Mrs S. M. Dennis, Mrs S. A. Kirk, Miss M. K. Tepper: A. Jeeves, K. G. Crump
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: Mrs H. Steele, B.Sc.

ENTOMOLOGY (*Alice Holt*)

D. Bevan, B.Sc., Head of Branch
Miss J. M. Davies, B.Sc., F.Z.S., 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, J. I. H. Walker, Miss J. F. A. Nichols
Office:	J. Ellison

Northern Research Station
ENTOMOLOGY

J. T. Stoakley, M.A., M.Sc., D.I.C., F.I.For., Head of Section
D. A. Barbour, B.Sc., S. G. Heritage, M.I.Biol., F.R.E.S.

---

*On a 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
R. C. Melville, B.Sc., M.I.For., M.I.Biol.

Research Foresters:	L. A. Tee: H. W. Pepper: M. Roe, C. S. Taylor, P. R. Ratcliffe, B.Sc. (*Glenbranter, Strathclyde*)
Laboratory:	B. A. C. Don, B.Sc., Miss C. I. Derrick, A. R. Hall
Office:	Miss J. E. Cooper

SEED (*Alice Holt*)

A. G. Gordon, B.Sc., Agric., Ph.D., Head of Branch

Laboratory:	D. C. Wakeman: Mrs S. Lewis, Mrs A. A. Rees, B.Sc., Miss E. Farr
Seed Store and Extractory:	T. A. Waddell: L. H. Crumplin, P. Groves-Hambidge
Office:	Mrs M. Greenwood: Mrs M. Foster

ENGINEERING SERVICES (*Alice Holt*)

R. E. Stickland, Head of Branch
H. G. W. Bodkin, R. D. Butt, M. F. Johnston, G. J. Keens

Northern Research Station
R. M. 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).

SILVICULURE NORTH (*Northern Research Station*)

J. Atterson, B.Sc., M.I.For., Head of Branch
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., R. McIntosh, B.Sc., M.I.For., D. A. Thompson, B.Sc., M.I.For.

Research Foresters:		*Centre*
Special Projects	J. Hunt	Northern Research Station
North Scotland Region	G. Bartlett	Newton, Grampian
North Scotland Area	W. G. Paterson: N. Mackell, J. D. McNeill, C. E. S. Fleming	Lairg, Highland
North East Scotland Area	C. H. Blackwood: A. M. Walker D. Yeats	Newton, Grampian
North West Scotland Area	A. A. Green: D. S. Coutts	Fort Augustus, Highland
Central Scotland Region	J. H. Thomson	Northern Research Station
East Scotland Area	A. L. Sharpe: J. D. Lindsay	Perth, Tayside
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
Borders and North England Region	E. Baldwin	Mabie, Dumfries and Galloway

Borders Area	G. S. Forbes: D. J. Furness J. Stannard	Kielder, by Hexham Northumberland
North East England Area	K. A. S. Gabriel: R. E. J. Howes	Wykeham, Scarborough, North Yorkshire
South West Scotland Area	F. S. Smith: W. R. Kinsey	Mabie, Dumfries and Galloway
Wales Region	G. Pringle	Betws-y-Coed, Gwynedd.
North Wales Area	G. A. Bacon: D. Downs	Betws-y-Coed, Gwynedd
South Wales Area	N. P. Danby: C. J. Large	Brecon, Powys

SITE STUDIES NORTH (*Northern Research Station*)

D. G. Pyatt, B.Sc., Ph.D., Head of Branch

Laboratory: Mrs M. M. Craven, B.Sc.

GENETICS (*Northern Research Station*)

R. Faulkner, B.Sc., M.I.For., Head of Branch
A. M. Fletcher, B.Sc., Ph.D., A.I.W.Sc., M.I.For., G. I. Forrest, B.Sc., M.Sc., Ph.D., J. G. S. Gill, B.Sc., M.I.For., C. J. A. Samuel, B.Sc., Ph.D.

Research Foresters: C. McLean: R. B. Collins, I. J. M. Dawson (*Westonbirt, Glos.*), M. T. T. Phillips (Newton, Grampian), G. C. Webb (*Westonbirt*), W. Brown, W. J. Dyce (*Newton, Grampian*), P. G. Ross

Laboratory: Miss A. P. Ash, Miss L. J. H. Bowie

PHYSIOLOGY (*Northern Research Station*)

M. P. Coutts, B.Sc., Ph.D., Head of Branch
M. R. Bowen, B.Sc., Ph.D., J. J. Philipson, B. A., Ph.D.

Research Forester: J. Sivill

Laboratory: Miss B. A. Eaton, B.A., Miss B. L. Nelson

ADMINISTRATIVE STAFF (*Northern Research Station*)

F. W. C. McLauchlan

T. Lees: J. Lamb, Mrs M. J. Brown, Miss S. Marron, J. W. Ralston, Miss M. D. Connelly, Miss S. J. Cochrane

Typists: Mrs L. B. Barr (Superintendent): Mrs L. M. Connolly, Mrs M. Smith, Mrs S. M. Swan

Telephone Operator: Mrs A. A. Martin

Messenger: C. Stewart

WORK STUDY (*Alice Holt*)

A. J. G. Hughes, B.Sc., M.I.For., Head of Branch
R. O. Smith, B.A.
T. R. Sawyer, N.D.F., M.I.For., M. J. R. Ingoldby
St. J. G. D. Bland-Flagg

Machinery Research and Development
R. B. Ross, M.I.Mech.E.
W. S. Mackenzie

Office: W. E. Powell: Mrs P. J. Holcombe, Mrs P. A. M. Pharo, Mrs R. J. Hales (Typist)

Field Teams:		*Centre*
North Scotland	M. Lofthouse, B.Sc. (Leader) F. W. Hayes, B. G. Allison	Smithton, Inverness
Office:	Mrs V. Mackenzie (Typist)	
Borders	A. Whayman, M.B.E., M.M., M.I.For. (Leader) J. D. A. Tyers: R. A. Sandilands K. A. Russell, H. Milner, J. B. Spencer	Kielder and Mabie, Dumfries
Office:	Mrs M. Park	
East England	M. N. Haworth, B.Sc. (Leader) K. E. Wallis, M.W.S.O.M.: L. A. Cohen, N. Head	Santon Downham, Thetford
Southern England	D. Howard (Leader): R. N. Gossling	Brockenhurst
Wales	A. T. Jones, B.Sc., D.M.S. M.I.For. (Leader) D. G. Davies, M.I.For.: M. Blud, B. S. Hicks, P. F. Jefferson	Brecon and Dolgellau
Special Duties	J. A. Drummond, B.Sc.	

FIELD SURVEYS (*Alice Holt*)

K. P. Thallon, M. A., M.I.For., Head of Branch
Office: Mrs M. E. Douglas

FIELD SURVEY SECTION

A. I. D. Horne, B.Sc.,* G. M. L. Locke, B.Sc. (*Edinburgh*)
Foresters stationed at Alice Holt:
R. Twallin: D. Case, M. D. Whitlock

Foresters stationed throughout England and Wales:
A. C. Dover, M.I.For.: P. A. V. Burke, E. B. Cordery, E. C. C. Gardner, D. Hammond, R. Morris, H. B. Painter, B. D. Patten, N. C. Day, H. Oram

Foresters stationed throughout Scotland:
R. F. Bartlett, J. Straiton: D. F. Anderson, N.D.F., M.I.For., F. W. E. Burlton, A. R. Brown, N. Dixon, G. R. Dunbar, D. E. Ellis, R. Evans, J. A. McIntyre, H. Schneider, A. A. Tait, G. Taylor, D. S. Whitaker, P. J. Williams

SITE SURVEY SECTION (*Northern Research Station*)

Foresters: D. G. Caird, J. Davidson, J. M. Gissop, J. D. Wilson, N. Bonsfield

MENSURATION SECTION

P. N. Edwards, B.A., M.Sc., M.I.For.

Foresters: J. M. Christie, M.I.For., J.P., E. J. Fletcher, S. Malone
Scientific Officer: Miss B. M. Gay, B.Sc.
Office: Miss J. Chiverton

DRAWING OFFICE (*Edinburgh*)

K. F. Ball
G. D. Bull, A. L. Cooper: D. B. Armstrong, Miss V. Colgan, G. H. Hunter, M. J. Potton, Miss E. Baillie, K. R. Fergus, Miss M. F. Innes, S. T. Johnstone, Miss V. M. Stupple, T. A. Wilkins, Mrs L. E. Marshall, Miss C. M. Harper, Miss E. McKeen, Miss S. Murchison
C. Shuttleworth (Photographer)

---

*Studying aerial photo interpretation at the Netherlands' National Institute for Aerial Survey and Earth Sciences.

STATISTICS AND COMPUTING (*Alice Holt*)

R. S. Howell, Head of Branch
I. D. Mobbs, M.I.S.,* R. C. Boswell, B.Sc., M.I.S., G. J. Hall, B.Sc., K. Rennolls, B.Sc., M.Sc.: Miss J. Smyth, B.Sc.: Mrs M. J. White

Research Foresters:	A. E. Coates, C. A. Thorne
Data Processors:	Mrs E. Butler, Mrs A. P. Daborn, Mrs P. F. Newell, Mrs S. M. Nicholls
Office:	S. Hankin, Mrs C. A. Yeomans: Mrs A. H. Clements (Typist)

STATISTICS AND COMPUTING (*Northern Research Station*)

D. H. Stewart, B.Sc., M.I.Biol., F.I.S., Head of Section
Mrs J. Thompson, M.I.S.: G. D. Bell, B.Sc., B. G. Miller, B.Sc.

Data Processors:	Mrs W. M. Slater, Mrs M. Stanley

COMMUNICATIONS (*Alice Holt*)

O. N. Blatchford, B.Sc., A.I.Inf.Sc., Head of Branch

RESEARCH INFORMATION SECTION

O. N. Blatchford, B.Sc., A.I.Inf.Sc., Head of Section
P. J. Langley, M.A.: Miss C. W. Bradshaw, B.Sc. (Librarian): J. G. Jackman: Mrs M. Butt, Mrs L. D. Birchall (Typist)

PHOTOGRAPHY SECTION

I. A. Anderson, F.I.I.P., Head of Section
Mrs T. K. Evans, F.R.P.S., J. Williams (Graphics Officer), Miss M. Trusler

PUBLICATIONS SECTION

K. W. Wilson, B.Sc., M.I.For., Head of Section
P. A. Mayne: Mrs A. C. Costain

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