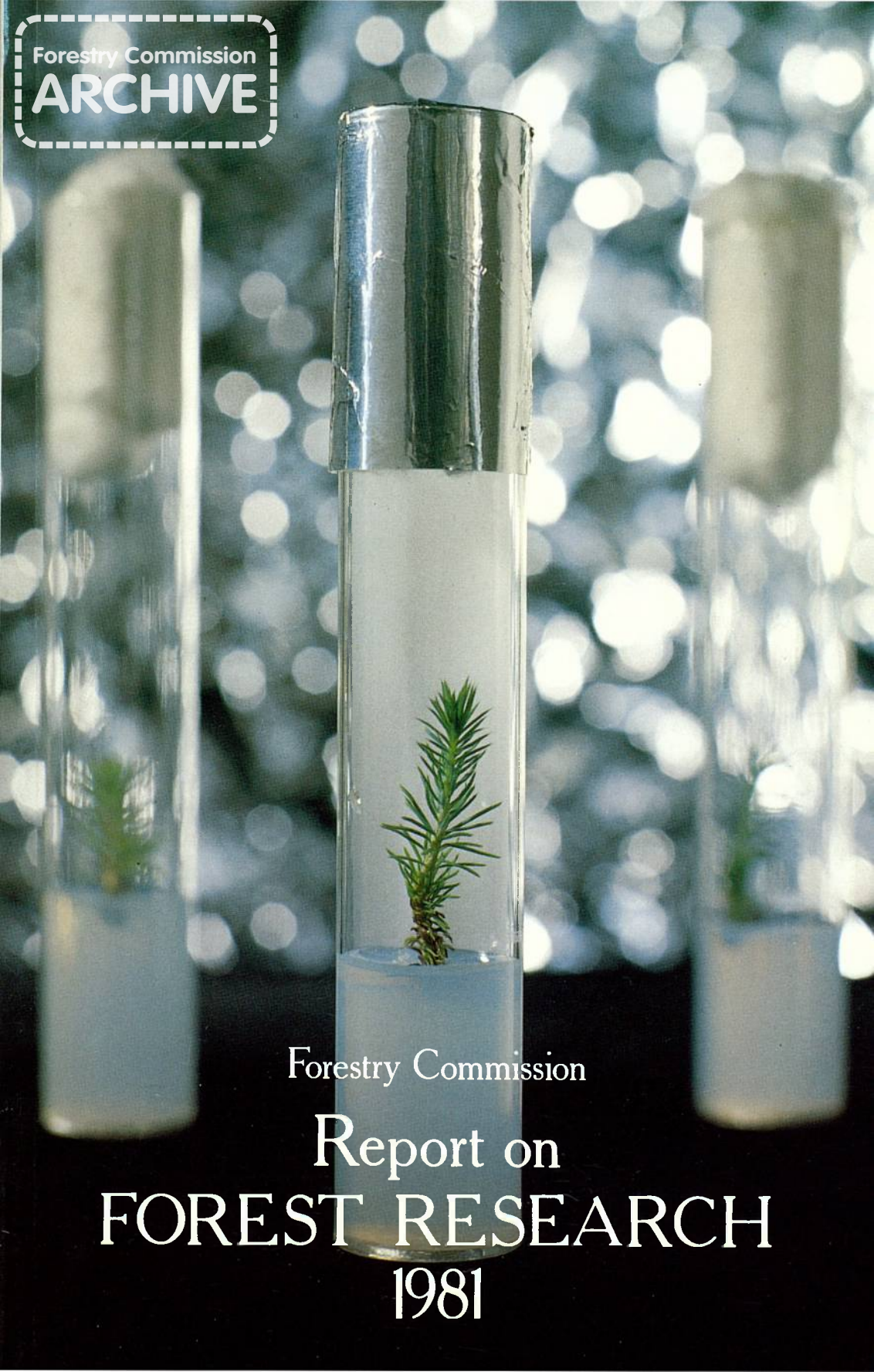

Forestry Commission

Report on FOREST RESEARCH 1981

REPORT ON FOREST RESEARCH

for the year ended
March 1981

LONDON
HER MAJESTY'S STATIONERY OFFICE

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TIMBER UTILIZATION

INTRODUCTION

By D. R. JOHNSTON
Director of Research and Development

House of Lords Committee

During the year a House of Lords Select Committee on Science and Technology investigated the scientific aspects of forestry in Britain. The Committee reported that they were impressed by the way in which the applied research carried out by the Forestry Commission is planned and conducted, and in which priorities have been assessed to make the most effective use of available funds. They considered, however, that there could be better coordination of the whole range of forest and forest-related research in Britain and they recommended that the Forestry Commission should take the lead in this coordination. The implications of this and other recommendations of the Committee are being studied by the various Government departments concerned with research with a view to formulating a joint advisory report to Ministers.

Contract Work

A contract to undertake arboricultural research on behalf of the Department of the Environment was completed at the end of 1980 and was extended for three years from 1 January 1981. Work on a five-year contract to investigate the rehabilitation of deep-mining spoil heaps, also for the Department of the Environment, continued during the year and will be completed in 1985.

During the year the EEC undertook to give financial support to a research project on coppiced trees as energy crops which the Forestry Commission is undertaking on behalf of the Energy Technology Support Unit of the Department of Energy.

Progress on the joint EEC Dutch elm disease project is reported in the Pathology Branch section of this report.

Computing

A new computer was installed at the beginning of the year at Alice Holt Lodge. It is a Prime 400 system with one megabyte of main memory, 192 megabytes of disk capacity, and lines for 30 interactive terminals. It is also connected to new key-to-disk data preparation equipment and to two remote computers.

Electron Microscope

A new Scanning Electron Microscope (ISI 100 A) was purchased. This is being used mainly for the study of pathology and entomology problems. Examples of its use are shown on Plate 1 illustrating the colonisation and deterioration of wood in pruning wounds, dispersal of Dutch elm disease spores, and morphological variation in perithecia and spores of *Nectria* spp. associated with Beech bark disease.

Tree Shelters

Considerable improvement in the growth of transplants when planted in the forest has been achieved in two growing seasons with the use of tree shelters made of clear plastic. This development could well open up a reliable technique for establishing broadleaves at wide spacing and a substantial effort is being

made to test different plastic materials and to determine the response of the main tree species on a range of sites. The longer term effect, particularly the stability of trees as they outgrow the shelters, can only be assessed after a further two or three seasons.

Mycorrhiza

A new project on the mycorrhizal colonisation of Sitka spruce has been undertaken by the Physiology Branch at the Northern Research Station. The collection and testing of fungal isolates has started in preparation for inoculation to assess the value of mycorrhizae in promoting survival and growth of Sitka spruce. This project involves close collaboration with the University of Surrey and the Institute of Terrestrial Ecology.

Dutch Elm Disease

Dr C. M. Brasier and colleagues carried out several surveys abroad as part of the EEC supported research on the origin and spread of new strains of Dutch elm disease. In July, Dr Brasier conducted a sample transect across Poland from the Russian to the East German borders and Baltic ports, with the assistance of the Institute of Forest Science in Warsaw and the University of Poznan. In September and October he carried out a 15,000 km overland trip with the help of two staff members to survey Yugoslavia, Rumania and central and eastern Turkey. Over 600 samples of Dutch elm disease were collected.

Aerial Survey

Because of unfavourable weather conditions during the year, only 50 per cent of the proposed programme was achieved. However, the cost per photograph was one half of the normal commercial rate, and will result in a very substantial saving on the census survey.

Visitors

Five hundred and ninety five people visited Alice Holt Lodge. The 21 parties included the House of Lords Select Committee on Science and Technology and a IUFRO Subject Group S5, Wood Technology.

The Northern Research Station received 620 visitors including the National Committee for Scotland.

Both Stations were visited by a forestry delegation from the People's Republic of China.

Visits and Conferences

Forty-one members of staff attended conferences in this country, and 14 conferences abroad. Other visits abroad amounted to 29. They included visits by Dr A. G. Gordon (Principal Seeds Officer) to Mexico to assist with a tropical tree seed workshop, to Honduras to advise on the administration of their seed bank and to Sabah to look at all aspects of seed supply for FAO.

Experiments have shown that Sitka spruce × White spruce hybrids can provide a fast-growing alternative to Lodgepole pine on some of the exposed and frost-prone sites in northern Scotland. The origin of the White spruce parents may be an important factor in developing hybrids and for this reason Messrs. R. Faulkner and I. J. M. Dawson (Genetics Branch) visited British Columbia to collect pollen from six widely separated regions within the province. A total of 120 trees were successfully sampled during the visit.

Staff Changes

Responsibility for utilisation studies has been transferred from Harvesting and Marketing Division and J. R. Aaron (Forest Officer I), who has been based at Alice Holt Lodge for some years, becomes the head of a Wood Utilization Branch in the Research and Development Division. I. D. Mobbs (Senior Scientific Officer) returns to Statistics Branch after a period of secondment with the Pay Research Unit.

Transfers in: A. C. Alexander (Forest Officer I) from West Scotland Conservancy to Work Study, Ae. P. M. Tabbush (Forest Officer I) from North East England Conservancy to Silviculture North, NRS. A. C. Thompson (Forest Officer II) from North Wales Conservancy to Work Study, Brecon. M. K. Hollingsworth (Head Forester) from North Scotland Conservancy to Silviculture North, NRS. D. J. Collins (Forester) from East Scotland Conservancy to Field Surveys, Culloden. T. P. Edge (Forester) from South East England Conservancy to Work Study, Brockenhurst. D. H. Jones (Forester) from Education and Training, HQ. to Work Study, Dolgellau. I. R. McNicol (Forester) from West Scotland Conservancy to Field Surveys, Ben More. J. C. Proudfoot (Forester) from the Show Unit to Field Surveys, Alice Holt. H. Roberts (Forester) from South Wales Conservancy to Field Surveys, Llandovery. R. J. Wallace (Forester) from East Scotland Conservancy to Silviculture North, Lairg. P. D. Finch (HQ Cartographic Draughtsman) from Ordnance Survey, Southampton to Field Surveys, HQ. A. M. Selbie (Cartographic Draughtsman) from North Scotland Conservancy to Field Surveys, HQ. J. R. C. Allely (Executive Officer) from North Scotland Conservancy to NRS.

New Appointments: A. G. Nairn (Higher Scientific Officer) Statistics, NRS. S. C. Pickett (Scientific Officer) Statistics, Alice Holt. R. W. Blackburn (Scientific Officer) Statistics, NRS.

Transfers out: M. Lofthouse (Forest Officer I) from Work Study, Inverness to Harvesting and Marketing, HQ. D. G. Davies (Head Forester) from Work Study, Dolgellau to South Wales Conservancy. R. N. Gossling (Forester) from Work Study, Brockenhurst to South West England Conservancy. W. R. Kinsey (Forester) from Silviculture North, Mabie to West Scotland Conservancy. C. J. Large (Head Forester) from Silviculture North, Brecon to North East England Conservancy. L. A. Cohen (Executive Officer) from Work Study, Thetford to South East England Conservancy.

Promotions: J. Evans (Silviculture South) to Forest Officer I. R. C. Melville (Wildlife) to Forest Officer I. R. G. Muhl (Work Study) to Forest Officer I. P. M. Tabbush (Silviculture NRS) to Forest Officer I. R. C. Boswell (Statistics) to Senior Scientific Officer. G. J. Hall (Statistics) to Senior Scientific Officer. C. J. A. Samuels (Genetics) to Senior Scientific Officer. Miss B. J. Smyth (Statistics) to Higher Scientific Officer. Miss J. E. A. Nichols (Entomology) to Scientific Officer. Mrs. A. A. Rees (Pathology, Alice Holt) to Scientific Officer. Mrs D. A. Waddell (Site Studies, Alice Holt) to Scientific Officer. Miss M. Trusler (Photography, Alice Holt) regraded to Photographer. Mrs L. E. Marshall (Field Surveys HQ, Cartographic Draughtsman) to HG Draughtsman. B. S. Hicks (Work Study, Dolgellau Forester) to Head Forester.

Resignations: R. E. Stickland (Senior Scientific Officer) Experimental Workshop, Alice Holt. Mrs S. A. Wright (Scientific Officer) Site Studies, Alice Holt.

Retirements: A. Whayman (Forest Officer I) Ae. R. B. Ross (Mech. Eng. I) Work Study, Alice Holt. J. Empson, (Clerical Officer) Alice Holt. Mrs E. A. R. Empson (Telephonist) Alice Holt. Mrs M. E. Douglas (Clerical Officer) Field Surveys, Alice Holt. J. Ellison (Clerical Officer) Entomology, Alice Holt.

Death: C. W. T. Young (Chief Forester) Pathology, Alice Holt.

PART I

The Work of the Forestry Commission

RESEARCH AND DEVELOPMENT DIVISION

BRANCHES AND THEIR PROJECT GROUPS

*No progress is reported during the year.

Field Surveys

Field and Site Surveys Section

Mensuration Section

Census Section

Drawing Office

Work Study

Statistics and Computing

Communications

Research Information Section

Photography Section

*No progress is reported during the year.

Publications Section

Wood Utilization

OTHER HEADQUARTERS DIVISIONS

Planning and Economics

*No progress is reported during the year.

SEED

Research

Nursery Experiments

Unreliable nursery production of the less common *Nothofagus* species has prevented their being used in species and provenance trials. Based on small laboratory studies a series of experiments were laid down at Headley Nursery to compare two or more of the following: fifty per cent shade with no shade; grit with sand as seedbed covers; irrigated with non-irrigated beds; and at least three presowing seed treatments from among the following: dry seed, seed soaked in water, seed soaked in 0·02 per cent thiram, seed prechilled for three, four or six weeks, seed soaked in 0·02 per cent thiram before prechilling, and seed soaked in 50 ppm gibberellic acid$_{4\backslash7}$. Two seed lots from different origins of *Nothofagus alessandrii, N. pumilio, N. dombeyi* and *N. antarctica* and one seed lot of *N. solandri* were used.

In all experiments there were interactions, particularly in the way the two different seed lots reacted, which made the interpretations of the results difficult, but the general effects can be summarised as follows: –

Shading. In the four species studied, shading increased the total germination of *N. dombeyi, N. solandri* and *N. pumilio* by from 10 to 20 per cent; at the end of season survival under shade was 10–20 per cent better for *N. solandri* and *N. pumilio,* but for *N. dombeyi* it was 40 per cent better than for treatments without shading. For *N. antarctica* total germination was 10 per cent better without shade but by the end of season survival was 10 per cent better with shade. For all species seedling height at the end of the season was considerably greater without shade.

Seedbed covering. In the three small-seeded species studied, *N. antarctica, N. dombeyi* and *N. solandri,* total germination and end of season survival was from 10 to 20 per cent better under grit than under sand. This is in marked contrast to the results obtained in 1979 for similar sized seeds of *Betula* species (See *Report,* 1980). There was no consistent difference in final seedling heights.

Irrigation. Only *N. alessandrii* was studied. Due to a six-week drought immediately following sowing, there was a threefold better total germination with irrigation than without. By the end of the season survival was six times better and seedlings were four times larger in irrigated than in non-irrigated beds. (In all other experiments irrigation was applied to all treatments when necessary.)

Seed treatments. For *N. alessandrii, N. antarctica, N. dombeyi* and *N. solandri* total germination and survival was poorer and seedling heights were smaller after sowing dry seeds than after any other treatments. Prechilling improved rate of germination, total germination, number of seedlings surviving at the end of the season and plant heights for all species. Six weeks prechilling was marginally better for *N. solandri* and marginally worse for *N. alessandrii* than three weeks prechilling on total germination and on the number of seedlings surviving at the end of the season. A 24-hour soak in GA$_{4\backslash7}$ produced greater total germination and more seedlings at the end of the season than prechilling treatments for *N. alessandrii* and *N. antarctica.* For *N. solandri* and *N. dombeyi* the GA$_{4\backslash7}$ soak resulted in better germination than the control but not quite such good germination as after the prechilling treatments, although in the *N. dombeyi* experiment the GA$_{4\backslash7}$ treatments were adversely affected by the lack of shading. For *N.*

pumilio the $GA_{4\backslash7}$ soak gave better total germination than all treatments except prechilling after a thiram soak. However by the end of season the number of *N. pumilio* seedlings surviving after the $GA_{4\backslash7}$ soak was very low (less than 50 per cent of the total germination).

In the absence of more evidence it is suggested that seeds of these five *Nothofagus* species should be prechilled for up to four weeks before sowing, should be covered with grit after sowing, should be protected from the sun by shading (not more than 50 per cent) and should have irrigation available.

The work reported on other broadleaved seed pretreatments (see *Reports* 1979, 1980) has now been completed. A broadleaved seed manual is in an advanced state of preparation.

A. G. GORDON, D. C. WAKEMAN

Laboratory Experiments

The scarification work described last year (see *Report*, 1980 p. 9) has continued in conjunction with Site Studies, aimed at breaking the hard seed coat dormancy of nitrogen-fixing legumes being used in reclamation trials (see page 25). The most effective method has been to mix one kilogram of seed in a 1:1 ratio W/W with lumps of carborundum waste in an End-over-End shaker run at about 60 rpm for 10 minutes. This has produced a short-term increase in the number of seeds that germinate within the first 14 days as well as a long-term increase in the total number of seeds that germinate within the first year. Large local collections of Tree lupin, have shown a relatively high germination percentage (without scarification) at time of collection in August and September. During cold artificial storage or natural storage in undehisced pods this germination percentage fell to levels normally experienced in processed seed lots. This phenomenon has previously been reported here for *Acer campestre* and *Sorbus* species.

D. C. WAKEMAN, N. BEST

Service

There has been a sixfold increase in the quantity of cones collected by conservancies in the last year, compared with the previous year when the cone crop was of similar size. Again the collection from private estates was disappointingly low. Although the collections were only made possible by the sudden availability of labour due to a drop in timber sales, the results do confirm the potential of British forests to be self-sufficient in most conifer species. Due to harvesting difficulties with oak from Registered stands in Europe, large collections of Unregistered seed were made under licence, mainly in the New Forest. In contrast, despite the best beech mast year for several years only 150 kg were collected. The balance of requirements was imported from Rumania. Because of the successful conifer collections, relatively little conifer seed was imported; importations were mainly of Douglas fir, Western hemlock, some origins of Lodgepole pine, Japanese larch and Grand fir. Despite the depressed timber market, despatches of conifer seed have stayed at approximately the same level as last year. A reduction in broadleaved seed despatches was caused by the shortage of oak seed and by ceasing to supply the more ornamental species.

A. G. GORDON

SILVICULTURE (SOUTH)

Plant Production

Seedbed and Transplant Bed Herbicides

Diphenamid, nitrofen, oxyfluorfen, terbuthylazine, napropamide, chlorthal-dimethyl and several mixtures were tested for weed control and crop tolerance in seedbeds.

Atrazine, terbuthylazine, and the two combined with simazine and simazine alone gave goods results on 1+0 Sitka spruce in transplant beds.

Broadleaved Trees in Paperpots (Polythene Greenhouse)

Broadleaved trees in Paperpots were raised indoors, with or without heating, and also outdoors. Heating gave an even early germination and rapid growth. When removed to harden-off outdoors however, the rate of height growth fell behind that of unheated stock which eventually produced suitable planting stock by the end of September.

The optimum greenhouse raising period for five broadleaved species given three separate sowing dates per species was investigated. Birch required 6 to 8 weeks, alder 10 to 12 weeks, oak 12 weeks, *Nothofagus obliqua* 10 weeks and sycamore 6 to 12 weeks. All plants were hardened-off for 6 weeks.

W. J. McCavish

Vegetative Propagation

Trials were continued in greenhouses to determine the best means of propagating a wide range of broadleaved species and cultivars from softwood and semi-ripe cuttings. Overhead automatic mist was used to prevent wilting and death of cuttings. Work designed to examine the relationship between substrate temperature and root initiation and development disclosed that several moderate to easy to root subjects, notably well-known cultivars of *Platanus, Populus, Salix, Tilia* and *Ulmus,* rooted as well on unheated benches as on heated benches during the summer. For the first time, woodland species capable of yielding wood of high quality were included in the trials. Cuttings were taken from young stock plants of seedling origin. Common ash, *Fraxinus excelsior* and Gean, *Prunus avium,* were easily propagated from softwood cuttings.

J. Jobling

Lowland Silviculture

Broadleaved Species in Paperpots (Forest Extensions)

Four broadleaved species were sown at four different dates in 1979 and given 0, 4 and 8 weeks hardening-off. Oak and birch benefited more than sycamore and beech from hardening-off especially when planted in June, July and August.

All four species in Paperpots survived better than bare-rooted stock when planted in July, but only oak and birch were better in June, August, September and October. Oak and birch bare-rooted transplants grew better than unhardened Paperpot plants when planted in May.

W. J. McCavish

Tree Shelters

In two years, oak *(Quercus petraea)* transplants in clear plastic tubes, 1·2 m tall and 8–16 cm diameter, have grown four times more in height and twice as much in diameter as trees without shelters (see Table 1 below).

TABLE 1

HEIGHT AND DIAMETER OF OAK AFTER TWO GROWING SEASONS IN DIFFERENT DESIGNS OF SINGLE TREE SHELTERS AT ALICE HOLT FOREST

	Size at planting	Height and diameter after one and two seasons in different designs of shelter					
		B	C	D	E	F	G
Transplants (1+1's)							
Height after one year (cm)	22	22	26	30	30	51	36
Height after two years (cm)		34	53	103	120	132	130
Stem diameter after one year (mm)	4·1	5·0	5·3	5·5	5·7	5·6	6·0
Stem diameter after two years (mm)		5·4	6·4	7·2	8·4	7·8	9·2

B – Control tree marked by a stake.
C – Biodegradable individual tree guard 8 cm diameter, 1·2 m tall.
D – C plus polythene tube cover 1·1 m long with 0·1 m gap at base.
E – C plus polythene tube cover 1·2 m long with no gap at base.
F – C plus polythene tube cover 1·3 m long with top hole 1·5 cm diameter.
G – Biodegradable individual tree guard 16 cm diameter, 1·2 m tall with polythene tube cover 1·2 m long with no gap at base.

Figures are mean values adjusted for initial differences between treatments. At the end of the second year the variation between mean heights was significant at the 0·1 per cent level and that between mean diameters was significant at the 1 per cent level.

Eight deciduous broadleaves and seven conifers were planted on five sites in 1980. There was some damage to a few plants but all species achieved greater height growth when inside shelters. The growth of oak (28 cm in shelters and 5 cm without), alder (51 cm and 25 cm) and Japanese larch (37 cm and 13 cm) were most promising.

A shelter life of three years should achieve adequate growth improvement but a longer period of deer or deer plus rabbit protection is desirable on many sites. Consultations with various manufacturers are producing more appropriate materials for testing.

Nothofagus

In 1981 and 1982 *Nothofagus obliqua* and *N. procera* will be established on a wide range of sites to determine where each species can be grown. Three origins of each species will be used to cover as much of the natural range as possible. Some minor species will be included on all sites.

Fast Growing Pines

The large differences in growth of origins of *Pinus muricata* and small differences in origins of *P. radiata* when sown in 1979 at Headley Nursery (Hampshire) were repeated in 1980.

G. TULEY

Broadleaves – silviculture

The few oak and beech provenance experiments have been reviewed and statistically significant differences in both form and growth rate have been found between seed origins. However, few generalisations are possible since only a small number of seed origins are compared and many only occur in one experiment. Also, several of the parent stands and sources of seed no longer exist. It is worth noting that Dean origin oak grows well and is of above average form, Carpathian (Rumania) oak appears excellent, but oak originating from the New Forest, Denmark and Scandinavia is poorer than average. For beech no British, Danish or French seed source was found much above average and some sources, e.g. New Forest, Watlington (Oxfordshire) and Czechoslovakia are poor. Carpathian beech (presently being imported) appears about average. The best beech origins tested are Forêt de Soignes (Belgium) and Holland.

Continuing studies of free growth of oak show that basal area growth is stimulated whether begun on small-pole trees or larger, older ones (Figure 1).

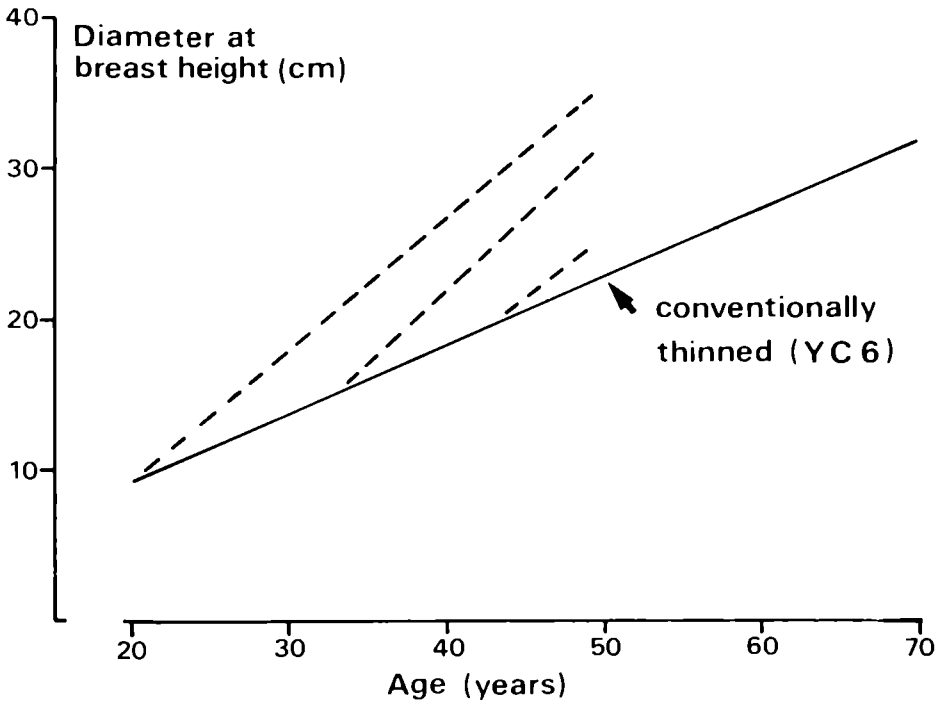

Figure 1. The effect of free growth on diameter increment of selected oak when begun at ages 20, 33 and 43 years. Crumbland (Tintern Forest).

Free growth is an important alternative to traditional silviculture and its one disadvantage of sometimes encouraging epicormics is being investigated using new methods of epicormic control including stem wrapping and application of chemicals.

Limited foliar sampling of old oak woods, mostly coppice-derived, on steep slopes around Dartmoor and Exmoor suggests that many trees are phosphate deficient. Further research is planned to investigate their poor growth and inadequate regeneration.

J. EVANS

Oak on Heavy Clays

An assessment of 25-year old oak in an experiment comparing three drainage intensities on Oxfordshire clay showed that intensive drainage (drains 7 m apart, 60 cm deep but not maintained after cutting) significantly improved growth rate, stocking and form.

J. EVANS, D. F. FOURT

Forest Weed Control

Herbicide Screening

Terbuthylazine at 8 kg ai/ha had little effect on conifers or broadleaved species applied April to June.

Cyprazine (a heather herbicide) was safe on several conifers, (Lodgepole pine, Sitka spruce, Douglas fir, Japanese larch, *Pinus muricata* and *P. radiata*). Western hemlock, *Sorbus aucuparia* and *Betula pendula* were seriously affected but *Fagus sylvatica*, *Quercus petraea* and *Acer pseudoplatanus* were not.

Glyphosate injury caused by spraying twice in the same season and in concurrent seasons is under investigation.

Triclopyr ester was screened at 2, 3 and 4 litres in June, July and August.

Control of Grasses and Herbaceous Broadleaved Weeds

Terbuthylazine gave good grass control at 6 kg ai/ha without affecting the health of oak, sycamore or birch.

An atrazine/dalapon (10%/10% w/w) granule ('Herbon Lignum') gave good weed control of grasses without affecting Corsican pine, Hybrid larch or Sitka spruce, at 40 kg product/ha. 'Fydulan' gave better weed control but caused die back and poor health at a similar rate.

Control of Heather

Cyprazine at 3 kg ai/ha and glyphosate at rates down to 0·54 kg ae/ha continued to give good control of *Calluna vulgaris* for a second season.

Control of Gorse, Broom, Deciduous Woody Weeds and Rhododendron

Ulex gallii continued to be well controlled by triclopyr ester and *Sarothamnus scoparius* (broom) by the amine.

Glyphosate gave better control of deciduous woody weeds than triclopyr formulations two years after treatment. August treatment at 1·08 kg ae/ha (3 litres/ha) appeared to give the best results.

Triclopyr ester, glyphosate, a solubilised glyphosate formulation and 2,4,5-T will be tested on cut-stumps as well as regrowth of rhododendron.

Control of Bracken

Glyphosate, at 1·08 kg ae/ha proved no better than asulam at 2 kg ae/ha, only offering advantages for mixed bracken/woody weed control.

W. J. McCAVISH

Arboriculture – Department of the Environment Contracts

Motorway Planting

Italian alder, sycamore and hawthorn transplants in an experiment laid down on the A610/A38 Ripley Interchange (Derbyshire) in 1979 have shown a highly significant positive response with increase in the area of basal weed control. Sycamore and hawthorn, but not Italian alder, also responded to the addition of nitrogen.

The final experiment in a series of four season-of-planting trials was established on the A45 Cambridge Northern Bypass during 1980 using Common alder as the test species. A second experiment was set up on the same site to investigate survival and growth of ash and sycamore transplants planted into a legume *(Melilotus* sp.*)* sward instead of the usual Department of Transport grass mixture.

A trial set up at Alice Holt in 1980 (Plate 2) to monitor soil temperature and moisture under different grass control treatments has provided clear indications of the physical benefits of removing grass which is competing with young trees (Figure 2–p. 16).

Moisture tension was determined by soil moisture blocks buried at 5, 10, 20, 30 and 40 cm depth. The moisture blocks under bare soil (herbicide treated) and both mulches show little change in resistance, and hence moisture tension during the spring drought of 1980, compared with those under the grassed plots. Mowing the grass reduced the moisture loss by only 25 to 30 per cent and appeared to slow up the rewetting process.

Measurement of the diurnal soil temperature variation under the treatment plots has shown that the least variation occurred under a 150 mm pulverized bark mulch, followed in order of increasing variation by, unmown grass, mown grass, bituminized felt sheet mulch and herbicide-treated bare ground.

Urban Planting

A street tree experiment in Plimsoll Road, Islington was concluded at the end of 1980. The rowan standards used gave no indication of any response to increasing the proportion of peat in the backfill.

Production of Amenity Stock

A series of experiments was carried out using ash and birch seedlings in an attempt to identify the physiological reasons for differences in response to drying by different species. Among the factors examined has been the carbohydrate distribution within the root systems.

H. INSLEY, J. B. H. GARDINER

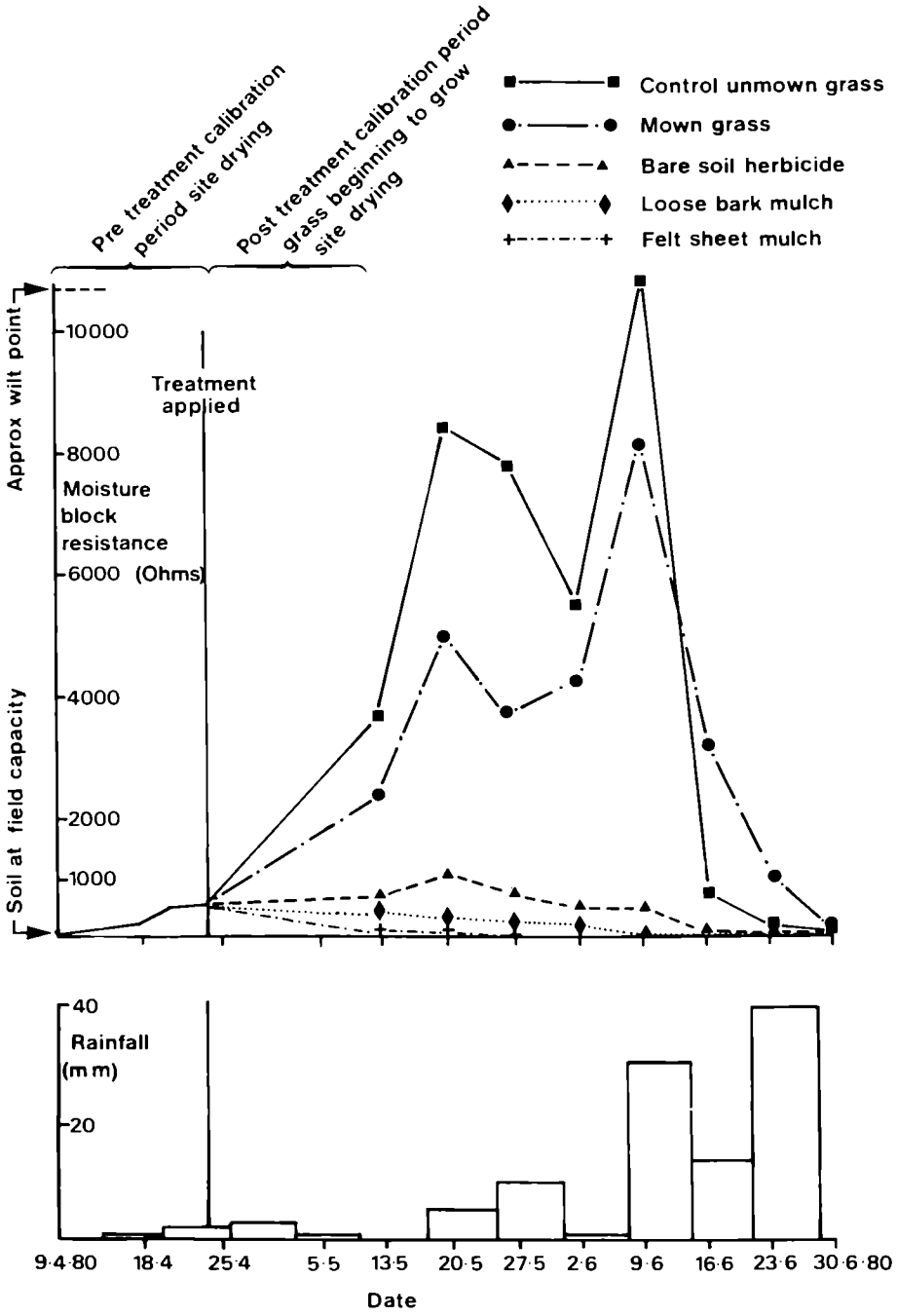

Figure 2. The effect of grass control methods on soil moisture at 10 cm depth.

Arboriculture Advisory and Information Service

During the year 15 Arboriculture Research Notes were published; two earlier Notes, *(Plastic Net Tree Guards,* and *English Elm Regeneration)* were revised. The new Notes reported results of Department of the Environment funded research *(Foliar Nutrient Levels of Lime* and *Treatment of Tree Wounds)* or provided statements of knowledge on currently topical subjects *(Coppice, How much wood for the stove?, Native and Exotic Trees in Britain,* and *Fungicide treatment of Dutch elm disease).* Texts prepared by specialists outside the Forestry Commission were also published as Arboriculture Research Notes. These covered *Bacterial Wetwood, Tree Roots and Foundations,* and *Improvement of Birch for Forestry and Amenity.*

In order to ensure the widest possible dissemination of current research results the Proceedings of the Seminar *Research for Practical Arboriculture* have been published as Forestry Commission Occasional Paper No 10.

The Advisory Service was used during the year by 1725 enquirers.

D. PATCH, F. R. W. STEVENS

Colliery Spoil

Experiments were started on reclaimed land in Northumberland, County Durham, West Yorkshire and Mid Glamorgan to study cultivation practices and planting methods in compacted spoil. Experiments were also laid down on other sites in the first three named counties, to compare the early behaviour of different sizes and types of planting stock, and to assess the relationship, if any, between season of planting and tree survival. Eight broadleaved species and three conifers were included in the experiments.

J. JOBLING

Short Rotation Coppice – Department of Energy Contract

Clonal poplar and willow, along with *Nothofagus,* alder and *Eucalyptus* are being used to establish experiments over a range of environmental site types. Disadvantaged agricultural land and low-grade broadleaved woodland are the sites envisaged for such a coppice system and spacing and rotation lengths are examined.

M. L. PEARCE

Dendrology and Arboreta

Dendrology

During the year 103 estates and gardens were visited, fifty-nine for the first time Of the 5,835 trees measured 3,634 were new entries on the Register; conifers 2,270; broadleaves 1,364. New species were 43, 38 of them broadleaved species. In Ireland 1,060 trees were measured, 583 of them were new. The Register now includes 54,598 specimens, 32,692 conifers and 21,906 broadleaves, comprising 1,387 species in total, and 819 cultivars. The revision and metrication of the Register is nearly complete for conifers and will be completed in 1981. Several genera of broadleaved trees have been similarly revised.

Bedgebury, Kent

The schoolroom has been furnished and equipped and now houses the Dallimore cone collection. The Dwarf conifer collection has been extended and many new cultivars planted in the Pinetum together with some new wild-source species.

A. F. MITCHELL

Westonbirt, Gloucestershire

Mapping of the collection is almost completed. Important or senile specimens have been very successfully propagated and new seed-lots, notably some from China have been successfully grown. A new range of *Nothofagus* provenances and an EEC collection of *Ulmus* clones have been established and additions made to the Hillier Cherry collection and the John White Willow collection.

The number of visitors has increased and was 175,000 for the year.

M. L. PEARCE

SILVICULTURE (NORTH)

Production of Planting Stock

Herbicides on Transplants

The 1978 Research Report described damage cause by propyzamide applied at 2 kg ai/ha to Sitka spruce transplants. An experiment in 1979/80 attempted to reproduce the damage under controlled conditions. Sitka spruce and Lodgepole pine seedlings were lined out in July and simazine applied at 2·25 kg ai/ha. Propyzamide was then applied to plots in mid September, October and November at rates of 1·5, 3·0 and 4·5 kg ai/ha. No serious damage was observed. Increments in the plots of both species treated at the highest rate and the earliest date were slightly reduced.

Cloches on Seedbeds

Covering seedbeds of Sitka spruce with polythene cloches for different periods after sowing showed that covering during the germination phase seriously reduced numbers. Covering at 6 weeks until 16 weeks after sowing produced seedlings twice the height of uncovered seedlings, without reducing numbers produced. Trials showed that shading in addition to the polythene cloche during germination prevented serious losses.

Liquid Fertilizers

Experiments have been established to test the use of liquid fertilizers. Because they can be applied easily, evenly and safely, liquid fertilizers are likely to have great advantages for top dressing. Solid fertilizers can cause scorch damage if conditions are not good.

Vegetative Propagation

Techniques for rooting Sitka spruce cuttings taken from young material of genetically improved origins are working successfully. Cuttings are collected in March and, without any hormone treatment, are inserted in a grit/peat medium

in an unheated polythene greenhouse with mist irrigation. Results from field experiments comparing cuttings with normal bare-rooted transplants so far are encouraging. Construction of a polythene greenhouse sufficient to raise 100,000 cuttings annually for large-scale trials has been started at Newton Nursery (Grampian).

Sitka spruce cuttings are well rooted by June and have usually been lined-out in the nursery after they have set bud. At this stage they have a low nutrient status and can be subjected to very dry conditions. Even so, summer lining-out results have been reasonable. If the cuttings are kept in the greenhouse, and the mist system is used for normal irrigation from June onward, then it is possible to use liquid fertilizers and by the end of the year produce a much better quality plant which is better able to withstand normal lining-out.

Better quality larch plants have been produced from cuttings by the use of an improved mist irrigation control. The control unit works by sensing the wet bulb temperature depression and switching on the mist whenever the depression falls below a preset level. A timing circuit overrides the humidity sensor and only allows the mist to come on for a few seconds every few minutes. Both the time on and the time off can be varied. Precise control of the humidity prevents wilting and also excessive watering. Either of these conditions can result in the cuttings bending and lignifying with the bend, a condition from which they are slow to recover.

P. BIGGIN

Planting

Deer Fencing

An experiment with fencing as a replicated treatment on a restocking site at Drummond Hill Forest (Tayside) is showing large differences in height growth in favour of the fenced plots. Superior height growth also results in less weeding being required in the fenced plots.

Restocking

Experiments are being established at Glenurquhart Forest (Highland) with Douglas fir and Sitka spruce, and at Huntly Forest (Grampian) with Sitka spruce to investigate the effects of cultivation and nutrition on establishment and growth following clearfelling. The relationship between moisture status at planting and subsequent survival will be determined for different plant sizes at Glenurquhart as part of the development of an electronic device for determining the moisture content of planting stock.

Spacing

A series of experiments with various species planted in 1955 at square and rectangular spacings show that a greater range of stem sizes is produced in the more rectangular spacing.

P. BIGGIN, P. TABBUSH

Species Trials

Trials of Alternative Species

Over the years a large number of species have been tested as alternatives to main species such as Sitka spruce and Scots pine. It is now clear that species which will surpass Sitka spruce on purely economic criteria are unlikely to be found. There are other grounds (insurance against wholesale calamity, better timber quality, disease risks, amenity, etc) for choosing alternative species which may not optimise net discounted revenue, yet still be profitable.

In 1965/66 three experiments were planted to compare *Picea* × *lutzii* Little (a naturally occurring hybrid between Sitka and White spruce) with two seed origins of Sitka spruce. After 15 years the *P.* × *lutzii* was 2·9–4·3 m high, while Alaskan origin Sitka spruce was 3·6–5·4 m and Queen Charlotte Island origin was 4·2–6·3 m. At all three sites the relationship for height was 70: 90: 100. The appearance of the *P.* × *lutzii* is more like Alaskan Sitka spruce than *P. glauca* but no cones have yet been produced. The sites were chosen because of their moderate rainfall (1,000 mm or less) as White spruce grows in a drier climate than Sitka, but the hybrid seems to have no advantage over Sitka spruce under such conditions. However, at Shin Forest (Highland) on a wetter peat where frost occurs regularly, *P.* × *lutzii* of the same origin was much taller than Sitka spruce at 10 years.

Also at Shin, artificial hybrids of Sitka × White spruce have been planted and are growing much faster and are more tolerant of frost than Sitka spruce. It seems possible that heterosis results when Sitka spruce is crossed with eastern seed origins of White spruce, whereas in the natural zones of introgression in Alaska and along the Skeena River, British Columbia (Lines, 1980) vigour is lost.

Another species which has been tested is *Pinus peuce* Grisebach with five experiments being established in 1961/62. This five-needled pine comes from the mountains of S. Yugoslavia and Bulgaria and before 1961 had scarcely been planted outside arboreta. Two plots at Kielder averaged 15·1 m at 39 years (equivalent to YC 10 Scots pine) and have excellent form. The sites cover a range of heathland and peatland of varying fertility and exposure. Early results were noted in the *Report on Forest Research* for 1972 (p34). Since then, growth rate has increased considerably with shoots up to 50 cm and, apart from susceptibility to deer, this can be considered a promising species, unaffected by snow damage which injured adjacent Scots and Lodgepole pine.

'Self-thinning' Mixtures

On sites with a high risk of windthrow, thinning may be undesirable but if not carried out the average diameter at time of felling may be unacceptably small. To overcome this problem, mixtures of species of different growth rate can be used but this in turn may lead to management difficulties. Both problems could be solved by using inherently slow- and fast-growing seed origins of a single species. Two experiments have been planted using different mixture patterns of slow-going Alaskan and fast-growing Queen Charlotte Islands origins of Sitka spruce. The prognosis is that the Alaskan spruce will help to reduce branch size and limit the core of juvenile wood over the first 15–20 years on the trees of Queen Charlotte Island origin. Thereafter natural suppression will slowly eliminate the Alaskan trees leaving a stand effectively at wider spacing.

Seed Origin Experiments

Major assessment programmes have been completed for the series of Lodgepole pine trials planted in 1970/71 and for the IUFRO series with Sitka spruce planted in 1974/75 (see Plate 3). Analyses of variation between origins and across sites is under way. A summary of current results from all seed origin trials with *Abies* species has been prepared for the XVII IUFRO Congress. An important event was the IUFRO Working Party meeting on *Pinus contorta* in Scandinavia (see Appendix I). As part of the alternative species project, collections of 33 seedlots of *Abies amabilis* and 30 seedlots of 'Interior spruce' (*Picea engelmannii, P. glauca* and their natural hybrids) are being sown this spring. Some of the plants will be used in standard seed origin trials; selected origins will be planted on a range of sites in combined species/seed origin trials in comparison with Sitka spruce and other major species.

R. LINES

Cultivation

Structural Rooting and Ground Preparation

Two experiments at Ae Forest (Dumfries and Galloway) and Teindland Forest (Grampian) are now established to investigate the rooting responses and stability implications of ground preparation methods, but effective techniques to assess rooting have still to be developed. An initial assessment of roots in an experiment at Clydesdale Forest (Strathclyde) was undertaken using a quadrant trenching technique which appears to be a reasonably effective, non-destructive technique which enables root morphology to be described and quantified in relation to ploughing methods.

Plough Development

In collaboration with the Scottish Institute of Agricultural Engineering and the Forestry Commission, Messrs William Clark and Sons (Parkgate), have developed a prototype plough which produces a series of separated soil mounds rather than the continuous plough ridge derived from conventional forest ploughs. This ploughing technique may improve the symmetry of structural rooting by restricting the tendency for root alignment along continuous plough ridges, whilst promoting site drainage and maintaining improved aeration and temperature conditions at the planting position. Further mechanical modifications will improve the size and placement of mounds, and incorporate mole draining in the ploughing action, to increase lateral rooting and drainage for improved stability.

K. MILLER

Nutrition

Establishment Phase

Interesting results are now emerging from the early experiments on deep acid peat which included species mixtures as a treatment. On the poorest unflushed deep peats, growth of pure Sitka spruce in the absence of nitrogen applications is now extremely poor, whereas Sitka spruce (SS) in mixture with Japanese larch or Lodgepole pine (LP) continues to grow well and has satisfactory foliar nitrogen levels. Mixture treatments were included in two new nutrition experiments

established at Rumster Forest (Highland) with SS/LP mixtures, and Glentrool Forest (Dumfries and Galloway) with SS/Alder mixture. Mixtures of Japanese larch and Sitka spruce were included in four new experiments established on heathland sites. These are designed to quantify the benefits of various fertilizer regimes on the growth of Sitka spruce on heathland soils following afforestation on complete cultivation and restocking following a first rotation of Scots pine. Two experiments were established to test the value of ground adularia shale as a source of potassium in comparison with standard potassium chloride.

Pole Stage

A thinning/fertilization interaction experiment was established in a Sitka spruce stand at Wauchope Forest (Borders) and a new experiment at Falstone Forest (Northumberland) with various regimes of N, P, and K.

Effort will be concentrated on examining the results of the 46 Sitka spruce and 20 Scots pine pole-stage experiments which have already been established. A response to applied nitrogen has been shown in the majority of the Scots pine experiments and the rate associated with maximum response appears to be between 200 and 250 kg/hectare of element. A nitrogen application can be expected to increase basal area increment for 3 to 4 years, and the degree of response can be estimated from foliar nitrogen levels prior to treatment.

Micro-nutrients

Copper deficiency in Sitka spruce has been identified at several sites throughout the uplands, and experiments have been laid down to observe the effect of applications of copper on tree growth and form, using different methods of application and different forms of copper.

R. McINTOSH, P. TABBUSH

Forest Weed Control

Glyphosate

The effect of glyphosate applied by the 'Herbi' is altered by the rate of dilution in water. Experiments have shown that a minimum of 70 per cent water to 30 per cent glyphosate product by volume is necessary for full effect. Rainfall of 1 mm, simulated with a fine rose watering-can applied three hours after an application of glyphosate, reduces the effect of the herbicide considerably.

Aerial Application

Helicopter trials using glyphosate on grass and heather areas planted with Sitka spruce have shown aerial application to be a very effective method particularly on rough ground. This method of application only has 'trials' clearance.

Heather Control

Further experimentation with glyphosate on heather has confirmed that rates of 1·5 kg ae/ha for peaty sites and 2·0 kg ae/ha for mineral soils are required to give satisfactory control. August is the best month for application and less tree damage can be expected from glyphosate than from 2,4-D, making it more suitable in plantations where the trees are less than 1 m high.

P. BIGGIN, R. McINTOSH

Wind

Prediction of Windthrow

The accuracy of the Windthrow Hazard Classification (Booth, 1977) in predicting the onset of windthrow has been assessed by surveying damaged stands over a wide range of site and stand conditions. Although individual forests may exhibit wide variation from the predicted windthrow response, these deviations often reflect unusual thinning practices or terrain configuration. Overall, the Classification predicts the onset of windthrow with acceptable accuracy.

In high hazard classes V and VI, onset of wind damage tends to occur slightly later than predicted (+2·1 m and +2·8 m respectively), whilst in hazard classes II and III, damage arose slightly earlier than expected (−2·0 m and −0·3 m respectively). Variations between actual and predicted top heights at the onset of damage were remarkably consistent within individual forests. This perhaps indicates the strong influence of local management practices in precipitating wind damage, and suggests that greater precision in the definition of windzone boundaries could improve accuracy. Site scoring for Windthrow Hazard Classification is now standardised against the Forestry Commission Site Classification for more consistent application.

Wind and Exposure Assessment

Detailed analysis of an extensive network of supplementary exposure flags suggests some modification of the National Windzone Boundaries. In particular, increased exposure levels in coastal areas of north Scotland and parts of south Scotland produce realignment of zone boundaries in these Conservancies, and a modified windzone map will replace the map in Research Information Note 22/77/SILN (Booth, 1977).

Topographic Influences of Wind Structure

Malfunctions in the transducers and data recording equipment installed in Glentrool Forest (Dumfries and Galloway) have necessitated extensive modification to improve reliability and precision in windspeed recording on this remote upland site. Preliminary processing of analogue windspeed records in conjunction with the Institute of Geological Sciences (Edinburgh) has indicated that particular decoding and analysis techniques are required to compare the Glentrool wind data with airflow data from wind tunnel assessments of a scaled topographic model of the study area.

A scaled topographic model of the South Wales coalfield forests was reassessed in Bristol University wind tunnel to assist in the definition of areas at high windthrow risk in the planning of clearfelling operations for these areas.

K. MILLER

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SITE STUDIES (SOUTH)

Foliar Analysis

Service

Samples presented for analysis during the year numbered 7000 of which 470 were advisory and 4580 research foliar samples. The remainder were diverse both in type of sample and analytical requirement, which is an increasing trend. The laboratory is collaborating in various research projects including a study by Wildlife Branch of red deer nutrition, where rumen contents are being analysed.

Methods

A Hewlett-Packard 5880A gas chromatograph has been purchased. This will be used to study the effects of nutrient stress on trees by investigating methods of assessing nutrient deficiencies which are more sensitive than the total nutrient contents as measured by Kjeldahl digestion.

Soil Analysis

Soils taken from various locations in the Borders and the North Yorks moors have been analysed for soluble forms of phosphorus. Results show that the optimum conditions for analysis of a sample are dependent upon the geological origin and the particle size distribution of individual samples. The work confirms previous conclusions (*Report* for 1980) and further demonstrates the differences between agricultural and forest soils.

A. WILLSON

Effects of Trees on Sites

Thinning and Spacing Trials

Repeated studies of the development of soil conditions under Sitka spruce have confirmed the suggestion (*Report* for 1980) that intermediate planting intervals of 1·5 to 2 m minimise litter accumulation on a range of upland soils.

Bioassays

Student projects have shown that *Sphagnum* species might be used practically as field discriminators of existing peat site classes, and that tissue analysis of foliar-phosphate concentrations in *Carex binervis* has potential for predicting Sitka spruce phosphorus deficiencies.

Whole-tree harvesting of Sitka spruce

Studies continue of the likely nutrient losses from sites at which forest residues as well as stem-wood are harvested. Crops of very low yield class (less than GYC 10) are currently being analysed. A joint project has begun with the Institute of Terrestrial Ecology to determine the magnitude of the influence of whole-tree harvesting on soil properties and establishment of the next crop.

M. ANDERSON, K. G. SHUKER

Lowland Production Forestry

Opencast Mineral Sites – Physical Treatments

Ridges to the standard 30 m × 1·5 m were constructed on four sites, all with slopes of less than 5 degrees. These were:

–a hoggin pit with a porous sandy base, with replaced top soil (see Plate 4.);
–a gravel pit with an impervious base, with replaced top soil;
–an open-cast coal site with heavy spoil over an impervious base, with well graded slopes and replaced top soil;
–an open-cast coal site formerly used for stock piling, on grey shales, without top soil.

All were cross-ripped with a Caterpillar D8 and winged-tine set, and on the heavy textures of the second and third sites the heavy ridging discs were used to elevate the planting position.

On the hoggin pit, well digested sewage sludge was spread from a large frame-steered tractor tanker along the sides of the ridge on two experimental plots. Tree growth and some physical characteristics will be monitored to enable us to refine the specification. On sites where slopes exceed 5 degrees, cross draining at 30 m spacing, after ripping down slope with the winged tines, should provide similar conditions.

Open-cast Mineral Sites – Tree Nutrition

Foliar analysis can be used to study the nutrition of trees planted on mining spoils. We have been able to identify and compare some of the site factors which influence uptake and distinguish those tree species best adapted to the condition.

On compacted spoils we have observed that phosphorus concentrations in the needles usually increase with the intensity of cultivation. On compacted gravels, often with winter waterlogging in the top soil cover, symptoms of magnesium deficiency are common. Trees planted on reclaimed heathlands, even with top soil and ripping, may have sub-optimal concentrations of nitrogen and phosphorus, reflecting the previous land use.

The coal shales of South Wales appear to release some combined nitrogen to planted trees over a 'honeymoon' period of about five years, after which increasing nitrogen deficiency checks growth. At Tumble (Pembrey Forest, Dyfed) an experiment planted in 1973 grew well until 1978, since when Lodgepole pine and Sitka spruce growth has declined, while Corsican pine and Japanese larch have continued to grow steadily (Figure 3.). Foliar analysis suggests that the larch are better than Lodgepole pine at taking up phosphorus from the shales. In addition, although all species were nitrogen deficient, the Corsican pine and larch were more tolerant of low available supplies than the Lodgepole pine and spruce; these observations are typical of many of the older plantings on coal spoils in South Wales.

Experiments to examine land forms, nitrogen-fixing cover crops and species-nutrient interactions have been set up at Rheola Forest (West Glamorgan).

Open-cast Mineral Sites – Legumes

Nitrogen fixation by alders and legumes offers advantages over other systems where there is an over-riding need to increase the soil nitrogen capital. (Marrs *et al,* 1980, consider 700 kg per ha total nitrogen to be essential for tree growth). During the year several trial sowings of abrasion-treated Tree lupin and other legume seeds were made (see page 10). The lupins grew well on coal-mining shales and on raw sand, but less successfully on gravel pit spoil.

Grazing damage to planted or sown legumes can be severe in the forest, so there is accordingly a premium on low palatability. The least damaged species are the Everlasting peas and garden lupins, with some browsing on Tree lupins and Sweet clovers. In contrast severe browsing on *Robinia,* broom, *Elaeagnus,* and other clovers limits their usefulness.

D. F. FOURT, N. BEST

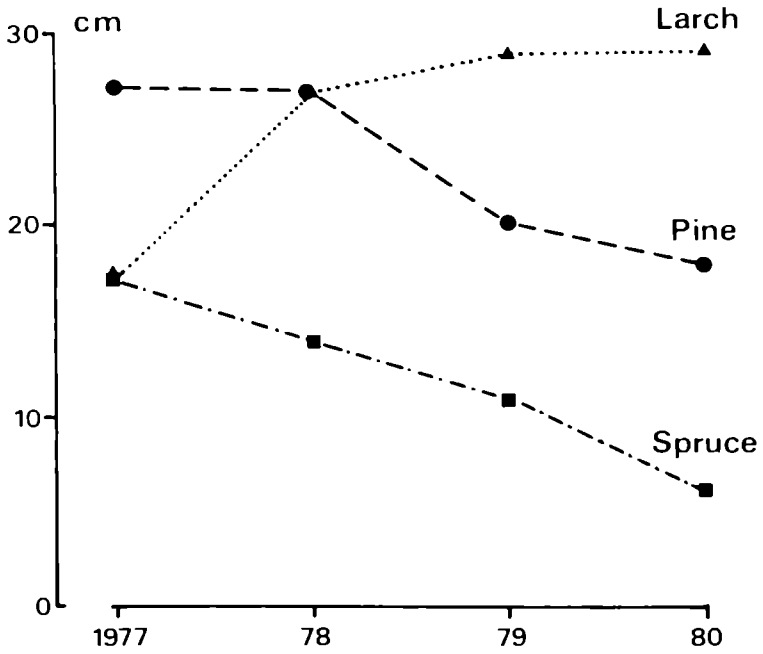

Figure 3. Average leader increments on completely cultivated plots of Japanese larch, Lodgepole pine, and Sitka spruce. Tumble (Pembrey Forest, Dyfed).

Upland Production Forestry

Drainage Trials

The drainage experiment at Crychan Forest (Powys) has now been clearfelled and the soil physical characteristics will be monitored during the establishment period of the successor crop.

R. CARNELL

Amenity Forestry and Arboriculture

Reclaimed Colliery Spoil

Physical investigations of deep-mined spoils (part of a Department of the Environment contract) have been carried out over the past 18 months on over 300 samples from 12 sites in Durham, Northumberland and West Yorkshire.

These included profiles of bulk density, total pore volume, particle size distribution, measurements of available water and of compactability. We found

that the total pore fraction of the spoils varied from 0·2 to 0·5, whereas in natural soils under agriculture they lie between 0·4 and 0·6. This and other results suggest that, under current restoration practice, physical conditions of deep-mined spoils do not inhibit the growth and vigour of established trees. We did conclude however that although the measurable effects of ripping do not persist for long, there is considerable benefit at the time of planting.

R. CARNELL

Domestic Waste Disposal

There is considerable interest by local authorities in planting domestic waste tips with trees after covering with inert fill or mineral material. We recommend raising the compacted waste to form domes up to 20 m high, or into large ridges, to keep much of the waste above ground water level and to ensure that subsidence does not cause future drainage problems. Raw mining wastes can be used where necessary to achieve the recommended 1 m thickness over the waste, and if necessary this can then be sown with lupins after ripping to raise soil nitrogen to levels suitable for tree growth. Such sites may be planted for amenity or for production forestry.

D. F. FOURT

Meteorology and Phenology

Routine recording and collation has continued in collaboration with the Meteorological Office and with the International Union of Forest Research Organisations.

M. ANDERSON, K. G. SHUKER

Advisory

There have again been enquiries about water use by trees; a leaflet on the subject has been published (Binns 1980). The technique and the effects of ripping on man-made sites continue to attract interest. At a minerals enquiry the effect of changes in water-table levels caused by mining for gravel were discussed in the context of wetland reserves and hedgerow trees. There continues to be interest in the effects of forestry and forest management practices on quality and yield of water.

W. O. BINNS, D. F. FOURT

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SITE STUDIES (NORTH)

Classification and Improvement of Upland Soils

Clay soils

Six related experiments have been laid down on the site of the large drainage experiment in Kershope Forest, Cumbria (see *Reports* for 1965, 66 and 67). The drainage was done in 1966–68 in a stand of Sitka spruce planted in 1948, and comprised three randomised blocks of three drain spacings × two drain depths. The 18 plots are each 1 to 2 hectares. It is proposed to fell a representative half of the experiments (9 complete plots) arranged in a continuous central area to minimise subsequent windthrow. The soil is a peaty gley on clayey till derived from Carboniferous sediments.

The first new experiment is concerned with the well-known difficulties of restocking on this soil type consequent on the marked rise in water-table which follows clear-felling. The experiment will compare 'flat replanting' with new ploughing or mole draining treatments superimposed on the existing draining plots. Prior to clear-felling, intensive monitoring of the soil water regime throughout the site will be used to make a rigorous assessment of the effects of the original drainage treatments. These measurements will be continued during and after felling. A detailed survey of peat depths has revealed some of the variability of the site and has emphasised the difficulty in designing traditional drainage experiments despite the great care taken in this example.

The second main experiment is concerned with the hydrological impact of clear-felling. Rainfall, throughfall, stemflow and runoff are being measured in four of the drainage plots. Three of these plots will be felled.

The other four experiments supplement the main lines of research and involve smaller scale but even more intensive studies of soil water regime, aeration and temperature. The concentrations of nutrients and other elements in soil water and runoff before and after clear-felling will be monitored by the Institute of Terrestrial Ecology.

D. G. PYATT

FOREST GENETICS

Testing

Pollinations

The 1980 pollination programme was one of the largest for several years. Thirty European larch clones were pollinated with a Japanese larch polymix and large quantities of pollen were collected for viability testing and storage experiments.

Sitka spruce flowering in the tree banks was good. In the polycross programme 66 further clones were pollinated using a 15 clone polymix, and 65 specific crosses were made in the diallel and population study programmes. The Sitka spruce × White spruce hybridisation programme was continued using White spruce pollen, provided from a 1979 collection made by the Canadian Forest Service, Ontario, together with two polymixes from the British Columbian Forest Service, on 29 selective Sitka spruce clones. The resulting yield of viable seed was very low in comparison with pure Sitka spruce crosses.

A two-man team visited British Columbia and made 20 single-tree pollen collections from each of six widely separated locations in the province; the pollen will be used in the 1981 pollination programme.

The emphasis in the Scots pine testing programme is now redirected to tests of specific-combining-ability amongst the best 44 general-combiners which currently form the basis of the clonal orchard programme. The best specific combinations will be used to form seedling orchards. The 44 clones are being tested in a series of disconnected partial diallel crossing patterns using six clones per cell.

In the programme of artificial pollinations between widely separated populations of Lodgepole pine, 96 single-pair matings were made between Skeena River (Terrace/Smithers) and Sonora Island, B.C. origins at Wykeham (Yorks).

The entire 1980 pollination programme resulted in 462 artificial crosses which involved 7219 isolations and 19,895 flowers; 523 pollen lots were extracted.

Forest Progeny Tests

A prolonged drought followed the 1980 planting season and caused heavy losses in the newly planted progeny tests of the 124 open-pollinated families of Sitka spruce and the 80 families of Lodgepole pine mentioned in the 1980 *Report*, p 28. These tests had to be abandoned. Most of the Sitka spruce families have been resown. The Lodgepole pine intra-specific hybrids will not be recreated since there are sufficient surviving progenies in tests to indicate the potential value of the Alaskan × South Coastal provenance hybrids.

Sitka spruce progeny testing continued with 273 open-pollinated families from a population of Queen Charlotte Islands origin, planted in replicated tests on three sites. This brings the number of Sitka spruce candidate trees with half-sib families in test to over 1,200. A test of a further 43 open-pollinated families from four populations of Sitka spruce, was established on a single site. This test parallels a 1979 polyhouse early-test of the same families, and will allow comparisons to be made between the early-test results and the growth and development of plants grown by traditional methods.

The Lodgepole pine programme continued with the planting on three forest sites of 91 hybrid families derived from single-pair matings of Long Beach, Coastal Washington × Terrace, B.C.; and Hazleton, B.C. × Long Beach origins. Thirty-four previously untested hybrid larch families, derived from European and Japanese larch plus trees × Japanese and European larch pollen mixtures respectively, were planted in Dean Forest.

A pilot clonal test was also established for Sitka spruce, to compare the performance of vegetatively-propagated, open-pollinated, half-sib families of plus trees of proven high general-combining-ability, with rooted cutting derived from unselected plants grown from a commercial imported seed lot from Masset, Queen Charlotte Islands.

Clonal Testing

Vegetative propagation of Sitka spruce trees by rooting cuttings rapidly becomes more difficult when the parent tree exceeds six years of age. With a view to developing a technique for rejuvenating Sitka spruce plant material derived from difficult-to-root old trees, an experimental programme was started in which the rootability of cuttings, taken from grafts, will be determined after

repeated grafting over four cycles. For this purpose scions were initially collected from the top 5–6 whorls of branches of twelve 45-year-old trees at Durris (Grampian), and from the same position in twelve 13-years-old trees (15 years from seed) in a progeny test at Speymouth (Grampian). The cuttings were inserted in a sand-bed under mist irrigation.

Seed Production

Seed Orchards

A total of 14.7 ha of new orchards was established. This consisted of 7·7 ha Lodgepole pine seedling seed orchards at Dunkeld (Tayside) and Coed-Preseli (Dyfed) forests, and a further 4·2 ha of hybrid larch at Torridge (Devon) and 2·8 ha of Sitka spruce at Coed-Preseli forests.

Seed Stands

Many requests were received for the registration of stands as seed sources. These arose as a direct consequence of pressure to remedy the acute shortage of seed in store in what was a generally poor year for cones for most species but a reasonably good mast year for beech and oak. An additional important contributory factor was the appointment of one or more seed liaison officers in each Conservancy, who had the task of screening many cone-bearing or fruiting stands for quality, before submitting them for final approval and registration by members of the Genetics Branch. A total of 165 stands were inspected of which 76 failed to meet the required standard. The 89 areas which were registered totalled 1057 ha and consisted mainly of Scots pine, Corsican pine, Lodgepole pine and oak.

Biochemical Variation

Monoterpene analysis of shoot resin sampled directly from natural stands of Lodgepole pine in north-west America has shown the genotypic variation over extensive areas of its natural range to be identical with that deduced from analysis on material grown in Britain from seed collected in America. Data are now available on the genotypic variation over many previously unsampled areas of origin, and studies of north-eastern origins have lent support to the view that in this region the primitive ancestor of both Lodgepole and Jack pine (*Prunus banksiana)* first became established in America, evolving into Lodgepole pine westwards and Jack pine eastwards.

Several continental origins of Scots pine have been compared using resin analysis with the biochemically defined regions of the relict Scottish woodlands. The data indicate that, during the post-glacial migration of the species from Europe into Scotland, the Scottish north-western relicts may have been derived from southern European sources, the south-western relicts primarily from Scandinavia, and the remaining bulk of the Scottish populations from middle European sources.

Analysis of monoterpene data from several Sitka spruce origins showed a cline in several characters from Alaska to Washington, but southern origins showed no geographic trends. These results are linked with the post-glacial history of the species.

Data Base

Through a contract with the Edinburgh Regional Computing Centre, work has continued on the data-base previously reported. Using the IDMS system, 24 record-types are interrelated in a network which describes all the activities of the breeding programme and the facility to add, delete, modify or list them is now available. The considerable task of completing retrospectively 21 new forms with information drawn from the variety of records which they replace is nearing completion and many of these data have been loaded. Software will be written to report on the progress of the breeding programmes and performance of progeny-tested material.

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

TREE PHYSIOLOGY

Root Growth and Form

Plant and soil water potential

The behaviour of the stomata and root extension of Sitka spruce seedlings were found to be sensitive to the water potential of the soil (ψs) and of the plant (ψp). As the soil dried, stomatal conductance and transpiration decreased in relation to ψs rather than to ψp. Indeed, closure of the stomata in response to conditions at the root delayed the onset of water stress in the plant. Observations on seedlings progressively water-stressed, but in which some root tips were maintained in moist soil, indicated that root growth in moist soil decreased with ψp and ceased when the latter declined to about -14 bars.

When plants were grown with root systems divided between soils of uneven matric potential, primary and woody roots grew more in wet (–50 mb) soil than in dry (–300 mb) soil. Comparison between the wet/dry treatment, and wet/wet and dry/dry controls, showed that a supply of water to one half of the root system did not enhance growth or survival in dry soil on the other side.

Anchorage

The effects of root architecture on tree stability are being investigated with a view to developing a mathematical model. Observations have included physical measurements of the roots and soil and the sequence of changes which occur in the rooting zone when mechanical stresses are applied to the tree.

M. P. COUTTS

Vegetative Propagation

Micropropagation

Callus cultures derived from mature embryos of Sitka spruce and Hybrid larch have proved to be unsuitable for large scale micropropagation as the rate of morphogenesis in them is low.

The rate of production of axillary buds *in vitro* on surface sterilised seedlings is about three per six week period, with subcultured apical buds producing axillary buds at a much higher rate than subcultured axillary buds. The addition of auxin and cytokinin to the agar medium had no effect on the rate of axillary bud formation. Attempts are being made to increase the rate of bud proliferation by manipulation of the growing conditions and to promote the rooting of extending shoots which has proved difficult *in vitro*.

A. JOHN

Mycorrhizae

A project investigating possible benefits of mycorrhizae to Sitka spruce was started. Preliminary surveys revealed differences in roots of transplants among and within nurseries. These differences are being investigated to see if they result from different mycorrhizal symbionts. Most of this first year was spent isolating and culturing likely symbionts from forests and nurseries. More than a thousand isolation attempts were made from roots or sporophores and over 100 cultures obtained. Work is proceeding to ascertain their mycorrhizal status and to examine their effects on establishment and growth of young trees. Much of this project is being carried out in cooperation with other organisations, in particular with the Universities of Surrey and Sheffield, and with the Institute of Terrestrial Ecology.

C. WALKER

Flower Induction

Applications of the hormone mixture gibberelin $A_{4\backslash7}$ to Sitka spruce to induce flowering have sometimes been successful but often fail to promote flower induction in poor flowering years. To investigate this $GA_{4\backslash7}$ was applied in a factorial experiment with temperature and drought which are cultural treatments thought to enhance flowering. Ten clones of potted mature 5-years grafted Sitka spruce were used to provide 10 replicates for each of the 8 treatments. $GA_{4\backslash7}$ was injected into the main stem in 1 ml of ethanol at 2 mg per application in May, June and July; the temperature treatments were inside or outside a polythene house and the droughted or watered treatments were maintained with controlled watering. Measurement of needle temperatures, transpiration and leaf water potential were made.

The cultural treatments alone stimulated flowering in comparison with the cool wet controls and droughting was more effective than heat; together these treatments produced a more than additive stimulation (Figure 4). $GA_{4\backslash7}$ produced no increase in flowering in the absence of any cultural treatment and this may explain the absence of stimulation with $GA_{4\backslash7}$ in poor flowering years. However, in the presence of cultural treatments $GA_{4\backslash7}$ application caused a marked stimulation of both male and female strobili and increased the proportion of female strobili per tree.

The data emphasise the importance of applying $GA_{4\backslash7}$ in the presence of a carefully controlled cultural treatment when attempting to enhance flowering and illustrates the potential for using potted trees in polythene houses for breeding and seed supply.

J. J. PHILIPSON

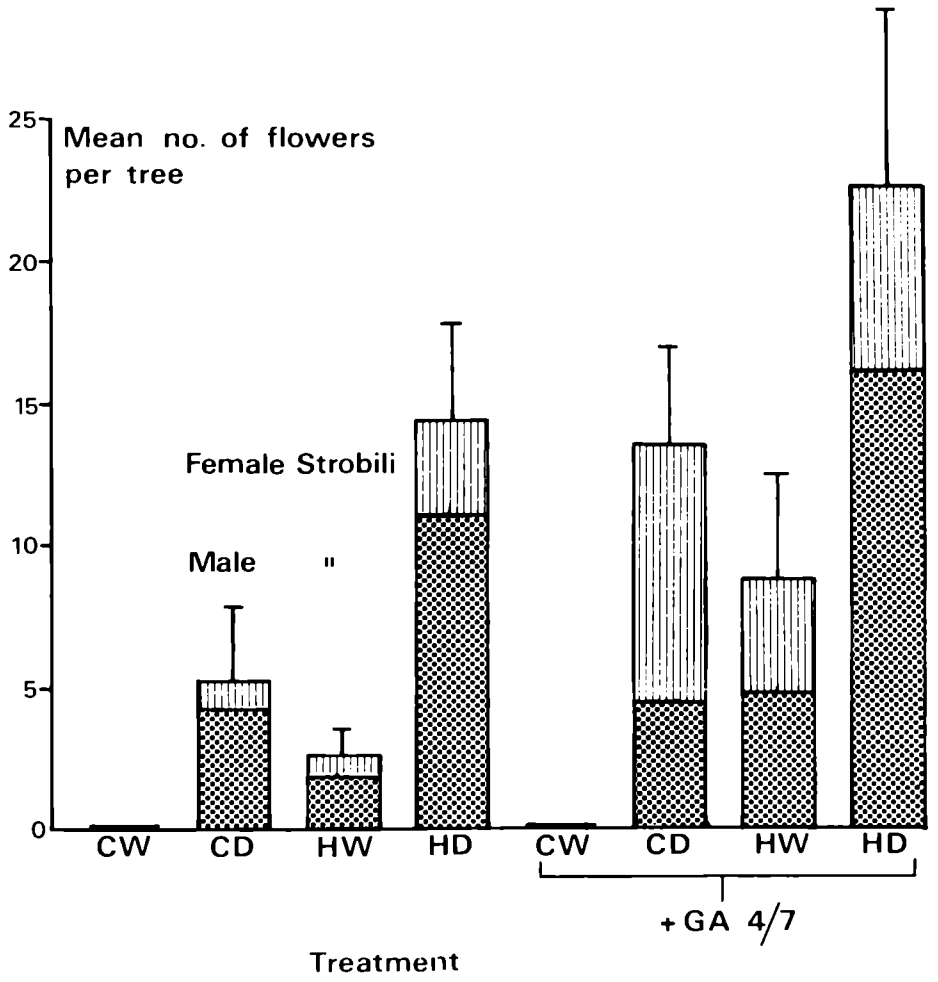

Figure 4. The effects of temperature (C = Cool, H = Hot), drought (D = Droughted, W = Watered) and $GA_{4/7}$ application on induction of male and female strobili in Sitka spruce. The vertical bars above the columns represent the standard error of the mean for males and females summed.

FOREST PATHOLOGY

Dutch elm disease

Elm Regeneration

Assessments on plots of regenerating elm established in 1977 (*Report* for 1979) showed that the mean disease level rose from 5·0 per cent in June 1977 to 15·7 per cent in September 1980. Crotch feeding by elm bark beetles was rare in 1980, indicating that the *Scolytus* spp. populations in the locality of the plots are now very low. In 1980, twelve new plots were established by selecting the best stems within areas of dense elm regeneration. In these plots the individual suckers are spaced about 1 m apart. During 1980, 5·2 per cent of these stems became diseased.

Fungicide Injection

Trials in 1980 with thiabendazole hypophosphite (TBZ) confirmed that high volume, low concentration injection with this fungicide could give good results as a curative treatment for trees with the early stage of disease. Thirteen of 16 trees curatively treated in 1978 and 1979, were completely free from disease in 1980; and in 12 out of 14 trees injected in 1980 the development of disease symptoms was halted. Laboratory assessment of twig samples from treated trees showed that fungicide was still detectable in most trees after 2 months and in about half the samples after one year. No fungicide was detected 2 years after treatment. The fungicide was marketed as 'Ceratotect' in Britain in 1980 and limited supplies were available for local authority trials, which in general gave poorer results than the Forestry Commission experiments.

B. J. W. GREIG

Biology of Ceratocystis ulmi

Research is continuing on the origin, distribution and spread of the races and strains of *C. ulmi* (see *Report* for 1980). In 1980, over 600 samples of the fungus were collected in EEC financed surveys of Poland, Yugoslavia, Rumania and Turkey.

Studies on the temperature-growth relationships of the aggressive and non-aggressive strains have shown that the aggressive strain (both races) has an optimum temperature for growth of *c* 20–22°C whereas that of the non-aggressive strain is near 30°. At 33° the non-aggressive strain grows much faster than the aggressive, the reverse of the situation at 20°. These two temperatures are now recommended for separating the strains on the basis of growth rate (Brasier, Lea & Rawlings, 1981).

It was initially thought that the recently discovered EAN (Eurasian) and NAN (North American) races of the aggressive strain had similar pathogenic properties (Brasier, 1979). However, a more extensive pathogenicity test has shown otherwise (Figure 5). Fourteen EAN and 14 NAN isolates from various countries were inoculated into clonal *Ulmus procera*. Two control non-aggresive isolates caused 16 per cent defoliation. Defoliation by the NAN aggressive isolates ranged from 82–100 per cent whereas that of the EAN ranged from 38–100 per cent. The mean defoliation caused by the EAN isolates, 82 per cent, lay significantly below that of the NAN isolates at 95 per cent. Some EAN isolates are evidently much less pathogenic. EAN × NAN crosses are in progress to examine the basis of these differences.

C. M. BRASIER

Beech Bark Disease

Disease Development

The long term survey of disease development continued at the eight plots which, in 1979, were chosen to represent the putative early, peak and decline phases of *Cryptococcus fagisuga* colonisation in young plantations. Initial data seem to confirm that the heavy infestation of individual stems may first appear in the stand at about age twenty, reaching a peak at about age thirty (with a corresponding peak of *Nectria* infection), and thereafter declining at the onset of an aftermath phase characterised by stabilisation of the coccid population.

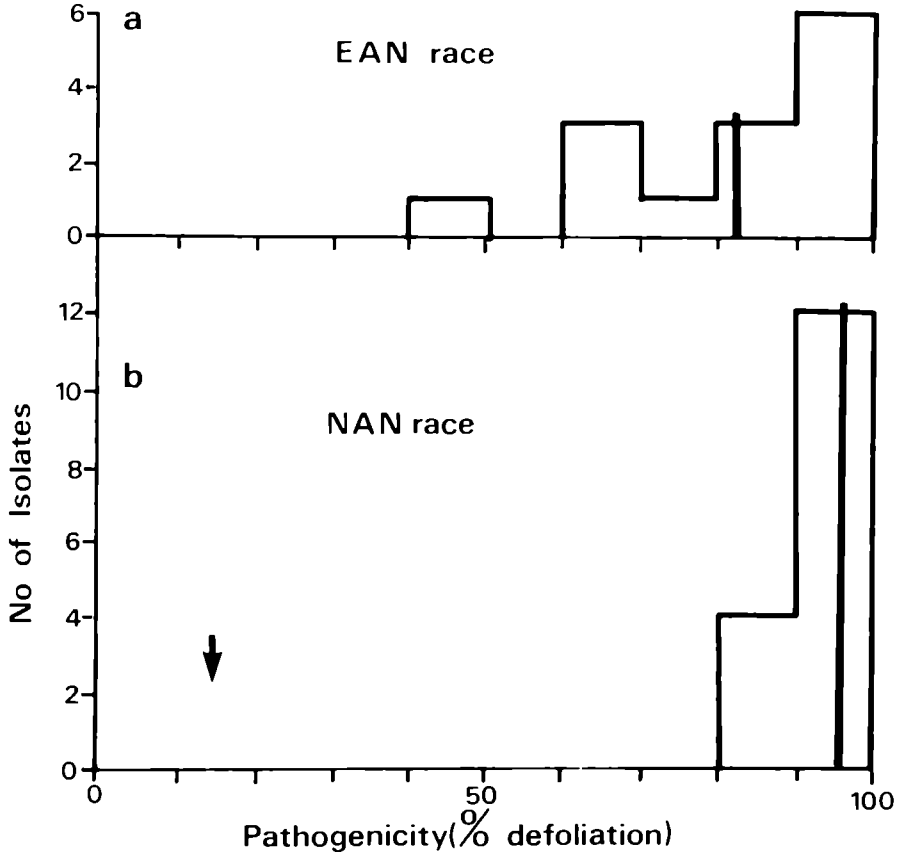

Figure 5. Pathogenicity distributions for *a*, 14 EAN and *b*, 16 NAN race isolates of the aggressive strain of *C. ulmi*. Bars indicate group means. Arrow at *b* indicates pathogencity of non-aggressive control isolates.

Abnormal Anatomy of Beech

Observations of the stem 'dimpling' associated with *Cryptococcus* infestation have shown a great reduction in xylem ring width in the central zone of the dimple (up to 97 per cent). In this zone cell differentiation is abnormal, vessels being sometimes absent, an effect suggesting hormonal activity of the type associated with ethylene. Implantation of an ethylene precursor (2-chloro-ethylphosphonic acid) into healthy bark caused local inhibition of vessel formation.

Ecology of Nectria

Nectria coccinea appears to be a stress-dependent parasite, and its ability to take advantage of host stress may depend on latent colonisation of the outer bark. Isolation tests have shown the presence of *Nectria* in the outer bark of some *Cryptococcus*-infested stems as well as in the waxy secretion of the insect. Among the other fungi present in these niches, some had antagonistic activity against *Nectria* in culture but *Nectria* was able to intergrow with and overtake cultures of *Cladosporium cladosporioides*, a dominant coloniser of old *Cryptococcus* colonies.

D. LONSDALE, E. J. PARKER

Decay of Sitka Spruce Following Deer Damage

The susceptibility of Sitka spruce stems to stain and decay following wounding is of current importance owing to increased concern about bark stripping by red deer in this species.

Seventy stems with 117 wounds between 4 and 12 years old were dissected: most were stained but this was generally slight and only 16 per cent of wounds had stain columns extending more than 1 m above their upper edge. In many stems much of the stained wood was an indistinct pink or red colour closely resembling some natural colourations and largely free of micro-organisms. It seems likely that such stain may represent a host response rather than microbial action.

Darker stains more typical of fungal discolouration were also present at most wounds, but this stain extended outside the original wound limits in only 36 per cent of the wounds studied. Columns of dark stain which extended more than 50 cm above or below the wound limits were associated with 9 per cent of wounds, most of which were among the largest encountered in the study, exceeding 400 cm^2 in area or 50 cm in length at wounding.

A variety of fungi was isolated from the darkly stained wood but only two stems, both exhibiting decay as well as stain, yielded decay-causing basidiomycetes. The two species recovered were *Haematostereum sanguinolentum* and *Sistotrema brinkmanii*.

S. C. GREGORY

Arboriculture, Department of the Environment Contract

Decay in Amenity Trees

Results of trials for the first five years of the contract are now being collated. These indicated that callus growth, at least in beech and lime, could be substantially improved by the use of certain wound treatments, of which the three best types were those containing thiophanate methyl, bitumen emulsions, and plastic emulsions. The effect was maintained over at least five seasons. On trunk wounds the use of black plastic wrap did not appear to accelerate the growth of callus from the wound edges, but did promote growth of tissue on the wound surface. None of these materials, nor any other examined, proved very effective at preventing general fungal colonisation of wounds. The most effective, a plastic emulsions. The effect was maintained over at least five seasons. On trunk prevented fungal colonisation for about 130 and 90 days respectively. Colonisation by basidiomycetes causing decay was prevented for at least 280 and 450 days by a solution of benodanil and the emulsion containing mercuric oxide.

Treatments with biological control agents have indicated that the application to wounds of suspensions of *Trichoderma viride* have kept the level of basidiomycete colonisation lower than in untreated wounds over a period of at least two years. A commercial preparation of *Trichoderma* spp. has kept wounds completely free of basidiomycetes for at least 280 days.

P. C. MERCER

Tree Seed Pathology, Overseas Development Administration Contract

Of 155 fungal species isolated from tropical pine seeds during this project, 27 have been recorded as plant pathogens.

Pathogenicity trials have been undertaken with one of these fungi, *Macrophoma sapinea (Diplodia pinea)*. Mycelial macerates of isolates of this fungus were sprayed onto six month old *Pinus caribaea* and *P. pseudostrobus* saplings 30–60 cm in height. Infection occurred through dwarf shoot and leaf axils at the fleshy stem tips, and spread downwards disrupting vascular tissue, causing shoot blight and eventual sapling death.

A. A. REES

Advisory Services

Alice Holt Lodge

Five hundred and forty-four enquiries were received.

A frost on the night of 8th May 1980 caused leaf and shoot browning on many broadleaves and conifers in southern Britain. Concurrently some plantations of *Tsuga heterophylla* and *Thuja plicata* a few years old suffered basal bark killing and developed frost rings, but this was only noticed 10 months later when the foliage of girdled plants yellowed and fell.

In August, about 20 of 200 three-year-old *Nothofagus obliqua* raised in a reputedly *Verticillium*-free nursery and lined out in a freshly cultivated meadow in Norfolk, developed typical Verticillium wilt symptoms and yielded *V. dahliae* in culture – apparently a first record for this host. In a Cambridgeshire nursery, the same fungus was isolated from stained xylem of one-year-old *Robinia pseudoacacia* shoots at the end of the growing season following budding. About 25 per cent of the crop was expected to die. This host is rarely mentioned as susceptible, but together with *Acer* and *Tilia* spp. is regularly affected on ex-potato and strawberry land in this nursery. Its variety 'Frisia' suffers equally badly there, never recovering once wilted, but 'Bessoniana' is little affected.

During the summer, most leaves and current shoots of a crop of 400 two and three-year-old *R. pseudoacacia* in Somerset were killed or severely damaged by an anthracnose disease. Recovery shoots from 1980 buds were also killed. *Phloeospora robiniae* (Lib.) Höhnel and *Phoma macrostoma* Mont. fruited abundantly on leaf lesions and the latter also on shoots. These fungi are known leaf pathogens of *Robinia* (Docampo and Nome, 1970) and jujube *(Zizyphus mauritiana)* (Sidhu and Singh, 1979) respectively. In inoculation trials in India, *P. macrostoma* damaged a wide range of woody plants although *Robinia* was not tested.

Cristulariella depraedans caused grey spotting and premature fall of lower leaves of sycamore *(Acer pseudoplatanus)* in scattered localities in southern England and Wales and *Guignardia aesculi* leaf blotch was common on many Horse chestnuts *(Aesculus hippocastanum)*.

Phellinus pini (Thore ex Fr.) Pil. was found fruiting on an old Scots pine *(Pinus sylvestris)* near Farnham, Surrey – a very rare species in England.

R. G. STROUTS

Northern Research Station

One hundred and seventy enquiries were received during the year and for the first time in several years cases of damage by living agents outnumbered those attributable to non-living agents.

Brunchorstia pinea (Gremmeniella abietina) was the most frequently recorded single pathogen, occurring on both Scots pine and Corsican pine. In most cases on Scots pine *B. pinea* was accompanied by the needle pathogen *Lophodermium seditiosum*.

For the second year in succession, widespread shoot and needle damage occurred on Lodgepole pine. However, unlike the 1979 damage in which shoot death was accompanied by general foliage browning and which was probably caused by extreme climatic conditions during the preceding winter, damage this year was restricted to death of scattered side shoots. Damage occurred in north and west Scotland in thicket and pole stage plantations. Similar symptoms were observed in 1970 (*Report* for 1971) but the cause could not be determined. It is believed that a fungal pathogen may have been responsible, and further work is in progress at Aberdeen University.

The incidence of foliage diseases was unusually high during the summer and this may have been related to extremely wet weather at that time. Necrosis of oak leaves caused by the fungus *Gloeosporium quercinum* was so severe in a number of cases that affected trees presented a withered appearance. Several relatively unusual leaf pathogens were also recorded: *G. betulinum* on birch and *Phleospora (Septoria) aceris* and *Cristulariella depraedans* on sycamore leaves.

Chemical damage and cultural malpractice accounted for over half of the total enquiries involving non-living agents. Within these broad categories, the two single, most frequently recorded causes of injury were misuse of herbicides and bad plant handling. The most notable occurrence of abiotic injury was that of numerous small physical wounds on young Sitka spruce throughout an Aberdeenshire plantation. The only apparent cause was a severe hailstorm which occurred in that area in mid-summer.

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

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ENTOMOLOGY

Population Studies

The Web-spinning Larch Sawfly, Cephalcia lariciphila

In South Wales there was a further reduction in the area affected by the sawfly and in remaining affected areas defoliation was light. One new outbreak occurred at Ystwyth forest (Dyfed) affecting several compartments. Population decline at Irfon (Powys and Dyfed) and Crychan (Powys) forests (*Report* for 1980) coincided with 80 per cent parasitism by *Olesicampe monticola.*

In the Forest of Dean (Gloucestershire) and Hafren forest (Powys) infestations have not increased appreciably in area but defoliation continues to be heavy.

D. J. BILLANY

The Pine Beauty Moth, Panolis flammea

There were no new outbreaks of this pest during 1980. Pupal surveys in areas with a high risk of *P. flammea* attack (*Report* for 1980) showed a need to spray a total of 140 ha in Naver and Helmsdale Forests (Highland) in 1981. This includes two small blocks at Helmsdale sprayed in 1978 which showed marked increases in population.

Collaborative work with the Chemical Entomology Unit, Southampton University, is in progress aimed at improving the effectiveness of pheromone traps in population monitoring of *P. flammea* (*Report* for 1980).

Work on the compilation of life tables for *P. flammea* is now in progress. It is hoped that this study will provide an insight into the population processes of this insect in pine plantations in Scotland.

J. T. STOAKLEY

The Pine Looper Moth, Bupalus piniaria

Overwintering populations of *B. piniaria* were sampled as previously described (*Report* for 1980). Populations were again very low, with a further decline in numbers in most units in 1980/81. Fourteen units were unchanged and six showed a small increase compared with 1979/80. Cannock (Staffs) had the highest count, up from 2·8 to 3·2 pupae per m^2.

R. M. BROWN

An analysis of data collected between 1954–78 from 47 pupal survey areas in the U.K. showed that *B. piniaria* populations were regulated about an equilibrium density of usually 1 per m^2 or less. Regulation was characterised by an immediate density-dependent (IDD) and a delayed density-dependent (DDD) component. Populations showing the strongest DDD effect tended to have an approximately six-year cycle, the most extreme peaks of the cycle representing outbreaks.

During cycles there were systematic changes in pupal weight and also abundance of some parasite species; e.g. the specific larval parasite *Dusona oxyacanthae* showed a strong negative correlation with *B. piniaria* survival in several populations.

In simulation models the cyclic (DDD) pattern was consistent with the expected behaviour of a parasite-host system, given a high intrinsic rate of increase by *B. piniaria*. With lower rates of increase resulting for example from poor early-larval survival, the interaction would probably become acyclic, with the IDD component of density-regulation predominating.

D. BARBOUR

Forest Insects imported from Canada

During 1980, large quantities of low-grade, sawn timber were imported from western Canada into English and Welsh ports and transported to numerous inland depots. Customs and Forestry Commission Plant Health Officers identified quantities of unacceptable bark on many consignments. Samples from ports and depots revealed the presence of large numbers of live insects not previously recorded in Britain. The majority of these insects were bark beetles.

The species collected were: –

Scolytidae – *Hylurgops porosus* Le Conte, *Hylastes ruber* Swaine, *Dendroctonus rufipennis* (Kirby), *Pseudohylesinus tsugae* Swaine, *Polygraphus rufipennis* (Kirby), *Crypturgus pusillus* (Gyll.), *Dryocoetes autographus** (Ratz), *Dryocoetes*

affaber (Mannerheim), *Orthotomicus caelatus* (Eichhoff) and *Ips pini* (Say). Cerambycidae – *Tetropium cinnamopterum parvulum* Casey, *Monochamus oregonensis** Le Conte, *Rhagium inquisitor** F. and a *Semanotus* spp. Other Coleoptera were: – a *Necrodes* spp. (Silphidae); *Serropalpus substriatus* Haldeman, (Melandryidae) and *Hylobius congener* D.T., (Curculionidae). Also collected were two species of Hymenoptera, *Sirex cynaneus* F.*, (Siricidae) and *Campanotus herculaneus pennsylvanicus* (De Geer), (Formicidae).

R. M. BROWN, T. G. WINTER

Host Plant Susceptibility

The Green Spruce Aphid, Elatobium abietinum

In controlled environment studies, some, mainly N. American, species and varieties of *Picea* supported a higher aphid growth rate and were more severely defoliated than Asian ones.

Some Sitka spruce provenance trials, planted in 1974, have become infested with *E. abietinum* during 1980/81. These are currently being assessed for defoliation damage and compared with previous measurements of seasonal changes in amino-acid composition between selected provenances.

During a late summer attack of Sitka spruce at a high elevation in Rhondda forest (Mid Glamorgan), a braconid parasite *Aphidius schimitscheki* Stary and a cynipid *Alloxysta* sp. were particularly common. Parasitism is usually insignificant in the normal spring populations.

The Lime Aphid, Eucallipterus tiliae

This aphid creates honeydew problems of lime trees particularly in urban areas. The relative growth rate of aphids feeding on leaves of twelve species of *Tilia* were compared. The two native species *T. cordata* and *T. platyphyllos* appeared equally susceptible to the aphid as did *T. americana* and *T. heterophylla*. On the other hand, certain exotic species less commonly cultivated in Britain showed a marked resistance to aphid development.

C. I. CARTER, J. F. A. NICHOLS

The Felted Beech Scale, Cryptococcus fagisuga

Beech clones showing differences in severity of attack by *C. fagisuga* (*Report* for 1980) were artificially inoculated with 1st instar larvae confined in cages attached to the bole. Susceptible clones supported development of larvae and fecund adults were produced. On resistant trees there was 100 per cent mortality of larvae.

D. WAINHOUSE

Biological Control

Cephalcia lariciphila

In current and former infestations of *C. lariciphila* up to 90 per cent of larvae were parasitised by *Olesicampe monticola (Ichneumonidae)*. No new parasites were found.

D. J. BILLANY

*Species indigenous to Britain or recorded on previous occasions.

Rhyacionia buoliana

The chemical E-9-dodecenylacetate (E9DDA) was used to disrupt mating of the Pine shoot moth, *R. buoliana* infesting 27 ha of Lodgepole pine at Kilveyhill, Coed Abertawe (W. Glamorgan) and in a 2·5 ha Lodgepole pine seedling seed orchard at Mayday Farm, Thetford (Norfolk). The pheromone was dispensed from Conrel fibres. From mid-June to early September mating frequency was reduced by 97·5 per cent (Kilveyhill) and 95·3 per cent (Mayday Farm).

*C. LONGHURST, D. J. BILLANY

Chemical Control

The Pine Beauty Moth, Panolis flammea

In late May 1980, 1440 ha of Lodgepole pine in Naver (Highland) and Bareagle (Dumfries and Galloway) forests were treated by ultra-low volume (ULV) aerial application of fenitrothion at 300 g ai/ha, under clearance from the Pesticides Safety Precautions Scheme. Good control was achieved except along the edges of two blocks in Naver forest, resulting in the death of about 10 ha of pine following defoliation. Such edge effects are being investigated by the Ecological Physics Research Group, Cranfield, to improve the effectiveness of future ULV aerial spraying. Collaborative work with Mr J. Parker** was initiated to compare the performance of the currently used micronair AU 3000 (Micronair Ltd) rotary atomiser, with a rotanet (Ciba-Geigy Ltd) for ULV spraying from fixed wing aircraft.

J. T. STOAKLEY

Dimilin (diflubenzuron) was sprayed by mist blower at a rate of 62·5 grams ai per hectare in a field trial to control *P. flammea*. When sprayed before egg hatch, Dimilin showed a slight ovicidal effect, but the best control was achieved at 50 and 95 per cent egg hatch.

S. HERITAGE

Scolytids

The Synthetic Aggregation Pheromone of Xyloterus (Trypodendron) lineatum (Oliver) – 'Lineatin'

'Lineatin', obtained from Canada was tested against *X. lineatum* in England at Dartmoor Forest (Devon). The host-derived volatiles α-pinene and ethanol were tested as synergists for lineatin or as behaviour modifying additives. Factorial experiments used 'fin' sticky-traps and 'Icopal' (Borregaard, Norway) perforated cylinder traps which capture beetles stimulated to enter holes in the trap.

Results from sticky traps showed lineatin to be highly attractive to *X. lineatum* and the addition of ethanol significantly increased attraction; α-pinene greatly reduced beetle capture with lineatin alone and in ternary mixture. Ethanol and α-pinene alone, or in mixture were not attractive.

Icopal traps caught few beetles with lineatin alone, indicating that boring activity (trap entry) was not stimulated. Lineatin plus ethanol stimulated entry and this behaviour was enhanced by the ternary mixture. Ethanol and α-pinene alone were not attractive but when mixed showed some activity.

C. J. KING

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* Chemical Entomology Unit, Southampton University
**College of Aeronautics, Cranfield

Chemical attractants for Scolytus scolytus (F.) and S. multistriatus (Marsham)

During 1980, 10 further field experiments were undertaken to evaluate the role of beetle and host-produced components in the chemically-mediated behaviour of *S. scolytus* and *S. multistriatus*.

Beetles were trapped on removable sticky covers of white, rigid PVC on 'fin' traps (*Report* for 1980). Re-randomisation of treatment positions within blocks increased experimental sensitivity and reduced trap/site effects compared with 1979.

Release rates of 4-methyl-3-heptanol greater than 800 μg/day (*Report* for 1980) did not increase catches but there was no evidence of inhibition for either species.

Only the natural α-isomer of multistriatin, in mixture with 4-methyl-3-heptanol, was found to be active. However, the type of response elicited was dependent on the α-multistriatin/4-methyl-3-heptanol release ratio. Low release ratios, attracted *S. multistriatus* with no apparent effect on *S. scolytus* but catches of both species were reduced by high release ratios. The latter may serve to disperse beetles from heavily colonised trees.

Three host (elm) substances, α-cubebene, β-pinene and limonene, were tested against both species. The higher activity of α-cubebene-4-methyl-3-heptanol mixtures compared with 4-methyl-3-heptanol alone was confirmed. β-pinene also showed promise as a synergist.

*M. W. BLIGHT, *L. J. WADHAMS, *M. J. WENHAM, C. J. KING

Research Studentships

Two studentships were initiated in 1980. A C.A.S.E. student at the Department of Forestry and Natural Resources, Edinburgh University, began a study of nutritional requirements of *Panolis flammea* larvae, and a N.E.R.C. research student at Alice Holt is studying the ecology of *Cryptococcus fagisuga*.

Advisory Services

Forestry Commission staff sent 77 enquiries to Alice Holt and 53 to the Northern Research Station. The number of private enquiries received was 128 at Alice Holt and 43 at the Northern Research Station (NRS). The NRS figures represented a 39 per cent increase over the previous year.

WILDLIFE MANAGEMENT

Management of Grey Squirrels and Other Mammals

Work continues on red deer performance in terms of both fecundity and habitat quality. A method of estimating roe densities in terms of forest structure has been developed and independent techniques for assessing its accuracy are being investigated. Methods of improving cull achievement are being monitored, particularly the use of glades by both red and roe deer.

*ARC Unit of Invertebrate Chemistry and Physiology, University of Sussex, Falmer, Brighton, BN1 9RQ.

Management of Birds

Work on bird communities on restocked and afforested areas has continued as has a study of the influence of different woodland types. Most of the work done previously has been linked with territorial bird census techniques in spring and summer. An investigation of the use of different forest types by winter resident and migrant flocks has been begun.

Damage Assessment and Evaluation

A standard method of damage assessment has been developed and made generally available. Work on the extent of bark stripping damage to Lodgepole pine (*Pinus contorta)* and the effect on height and girth increment is being written up. A significant relationship between severity of stripping and tree height was found at Rannoch Forest (Tayside) where smaller trees were more severely and more frequently stripped. Surveys of multiple leader development in Sitka spruce *(Picea sitchensis)* following browsing by ungulates showed that up to 60 per cent of a crop could be affected but this proportion decreased in crops where the leader was no longer vulnerable.

Chemical and Mechanical Repellants

A joint MAFF/FC comparison of different rabbit fence specifications, including temporary electric fences, has been begun. A one-metre wide hinge joint netting has been developed and is available for deer fencing.

Polyethylene individual tree guards have been tested against cattle – the guards are satisfactory provided the animals do not rub against them.

No results are yet available from trials of an Austrian rabbit repellant.

Wildlife Management Techniques

A variety of methods of assessing and recording conservation status for woodland management purposes were investigated.

Miscellaneous

The use of the direct access by VDU to the Prime 400 computer encouraged considerable development of data manipulation methods. A major improvement of the input editing of the Squirrel Questionnaire was due to the use of the Rapport database management system developed for Forest Name Changes. A record of these changes in the Forestry Commission from 1949 to date and location on a 10 km square basis is now readily available.

J. J. ROWE

ENGINEERING SERVICES

Maintenance of Electro-Mechanical Services

The Branch has provided a service for the manufacture of special equipment, also mechanical and electrical maintenance of existing equipment. The cable system routing input lines to the computer from all parts of the building has been extended and there have been frequent calls for re-allocation of connections.

W. H. HINSON

FIELD SURVEYS

FIELD AND SITE SURVEYS

Field Surveys

Surveys were completed in 13 forests during the year, comprising some 15,000 ha. At the end of the year, work was in progress in a further 18 forests, within which, about 19,000 ha had been completed. The total of 34,500 ha involved about 16 man years, giving an output of some 2,200 ha per man year.

This output is about half the desirable programme. The situation is due to the need to devote a substantial proportion of survey resources to the census and to the preparations for the 1982 valuation and forecast.

Site Surveys

Six surveyors were employed full-time on this activity in Scotland and between them they completed some 15,000 ha, about two-thirds of which were in the plantable reserve and the remainder in established forests.

Field survey teams collected site data from some 17,000 ha in England and Wales in the course of their normal survey duties.

MENSURATION

Sample Plots

Completion of the detailed sample plot data base has been delayed by computer programming problems, but all the data have been checked and are now in computer store.

Services to the Field

The tariff check has been linked to the assortment forecasting program and is expected to offer a valuable service to field managers for valuation and sales purposes.

Research

Investigations into the growth curves for Sitka spruce and Scots pine have begun and further development in individual tree models is in hand.

Mortality functions have been derived for the improvement of yield models in a range of species.

CENSUS

Of the 63 counties and county groups in Great Britain, field work in 20 English counties is complete.

The Welsh survey is about to start, and in Scotland preparations are well advanced.

Due to computer programming problems, it is unlikely that any county or county group reports will be available until late in 1981. All should be complete by mid 1982 and the main Great Britain report should have been published early in 1983.

Electronic hand-held data terminals, currently used in the census are under development to provide for all branch data capture within the next two years.

DRAWING OFFICE

A 25 per cent turnover in staff during the year has led to a virtual reduction in available manpower of some 10 per cent. In spite of this and the substantially greater volume of work than was expected and generated by the census, some real progress has been made except in the preparation of final forest maps where the backlog remains substantial.

The small air survey group has produced what is probably the best register of available commercial air photo cover in Great Britain.

The work done by the drawing office in support of the census has led to greatly improved map records of private woodlands in conservancy offices. It will be essential to maintain these in the future if the full benefit of this not inconsiderable investment is to be realised.

K. P. THALLON

WORK STUDY

Forest Management: Method Study

Initial trials of a Zijlstra and Bolhuis nursery plant lifter were carried out, showing size of stock to be critical. Despite modifications, lifting of material below 200 mm proved impossible while stock in excess of that size was lifted and bundled satisfactorily.

Some work was undertaken to examine alternative means of monitoring aerial fertilization applications with the objective of producing a quick and reliable assessment of treatments.

The fire fighting project continued, confirming the use of foam as a barrier with experience in 30 local wildfires. Developments during the year permitted foam to be produced from 5 hp pumps through 25 mm (1″) hose which has extended the advantage of the technique. Trailer units, pumps and hose have also been examined.

An Excarotor rotary ditcher continued trials on mineral soils and despite initial problems has shown itself capable of producing a good quality drain with outputs of up to 150 metres per hour.

A Leno Scarifier was evaluated as an alternative to ploughing on difficult sites and showed that scarified patches, as a planting medium, can be readily produced.

A modified GM4 Forest Scrubcutter was assessed for lop and top treatment.

Forest Management: Servicing and Continuous Review

A development to combine a stump treatment sprayer with a clearing saw brought operational advantages in respacing work.

Trials of tractor-mounted controlled drop applicators on upland heather control continue but indicate the greater problems associated with terrain and climatic conditions.

Evaluation of electrostatic sprayers and direct herbicide applicators show potential advantages in specific situations.

Trials of Husqvarna 165R and 140R modified clearing saws have been encouraging as has been the new Husqvarna 7-tooth blade for use with the 140R in heavy grass/herb weeding.

The Turner Heavy Duty Rotary Slasher confirmed initial indications that it has a capacity equal to any scrubcutter presently used. A Holder 60/Shaw Weeding Flail unit is also under trial.

Forest Management: Work Measurement

A Standard Time Table on replanting was issued as was an Output Guide on replanting by Pottiputki.

Harvesting and Marketing: Method Study

A full programme of machine evaluation including, where appropriate, a review of working methods has been undertaken with the following machines:

Kockums 880 Feller Buncher, Kockums 84-31 Forwarder, Tree Farmer C4D Skidder, Hammerise Independent Loader, Jones Thinnings Tractor, Valmet 872K Forwarder, Gremo TH25 Harvester, Bruunett Mini Processor, Steyr KSK16 Mobile Spar Yarder, Massey-Ferguson 50B Independent Loader, Bell Logger, Radio-Tir 1200 Ground Skidding Winch and Smith Timbermaster Cable Crane.

An examination of timber movement incorporating the relationship between harvesting, extraction and haulage was completed stressing the need for the overall system to be integrated.

A comparison of forwarder and skidder systems on thinnings – to complement the previous work on clearfelling – was completed.

With the wider use of the Bruunett 578F Forwarder, studies of tyres and bunk formats were carried out to ensure maximum performance.

An examination of clearfelling for cable crane extraction was completed with an advantage from bench felling of 20 per cent increased winch output indicated. Other aspects of cable crane structure and operation have been examined including modifications to the Trailer Alp and tractor, development of a powered line pay-off carriage and methods of offsetting trailer mounted equipment.

Harvesting and Marketing: Servicing and Continuous Review

Evaluation of larger than normal capacity chainsaws for special situations was carried out, and as a result the Husqvarna 285CD and 2100CD models were added to the approved list.

In addition, examination of new chainsaws and alternative guide bars and chains continues.

The Sperber Portable Chainsaw Mill was evaluated and shown to be effective and of potential benefit to those in the private sector without full milling facility.

A full report on chokers and choker hooks was issued nationally to all forests.

A supplement to the national report on *Harvesting Aid Tools* was issued to ensure that information on this subject is up to date.

An evaluation of log marking systems was completed.

Harvesting and Marketing: Work Measurement

The following Standard Time Tables were published during the year:

Norway Spruce – Clearfelling, Sitka Spruce – Thinning, Japanese and European Larch – Clearfelling, Japanese and European Larch – Thinning, Douglas Fir – Clearfelling, Douglas Fir – Thinning, and Extraction by Roadless Logmaster Skidder.

Forest Authority

Alternative data collectors have been examined.

Investigations into noise dose meters and carbon monoxide meters and their application to the working environment have been undertaken.

A number of Technical Notes for the Home Grown Timber Advisory Committee have been prepared.

Safety

Draft Forestry Safety Council Guides have been reviewed and comments submitted.

Regular meeting of Work Study, Safety Officer and Education and Training Branch have taken place to ensure a co-ordinated approach to safe working techniques.

Training

The Branch has participated fully in Education and Training Branch courses.

A. J. G. HUGHES

STATISTICS AND COMPUTING

Data Preparation and Computing

A Prime computing system was installed and accepted at the beginning of the year at Alice Holt. The system included a Prime 400 central processor with ½ Megabyte (Mb) of main memory, two 96Mb disk drives (each with a 16Mb exchangeable cartridge), a 430 line per minute upper and lower case printer, a 300 card per minute card reader, and a Calcomp 1012 plotter. The system also had a communications capacity for 30 user terminals and links to two remote computers, one at UCC (UNIVAC 1108) in London and one at the Rutherford Laboratory (IBM 360/195). The demands made on the central system grew so fast, however, that a further ½Mb of main memory was installed after only 6 months of operation.

Towards the end of the year a Kode XL20 key-to-disk data entry system, replacing the punched card machines, was linked to the Prime system via an upgraded communications device which also services the links to the remote computers. A Tektronix 4025 raster scan character/graphics terminal was installed at about the same time.

The operating routine for the new computer has developed as demand has grown. The running of 'phantom user' jobs overnight is a normal feature now that the computer is regularly left switched on 24 hours per working day. The time-consuming duty of backing-up users' data areas and the present constraint imposed upon users' access to their databases have led to a requirement for a magnetic tape drive and further disk drives. The Computer Users' Group has recommended these additions to the system.

At the Northern Research Station plans and preparations were made to improve the computing facilities there. The bulk of the data for the Genetics Branch database has now been mounted on the Edinburgh Regional Computing Centre's ICL 2980 computer.

A Transdata CX400 micro-computer with twin floppy disks and a printer was installed at the Westonbirt Arboretum, with the AUTOINDEX database system, as an aid in the management of the growing stock.

Statistical Service to Research and Development Projects

Advice on experiment and survey design, analysis and interpretation of results continued to take up much of the statisticians' time. Use of the GENSTAT programming language has allowed statisticians regularly and easily to perform more sensitive analyses, and some project leaders to do analyses for themselves. In some areas of work (e.g. Work Study) it has proved possible for research workers to use interactive programs to analyse data without any knowledge of the GENSTAT language. The new facilities at Alice Holt have thus had a very marked effect on the speed and quality of the analytical service.

Statistical Service to External Units

Some linear programming work on yield planning was done for Planning and Economics Division. For South Scotland Conservancy, the 1979 and 1980 surveys of deer damage in Galloway were analysed. Help to the Unit of Invertebrate Chemistry and Physiology at Sussex University was again given in the design and analysis of field experiments.

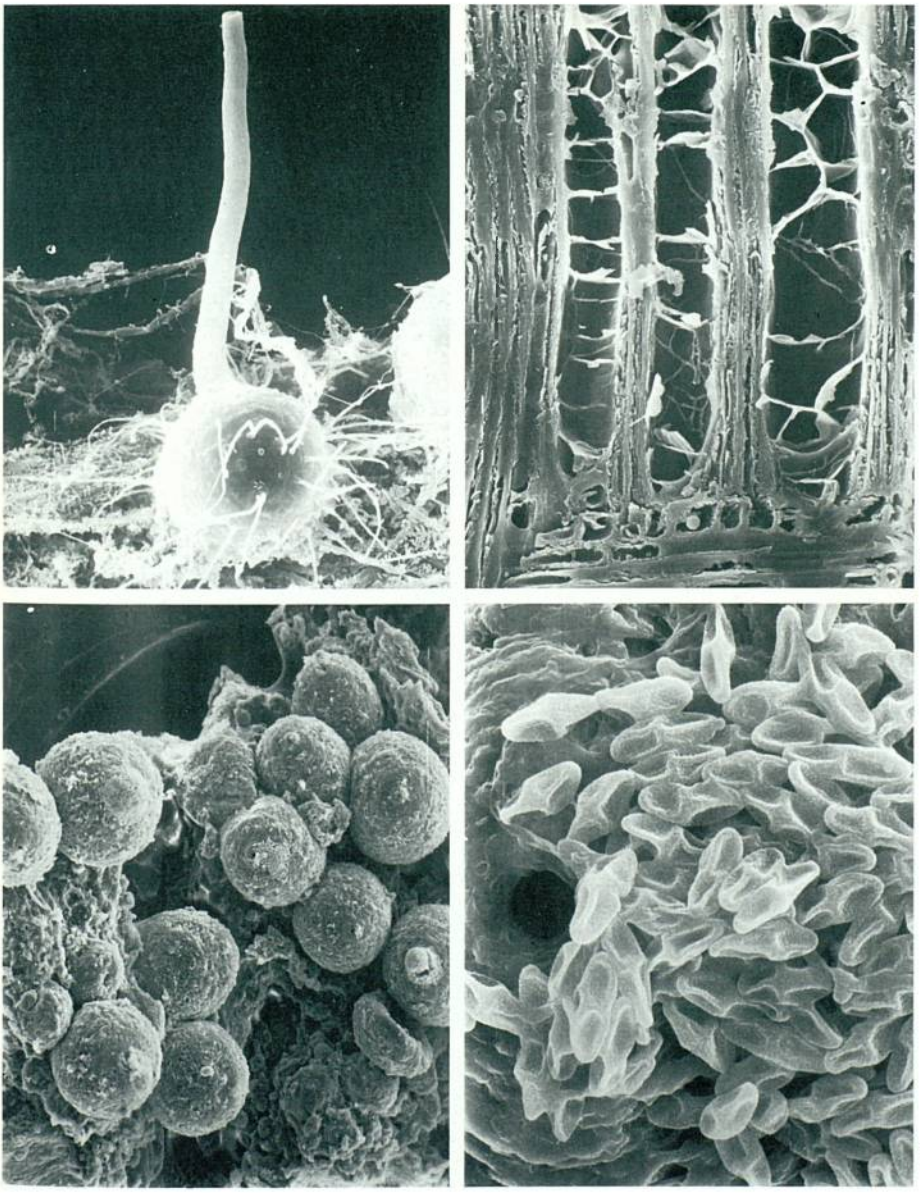

Plate 1(a)
Scanning electron micrograph of a perithecium of *Ceratocystis ulmi*, agent of Dutch elm disease. × 400.

Plate 1(b)
Scanning electron micrograph of fungal hyphae in the reaction zone of a pruning wound. × 300.

Plate 1(c)
Scanning electron micrograph of perithecia of *Nectria coccinea*, a fungus associated with Beech bark disease. × 84.

Plate 1(d)
Higher power picture of part of Plate 1(c) showing the ostiole of a perithecium and reticulated spores. × 1800.

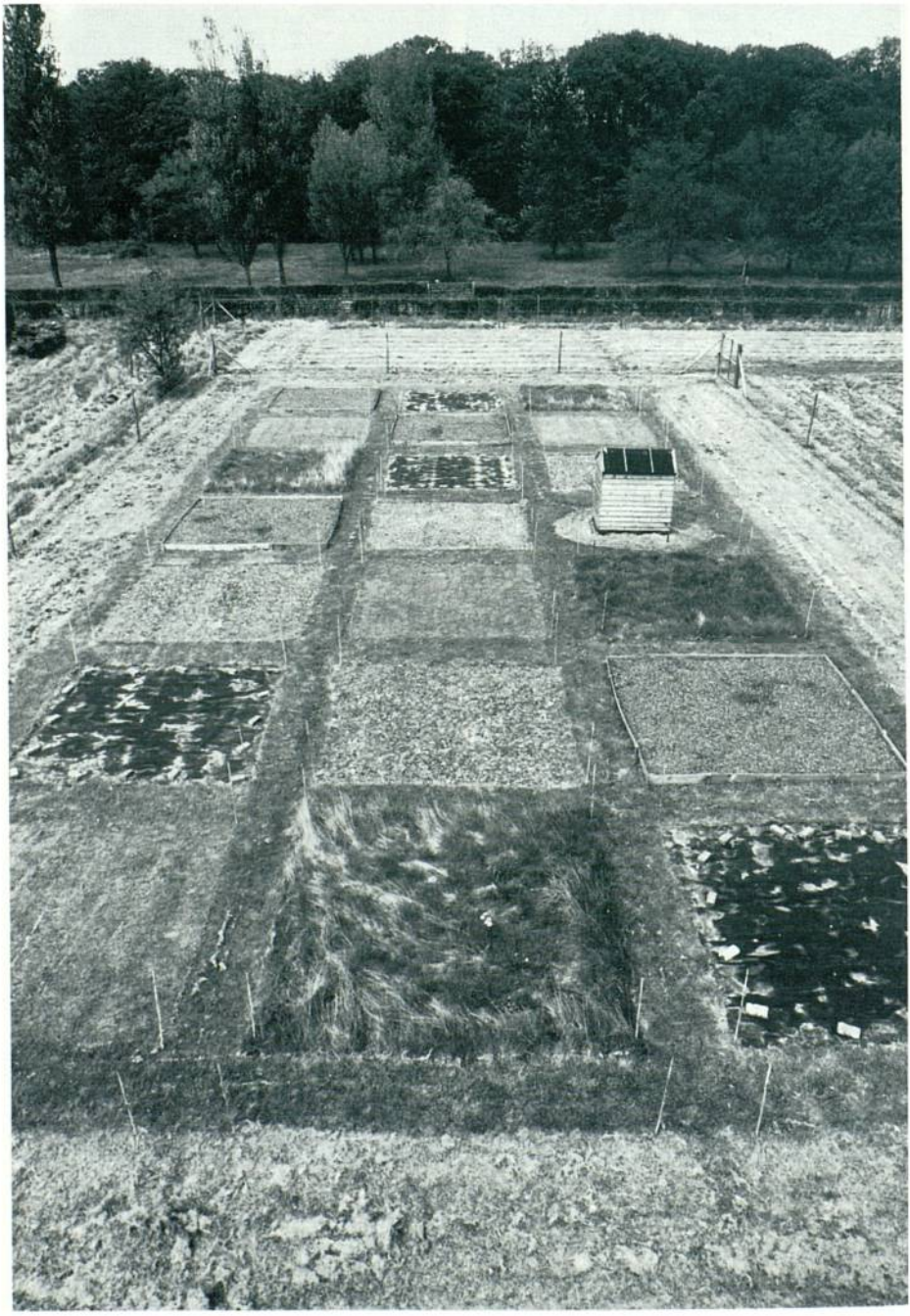

Plate 2

An experiment at Alice Holt to monitor soil temperature and moisture under free growing grass, grass mown to 3 cm, bare ground, a 15 cm bark mulch and a bituminous sheet mulch. *B9070*

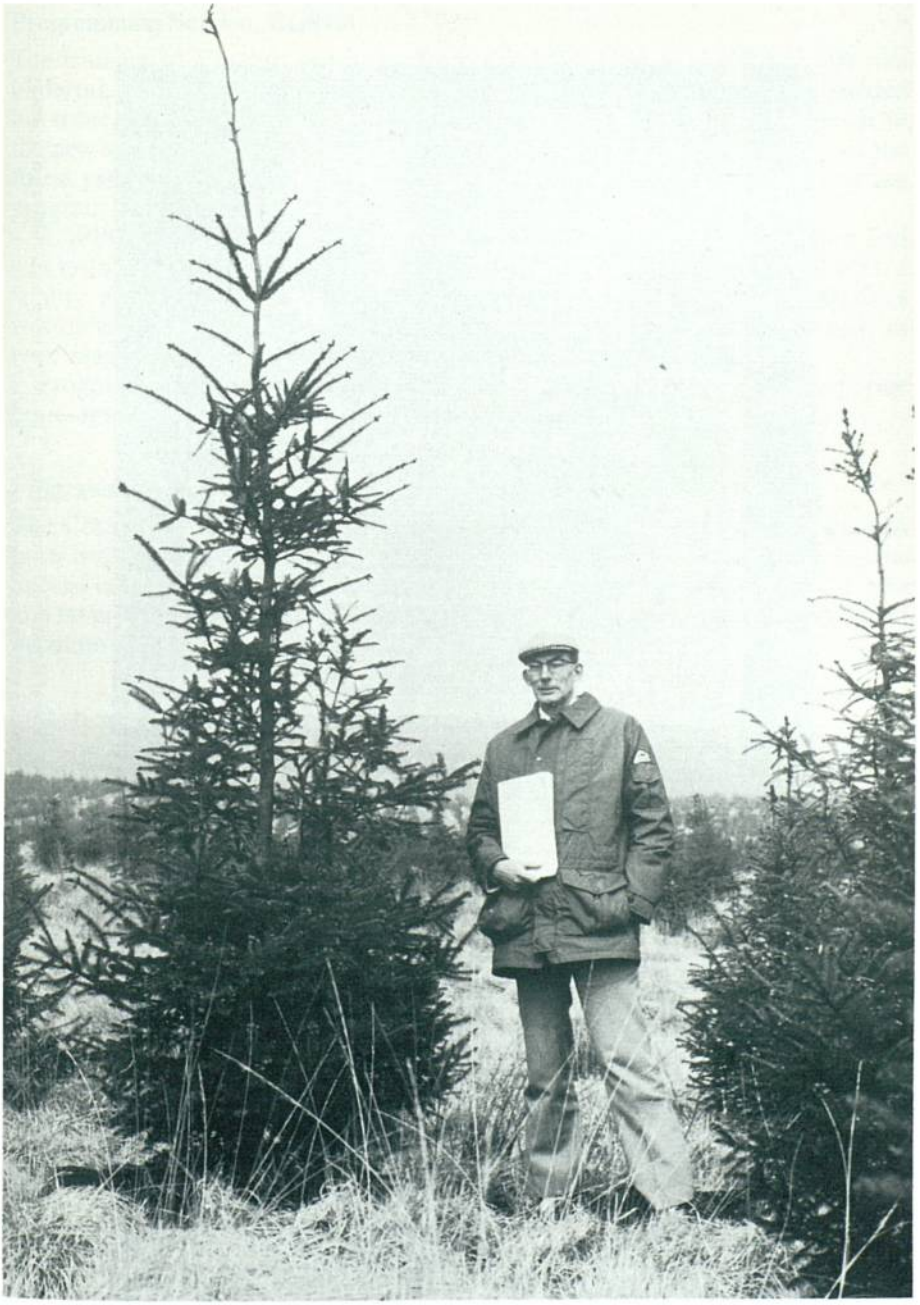

Plate 3

Six year old Sitka spruce from Gold Beach, S. Oregon, in the IUFRO seed origin experiment at Rhondda Forest, Mid Glamorgan. Mean height of plot 2·34 m. Note narrow crown (p. 21). *N 5151*

Plate 4

Thirty metre wide ridges on restored gravel workings on a porous sandy base at Bramshill Forest, Hants. The ridges have been cultivated crossways with winged tines, followed by a final cultivation along the furrows to ensure vertical percolation (p. 25). *B 9067*

Programming Service, General

The transfer of Fortran programs from the IBM 1130 to the Prime 400 was undertaken and completed during the year. Few semantic changes were needed but some of the programs were rewritten to utilize the extra facilities available on the new system. Preparations were made for the quinquennial evaluation of the forest estate in 1982. These included specification of the revised forecasting program and upgrades to the entire forecasting system.

RAPPORT, a relational database management package, from Logica Ltd was installed on the Prime 400 to meet demands from many branches for such a facility. At the Northern Research Station a taxonomic key to Basidiomycetes was indexed using the CATALOG keyword package and interactive searches were made to identify unknown fungi by their characteristics.

Programming courses given by our own staff were attended by at least one representative of each Research Branch at Alice Holt.

Programming Service, Mathematical/Statistical/Technical

The Census of Woodlands was again the major project of the year. Programs have been written to allow all processing and primary data storage in-house. Special commands were programmed to simplify the processing of Census data and several are of general use, especially those enabling parameter substitution in command files.

Statistical, Mathematical and Computing Methods

The superpopulation-prediction approach has been used to derive estimators suitable for the Census of Woodlands, and the robustness of such estimators to some types of errors in model specification has been studied.

In collaboration with Wildlife Branch a new model of animal home-range has been developed and fitted to Grey squirrel trap data.

A non-linear markovian model has been developed and fitted to mortality data from unthinned sample plots and the use of such a model for stands in which thinning has been stopped is being considered.

Diffusion models of growth have been investigated. A model extending previously available theory has been fitted to various data sets, and is being used in an interactive computer program.

A cable-crane simulation program has been written to allow the calculation of optimum rack spacing and roadside space requirements. With further development it should allow the investigation of interactions between various combinations of harvesting equipment.

Data Capture and Associated Computing

The data from MSI hand-held terminals, operated by Census field staff and collected centrally on Transdata CX400 floppy disk, is now transferred directly to the Prime 400 and validated. Such terminals are also being used increasingly for experiments, and in some cases the availability of programs to edit, summarise and analyse the data have led to results being available for interpretation within hours of the data being collected.

D. H. STEWART, R. S. HOWELL

COMMUNICATIONS

RESEARCH INFORMATION

Library

A further 235 books were acquired and subscriptions taken out for another nine journals. Loan requests satisfied reached an all-time high of 10,010 with 5,388 loans from stock, 675 borrowed from other libraries and 3,947 photocopies.

During the year a trial of computerised housekeeping operations, using the newly installed Prime computer, was carried out. Delays in response and unavailability at certain times resulted in a return to manual systems, which allow more flexibility.

A survey of Alice Holt Lodge library users showed that there is general satisfaction with services.

Information Services

The information services provided by the Arboricultural Advisory and Information Service rely increasingly upon the literature acquired by the library (e.g. 2,132 photocopies taken).

The literature database, which had been searched off-line on the previous computer, can now be searched on-line with the successful transfer of the old programs.

PHOTOGRAPHY

Aerial Photography

The first full year of flying for the Census has, despite the poor summer weather of 1980, been very successful. Productivity, in terms of targets acquired and photographed per hour flown, has been greater than anticipated. The results have fully justified the operation. The cost per print is less than commissioning surveys or of 'buying-in' existing cover. As, to save time, existing cover has been used whenever possible, it follows that most of our flights have provided cover unobtainable elsewhere.

The camera system, though simple and uncomplicated, has worked well. However, as all the Census runs are E–W or N–S, the fixed mount has occasionally given rise to problems with drift. This has not been critical on the single line runs required, but could be a consideration when we move on to more extensive surveys after the Census ends. A new mount is now being devised to obviate this. A fixed TV camera will be mounted vertically in the fairing which accommodates the twin 70 mm cameras. This will show, on a small monitor screen positioned near the pilot, the ground passing directly beneath the aircraft. A rotating cursor on the face of this will effectively turn it into a drift sight. The 70 mm cameras will be able to be rotated in unison, but each about its own optical axis, so that they can be displaced from the aircraft centre-line by an amount equal to the drift obtained from the monitor.

I. A. ANDERSON

PUBLICATIONS

The Section published* for the Forestry Commission or prepared for publication by Her Majesty's Stationery Office the following twenty-four titles:

Reports

60th Annual Report and Accounts of the Forestry Commission (1979-80) (£7·20)
This included a Special Review for the Commission's Diamond Jubilee.
Report on Forest Research, 1980 (£4·90).

Forest Records

No. 121—Production of Wood Charcoal in Great Britain, by J R Aaron (75p).
No. 122—Nothofagus in Britain, by G Tuley (£1·00).

Leaflets

No. 56—Grey Squirrel Control (revision), by Judith J Rowe (80p).
No. 75—Harvesting Windthrown Trees, by A T Jones and R O Smith (£1·00).
No. 76—Nutrient Deficiencies in Conifers in British Forests – an illustrated guide, by W O Binns, G J Mayhead and J M MacKenzie (£1·25).
No. 77—Line Thinning, by G J Hamilton (90p).
No. 78—The Management of Forest Streams, by D H Mills (70p).

Arboricultural Leaflets

No. 4—Virus and Virus-like Diseases of Trees (revision), by J I Cooper (£1·00).
No. 6—Trees and Water, by W O Binns (£2·00).

Research and Development Papers*

No. 125—International Plant Health Control: Conflicts, Problems and Co-operation – A European Experience, by D H Phillips.
No. 126—The Formulation of Research Programmes, by D R Johnston.
No. 127—Developments in Forest Road Planning, by E F Granfield, C D MacMahon and D A Mithen.
No. 128—Developments Towards Whole Tree Utilization of Softwoods, by E G Richards.
No. 129—Chemically Mediated Behaviour in the Large Elm Bark Beetle, by Margaret M Blight, C J King, L J Wadhams and M J Wenham (£1·50)

The Papers Nos. 125–128, together with Occasional Paper No. 9 below, were published for the 11th Commonwealth Forestry Conference held in Trinidad. In addition to producing programme and agenda papers, three papers were edited and produced for authors in FAO, Guyana and Tanzania.

Occasional Papers*

No. 6—Forestry and Farming in Upland Britain (£3·00).
No. 7—Establishment of Trees in Regraded Colliery Spoil Heaps, by J Jobling and F R W Stevens (£1·00).
No. 8—The Forestry Mission to China, 1979, edited by K W Wilson (£1·50).
No. 9—Progress Reports 1973-79 by the Forestry Commission of Great Britain and the Forestry Division of the Department of Agriculture for Northern Ireland.
No. 10—Research for Practical Arboriculture (£2·00).

Other Publications

A report on 'Coppice Crops for Energy' by M L Pearce was edited and produced for submission to the Department of Energy.

The Section was again involved in the Calendar *Trees for all Seasons, 1981* for which there was a good demand from the public and the forestry industry. A revision of the catalogue of publications was made and published as the *Forestry Commission Book List 1981/82.*

K. W. WILSON

WOOD UTILIZATION

The Joint Project with the Electricity Council for developing the use of Norway and Sitka spruce power transmission poles, by improving their permeability to wood preservatives, continued. As it had been thought that the disappointing results of the earlier trials might have been due to the use of less suitable bacteria during the water treatment, a further experiment was undertaken in which 42 three-metre logs of Sitka spruce were sprayed with water, seeded with a mixture of 14 species of bacteria supplied by the Institute for Industrial Research and Standards in the Irish Republic.

The logs were sprayed for 148 days during which the levels of bacterial activity were recorded by the Biodeterioration Centre at the University of Aston. They were then allowed to dry for 278 days, after which their ends were sealed prior to creosoting under pressure. While no appreciable improvement was observed in the radial penetration of creosote over logs which had been sprayed with unseeded water from local wells (relying upon naturally occurring bacteria), a considerable amount of useful information on the bacterial populations in wood was obtained. However, it was particularly frustrating to note that an apparent increase in permeability, as assessed by monitoring the absorption of 20/50 lubricating oil, was not matched by a comparable acceptance of creosote under pressure. It was therefore decided that in future experiments water-borne copper chrome arsenate would be used instead of creosote.

In the earlier work there had been some evidence that immersion of the poles in ponds, rather than water treatment by spraying, resulted in better permeability. A new series of trials was therefore started in which poles of both species of spruce have been immersed in ponds at three contrasted sites in the Forest of Dean (Gloucestershire), Dyfnant (Powys) and Drummond Hill (Tayside).

J. R. AARON

OTHER HEADQUARTER DIVISIONS

PLANNING AND ECONOMICS

Economic Research

The most dramatic events of 1980 affecting the economics of forestry in Britain were the closure of two pulp mills and continued falls in price (in real terms) of a number of roundwood specifications. While the international recession and the general level of demand in the British economy played their part in events in the

wood market, the possible impact on wood product prices of recent increases in the sterling exchange rate has been of major interest. As an example of sterling's appreciation, it may be noted that the real dollar/sterling exchange rate, that is the inflation-adjusted market exchange rate, rose more rapidly, and to a greater extent in the 4 years 1976 to 1980, than at any other time this century. An investigation was carried out to see how far sterling's appreciation was reflected in falling (sterling) prices of imported wood products. The extent of the fall may be limited if overseas suppliers, or importers, choose to maintain prices and so cushion the exchange rate effect, at least temporarily, rather than allow effective prices to U.K. final buyers to fall in line with exchange rate changes. Export prices or unit values of sawnwood, chemical pulp, newsprint and particle board in major supplying countries were examined against U.K. import prices for the same products. Regression analysis showed that the thesis that exchange rate changes rapidly affect import prices was supported by the evidence relating to only a few of the markets investigated. No clear view of the extent and timing of market response in the other cases is available as yet.

A. J. MOON

Guides to Management

Thinning

Earlier work on the optimum timing of first thinning (*Report* for 1979, p.48) was extended to take into account the effects of variation in price and of windthrow risk. Discounted revenues were calculated at discount rates of 3 per cent and 5 per cent for different ages of first thinning and for no thinning, using a variety of price-size curves combining variation in marginal tree size (the tree volume at which standing value is zero) with 3 upper bounds. The results indicated that the major determinant of the overall profitability of thinning is the size of the marginal tree. The optimum timing of thinning, chosen on the basis of maximum net discounted revenue, was then determined for a range of marginal tree sizes, different levels of road cost and different Windthrow Hazard Classes, after allowing for the effect of timing of thinning on probable terminal height where crops are subject to windthrow. General conclusions were that thinning is not profitable in Windthrow Hazard Classes V and VI and that, on more windfirm sites, only exceptionally is first thinning at Management Table age justified when the marginal tree size is greater than 0·05 m^3. The results also indicate that, in general, if a thinning makes a loss, it cannot be justified on grounds of longer term profitability. The initiation of thinning in a given period is thus closely bound up with the current market position. Equally, if stands have already received a first thinning and marginal tree size remains or is high, later thinning may not be appropriate judged by reference to stand profitability. While these findings make supply more price-elastic, other considerations such as maintenance of employment and fulfilment of contracts may limit the effects in this regard.

M. F. GARFORTH, A. J. GRAYSON

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

Studies of tree growth in relation to the input and movement of nutrients in early thinning-stage Sitka spruce have continued (Miller and Williams, 1973). In the past year the fifth of the six experiments, that at Kershope forest (Cumbria), reached the end of the planned five years of intensive studies during which the trees, soil organic layers, litterfall and rainfall have been sampled in considerable detail in both fertilized and unfertilized plots. Response to NPK fertilizer at this site was significant, although not large, and showed essentially the same pattern as that already reported for the experiments at Leanachan (Highland) and Fetteresso section of Mearns (Grampian) forests, i.e. a reduced response to nitrogen in plots also given phosphorus, or given heavy rates of phosphorus and potassium applied together (Miller, 1978). Following the final sampling, the experiments are being thinned and refertilized each year for three years. After two years of such treatment, the response in basal area at Leanachan has been quite marked (3·0 m^2/ha rising to 5·5 m^2/ha over two years) but the pattern has remained as reported above. The rather pronounced response is believed to be due to the need to reconstruct the canopy after the thinning.

Data collection is nearly complete in the study of nutrient input from the atmosphere (in rain and through the capture on tree surfaces of nutrients in mist, aerosols, dust etc.) at the six spruce sites. The concepts and methods of measurement have been the subjects of recent publications (Miller, Unsworth and Fowler, 1980; Miller, 1980). Concentrations of elements in rainwater collected in gauges surmounted by a vertical cylinder of polyethylene coated wire mesh (filter gauges) were up to six times, and usually two to three times, greater than those concentrations found in water from standard rain gauges. Examination of the ionic ratios in water from the filter gauges suggests that for potassium, calcium, magnesium, chloride and mineral nitrogen, most of the additional material caught by the filter surfaces is sea-derived (Miller and Miller, 1980). At remote sites the additional sulphate was also essentially sea-derived but closer to industrial areas there was clearly a large anthropogenic contribution. The magnitude of this acid sulphate introduction in relation to the flux of hydrogen ions generated within the ecosystem is the subject of a new investigation.

The data originally collected for Corsican pine at Culbin, Laigh of Moray (Grampian), forest (Miller and Williams, 1976) have been used, in conjunction with the Forestry Commission Yield Tables, to produce tables of biomass and nutrient accumulation by age for different growth rates of this species (Miller, Miller and Cooper, 1980a). Using these to calculate the nutrient removal that would result from different harvesting policies it was shown that such losses are

seldom likely to be greater than the anticipated input from the atmosphere (Miller, Miller and Cooper, 1980b).

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THE EFFECT OF HEAVY METALS ON SOUTH WALES FORESTS

By K. W. BURTON and E. MORGAN

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This three-year study is to determine the extent of and way in which heavy metal pollution in South Wales affects the growth of Sitka spruce.

Seedlings are grown in both solution and soil to establish the tolerance to particular metals and mechanisms of action of high concentrations of both essential and non-essential elements which can accumulate in the soil.

The method developed by Beckett and Davis (1977) has been used to produce information on the upper critical concentration in the active tissue of seedling shoots.

The seedlings are grown in a controlled environment for a period of up to 100 days. Variation of the solution concentration of the metal produces a wide range of concentrations in the plant at levels below and above the point where the yield is affected.

The results so far show that Sitka spruce is tolerant to concentrations up to 500 parts per million (ppm) of zinc and 120 ppm copper. A decrease in the yield is found when an accumulation of above 10 ppm cadmium has taken place. Preliminary experiments have also shown Sitka spruce to be sensitive to low concentrations of mercury and nickel. Observations have shown that low solution concentrations of cadmium will produce a yellowing of the needle colour. Similar observations were recorded at higher levels of copper, nickel and zinc. Studies of heavy metals in the plants have shown that they are not immobilized in the roots and are transported readily to the shoots, where they may affect the normal metabolic functions of the plants.

A survey of the forest soils in the area is being undertaken at present to estimate the 'available' and total concentrations of heavy metals. The results show that 'available' heavy metals are cadmium, zinc and copper. Studies to estimate concentrations of heavy metals in the trees for correlation with the work done in the controlled environments and soil studies are in hand.

This work is supported by the award of a SRC/CASE studentship (Forestry Commission/Polytechnic of Wales) to this project.

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HERBICIDES

HERBICIDE EVALUATION FOR FORESTRY USES

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Herbicide studies with pot-grown crop and weed species have continued. The work complements other screening programmes which concentrate on weeds of agricultural land.

Studies relating to weed control in seed beds

Two new grass herbicides, ARD 34/02 (NP55) and PP009, had, as expected, almost no effect on seedlings of coniferous or broadleaved trees. However, neither has much effect against *Poa annua*, probably the commonest weed of seed-beds. For this reason, these new compounds are unlikely to be used extensively on seed-beds, except perhaps in mixtures.

The potential of herbicide 'antidotes' or 'safeners' was tested in a large experiment involving four conifer and one broadleaved crop sepcies. Napthalic anhydride, used in agriculture to protect seeds of maize and sorghum against grass-killing herbicides, had no obvious effect on any crop when applied pre-sowing by soaking or as a seed dressing. A second 'safener', R 25788, was itself moderately phytotoxic. In most instances, there was little evidence of either compound protecting tree seed against the effects of herbicides, though napthalic anhydride treatment did reduce damage in certain conifer species exposed to the herbicides EPTC and napropamide. Further work in this field is planned.

Studies relating to transplant lines and young plantations

Relatively few new herbicides were tested in 1979/80. A Dupont compound, DPX 4189, had interesting effects on weed species, but severely injured many crops. Sitka spruce was very susceptible, being killed by doses as low as 50 g/ha of active herbicide. At 4 kg ai/ha the new grass herbicide ARD 34/02 (NP55) gave good control of *Deschampsia caespitosa* but was relatively ineffective against *Holcus mollis, Calamagrostis epigejos* and *Molinia caerulea.*

In the absence of new materials, attention has again concentrated on methods of making established products work more effectively. Summer applications of triazines used for grass control again gave promising results. July treatments with atrazine and terbuthylazine again controlled *Molinia* more effectively than sprays applied in spring. Activity was enhanced by the use of an oil adjuvant, Actipron. Summer applications of propyzamide were unexpectedly effective against *Deschampsia, Calamagrostis* and *Holcus mollis.* With the last species, 2 kg/ha of propyzamide in July was more effective than any other summer herbicide treatment. This result, which is at variance with present commercial recommendations, is to be investigated further.

Glyphosate treatments applied in autumn to grasses were more effective than equivalent summer sprays. Applying the herbicide at this season had no adverse effect on Sitka spruce or Lodgepole pine.

Salt formulations of triclopyr appear to be less toxic than esters to woody species, but more effective against herbaceous weeds such as Rosebay willow-herb. Possibly the water soluble formulation is translocated better. It is intended to examine this difference in more detail. At present, the intention is to market only triclopyr ester in the U.K. Salt formulations are, however, currently used in the USA and could perhaps be made available here.

In experiments with *Rhododendron ponticum,* solublised glyphosate and hexazinone (Velpar) were much more phytotoxic than ordinary aqueous sprays. These formulations are expensive, but it is also possible to enhance activity by adding 5 per cent – 10 per cent of an oil-surfactant blend 'PB' to aqueous sprays. This oil-surfactant mixture was originally developed for use with a wild oat herbicide, difenzoquat, but now seems to be of more general use.

TREE PHYSIOLOGY

RAPID VEGETATIVE PROPAGATION OF SILVER BIRCH AND SCOTS PINE BY TISSUE CULTURE

By A. D. CAMERON and J. D. MATTHEWS

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Tissue culture has considerable potential in vegetative progagation through high rates of multiplication and the prospect of cloning species difficult to propagate by conventional methods. The term 'tissue culture' is used to describe three areas: true tissue culture which involves formation of an undifferentiated callus before subsequent organ formation, known as organogenesis; organ culture, where organised regions of cells are cultured but remain physiologically intact, for example bud meristems; and cell suspensions where the culturing unit is a single cell. Most of the present research with Silver birch (*Betula pendula* Roth) has concentrated on culturing stem internodes. Pines, like many conifers, are difficult to culture even from juvenile material, so research workers usually resort to culturing embryos and, in several cases, successful organogenesis has occurred. Tissue culture of Scots pine (*Pinus sylvestris* L), therefore, is with embryos.

Silver Birch

Huhtinen and Yahgaoglu (1974) showed that formation of shoots from birch cultures is possible but, so far only with seedling source material. This project aims at developing more general techniques of tissue culture using older material. Background knowledge is required on the numerous growth substances available and their effects on birch cultures. Five common auxins, indole-3-acetic acid (IAA), indole-3-butyric acid (IBA), naphthaleneacetic acid (NAA), p-cholorophenoxyacetic acid (pCPA) and 2, 4-dichlorophenoxyacetic acid (2, 4-D), and two cytokinins, 6-furfurylaminopurine (kinetin) and 6-benzylaminopurine (BAP) are widely used in the culture of many broadleaved, woody species. However, there is little agreement about which, if any, are most effective. An experiment was set up to examine these five auxins at several concentrations with and without kinetin. After one month of darkness, previously found essential for callus development, the stem-internodes, now enveloped in white callus, were assessed for callus development and root formation. IAA was most effective at producing callus at the relatively high level of 25 ppm, whereas IBA and NAA were most effective at 10 and 1·0 ppm. 2, 4-D and pCPA, however, were effective at the lower concentration of 1·0 and 0·1 ppm. IBA was better than the other auxins at inducing callus and the presence of kinetin at 0·5 ppm enhanced callus development. Roots were most evident on cultures treated with IBA, but were rarely present on cultures treated with 2, 4-D and pCPA. Roots showed no geotropic response in darkness and, after removal to continuous light, they usually died. Calluses turned green in light and growth slowed down or stopped. 2, 4-D and pCPA retained their activity longer than the remaining three auxins.

Auxins are known to inhibit formation of adventitious buds so the cultures were transferred to fresh medium containing 0·5 ppm kinetin only. After one month there was no evidence of bud formation so the individual cultures were divided and each half placed on medium containing 5 ppm and 15 ppm kinetin. After two weeks buds formed on several cultures. Future work will aim at inducing shoot growth and subsequent plantlet formation.

Scots Pine

Much work has already been done on embryo culture of several pines and this provides a basis for work on Scots pine. NAA and BAP are the preferred growth substances so these were tested at various concentrations. After four weeks in continuous light buds were observed. The presence of BAP was essential to bud formation, the higher level of 5·0 ppm being more effective than 0·5 ppm. Cultures with and without NAA produced buds but more buds were present if a low level of NAA (~0·05 ppm) was used. The next stage will involve producing shoots from these buds and rooting them to form separate plants.

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FOREST ZOOLOGY

LONG-HAIRED FALLOW DEER

By R. H. SMITH and ELIZABETH JOHNSON

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Four out of the eight crosses set up in enclosures in Mortimer Forest (Salop) in September 1979 (Smith and Johnson, 1980) produced fawns in Summer 1980. Three of the crosses were between short-haired parents and produced short-haired offspring. The fourth cross was between a short-haired buck (L22) and a long-haired doe (L1) and produced a short-haired fawn (L33); the doe L1 had previously produced both short-haired (L24) and long-haired (L28) offspring and the results are consistent with the hypothesis that long-hair is genetically dominant.

The crosses set up in a New Forest (Hampshire) enclosure using the long-haired buck L9 and three New Forest does produced three fawns in Summer 1980. Although the New Forest fawns have not yet been captured and handled, they have been observed using binoculars on a number of occasions and have been classified as two long-haired and one short-haired. The result confirms that long-hair is genetically dominant because the New Forest does must have been homozygous for short-hair alleles. The suggestion that the long-haired buck L9 is heterozygous (Smith & Johnson, 1980) is also confirmed. The New Forest fawns will either be back-crossed or sib-mated in order to produce further confirmation that long-hair is dominant.

A number of practical problems have arisen since 1979. It is not known why the two long-haired does and one short-haired doe mated in Autumn 1979 did not produce fawns in 1980. All the fawns in the Mortimer Forest enclosures were produced late, one not until early September 1980. Several deer have escaped through the enclosure fences, including the doe L2 and the fawn L28 in early 1980, and the does L15 and L18 with their previous year's offspring L29 and L30 in early 1981. Despite set-backs it is intended to continue the genetical study for at least a further two years.

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REPRODUCTIVE PHYSIOLOGY OF THE GREY SQUIRREL

By ELIZABETH JOHNSON

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Since January 1979, Miss G. Webley (Forestry Commission/SRC CASE student) has monitored the weights of testes and accessory reproductive organs of male grey squirrels and related them to plasma testosterone levels. Weights of the reproductive organs show a regular seasonal pattern, with large organs during the breeding season and regression in June/July. The regression may last from July to November, as in 1980, when squirrels with large testes were again trapped, or the regression may be prolonged to the following March, as in 1979. As reported last year (Tait and Johnson, 1980), a prolonged regression is a frequent occurrence in the study area and evidence is accumulating which suggests that food supply is the controlling factor. Plasma testosterone levels show a similar seasonal pattern, with high levels from squirrels with active testes and low to undetectable levels from squirrels in regresssion. It is hoped that further studies now in progress on pituitary and brain hormones will elucidate the hormonal control of the seasonal regression.

Continuing observations on female squirrels lend further support to the view that the male squirrel acts as a sexual trigger to oestrus in the female. In spring 1981 a female squirrel housed in a forest enclosure without males showed a vaginal smear of a pro-oestrus type. Pro-oestrus was maintained for three weeks before the squirrel returned to anoestrus without showing an oestrus type smear. A vasectomised male squirrel has been introduced to this enclosure (April 1981). Further observations on the female should determine whether oestrus and ovulation are thereby induced.

Studies on the effects of an anti-androgen on male squirrels have continued with the collaboration of the Forestry Commission (Wildlife Management Branch) since December 1980, when Dr Tait resigned his Fellowship with the Forestry Commission to take up a permanent appointment elsewhere.

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FOREST RODENT POPULATIONS

By JOHN GURNELL

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Studies on the dynamics and habitat distribution of forest rodents at Alice Holt Forest continue (Gurnell, 1980). In the main oak wood study area, wood mice and bank voles exhibited typical changes in numbers during the year. Numbers declined in the spring to a low level in early summer. This was followed by a gradual increase until early autumn. Detailed studies showed that the acorn crop was very poor in the autumn of 1980, as it was in 1979. In consequence, mice and voles stopped breeding early in the year and numbers reached their highest level in October. The combined density of mice and voles at that time was 60 animals/hectare and this fell to 30 animals/hectare by the start of the following breeding season in March 1981. Work being carried out by a University of London post-graduate student, Miss I. C. Knee, on movement patterns within and in and out of the study wood has showed that mice tended to range further than voles and some adult male mice regularly moved throughout the entire study area of some 9 ha. Such large-scale movement was not necessarily connected with reproduction, and if the male mice were foraging for food it is interesting to speculate why female mice and voles were not doing the same. In addition, numbers, body weights and survival of mice and voles living in habitats adjacent to the oak wood appeared to be higher than those animals living within the wood.

Further evidence on the relationship between mast crop and breeding came from trapping studies on grey squirrels. The seed crop failed in 1979, squirrels did not breed in the spring of 1980 and the normal summer period of litter production extended into September and October. In contrast to the previous year, squirrels bred in the spring of 1981 which indicates that, although the acorn crop was poor, there must have been sufficient alternative food supplies. No clear-cut patterns in trap-revealed movement of squirrels have so far been obtained.

Laboratory studies by Miss I. C. Knee have shown that there is a considerable amount of individual variation in food consumption and energy requirements of mice and voles. Data on the effects of body weight, pregnancy and lactation on food consumption have been gathered, and future work will concentrate on the effects of group size, daylength and temperature. Similar work with wild-caught squirrels in large, specially designed metabolic cages has been hampered by problems associated with stress in the animals which was particularly noticeable after handling and weighing. This resulted in a marked reduction in body weight and food consumption which tended to last for several days. These problems have now been overcome by using hand-reared squirrels which do not appear to be affected by disturbance during the feeding trials.

Studies by D. J. Lord (F.C./N.E.R.C. CASE student) on the ecological genetics of wood mice, bank voles and grey squirrels living in the oak wood are progressing (Gurnell, 1980). A preliminary analysis of the data obtained shows that wide fluctuations in gene frequency at particular loci occur over short periods of time. This is especially seen in mice and voles which exhibit high population turnover rates. The reasons for these changes are being studied by considering the interrelationships between genotype, individual life history, population and environmental factors. For example, there is good evidence to show that wood mice which disperse from the population are not genetically the same as the resident mice in the population. Marked gene frequency changes over autumn and winter have also been observed at one locus in the grey squirrel and may result from either differential survival or dispersal between genotypes. Finally, both wood mice and bank voles have shown similar gene frequency changes at Dipeptidase loci during the breeding season.

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SOCIAL ORGANISATION AND ECOLOGY OF SIKA DEER

By R. J. PUTMAN and J. C. E. MANN

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This three-year study is now well into its second year. Fieldwork in the main area of study (the New Forest) continues, while in addition, comparative work has now also been started at Wareham and at Purbeck, in Dorset.

The field work completed last year in the New Forest has yielded data on patterns of habitat use by the deer from static watches and walked transects. Analysis of this material is in progress. This information is complemented by additional data on habitat use derived from measures of faecal accumulation. This year's work in all areas is based upon driven transects, with areas surveyed by car over several 24 hourly periods each month. The aim of these additional observations is to clarify patterns of habitat use – both diurnal and seasonal – and to compare the possible differences between the two different regions (the Doreset forests are predominantly coniferous while the New Forest is mainly deciduous). It is hoped to pinpoint other differences of behaviour and social organisation between the areas and perhaps to relate these too, to the habitat.

The collection of culled animals samples has gone very well and microscopic analysis of three winters-worth of New Forest rumina has been completed for dietary composition. Three sets of samples are also available from Wareham and analysis of these is in progress at the time of writing. Further sets of samples have been and are being collected in five forests in Scotland with the kind cooperation of the rangers. Lower jaws have been taken from each animal shot and teeth are being sectioned so that dietary differences may be related to age and sex.

Reproductive status may also be related to age, while the age structure revealed in cull samples will also assist in determining age and sex structure of the parent populations.

It is hoped that one further season's cull data will be available during the current year. Fieldwork, as noted, has been extended for comparison of patterns of habitat use and social organisation (group sizes and composition) between the New Forest, Wareham and Purbeck.

Although only preliminary analyses have been carried out so far on data from last year, results from field observations indicate a distinct diurnal feeding pattern (the traditional dawn and dusk peaks) and in addition a definite change in habitat preferences between seasons. These emerge consistently from all sampling methods and can probably be explained in terms of the differing availability of food and shelter. Analysis of the New Forest rumen samples has revealed a distinct change in dietary composition throughout the winter with acorns (subject to availability) being the main component in October and November, and the preference shifting to pine needles and bark by the end of January. The area has been subjected to extensive forestry operations and although this will undoubtedly have affected the animals, in 1979–1980 when the acorn crop was almost non-existent the deer were feeding on the needles and other browsed material earlier than in either the preceeding or subsequent year.

This work is supported by the award of an SRC/CASE studentship (Forestry Commission/Southampton University) to this project.

INDIVIDUAL QUALITY AND DISPERSAL IN THE GREY SQUIRREL

By B. A. C. Don

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It was suggested (Don, 1980) that dispersal of grey squirrels is a key process in the understanding of habitat utilisation during the summer months, and quantitative and qualitative aspects of dispersal may be of great importance in the development of more realistic squirrel management techniques. In view of this, further information has been collected to answer such questions as whether dispersal is density dependent, and what sort of individuals (with respect to sex, age, reproductive condition and body condition) undertake long-distance movements in the summer. Although the former three variables are readily ascertained from live-trapping or post-mortem examination, there has never been any objective criterion for assessing body condition in this species.

Body Condition Manipulation Experiment

In order to investigate the effects of the plane of nutrition upon a range of body condition indices, a laboratory experiment was set up with a total of 44 individually caged adult squirrels of both sexes. Half of these animals were fed on an *ad lib* diet, and half on a restricted diet. Animals were sacrificed at 7, 14, 21 and 28

days after the treatment began. Condition indices were evaluated by their ability to reflect consistently the changes in nutritional level of the animal. As a result of this work certain indices (e.g. percentage femur marrow fat) were rejected due to their insensitivity, whilst others (e.g. whole body fat extract) took too long to assess to be of general use. Surprisingly, simple subjective estimates such as percentage kidney fat cover gave encouraging results, and these are now being applied to wild-caught animals. Other simple indices, such as body weight: length index ratios, are well correlated with more rigorous indices as shown in Figure 6, for example.

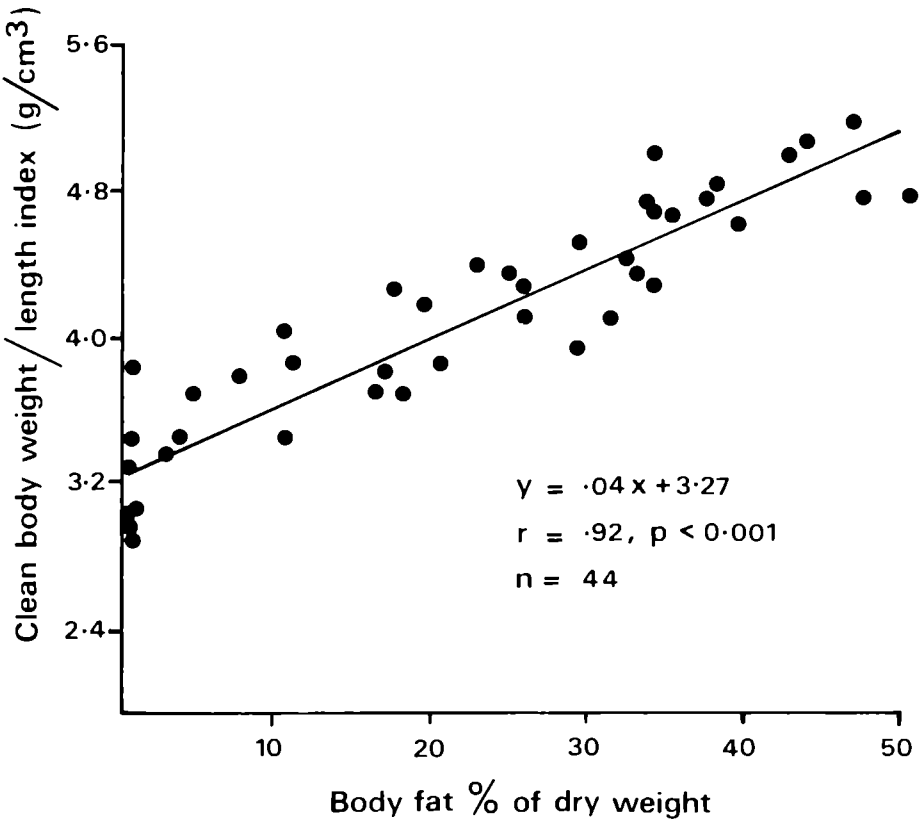

Figure 6. Relationship between ether extracted body fat percentage and clean weight:length index ratio for experimentally fed squirrels.

Disperser Quality

A detailed comparison of quality between resident and dispersing (as determined by the trap-out grid technique) individuals has been performed for data collected during summer 1980. This analysis may be summarised by stating that relative to residents the disperser class contains a greater proportion of males and younger cohorts. Within comparable age classes no significant differences in reproductive or body condition exist, whilst younger dispersers show less reproductive development but are in better body condition than older dispersers. These patterns are to be investigated further in summer 1981.

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FOREST ENTOMOLOGY

THE CONTROL OF POLYMORPHISM IN THE GREEN SPRUCE APHID, ELATOBIUM ABIETINUM

By M. FISHER

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Polymorphism

In the British Isles *Elatobium abietinum* (Walker) is usually anholocyclic, spenting most of the year as wingless (apterous) parthenogenetic viviparae on spruce. Winged (alate) *E. abietinum* appear in May and June and a few males and egg-laying females (oviparae) in autumn. The effect of nutrition, aphid density, photoperiod and temperature on the induction of alatae in spring and sexual morphs in autumn are being investigated in the laboratory.

Crowding *E. abietinum* on Sitka spruce during autumn, winter and spring for two or three generations did not, by itself, induce alatae. In spring, however, on those trees that were undergoing bud burst, alatae were produced in both isolated and crowded conditions. Crowding did not appear to be necessary for alatae production, although it possibly increased the proportion of alatae produced. Thus, the quality of the nutrition available may be critical. To test this, *E. abietinum* is being reared simultaneously on Sitka spruce trees at three different growth stages.

A few males and oviparae were collected from spruce on the campus of the University of East Anglia in the autumn of 1980. The oviparae laid eggs and thirty fundatrices (first generation aphids) hatched. A few oviparae have been produced in the laboratory at a low temperature and a short photoperiod. The possible role of growth stage of the host tree in the determination of the sexual morphs is being studied.

Needle Damage and Aphid Performance

When *E. abietinum* feeds on a spruce needle it causes the development of a characteristic chlorotic band. This gradually spreads over the whole needle which then dies and is shed. The mean relative growth rate (MRGR) achieved by *E. abietinum* over the fourth nymphal instar was found to be greater on previously infested (yellow) than on uninfested (green) Sitka spruce needles. Therefore, in its initial stages at least, the changes in leaf physiology associated with the chlorotic band improve aphid growth.

The greater MRGR and adult weight achieved on yellowing needles could be due to aphids settling more readily, or to the better quality of food available. Samples of both infested and uninfested needles are being collected for amino-acid analysis. Aphid settling behaviour is being studied as well.

TRAP TREES TO CONTROL ELM BARK BEETLES, MERSEYSIDE TRIALS 1980

By D. P. O'CALLAGHAN and C. P. FAIRHURST

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In the United States, pheromone-baited trap trees have been used with some success to control the elm bark beetle vectors of Dutch elm disease. Hopelessly diseased elms are killed with an arboricide and baited with pheromone to ensure early mass-attack by beetles. The chemical treatment induces drying of the bark and, directly or indirectly, causes beetle broods to fail. In Syracuse, New York State, the treatment has been shown to cause a significant decline in the Dutch elm disease rate (O'Callaghan *et al*, 1980).

Trials of this technique have been under way in Liverpool and Southport, Merseyside, since April 1980. The two experimental areas jointly contain about 3,000 elms, of which 1,200 were diseased or dead at the beginning of 1980. During June and July a total of 137 diseased elms were treated with the arboricide (cacodylic acid) by pressure injection and application to axe wounds. The trees wilted completely within a week and were dead in about three weeks. Almost all were attacked by *Scolytus scolytus* and some also by *S. multistriatus*. Preliminary results indicate that the brood productivity in trap trees was substantially lower than that to be found in untreated brood trees in the vicinity. The trials continue in 1981.

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SOME EFFECTS OF LATITUDE ON THE BIOLOGY AND DISTRIBUTION OF ELM BARK BEETLES, VECTORS OF DUTCH ELM DISEASE

By S. G. KIRBY and C. P. FAIRHURST

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Kirby (1980) presented some initial results on the colonisation of elm logs by *Scolytus scolytus* F. and *S. multistriatus* (Marsh). An analysis has now been completed on beetle galleries established during 1979 and 1980 in logs of English elm (*Ulmus procera* Salis) at Crediton (Devon) and Northwich (Cheshire) and of Wych elm (*U. glabra* Huds) at Edinburgh. In *S. scolytus* gallery length and the number of larval mines were positvely correlated (Figure 7) and showed a significant progressive reduction with increasing latitude (Table 2). *S. multistriatus* was not present in the Edinburgh logs and although the data shown does indicate a similar latitudinal effect the difference between sites was not significant.

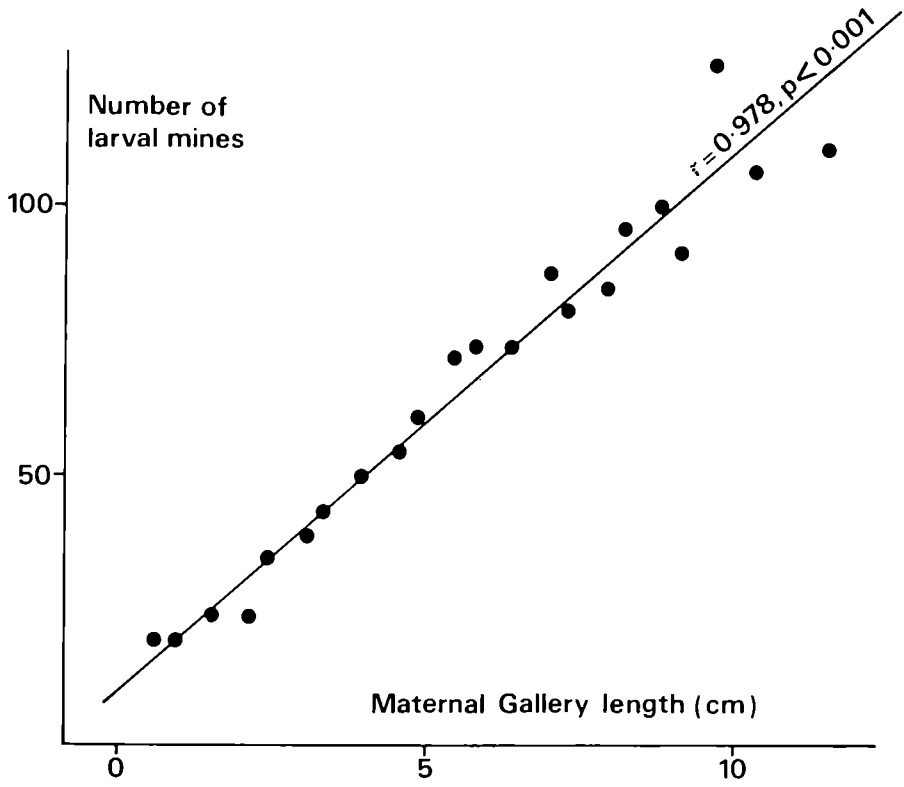

Figure 7. *Scolytus scolytus:* relationship between maternal gallery length and number of larval mines.

TABLE 2

THE EFFECT OF LATITUDE ON MATERNAL GALLERY LENGTH AND NUMBER OF LARVAL MINES

		CREDITON	NORTHWICH	EDINBURGH
S. scolytus	Length (cm)	4·72	3·03	2·07
	No of Mines	63	40·3	27·6
S. multistriatus	Length (cm)	3·43	3·17	—
	No of Mines	60·6	50·2	—

S. multistriatus has not been recorded from Scotland (Redfern, 1977) and the present study has shown it to be locally common only as far north as Merseyside. By contrast, *S. scolytus* is well established in Scotland. The retarding effect of latitude on *S. scolytus* productivity together with the effect of climate in reducing the number of generations completed each year could increase the importance of *S. multistriatus* as a vector in certain areas. There is a significant negative

relationship ($p<0.05$) between density estimates for both species in infested bolts. The spatial distribution of one species within infested elms may not, therefore, be considered in isolation.

In the south of England the majority of *S. scolytus* larvae overwinter in the bark layers with only a small number excavating cells in the outer sapwood. In the north there is an increase in the number behaving in this manner although the majority still overwinter in the bark. The factors influencing this behaviour remain obscure but its relevance to future control strategies must be considered since debarked timber presents a source of emerging beetles. *S. multistriatus* is not known to construct sapwood larval cells (Kirby and Fairhurst, 1981).

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FORESTRY AND FARMING

THE INTERACTION OF FORESTRY AND FARMING

By W. E. S. MUTCH and A. R. HUTCHISON

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The investigation was concerned with the economic interaction of forestry and farming in Scotland and the north of England. It did not consider the results of selling whole farms for afforestation, but the effect of creating a mixture of successful farming and forestry, and the development of technical collaboration between them.

The major part of the report produced (Mutch and Hutchison, 1980) comprises thirteen case studies based on visits to the farms, on farm accounts and on the annual statistical returns.

Some of the cases show the financial results of farmers themselves investing in forestry on their own land. On other farms land was sold to a forestry agency and the money realised by the sale was reinvested in the farm, so that an afforestation sale was the means to more intensive farming.

On twelve farms the interaction involved afforestation of just over a quarter of the land, a total of more than 5000 hectares out of nearly 17,000. Over the same period cattle numbers went up from 412 to 891 (+116 per cent) and weaned lambs went up from 8678 to 11,321 (+30 per cent). The number of lambs sold went up by even more because fewer ewe flock replacements were required.

Employment went up from 37 before integration (35½ in farming and 1½ full-time in forestry) to 60 afterwards (32 in farming and 28 in forestry). Few of the afforested areas are yet producing timber but they should give a sustained annual yield of about 55,000 cubic metres.

The last case study records the experience of a forest worker's holding, a highly productive small farm run by a full-time employee of the Forestry Commission, showing the possibility of intensive farm management combined with forestry work.

Many of the difficulties and the deterrents to integration of farming and forestry are illustrated as well as the advantages of shelter, plantation grazing, the provision of access roads and forestry fences.

The authors suggest that although a sale of land for afforestation may allow useful interaction between forestry and farming, by providing the financial liquidity for new farm investment, it seldom promotes real integration. Useful integration of farm and forest does not simply happen and is difficult to achieve between separate ownerships. Integration requires a clear definition of objectives and the commitment of resources to attain them. It has to be positively managed.

Several farmers were interested in forestry initially only as a market for land in order to find funds for reinvestment in farming. Nevertheless, some of them have already experienced considerable advantage in selling forest produce, thus diversifying their production from a narrow farming base. Early thinnings from high yield class stands offer an advantage to farmers who plant more fertile land than is usually available now for large-scale afforestation. Much of the advantage of forestry to farmers lies in the opportunity for planning an integrated land development scheme, with forestry fences the basis of paddock fencing and forestry roads the key to hill farm access.

REFERENCE

MUTCH, W. E. S. and HUTCHISON, A. R. (1980). *The interaction of forestry and farming*. East of Scotland College of Agriculture Economics and Management Series No. 2.

TIMBER UTILIZATION

JOINT RESEARCH PROGRAMME ON BRITISH-GROWN TIMBER

By T. HARDING

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

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

The Influence of Growth Characteristics on Grade Yield

The programme of work on the effect of silvicultural practices on wood quality and wood performance is now centred on the significance of growth characteristics – knot size, rate of growth, size of juvenile core, etc. – on the machine grade out-turn of sawnwood.

Strength Tests on Structural-Size, British-Grown Douglas Fir

This project was initiated to resolve the incompatibility between the published stress values in the Code of Practice (BSI, 1971), which were derived from small clear tests, and the structural-size test results previously reported. This incompatibility, which became evident through very low machine grading yields, could not be explained by studies of possible sampling differences, based on specific gravity. As an interim measure, amendment 5 to the Code of Practice reduced the bending grade stresses by about 19 per cent to become equivalent to imported redwood/whitewood and British-grown Scots pine.

A recent project involved testing two sizes of British-grown Douglas fir, 38 × 100 mm and 47 × 200 mm, from trees selected at random from Forestry Commission sites throughout Britain. The results of this project show that the revised bending stresses in amendment 5 are still about 10 per cent too high, although the modulus of elasticity values which were also brought into line with redwood/whitewood are consequently underrated. The analysis also determined the necessary strength/stiffness relation to enable grading machine settings to be derived and limits have been issued to a sawmiller for trial purposes.

Conversion of British-Grown Timber

Work to develop a practical computer-controlled conversion aid for British softwood sawmills has continued throughout the year. A high speed microcomputer, capable of dealing with the data arising from the prototype scanning system and capable also of optimising the subsequent conversion of the log into sawn timber, has been tried initially at a sawmill having the structural market as one of its outlets.

This trial was a data-gathering and proving exercise, and again indicated that improvements in conversion yield of approximately 5 percentage points (i.e. 8–10 per cent of the sawn timber volume) could be expected. This is in line with the figures obtained from the previous two trials.

A cant alignment aid using computer-controlled, servo-positioned laser lines has been developed and tested, and the complete system, comprising the scanning, optimising and alignment modules has been code named LOCAS (Laser Optimiser and Cant Alignment System).

A prototype system was installed in a structural sawmill in Nairn in November as a working demonstration for the benefit of the timber industry in Scotland and potential manufacturers/licensees. It is intended to hold a longer proving trial and a second demonstration at a sawmill in Wales in 1981.

Papers on this subject were presented at the Eleventh Commonwealth Forestry Conference, Trinidad, (Smithies, 1980a) and at the IUFRO Division 5 Conference, Oxford, (Smithies, 1980b).

REFERENCES

BRITISH STANDARDS INSTITUTION (1971). *The structural use of timber.* Code of Practice 112. Part 2.

SMITHIES, J. N. (1980a). *Assessing and optimising efficiency in sawn timber production.* Commonwealth Forestry Conference 1980.

SMITHIES, J. N. (1980b). *The use of laser scanners to control sawlong conversion in existing mills.* IUFRO Division 5 Conference, 1980.

APPENDIX I

Publications by Forestry Commission Staff

*Publications marked * are available from Her Majesty's Stationery Office at addresses shown on the back cover. These, together with titles marked ** and which are published by the Forestry Commission, are available also from the Publications Officer at the address on p. 98*

*AARON, J. R. (1980). *The production of wood charcoal in Great Britain.* Forestry Commission Forest Record 121.

An up-dating of an earlier Forest Record 19, *The Manufacture of Wood Charcoal in Great Britain* – Reynolds, L. 1953. It covers the current uses, methods of production, by-products, geographical distribution of manufacturers, specifications for raw material, and statistics of recent production together with trends and prospects.

[CAMPBELL, D. A. and] AARON, J. R. (1980). New markets for poplar. *Forestry and British Timber* **9** (6), 24–25.

The Report of an *ad hoc* panel set up by the Technical Sub-Committee of the Home Grown Timber Advisory Committee following the loss of the match splint and veneer package markets for poplar logs. It records the geographical distribution of poplar plantations, outlines the wood properties, and reviews possible alternative markets. It concludes that as a result of the growth in the demand for vegetable crates and pallet boards, the loss of the market for peeler logs for the above industries has been less disastrous than was at first feared.

ALDHOUS, J. R. (1980). Tendances actuelles dans les pepinieres forestières de Grande-Bretagne. *Bulletin de la vulgarisation forestière* **80** (1), 3–9.

A summary of current British practice and scale of use of planting stock. In the more traditional nurseries attention must be paid to good nutrition, control of weeds, seed treatment, plant handling and storage. Plants raised in polythene greenhouses offer advantages in particular conditions. Broadleaves in particular are responding to growth in greenhouse conditions.

ATTERSON, J. (1980). The challenge for research – establishment. In *Research Strategy for Silviculture,* ed. Malcolm, D. C. Edinburgh, Institute of Foresters, 44–49.

Silvicultural systems which will produce the highest yield of the type of timber required by managers in the future and using the least energy-intensive methods of establishment should be sought. As the future is uncertain, a manager cannot risk having all his eggs in one basket and as circumstances change, advice should be available to allow him to alter his systems.

Within the fields covered, research on species, including provenances and species mixtures, would appear to be the one requiring most work in the near future, coupled with establishment operations which influence stability such as cultivation and spacing.

ATTERSON, J. (1980). Gambling with gales. Paper presented to the Forestry Section of the *British Association for the Advancement of Science Annual Meeting,* September 1980. 10 pp.

Britain is the windiest country on earth where forests are grown commercially. Catastrophic destruction is caused by winds of storm force and above which periodically hit these islands, but such damage probably only accounts for a loss of *potential* production from British forests of less than 1 per cent. Lesser gales occur much more frequently and cause endemic windthrow which possibly results in a 10 per cent reduction in potential volume production.

Foresters can do little about catastrophic damage but they can lessen the effect of the more frequent winds of gale force by deep cultivation of shallow soils and by not thinning forests in areas of high wind risk. Forests can be divided into windthrow hazard zones within which silviculture can be modified to minimise and delay gale damage.

BIGGIN, P. (1980). Weed control in conifer transplant lines. In *Proceedings of the Conference on Weed Control in Forestry, Nottingham University,* Association of Applied Biologists, 175–181.

Weed problems in conifer transplant lines are discussed. Experiments set up to study control of persistent weeds such as *Equisetum arvense* and *Rumex acetosella* are described. If applied correctly the herbicides, simazine, diphenamid, nitrofen, propyzamide, MCPA and glyphosate all have a place in the control of weeds in conifer transplant lines.

[TAIT, F.,] BIGGIN, P. and McCAVISH, W. J. (1980). A review of trials with diphenamid in forest nurseries in Great Britain. In *Proceedings of the Conference on Weed Control in Forestry, Nottingham University,* Association of Applied Biologists, 159–166.

Trials and practice since 1971 have shown that diphenamid is well tolerated in the seedbed stage by the conifers and some of the broadleaved species grown commercially in British forest nurseries. It is particularly safe for use in Sitka spruce and Lodgepole pine. Pre- or post-emergence application can be used with the former giving the best weed control. Diphenamid can reduce by 75 per cent the time spent hand weeding. Repeat doses to prolong weed control can be made if needed in the season. Diphenamid is also an alternative herbicide for use in transplant lines where simazine susceptible cultivars are being grown.

[THOMPSON, S. and] BIGGIN, P. (1980). The use of clear polythene cloches to improve the growth of one-year-old Lodgepole pine seedlings. *Forestry* **53** (1), 51–63.

Nursery seedbeds, sown with Lodgepole pine, were covered with clear polythene cloches, with or without the edges buried, from the date of sowing for 0, 8, 16 and 21 weeks. Germination rate and numbers of seedlings germinating were increased by all the cloche treatments. Deaths of seedlings under cloches with unsealed edges were greater than for the cloche treatments with completely buried edges. Due to increases in both stem unit number and stem unit length, the cloche treatments increased height growth in proportion with duration of cloche cover. Production of clothed seedlings suitable for lining-out or forest planting is discussed.

BIGGIN, P. (1981). Forest weeding – choosing a herbicide. In *Proceedings. Crop Protection in Northern Britain* 17–19 Warch 1981. Dundee, Scottish Crop Research Institute, 243–248.

Weeding can sometimes be avoided by management practices, such as ploughing, fencing to prevent browsing damage, or any technique which encourages or permits newly planted trees to grow quickly. On upland sites the need to weed must be carefully assessed. Survival of the trees should be the main objective as improved growth as a result of herbicide applications is difficult to predict or quantify. Where weeding is unavoidable, a manager can choose between hand, mechanical or chemical methods. All herbicides have an optimum time for application which is a major factor determining choice.

BILLANY, D. J. and BROWN, R. M. (1980). The web-spinning larch sawfly, *Cephalcia lariciphila* Wachtl. (Hymenoptera – Pemphiliidae). A new pest of *Larix* in England and Wales. *Forestry* **53** (1), 71–80.

The first reported outbreak of *Cephalcia lariciphila* in Britain occurred at Margam forest, West and Mid-Glamorgan, in 1972 on *Larix kaempferi*. Twenty-two forests subsequently became affected in England and Wales between 1972 and 1978.

Reduced host vigour was noticed in 1977 in areas defoliated for five successive years and deaths in 1978 necessitated sanitation felling.

A decline of damage at Margam and Rheola forests is ascribed to the parasite *Olesicampe monticola* but widespread collapse of the infestation has not so far occurred.

Immediate aims are the biological control of the sawfly by naturally occurring parasites and pathogens. Longer term investigations into control involve the location, isolation and synthesis of pheromones.

BINNS, W. O. (1980). The challenge for research – nutrition. In *Research Strategy for Silviculture,* ed. Malcolm, D. C. Edinburgh, Institute of Foresters, 50–57.

The three pillars of nutritional research are: an understanding of the law of limiting factors, treatments which perturb the system, and sound experimental design. The main problems are nutrition at the pole stage and nutritional aspects of regeneration. Mycorrhizal research is only likely to produce useful returns on former industrial sites. Effects of forest fertilizing on water quality need study. The implications of the very fast early growth which follows the removal of site limitations have not yet been seriously considered. Nitrogen supply and cycling are again being studied, including the use of nitrogen-fixing trees and other plants.

*BINNS, W. O. (1980). *Trees and water.* DOE/FC Arboricultural Leaflet 6.

Describes the water cycle and the infiltration of water into the soil, soil water availability, uptake and evaporation by plants, and stresses the importance of interception of rainfall by trees. Water use by forests and individual trees is discussed together with rooting habits. Advice is given on the water needs and treatment of newly planted trees, together with comments on trees in relation to buildings.

*BINNS, W. O., MAYHEAD, G. J. and MACKENZIE, J. M. (1980). *Nutrient deficiencies in conifers in British forests. An illustrated guide.* Forestry Commission Leaflet 76.

Symptoms of nitrogen, phosphorus and potassium deficiency in forest stands up to 5 m tall are described and illustrated for Sitka spruce, Scots pine and Lodgepole pine. Less complete coverage is given for Norway spruce, Corsican pine, Douglas fir, Western hemlock and larches, as well as for the rare deficiencies of magnesium and copper. Concentrations of nutrients in the foliage associated with deficiency are given for the different species, and the site types where deficiencies in spruce and pine are most likely are tabulated.

Deficiency symptoms, used in conjunction with foliar analysis and site-types, form a practical basis for prescribing fertilizer treatment; they should not, however, be used on their own without considerable local experience.

BINNS, W. O. (1981). Forestry and fishing. *Forestry and British Timber* **10** (1), 31.

Forests appear in some circumstances to have adverse effects on water quality and thus on stream life, including the fish. The reasons are not entirely clear, though shading, debris from needle fall and from harvesting operations, together with erosion from drains, are probably involved, while organic acids from drained peats may lower the pH. While good management can help, particularly in relation to drainage, new research now in progress should eventually lead to a better understanding of this important part of the forest environment.

**BINNS, W. O. and FOURT, D. F. (1981). Surface workings and trees. In *Research for Practical Arboriculture*, Forestry Commission Occasional Paper 10, 60–75.

Restoration for forestry requires careful planning in which foresters must be involved. Restored spoils of all textures are almost always compacted. Thirty-metre wide ridges with slopes of 1:10 to 1:15 both shed water and allow it to move in the spoil. The ridge should slope length-ways and drains may be needed in the gullies on heavier spoils. Compaction can be relieved by deep cultivation across the ridges with a 300 horsepower tracked tractor and mounted triple tines, preferably winged. Where there is insufficient material to raise the restored ground above the water table, carefully sited lakes may help and also form useful habitats for wildlife. On poor sites alders or *Robinia* should form 50 per cent of the crop, with pine as the commercial species at low elevations. Climax species such as oak, beech, hemlock and spruce should be avoided.

BLATCHFORD, O. N. (1980). *Your book of forestry*. London: Faber. 57 pp.

A brief, comprehensive introduction to the work of the forester in Great Britain written for 11–14 year olds.

BRADLEY, R. T. (1980). Forest management for an uncertain future. Paper presented to the Forestry Section of the *British Association for the Advancement of Science Annual Meeting*, September 1980. 10 pp.

The paper reviews the ways in which the various forestry operations can be carried out to leave opportunities for adapting to future changes in policies and attitudes which are difficult to predict. Increasing interest in landscape, wildlife and botanical conservation suggests that this may be one of the changes that foresters may have to adapt to in the future to an increasing extent. However, the author is confident that this is well within the scope of good forest management if practised with regard to the possible need for changes of this sort.

BRADLEY, R. T. (1980). A review of current silvicultural practice in the Forestry Commission. In *Research Strategy for Silviculture*, ed. Malcolm, D. C. Edinburgh, Institute of Foresters, 1–4.

The individual silvicultural operations and associated activities such as site survey and nursery management are reviewed and changes and developments noted. In conclusion there are references to underlying factors such as the hidden costs of employing men with new attitudes to health and safety, transport to work, sickness benefits and wet weather work together with the escalating costs of mechanisation, the limitations on the use of chemicals and the need to take account of conservation interests. The challenge for the manager is in adapting to these new developments.

BURDEKIN, D. A. (1980). Trees at risk – a balanced view of tree diseases. *Quarterly Journal of Forestry* **74** (3), 177–179.

A discussion paper on the significance of newly introduced pathogens and their control, with an indication of the most important principles to be considered when assessing the importance of tree diseases and their control.

BURDEKIN, D. A. (1980). Tree health insurance policies. Paper presented to Forestry Section of the *British Association for the Advancement of Science Annual Meeting*, September 1980. 5 pp.

The recent epidemic of Dutch elm disease has emphasized the need to examine the possible risks from other tree diseases and to consider what preventative measures should be taken to forestall such outbreaks.

Many serious outbreaks of tree diseases have followed the introduction of pathogens from one continent to another. Potentially dangerous alien pests and diseases should be recognized and guarded against. However, it must be remembered that relatively minor pathogens in one region can cause major problems when moved to a more favourable environment. Native diseases should not be forgotten – there are a number which are a matter of serious concern.

**BURDEKIN, D. A. (1981). Decay – some management considerations. In *Research for Practical Arboriculture*, Forestry Commission Occasional Paper 10, 16–22.

Every tree owner is under a duty to inspect his trees to assess their safety and he may be judged negligent and liable for damages if a decayed tree falls and causes injury or damage. A number of the principles which need to be considered in the organization of tree inspections are discussed, with particular reference to decay. A series of examples of visible indicators of decay are described.

**BURDEKIN, D. A. (1981). Susceptibility of London plane clones to anthracnose. In *Research for Practical Arboriculture*, Forestry Commission Occasional Paper 10, 119–124.

The hybrid origin and characteristic features of London plane are described. The symptoms of anthracnose are separated into four distinct forms of damage: bud, twig, shoot and leaf blight. The initial results from research studies in the United States and Britain indicate there is marked variation in susceptibility of London plane trees to the disease.

COUTTS, M. P. (1980). Control of water loss by actively growing Sitka spruce seedlings after transplanting. *Journal of Experimental Botany* **31** (125), 1587–1597.

The roots of actively growing Sitka spruce seedlings were damaged to different degrees by transplanting treatments carried out in a growthroom. The treatments stopped root extension and after 2–4 h the transpiration rate of treated plants declined, indicating closure of the stomata, and transpiration continued to decrease for a few days. The hydraulic conductivity of the root system was reduced slightly by the treatment but leaf water potential increased or remained unchanged, therefore no water stress occurred to account for closure of the stomata. It is suggested that the transpiration rate was reduced as a result of a chemical stimulus originating in the root and acting on the stomata.

CROWTHER, R. E. (1980). Lowland broadleaved woodlands and silvicultural research. In *Research Strategy for Silviculture*, ed. Malcolm, D. C. Edinburgh, Institute of Foresters, 68–73.

Recent research work on broadleaved woodland is described. The revival of coppice, the prospects for improvement by tree selection and the trend towards wider spacing and individual tree protection are covered.

CROWTHER, R. E. (1980). Wood for the woodburning stove. *Forestry and British Timber* **9** (10), 25–26.

The amount of wood needed for domestic heating by a modern wood burning stove is evaluated and related to the potential yield from traditional coppice.

DAVIES, E. J. M. (1979). *Douglas of the Forests*. Edinburgh: Paul Harris Publishing, 191 pp.

A re-editing of the Journals of the great Scottish plant collector, David Douglas (1799–1834). Illustrated with photographs and maps and supported by appendices dealing with the plant collector's letters, biographical notes of his friends and acquaintances, and an up-to-date list of his 200-odd introductions. Also published in the United States by the University of Washington.

DAVIES, E. J. M. (1980). Useless. The case against *contorta*. *Scottish Forestry* **34** (2), 110–113.

A controversial account of the folly of the large coastal Lodgepole pine plantings that have taken place in Scotland in the post-war years. The author considers that succeeding foresters will have some very serious problems with which to contend owing to the species' liability to insect attack, snow damage, red deer damage, and its inherently poor stem form, etc.

DAVIES, E. J. M. (1981). Return of the pine marten. *Country Life* **169** (4357), 464–465.

A review of the gradual disappearance of the Pine marten and slow recolonisation of the Highlands of Scotland following afforestation.

A detailed account of the attempts made to reintroduce it to the Galloway Forest Park in 1980, an area from which it had been absent for about a century. The animals appeared to suffer little stress during their move.

EDWARDS, P. N. (1980). Inventory methods in Great Britain. *Mitteilungen der Forstlichen Bundes-versuchsanstalt Wien* 130, 63–66.

The paper briefly outlines the inventory methods used in Great Britain by the Forestry Commission and the reasons for using these methods. The uses of the inventory data are discussed, and some possible improvements are mentioned.

EDWARDS, P. N. (1980). Does pre-commercial thinning have a place in plantation forestry in Britain? *Schriften aus der forstlichen Fakultat der Universität Gottingen und der Niedersächsischen Forstlichen Versuchsanstalt* 67, 214–223.

Pre-commercial thinning, or respacing, is common forestry practice in many parts of the world. It is often necessary in Britain in naturally regenerated stands. In planted stands, the advantages of respacing include easier establishment, and the opportunity to remove poor quality trees. The disadvantages include the increased cost of establishment and the cost of the respacing. It is difficult to predict the effect of respacing on timber quality.

The paper concludes that there is no evidence that close spacing followed by respacing is worthwhile in Britain, but that further research is required.

EVANS, J. (1980). Preliminary data on foliar nutrient levels in Klinkii pine *(Araucaria hunsteinii)*. *Malaysian Forester* **43** (2), 212–218.

Evidence of variation in foliar nutrient levels within the crown and between canopy classes of *Araucaria hunsteinii* is presented. It is recommended that only dominant trees should be sampled, and that samples be taken from about a third whorl below the leading shoot. Foliar analysis identified a case of nitrogen deficiency, and it is tentatively suggested that the critical foliar level for N is 1·2–1·3 per cent oven-dry weight.

EVANS, J. (1980). Footpaths and forestry in the Zurich Oberland. *Quarterly Journal of Forestry* **74** (3), 152–157.

Long-distance forest paths in Switzerland give the walker a chance to enjoy the beauty of the uneven-aged coniferous forests so typical of that country.

EVANS, J. (1980). Prospects for Eucalyptus as forest trees in Great Britain. *Forestry* **53** (2), 129–143.

In Britain, eucalypts are mainly of ornamental interest because of a reputation for poor cold tolerance. Examination of trials plots and single trees indicates that some species can survive British winters without serious damage, notably *E. archeri, E. niphophila* and higher altitude seed origins of *E. coccifera, E. debeuzevillei, E. glaucescens* and *E. gunnii*. All non-shrub species show fast growth.

The evidence of adequate cold tolerance and fast growth suggests that some eucalypts may have a role in British forestry. A small research programme is being undertaken to evaluate eucalypts on a range of sites and to identify cold tolerant seed origins.

FAULKNER, R. (1980). Better trees for better forests. *Lloyd's List* **51** (542), 16.

A brief review of current tree breeding work in Britain.

FLETCHER, A. M. [and BARNER, H.] (1980). The procurement of seed for provenance research with particular reference to collections in N. W. America. In *Proceedings of the IUFRO Joint Meeting of Working Parties, Vancouver, Canada, 1978*. **1,** 141–154.

Reasons for the establishment of the IUFRO programme for provenance seed collections are given, together with the main objectives. Collections started in 1966 and samples of *Pseudotsuga menziesii, Pinus contorta, Picea sitchensis* and *Abies grandis* have been collected; a total of 767 kg of seed from 493 sources. The background to the sampling method is discussed. The areas were selected after a detailed preliminary survey and only natural stands typical of the general area were used whenever possible. Collection areas were divided into – commercially collectable areas; collectable areas; and scientific interest areas. At each collection site a range of phenotypes were sampled to provide 15 to 20 trees.

[TOMPSETT, P. B.,] FLETCHER, A. M. [and ARNOLD, G. M.] (1980). Promotion of cone and seed production on Sitka spruce by gibberellin application. *Annals of Applied Biology* **94**, 421–429.

Gibberellin mixtures were applied to large, mature scions of Sitka spruce. Large increases in coning and seed production and in number of clones producing seed, occurred in the year after treatment. Cone and seed yields varied with the timing and concentration of hormone treatment and were greatest when applications were made in the top two branch whorls on the tree. Clonal differences in seed production were observed among gibberellin-treated branches. Seed quality, judged by seed weight and percentage germination, appeared normal. Promotion of male strobili was greater in low branch whorls than in the top branch whorl on the tree.

FORESTRY COMMISSION/HOME GROWN TIMBER ADVISORY COMMITTEE (1980). Technical Note 27. Felling cushion. *Forestry and British Timber* **9** (4), 23.

FORESTRY COMMISSION/HOME GROWN TIMBER ADVISORY COMMITTEE (1980). Technical Note 28. The mini Bruunett 578F forwarder. *Forestry and British Timber* **9** (8), 21.

FORESTRY COMMISSION/HOME GROWN TIMBER ADVISORY COMMITTEE (1980). Technical Note 29. Dondi DBR 75/32/540 rotary ditcher. *Forestry and British Timber* **9** (9), 45–46.

FORESTRY COMMISSION/HOME GROWN TIMBER ADVISORY COMMITTEE (1980). Technical Note 30. Volvo BM 4300 Front end loader. *Forestry and British Timber* **9** (10), 29–30.

FORESTRY COMMISSION/HOME GROWN TIMBER ADVISORY COMMITTEE (1980/81). Technical Note 31. The roadless logmaster skidder. *Forestry and British Timber* **9** (12), 33–34.

FORREST, G. I. (1980). Genotypic variation among native Scots pine populations in Scotland based on monoterpene analysis. *Forestry* **53** (2), 101–128.

The monoterpene composition of the shoot cortical resin of native Scots pines from 41 Scottish sites was determined. Variation between sites enabled the natural range to be divided into several areas, the most distinct being a north-western region with Shieldaig the most distinctive site. Other areas included a northern group, a south-western group centred on the Great Glen, a central north-south region, central Speyside, and outer Speyside with eastern Deeside. Relationships between sites can be used as a guide in planning replanting programmes.

FORREST, G. I. (1980). Geographical variation in the monoterpenes of *Pinus contorta* oleoresin. *Biochemical Systematics and Ecology* **8**, 343–359.

The monoterpene composition of the shoot cortical oleoresin allowed the natural range of Lodgepole pine to be divided into chemically distinct regions. The trees examined were grown in Britain from seed collected from 150 localities in north-west America. Populations from the central area of the natural range contained a wide variety of monoterpene pattern-types, while peripheral populations were more exclusively characterised by their own specific pattern-types. Evidence for introgression with Jack pine was detected in central British Columbia populations. Analysis of 25 trees is usually sufficient to determine the origin of an unknown population.

FORREST, G. I. (1980). Variation in monoterpene composition of the shoot cortical oleoresin within and between trees of *Pinus contorta*. *Biochemical Systematics and Ecology* **8**, 337–341.

Ten young Lodgepole pine trees were studied for variation in monoterpene composition of the shoot cortical oleoresin due to position within the crown. There was no significant difference between whorls, but small differences occurred between the lateral and terminal shoots of branches. The nature of the differences varied between trees; 3-carene showed the most consistent positional difference.

FORREST, G. I. (1980). Seasonal and spatial variation in cortical monoterpene composition of Sitka spruce oleoresin. *Canadian Journal of Forest Research* **10** (4), 452–457.

Cortical oleoresin composition was studied in young Sitka spruce trees selected to provide a wide range of chemical types. Main stem and branch shoot apex resin systems differed from each other, but for each system the variation within trees was significant only in basal and apical regions. Seasonal changes in composition of main stem resin were insignificant. Young shoots immediately after flushing showed monoterpene compositions different from those of the previous year's mature shoots, and gradually reached the mature compositions during summer and early autumn. The nature of some of the differences, notably that of α-pinene, varied between trees.

FORREST, G. I. (1980). Geographic variation in the monoterpene composition of Sitka spruce cortical oleoresin. *Canadian Journal of Forest Research* **10** (4), 458–463.

Cortical oleoresin monoterpenes were studied in stems and in branch apical shoots of eight Sitka spruce origins; the compositions showed high variation within origins. The Vancouver Island origin was the most distinct. There was a cline in several monoterpene characters, notably a decrease in β-phellandrene and an increase in 3-carene, both by itself and also accompanied by limonene, from Alaska to north Washington, but the Washington and Oregon origins showed no geographic trends. The results are discussed in the context of the postglacial history of the species.

GIBBS, J. N. (1980). Dutch elm disease and the wicker basket theory. *Phytopathology* **70** (8), 699.

An evaluation of the hypothesis that Dutch elm disease might have been introduced to Europe by Chinese labourers recruited to dig trenches during the First World War.

GIBBS, J. N. (1980). Survival of *Ceratocystis fagacearum* in branches of trees killed by oak wilt in Minnesota. *European Journal of Forest Pathology* **10**, 218–224.

The survival of *Ceratocystis fagacearum* in the branches of *Quercus ellipsoidalis* killed by oak wilt in Minnesota depends on the time of year when the trees die. In trees which wilt in May or June the pathogen can be isolated from the xylem for only 1–2 months. In trees which die later in the summer it may persist through to the following spring. Observations on oak bark beetles (*Pseudopityophthorus* spp.) breeding in the dead trees do not suggest that these beetles are important vectors of the disease in Minnesota.

GIBBS, J. N. [and FRENCH, D. W.] (1980). *The transmission of oak wilt*. USDA Forest Service Research Paper NC-185.

Provides an up-to-date review of factors affecting the transmission of oak wilt, *Ceratocystis fagacearum*. Discusses the history and severity of the disease, the saprophytic existence of the fungus in the dying tree, seasonal suceptibility of trees to infection, overland and underground spread, the role of animals and insects as vectors or tree wounders, and the distribution of the disease.

**GRANFIELD, E. F., MACMAHON, C. D. and MITHEN, D. A. (1980). *Developments in forest road planning*. Forestry Commission Research and Development Paper 127.

The paper emphasises the developments which have taken place both in the mechanisation of harvesting in Commission forests, enabling forest roads to be more widely spaced, and in road construction and maintenance whose standards have been increased because of the sustained usage of larger lorries.

Dealt with too is the need, in planning, to prepare a terrain classification followed by the selection of an appropriate harvesting system and allowing for factors such as crop characteristics, market requirements and so on. The economic road spacing can then be calculated, the optimum occurring when the extraction movement costs equal total road costs.

GRAYSON, A. J. (1980/81). Commonwealth Foresters' Conference. *Forestry and British Timber* **9** (12), 41–42.

This report on the 11th Commonwealth Forestry Conference held during September 1980 in Trinidad and Tobago includes nine highlights prepared by the Director-General of the Forestry Commission. These points emphasise problems of forestry in the developing countries of the Commonwealth and proposed solutions to them. Among particular issues identified are the critical importance of fuelwood, the value of co-operative efforts in using agro-forestry techniques, concern over the rapid depletion of tropical forests, the desirability of improved pricing practices in marketing of roundwood and the justification of increased funding for reforestation.

GREIG, B. J. W. (1980). Chemical, biological and silvicultural control of *Fomes annosus*. In *Proceedings of the 5th International Conference on Problems of Root and Butt Rot in Conifers, Kassel 1978*. IUFRO Working Party S2.06.01. 75–84.

Control measures against *F. annosus* fall broadly into two categories, the first of which aim to prevent its entry and the second of which seeks to evade its effects. Under the first category methods of preventing the pathogen entering a previously uninfected crop include stump protection by chemical or biological means and stump removal to eliminate infection sources. Evasive actions include use of resistant species, mixtures, avoidance of thinning, short rotations, wide spacing and utilisation of infected produce.

*HAMILTON, G. J. (1980). *Line thinning*. Forestry Commission Leaflet 77.

This publication provides information on the various effects of line thinning and offers some guidance on appropriate methods of working. Aspects which are covered are the effects of line thinning on growth and yield, crop stability, risks of damage to site and crop, and harvesting. The economic implications of these features are discussed.

HOLMES, G. D. (1980). The ecology of even-aged plantations. An introduction to forestry in upland Britain. *Quarterly Journal of Forestry* **74** (2), 73–81.

The paper discusses the structure and distribution of the upland forests of Britain and the prospects for expansion in future. It also considers the ecological changes that result from afforestation and how the needs of efficient timber production can be reconciled with the conservation of nature and environmental values.

HOLMES, G. D. (1980). Weed control in forestry – achievements and prospects in Britain. In *Proceedings of the Conference on Weed Control in Forestry, Nottingham University*, Association of Applied Biologists, 1–11.

This is a general review paper presented as the opening address at a two-day conference on Weed Control in Forestry, organised by the Association of Applied Biologists and the Institute of Foresters of Great Britain in April 1980. It outlines the nature of the weed problem in forestry, the extent and cost of weeding operations and also suggests priorities for improving the safety and effectiveness of chemical and mechanical weeding by research and improved training and communications.

HUGHES, A. J. G. (1980). Mechanised tree harvesting. In *Wood Processing and Mechanical Handling*, Supplement to *Timber Trades Journal* 27 September 1980, 3–4.

A general survey of mechanised harvesting equipment working currently.

HUGHES, A. J. G. (1980/81). The harvesting scene today. *Forestry and British Timber* **9** (12), 13–15.

A general survey of mechanised harvesting equipment working currently.

INSLEY, H. (1980). Wasting trees – the effects of handling and post planting maintenance on the survival and growth of amenity trees. *Arboricultural Journal* **4**, 65–73.

The effects of morphological and physiological characteristics on the survival and early growth of broadleaved planting stock are reviewed by reference to Forestry Commission and other work. Sampling of plant deliveries made to Forestry Commission motorway foresters in 1977/78 indicated that up to 10 per cent of the trees were so dried out on receipt from the nurseries that they would have been unlikely to survive when planted. The response by broadleaved trees to weed control, especially on difficult man-made sites, is also examined.

INSLEY, H. and BOSWELL, R. C. (1980). The enhancement of the chemical defoliation of amenity tree nursery stock, *Betula pendula* Roth., *Alnus incana* (L) Moench, *Carpinus betulus* L. and *Platanus* × *hispanica* Muench, by ethephon pretreatment. *Journal of Horticultural Science* **55** (2), 119–125.

Varying concentrations of five chemicals (RH 2915, Ethrel R, DEF, potassium iodide and ammonium sulphate) were applied, with and without a pretreatment spraying of a 0·5 per cent solubized solution of ethephon, to broadleaved transplants. All these chemicals caused defoliation compared with a control of water plus a wetting agent. In all cases, except with a 0·8 per cent solution of potassium iodide on *Alnus incana*, ethephon pretreatment increased the effectiveness of the defoliant chemical. There was a wide variation in response between species. *Platanus* × *hispanica* proving the most difficult and *Carpinus betulus* the easiest to defoliate.

INSLEY, H. [and BUCKLEY, G. P.] (1980). Some aspects of weed control for amenity trees on man-made sites. In *Proceedings of the Conference on Weed Control in Forestry, Nottingham University*, Association of Applied Biologists, 189–200.

Lolium perenne and *Festuca rubra*, commonly used to grass man-made sites, are efficient competitors with young trees. Dry weight of pot-grown birch seedlings was shown to be inversely proportional to the biomass of competing *Lolium*. Vegetation may be essential for soil stabilisation or appearance but a considerable penalty is often paid in reduced tree survival and growth. While the optimum degree of weed control is difficult to specify, early spot treatment is clearly effective. After three years, ash growing in 0·1 m^2 weed-free spots among *Poa pratensis* and *Phleum pratense* had shown twice as much height growth as unweeded trees.

INSLEY, H. [and BUCKLEY, G. P.] (1980). Some aspects of weed control for amenity trees on man-made sites. *Arboricultural Journal* **4** (2), 128–136.

Reprint of above.

**INSLEY, H. (1981). Nutrients and the tree. In *Research for Practical Arboriculture*, Forestry Commission Occasional Paper 10, 23–30.

Foliar analysis is being used to examine nutrient concentrations in broadleaved amenity trees. Concentrations of macronutrients in healthy broadleaved trees tend to be higher than those found in conifers. Broadleaved trees showing healthy growth were found to have nutrient concentrations (expressed as % oven dry weight) of N 2·0+, p 0·2+, k 1·0+, Ca 1·5+ and Mg 0·2+, for leaves collected in July or August. In lime no significant variation was found in foliar nutrient concentration with height or aspect on the crown, provided that the samples were collected from the tree crown and consisted of fully expanded, clean, undamaged leaves which had been fully exposed to the light.

**INSLEY, H. (1981). Moving plants safely. In *Research for Practical Arboriculture*, Forestry Commission Occasional Paper 10, 49–57.

The effects of dessication on the survival and growth of broadleaved planting stock are described. Chemical defoliants in single and multiple doses are being investigated in an attempt to induce leaf fall without causing damage. This would permit nurserymen to programme and extend the lifting season. Results of defoliant trials are discussed.

**INSLEY, H. (1981). Roadside and open space trees. In *Research for Practical Arboriculture*, Forestry Commission Occasional Paper 10, 84–92.

Tree plantings on roadsides and in urban open spaces where the soil has been disturbed are commonly subject to problems of soil compaction, disrupted drainage and low fertility. Trials with container-grown stock have not demonstrated any marked advantage over well handled bare-rooted stock. Control of competing swards by mulches or the use of herbicides has produced significant growth response.

**JOBLING, J. and STEVENS, F. R. W. (1980). *Establishment of trees on regraded colliery spoil heaps*. Forestry Commission Occasional Paper 7.

Between October 1976 and September 1977 a critical appraisal was carried out under contract to the Department of the Environment into problems of establishment and management of trees and other woody plants on regraded colliery spoil heaps. This paper reviews the evidence accumulated.

The factors limiting successful revegetation of colliery spoil and information on engineering and cultural practices on reclaimed land are considered. The choice of grass seed mixtures and of tree species are discussed. Information of special interest to practitioners and details of amendment operations and of sowing and planting on more than 30 sites are contained in tables and appendices.

**JOBLING, J. (1981). Reworked spoil and trees. In *Research for Practical Arboriculture*, Forestry Commission Occasional Paper 10, 76–83.

For 18 months in 1978–79, research was carried out under contract to the Department of the Environment into the problems of colliery spoil compaction and its assessment and relief, and the relationship between tree root extension and the physical and chemical properties of the spoil. Some results of the work, on root extension in compacted spoil, tree planting in cultivated spoil and on tree growth in acid spoil, are discussed.

JOHN, A. (1980). Propagation of hybrid larch by summer and winter cuttings. *Silvae genetica* **28** (5–6), 220–256.

Summer and winter cuttings from young Hybrid larch, *Larix* × *eurolepis* (Henry), were rooted with ~90% success. The rate of rooting of summer cuttings was increased by indole butyric acid treatment though the final level was unaffected. Rooting decreased when the cuttings were collected later in the growing season. Cold storage of winter cuttings increased rooting whereas warm storage of more than three weeks resulted in extensive callus development but a large reduction in subsequent rooting. Extended warm storage followed by cold storage drastically reduced rooting.

**JOHNSTON, D. R. (1980). *The formulation of research programmes*. Forestry Commission Research and Development Paper 126.

Research can be organised in many ways but there appear to be advantages for the state forest service to be primarily responsible for applied research. These advantages are only fully realised if

there is some exchange of staff between research and management. A conscious effort is required to ensure adequate collaboration not only between research and management but also between basic and applied research, between different but associated fields of research and between different agencies. A research programme is largely a matter of judgement and is related to the stage of development and the physical conditions of a country.

**JOHNSTON, D. R. (1980). Forest administration in China. In *The Forestry Mission to China 1979*, Forestry Commission Occasional Paper 8, 10–26.

China has 960 million people in 960 million hectares. About half of the 120 million hectares of forest are controlled by the Ministry of Forestry and about half by the communes and by Heilongjiang province.

An important aspect of China's forestry is the environmental planting to protect agricultural land against windblown sand and flood water and for amenity. The environmental planting appeared to be of a higher standard than the 28 million hectares of timber plantations established since 1949.

Forest management and research suffered greatly during the Cultural Revolution but are now beginning to recover.

JOHNSTON, D. R. (1980). The future of arboricultural research. *Arboricultural Journal* **4** (2), 160–167.

Most arboricultural research in the foreseeable future will be a continuation or development of work which has been done over the past few years. The paper therefore concentrates on the programme of research undertaken by the Forestry Commission and the Institute of Terrestrial Ecology on behalf of the Department of the Environment. A number of other agencies are engaged in research which is directly or indirectly related to arboriculture. These various research projects undertaken by all these agencies are reviewed briefly in the paper.

JOHNSTON, D. R. (1980). The response of tree crops to fertilizing. *Forestry and British Timber* **9** (3), 16–17.

The Forestry Commission is conducting various lines of research into different aspects of tree nutrition. Some of this research has been going on for many years and has yielded firm results. Some has reached a stage where it is possible to make reasonably confident hypotheses while the more recent projects have, so far, done no more than suggest possible relationships between fertilizers and tree growth. The earlier research was concerned primarily with early establishment and with the prevention or release of checked early growth. The more recent research is being directed at pole stage fertilizing.

*JONES, A. T. and SMITH, R. O. (1980). *Harvesting windthrown trees.* Forestry Commission Leaflet 75.

A description of working techniques appropriate for windthrow harvesting with corresponding output data. Basic organisational problems are described but the emphasis is on operational procedures and as such is aimed at the chainsaw operator and his immediate supervisor.

LINES, R. (1980). The IUFRO experiments with Douglas fir in Scotland. In *Proceedings of the IUFRO Joint Meeting of Working Parties, Vancouver, Canada, 1978.* British Columbia, Ministry of Forests, **1**, 297–303.

Twenty-nine seed origins of Douglas fir have been included in two main experiments in Scotland and six to nine of these were planted in two subsidiary experiments. In the main experiment at Dunkeld Forest in the Tay Valley there were major differences in early survival and growth up to six years after planting and in autumn frost damage at three years. The heights at six years showed a complex pattern, with little evidence of clinal variation with latitude, elevation or distance from the coast. A fast-growing group came from relatively low elevations near the mouth of the Columbia River, though the tallest individual origin was from Enumclaw.

LINES, R. (1980). The IUFRO experiments with *Pinus contorta* in Britain – results after six years in the forest. In *Proceedings of the IUFRO Joint Meeting of Working Parties, Vancouver, Canada, 1978.* British Columbia, Ministry of Forests, **2**, 125–135.

Results are given from six experiments with 24 origins of the IUFRO *Pinus contorta* collection. Height growth has followed the pattern already reported after three years. Survival has remained very high except at the most severely exposed site. Diameter measurements show highly significant differences and the height/diameter ratios indicate wide differences in stem form, with the northern

coastal ones having the most stocky form, while those from South and East Vancouver Island and the Puget Sound had the most slender stems. Stem defects (lean and basal bow) have become more obvious. Height and bow are highly correlated and there is no sharp disjunction between groups of origins affected by bow and those unaffected by it.

LINES, R. (1980). The IUFRO experiments with Sitka spruce in Great Britain. In *Proceedings of the IUFRO Joint Meeting of Working Parties, Vancouver, Canada, 1978.* British Columbia, Ministry of Forests, **2,** 211–225.

In 1974/75 eighteen experiments were planted on sites covering most of the main site types in Britain. Sixty-nine origins are present in the northern series of experiments and 27 origins in the southern series. Apart from the far southern origins there were negligible losses at establishment. The third year height assessments show highly significant differences, with the tallest individual seed lot coming from the Queen Charlotte Islands in both series. There was a significant site × origin interaction, with Alaskan origins achieving their best relative growth on exposed northern sites, while Washington and Oregon origins grew better on mild sites near the west coast. There were also significant variations in shoot length, frost damage, forking and incidence of lammas shoots.

LINES, R. (1980). The IUFRO experiments with *Abies grandis* in Britain – nursery stage. In *Proceedings of the IUFRO Joint Meeting of Working Parties, Vancouver, Canada, 1978.* British Columbia, Ministry of Forests, **2,** 339–345.

Until recently, very little was known about genetic variation in *Abies grandis,* though it grows very fast in Britain. Two nursery experiments containing 36 IUFRO seed origins and one Scottish provenance were sown in 1976/77. These showed highly significant differences between origins in rate of emergence and height of seedlings in both years and the differences were accentuated with transplants. Frost in May caused some damage (which varied with origin) but appeared to have little effect on transplant height in autumn. These results are discussed in relation to an earlier experiment with commercial seed sources.

LINES, R. (1980). *Pinus contorta* – another viewpoint. *Scottish Forestry* **34** (2), 114–116.

A reply to the critical comments by E. G. M. Davies "Useless? the case against *contorta*" (see Davies (1980) – page 00) pointing out the lower nutrient requirements of this species compared with Sitka spruce. This gives the manager greater flexibility on the poorest sites, where spruce without repeated fertilizer would fail. It is also frost hardy and selected seed origins of *P. contorta* give useful timber, which is stronger than spruce and superior for joinery purposes. Sitka spruce will continue as our major species and only on the worst sites would one consider *P. contorta* as an alternative.

LINES, R. (1980). Stability of *Pinus contorta* in relation to wind and snow. In *Pinus contorta as an Exotic Species.* Swedish University of Agricultural Sciences, Department of Forest Genetics, Research Notes 30, 209–219.

Studies on the stability of Lodgepole pine have continued for 27 years. These include investigation of root/shoot ratios from trees 1–44 years old and root excavations to assess root form and distribution. Wind tunnel studies of crown drag and analyses of crown morphology have been carried out. Results of stability assessments in provenance and progeny trials are presented. Effects of site factors and cultural treatments also influence stability.

LONSDALE, D. (1980). *Nectria coccinea* infection of beech bark. Variations in disease in relation to predisposing factors. *Annales des Sciences forestieres* **37** (4), 307–317.

The development of *Nectria* lesions in beech bark was influenced by high intensities of *Cryptococcus fagisuga* infestation, by nutritional deficiency in the tree and by drought. Large lesions formed only when one or more of these stress factors was present. The nature of the lesions (e.g. presence or absence of callusing) seemed related to the severity and duration of the stress. These findings support the idea that the parasitic ability of *N. coccinea* is largely stress dependent. The existence of different sources of stress may be responsible for the contradictory views of the aetiology of beech bark disease.

LONSDALE, D. (1980). Nectria infection of beech bark in relation to infestation by *Cryptococcus fagisuga* Lindiger. *European Journal of Forest Pathology* **10,** 161–168.

Wound inoculation with an isolate of *Nectria coccinea* produced lesions in beech bark, the size of which was related to the severity of the naturally occurring *Cryptococcus fagisuga* infestation. Another isolate of the fungus showed no significant pathogenicity. Surface inoculation of unwounded bark produced no lesions where the *C. fagisuga* infestation was generally light though locally dense at the inoculation point. Inhibition of the host's response to fungal invasion is considered to be

an important part of the insect's role in assisting the development of beech bark disease.

McCAVISH, W. J. (1980). Herbicides for woody weed control by foliar application. In *Proceedings of the 1980 British Crop Protection Conference*, Brighton, November, 729–737.

The use of 2,4,5-T, glyphosate, triclopyr ester and fosamine ammonium for the selective control of woody weeds in conifer plantations is described. Field trials and experiments on a range of woody weeds over the six year period 1975 to 1980 have shown that all four herbicides effectively control broadleaved deciduous woody weeds but that only 2,4,5-T and triclopyr ester are really effective against evergreen woody weeds such as gorse and broom. Glyphosate was only effective if applied early in the season, the time for this type of weed. The paper has three tables.

McCAVISH, W. J. (1980). Hexazinone – a new forest herbicide. In *Proceedings of the Conference on Weed Control in Forestry, Nottingham University*, Association of Applied Biologists, 217–225.

The results of screening trials with hexazinone, a recent herbicide introduction to British forestry, are described. Eight conifers were tested for tolerance. Its effectiveness against several grass species is described and a rate of 1·8 kg ai/ha is recommended. The paper contains two tables and two figures.

[BALL, R. W. E. and] McCAVISH, W. J. (1980). The use of asulam for the control of *Pteridium aquilinum* in forestry. In *Proceedings of the Conference on Weed Control in Forestry, Nottingham University*, Association of Applied Biologists, 113–120.

The results of screening trials with asulam on eight conifers commonly used for afforestation in Great Britain are described. They conform with results from oversea. Asulam provided in excess of 90% control of *Pteridium aquilinum* (bracken) using 4·5 kg/ha between June and September. The paper contains five tables of results.

McINTOSH, R. (1980). The effect of weed control and fertilization on the growth and nutrient status of Sitka spruce on some upland soils. In *Proceedings of the Conference on Weed Control in Forestry, Nottingham University*, Association of Applied Biologists, 55–63.

Experiments are described, examining the effects of herbicide and fertilizer treatment on the growth of Sitka spruce on a range of soil types in south Scotland. Herbicide treatment had no significant effect on tree survival but gave rise to substantial growth improvements on the mineral soil sites. Fertilizer had little effect on growth unless accompanied by herbicide treatment and survival was only affected by the application of nitrogen which appeared to greatly stimulate the natural grass sward. Analysis of foliar nutrient contents suggested that the antagonistic effect of the grass sward was not due to competition for nutrients.

McINTOSH, R. (1981). Fertilizer treatment of Sitka spruce in the establishment phase in upland Britain. *Scottish Forestry* **35** (1), 3–13.

Results are presented from experiments looking at fertilization and herbicide treatments in Sitka spruce stands in the pre-canopy closure stage. Indications of the likely nutritional inputs needed at this stage are given for a range of soil types along with expected yield classes.

MACRAE, F. (1980). The native pinewoods of Glen Affric. *Arboricultural Journal* **4** (1), 1–10.

The article sets out to describe the strong effort taken in North Scotland Conservancy since the early 60's to regenerate a large, isolated, but particularly unspoiled remnant of our native pinewood at Glen Affric.

The broad ecology of natural Scots pine, its historical significance, and its aesthetic value are the background to the Forestry Commission efforts to save this distinctive sub-species (var *Scotica)* from extinction.

The fragility of the situation is worth emphasising, the whole adventure merely hoisting sail at this stage.

MERCER, P. D. (1980). Scientific attitudes towards the care of damaged trees. In *Report of the 25th Askham Bryan Horticultural Technical Course 1980*, 25–30.

Agents and factors leading to damage in trees are described and the reaction of trees to this damage is evaluated. Practical suggestions are made for the minimisation of decay resulting from damage.

*MERCER, P. C. (1981). Decay – its detection and treatment. In *Research for Practical Arboriculture*, Forestry Commission Occasional Paper 10, 10–15.

Possible techniques for detecting decay in trees are reviewed and particular reference is made to experience gained in research projects using the Shigometer.

Treatment of established decay in trees and preventative measures are also assessed.

MILLER, K. F. (1980). Future stability research in British forestry. In *Research Strategy for Silviculture*, ed. Malcolm, D. C. Edinburgh, Institute of Foresters.

Wind damage involves extremely complex interactions between site, stand and meteorological variables. Accurate prediction of windblow, and the definition of effective preventive management are difficult and often inconsistent. The Windthrow Hazard Classification, based on site factor assessment, indicates endemic windblow susceptibility in extensive conifer plantations, and although predictive accuracy is acceptable, further research is required to validate its application and improve precision for a wider range of site and stand conditions. Fundamental and applied research in the following subjects is proposed: airflow structure, root architecture, stand manipulation.

MITCHELL, A. F. (1980). Conifers in the landscape. *Country Life* CLXVIII (4342), 1646–1647.

With five illustrations, makes the case for conifers as valuable components of scenery and providers of shelter for wildlife. Their variety of colour, form and texture is as important as their good growth in cold, upland regions and on poor soils. Their largely conic slender crowns are in contrast to the diffuse domes of broadleaved trees and complement them.

NEUSTEIN, S. A. (1980). The response of silvicultural practice to changing environments. In *Research Strategy for Silviculture*, ed. Malcolm, D. C. Edinburgh, Institute of Foresters, 7–13.

Silviculture must respond to physical, economic and social changes in the world. Several possible 'futures' are briefly described and some silvicultural effects and associated research needs are discussed. The scenarios considered include changes in climate, site types, markets, energy costs (both increasing and decreasing) and social aspects including war.

NEUSTEIN, S. A. (1981). The time to grow trees. *Scottish Forestry* **35** (1), 14–21.

Forestry is distinguished from most other sciences and activities by its long time scale. Developments in research and wider forest policy are described in general terms in the context of national reviews of these topics.

PARKER, E. J. (1978). Causes of damage to some Zambian wild fruit trees. *Zambia Journal of Science and Technology* **3** (4), 74–83.

Damage caused by fungi, insects, or abiotic agencies, to some of the more important indigenous Zambian trees bearing edible fruits or nuts is recorded. Predominant problems are insect initiated. Diseases and pests are often specific within host genera, although some common types of damage result either from organisms with a broad host range, or from a variety of organisms within a similar ecological niche. It is not practicable to undertake integrated control measures for trees in indigenous woodland. Only in nurseries or orchards of improved fruit tree varieties established for commercial cropping and utilization can protection be economically envisaged.

PARKER, E. J. (1980). Population trends of *Cryptococcus fagisuga* Lind. following different thinning intensities of young beech. *Annales des Sciences forestieres* **37** (4), 299–306.

Infestations of *Cryptococcus fagisuga*, and other symptoms of beech bark disease, were recorded annually for eight years, in plots following different thinning regimes. The intensity of thinning had no apparent effect on the increase of *C. fagisuga* within a stand. Increase of *C. fagisuga* on individual trees occurred irrespective of their diameter. Competition within a crop may help BBD to kill more trees through lowered host resistance. It is suggested that BBD losses in young stands are recouped in a few years by compensatory growth of surviving trees.

PATCH, D. (1981). Broadleaved trees for amenity. *Quarterly Journal of Forestry* **75** (1), 29–35.

This paper discusses the problems connected with the supply and management of urban amenity trees; and makes suggestions concerning choice of species.

PEARCE, M. L. (1980). *Coppiced trees as energy crops.* Farnham, Forestry Commission.

A report to the Energy Technology Support Unit (of the U.K. Department of Energy) as part of a solar energy programme 'Fuels from Biological Materials'. The report examines the potential production levels and costs of a broadleaved coppice system managed over ultra short rotations. Clonal poplar and willow, with *Nothofagus,* alder and *Eucalyptus* are suggested as the candidate species and annual production levels to a maximum of 20 tonnes (dry)/ha are predicted.

PEARCE, M. L., WHITE, J., WEBBER, C. and MacDONALD, J. (1980). *Westonbirt Arboretum Annual Report, 1980.*

A report to the Westonbirt Arboretum Consultative Committee, but aimed at a wider public. Sets out the realisations of the past year to achieve a better understanding of the wider role of the Arboretum in the Research and Development Division. Contains sections from the Curator/ Botanist, the Superintendent and the Propagation Forester along with visitor information.

PETTY, S. (1980). The wildlife value of upland spruce forests in the Borders. *Roebuck* **30,** 25–31.

Recounts the destruction of natural forests in the Border uplands and their further impoverishment by intensive grazing. The benefits of commercial afforestation and the successional changes found in wildlife communities are described.

PHILIPSON, J. J. and COUTTS, M. P. (1980). The tolerance of tree roots to waterlogging. IV. Oxygen transport in woody roots of Sitka spruce and Lodgepole pine. *New Phytologist* **85,** 489–494.

Internal oxygen movement was demonstrated in woody roots of both Sitka spruce and Lodgepole pine by partially submerging detached roots in reduced indigo-carmine solution and noting the appearance of the blue halo due to re-oxidisation of the dye.

Transport in the flood-tolerant pine occurred in both wood and bark and was greater than that in spruce where it was confined to the bark.

The pathways of oxygen movement within the tissues are discussed and the results are considered in relation to the survival of tree roots when waterlogging of both primary and woody roots occurs.

PHILIPSON, J. J. and COUTTS, M. P. (1980). Effects of growth hormone application on the secondary growth of roots and stems in *Picea sitchensis* (Bong.) Carr. *Annals of Botany* **46,** 747–755.

Indol-3-ylacetic acid (IAA), gibberellin A3(GA) and 6 benzylaminopurine (BAP) were applied factorially each at 3×10^2 M in lanolin to the roots and stems of Sitka spruce seedlings and the activity of the two secondary meristems, the vascular cambium and phellogen, and of the parenchymatous tissues between them, was examined. All the treatments, with the exception of GA produced a localized stimulation of radial growth at the point of application and there was a similarity in the response of the various tissues in both the root and stem.

In roots and stems the application of BAP altered the derivatives produced by the vascular cambium, resulting in the production of large multiseriate rays in the xylem, and giving rise to an overall increase in the proportion of ray tissue.

**PHILLIPS, D. H. (1980). *International plant health controls. Conflicts, problems and co-operation. A European experience.* Forestry Commission Research and Development Paper 125.

Legislation to prevent the movement of plant pests and diseases into new areas involves international agreement, which is not easily achieved. The assessment of the potential importance of alien organisms is difficult, and funds for research and control are limited. The EEC has prepared a Plant Health Directive as the basis of the phytosanitary legislation of its Member States. The Directive includes measures to protect trees against alien pests and diseases. At all times legislation must be kep up to date, and must attempt to provide the maximum security with the minimum interference with trade.

PHILLIPS, D. H. (1980). Plant health legislation and forest trees in Britain. *Arboricultural Journal* **4** (2), 152–157.

In theory the entry of alien pests and diseases of trees into new areas could be prevented by prohibiting the importation of tree seeds, plants and wood, on which these organisms may be carried. Necessary trade prevents so simple a solution. The likely importance of individual organisms must be assessed, and appropriate legislative measures introduced to deal with them to best effect with the resources available. The paper discusses criteria for pest and disease assessment, and briefly describes the tree pests and diseases included in the EEC Plant Health Directive and the measures prescribed to control their international movement.

PHILLIPS, D. H. (1981). Legislating for introduced species: the lessons from plant health. In *Conservation and Introduced Species*, ed. Pinder, N. London, British Association of Nature Conservationists/UCL Ecology and Conservation Unit, 50–59.

In spite of plant health legislation, some pests and diseases, like the Colorado beetle, and the White rust of chrysanthemum, frequently enter Britain. Some, like fireblight of rosaceous plants, have become established there. Dutch elm disease became established because the British elms are very susceptible, they form a continuous countryside network, they are often connected by their root systems, and the disease has very effective vectors. Various pests and diseases differ greatly one from another, and plant health authorities must always expect the unexpected. To do their work they need the active support of trade interests and the general public.

PYATT, D. G., McLAREN, K. T. and CRAVEN, M. M. (1980). Physical properties of four soils at Newcastleton Forest, South Scotland. In *The Properties of Upland Soils and their Implications for Agriculture and Forestry*. Proceedings of North of England Soils Discussion Group 15, 35–63.

Soil moisture and temperature were measured for three years. In the brown earth there was no water table within 1 m of the surface but periods of wetness totalled 40–90 days each year. The peaty ironpan soil was wet or waterlogged above the pan for most of the year but rarely wet beneath the pan. In the surface-water gley and peaty gley soils a shallow water table was present for 6½–8½ months of the year overlying waterlogged fine textured subsoils. Soil temperatures were similar in the four soils and had a small annual range. Additional comments are made about soil aeration.

RENNOLLS, K., CARNELL, R. and TEE, V. (1980). A descriptive model of the relationship between rainfall and soil water table. *Journal of Hydrology* **47**, 103–114.

The first-order autoregressive model is used to describe the response of the water level in a borehole to a series of rainfall events. The parameters of this model are then estimated using M.L. and fitted trajectories compared with L.S. fits on a simulated series. The model is applied to data from a drainage experiment. The characterisation of the dynamic behaviour of the borehole levels by the three parameters of our model is better than by static methods such as means and variances. Our model can be used to predict borehole levels in response to given rainfall events.

**ROWE, D. C. F. (1981). The best from seed. In *Research for Practical Arboriculture*, Forestry Commission Occasional Paper 10, 36–48.

Germination problems of seeds of a number of broadleaved tree species are surveyed with particular reference to interactions between dormancy controls, presowing seed treatments, and subsequent germination.

The results of various experiments carried out by the Forestry Commission Seed Branch are presented to demonstrate the value of presowing seed treatments producing reliable germination. Seed pretreatment conditions are described.

It is suggested that some nurserymen have not appreciated that reliable broadleaved seedling production is possible, and have been dissuaded from attempting pretreatments on the basis of misleading past experience.

*ROWE, J. J. (1980). *Grey squirrel control.* Forestry Commission Leaflet 56, 2nd ed.

Describes methods available for managing grey squirrels and the tactics recommended for different situations with grey squirrel damage.

RUSHFORTH, K. (1980). *The Mitchell Beazley Pocket Guide to Trees.* London, Mitchell Beazley, 192 pp.

The Pocket Guide to Trees is designed particularly for the amateur and lay market. It features over 350 species of the most commonly encountered trees in Great Britain and northern Europe. Identification is achieved by the use of over one thousand full-colour illustrations and with annotated text. Simple keys enable the reader to track down the genus or section of genus to which each plant belongs, and particular emphasis is given to the winter identification of deciduous trees. In addition to the 350 species illustrated, descriptions of many cultivars and related species are also given.

[PAGE, C. N. and] RUSHFORTH, K. D. (1980). *Picea farreri:* a new temperate conifer from Upper Burma. Notes from the Royal Botanic Garden, Edinburgh **38** (1), 129–136.

A new species of temperate conifer *Picea farreri* Page and Rushforth (Pinaceae) is described from Upper Burma. The plant shows affinities with both *P. spinulosa* (Griffith) Henry and *P. brachytyla* (Franchet) Pritzel. Both herbarium and living material have been studied. Affinities and geography of the new species are discussed.

STOAKLEY, J. T., [BAKKE, A., RENWICK, J. A. A. and VITE, J. P.] (1978). The aggregation pheromone system of the larch bark beetle, *Ips cembrae*. *Zeitschrift für angewandte Entomologie* **86** (2), 174–177.

The aggregation pheromone system of *Ips cembrae* appears to consist of three compounds by attacking males. Gas chromatographic analysis of hindgut volatiles revealed the presence of ipsenol, ipsdienol and an additional compound which was identified as 3-methyl-3-buten-1-ol. Field bioassays in Scotland and in Germany indicated that neither ipsenol nor ipsdienol alone is effective, but the combination is attractive, and the addition of the methyl butenol increases the response considerably.

STROUTS, R. G. (1980). Arboriculture – death in Ely. Why did so many Lombardy poplars die in the East of England last year? *GC & HTJ* **188** (7), 53–56.

During summer 1979, deaths, severe dieback and branch cankering of Lombardy poplars (*Populus nigra* 'Italica') was reported from eastern England. As this damage, like earlier similar instances, appeared after a notably cold winter, low temperature injury was at first suspected. Trees elsewhere which experienced similar 1978/79 winter weather were unaffected, however, so apparently some other factor was also involved. Evidence is presented suggesting that the damaged trees were predisposed to cold injury by premature defoliation in 1978 by the fungus *Marssonina populi – nigrae*.

THOMPSON, D. A. (1980). Regeneration lessons from Ontario's clay belt forests. *Scottish Forestry* **34** (3), 173–177.

A brief description of the problems faced in the mainly Black spruce forests on peat over clay where large tracts have been logged by lumber and pulp companies under licence to the government which (since 1962) has responsibility for regeneration. Major problems with clear-felled sites are skidder-damage to unfrozen ground, lack of seed trees, predominance of poplars in natural regeneration and high stumps (after winter felling) which restrict the use of silvicultural machinery. Methods of planting are described, mainly using cold-stored bare-root stock. The roots are soaked in water for at least four hours before planting.

TOLEMAN, R. D. L. (1980). The use of soil and site information in the Forestry Commission. In *The Properties of Upland Soils and their Implications for Agriculture and Forestry*. Proceedings of the North of England Soils Discussion Group 15, 21–34.

The current site classification in use in the Forestry Commission is summarised, together with the related exposure classification and terrain classification. Tables are included of the site type distribution in upland Britain. Examples are given of the aid to management given by these classifications.

WAINHOUSE, D. (1980). A portable suction trap for sampling small insects. *Bulletin of Entomological Research* **70**, 491–494.

A suction trap for sampling small insects in areas without mains electricity is described. The traps were operated from two 25-ampere-hour 12 V batteries connected in parallel, giving an average airflow of 329–355 m^3/h over a 12 h period. The trap was used successfully to catch first-instar larvae of *Cryptococcus fagisuga* Ldgr. in a beech forest in England.

WAINHOUSE, D. (1980). Dispersal of first instar larvae of the felted beech scale, *Cryptococcus fagisuga*. *Journal of Applied Ecology* **17** (3), 523–532.

1. Dispersal of *Cryptococcus fagisuga* in a beech forest was studied using suction traps and sticky traps.
2. The larvae were the main dispersive stage and were carried passively downwind from infested trees.
3. In mean windspeeds of $\cdot$ 1 m/s larvae dispersed a mean distance of about 10 m from a source tree which was infested from near ground level to the lower canopy.

4. In suction traps sited from 1 m above the ground to 6 m above the canopy (18 m above the ground) most larvae were trapped at 1 and 3·2 m above the ground. About 0·7 per cent were trapped at or above the top of the canopy.

5. The larvae dispersed along a short-range steep gradient under the canopy and a potentially long-range shallow gradient above the canopy.

WAINHOUSE, D. [and DEEBLE, R.] (1980). Variation in susceptibility of beech (*Fagus* spp.) to beech scale *(Cryptococcus fagisuga). Annales des Sciences Forestieres* **37** (4), 279–289.

Data are presented showing clonal differences in severity of attack by *Cryptococcus fagisuga* on beech scions in three seed orchards in southern England. These differences may be due to genetically controlled resistance or to stock/scion incompatibility producing changes in the scion favourable for growth and development of *C. fagisuga.* It is concluded that differences are probably genetic in origin but that host response to attack and environmental factors probably interact to produce the complex pattern of attack seen in the forest.

WALKER, C. [and RHODES, L. H.] (1981). *Glomus albidus:* a new species in the Endogonaceae. *Mycotaxon* **12** (2), 509–514.

A 'White reticulate' type of spore formed by a fungus forming vesicular-arbuscular mycorrhizas is described and illustrated as part of work done at Iowa State University and Ohio State University.

WALKER, C. [and TRAPPE, J. M.] (1981). *Acaulospora spinosa* sp. nov. with a Key to the species of *Acaulospora. Mycotaxon* **12** (2), 515–521.

A new endomycorrhizal fungus in the Endogonaceae is described and illustrated.

Specimens from Iowa and Mexico were used for the descriptions in the protologue. A key to all currently described species in the genus is included. This work was done jointly by Iowa State University and the United States Department of Agriculture, Forest Service at Ames, Iowa and Corvallis, Oregon respectively.

**WILSON, K. W. (1980) (Ed.). *The Forestry Mission to China 1979.* Forestry Commission Occasional Paper 8.

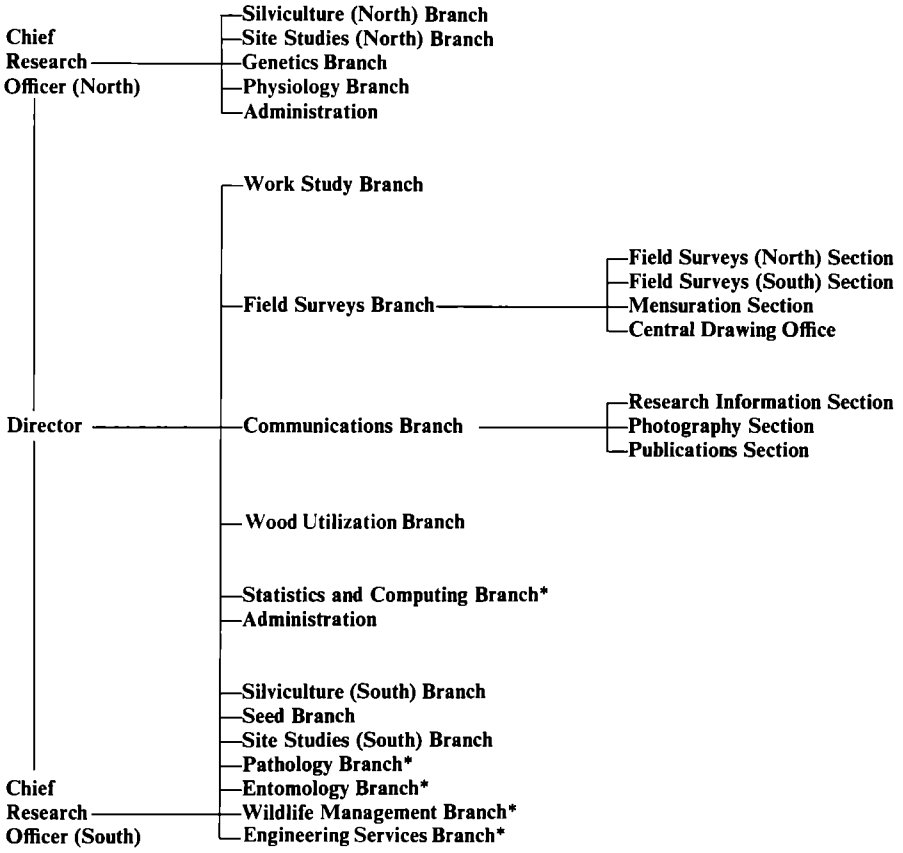
In the autumn of 1979, soon after the establishment in China of an independent Ministry of Forestry, a group of foresters, each representing a major aspect of British forestry, were invited to examine the recent developments in Chinese forestry. This edited collection of papers gives a useful and unique account of some social aspects of Chinese life and their impact on forestry, forest research and forest-based industries.

ZEHETMAYR, J. W. L. (1981). The role of forestry in the future environment of mid-Wales. *Quarterly Journal of Forestry* **75** (1), 23–29.

Mid-Wales, by the nature of its topography, soils and climate, carries a higher than average woodland cover; 14 per cent at present which could approach 20 per cent by the end of the century. While expansion by afforestation is currently at a post-war low, timber production increases by 10 per cent a year and employment exceeds 1,300 in an area of chronic rural depopulation. The effect of forest on the landscape and general environment of mid-Wales is considered briefly.

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 31st March 1981

The main centres for research and development are:

FORESTRY COMMISSION RESEARCH STATION

Alice Holt Lodge
Wrecclesham
Farnham, Surrey GU10 4LH. Tel. Bentley (Hants) 22255 (STD Code 0420)

FORESTRY COMMISSION NORTHERN STATION

Roslin
Midlothian EH25 9SY
Scotland. Tel. 031 445 2176

Some staff engaged in research and development 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	J. E. Applegate *(Alice Holt)*
Director's Secretary	Mrs V. O. C. Lampard *(Alice Holt)*

Cheif 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.)

Chief Research Officer (North) ..... D. T. Seal, B.Sc.(For.)., F.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.)

STAFF AT ALICE HOLT LODGE

SILVICULTURE BRANCH (SOUTH)

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

Research Foresters:		*Centre*
East England Region	P. W. W. Daborn	Alice Holt
	D. Elgy, J. B. H. Gardiner	Alice Holt
	F. R. W. Stevens:	Alice Holt
	P. D. Howard, P. Marsh	Alice Holt
	P. G. Risby, C. W. Shanks	Alice Holt
	A. W. Westall: M. J. Scott	Bedgebury Pinetum
	I. H. Blackmore: P. R. Barwick	Thetford
West England Region	M. L. Pearce, M.I.For.	Westonbirt Arboretum
	K. F. Baker: D. J. Lyons	Exeter
	R. E. Warn	Dean
	J. I. MacDonald, C. W. Webber	Westonbirt Arboretum
	J. E. J. White	Westonbirt Arboretum

ARBORICULTURAL ADVISORY SERVICE (Department of the Environment)

D. Patch, M.Sc., B.Sc.(For.), M.I.For., N.D.Arb.: F. R. W. Stevens.

SITE STUDIES BRANCH (SOUTH)

W. O. Binns, M.A., B.Sc.(For.), 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: N. Best, K. G. Shuker
Laboratory:	Mrs D. A. Waddell: Miss C. A. Howard, Miss D. V. Kitson

PATHOLOGY BRANCH (with Section at Northern Research Station)

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., M.I.For.: Miss J. F. Webber**, B.Sc., Ph.D.

Research Foresters:	B. J. W. Greig, M.I.For., R. G. Strouts, R. A. G. Coxwell
Laboratory:	Miss F. M. Barnby, B.Tech., N. C. Henderson†, B.Sc., M.Sc., Mrs A. A. Rees, B.Sc.: Miss J. A. Chown, Mrs S. A. Kirk, Mrs T. C. Reffold: A. Jeeves, K. G. Crump

ENTOMOLOGY BRANCH (with Section at Northern Research Station)

D. Bevan, B.Sc.(For.), F.R.E.S., Head of Branch
C. I. Carter, M.Sc., M.I.Biol., F.R.E.S., D. Wainhouse, M.Sc., Ph.D., T. G. Winter, M. R. Jukes, M.I.Biol., Miss J. F. A. Nichols, B.Sc.

Research Foresters:	R. M. Brown, C. J. King, D. J. Billany
Laboratory:	N. J. Fielding

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*Seconded from University of Surrey
**Seconded from the University of Southampton
†On secondment to ARC Unit of Invertebrate Chemistry and Physiology, Brighton

WILDLIFE MANAGEMENT BRANCH

Miss J. J. Rowe, B.Sc., Dip.Cons., M.I.Biol., Head of Branch
R. C. Melville, B.Sc.(For.), M.I.For.

Research Foresters:	L. A. Tee: H. W. Pepper, P. R. Ratcliffe, B.Sc., M.I.Biol. *(Glenbranter, Strathclyde)*: M. Roe, C. S. Taylor
Laboratory:	Mrs B. A. Mayle, R. R. Allan

SEED BRANCH

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

Laboratory:	D. C. Wakeman: Mrs Y. K. Samuel, T. A. G. Smith, Miss K. Spriggs
Seed Store and Extractory:	T. A. Waddell: L. H. Crumplin, N. C. Keatley, P. A. Sharman

ENGINEERING SERVICES BRANCH (with Section at NRS)

W. H. Hinson, B.Sc., Ph.D., Head of Branch
H. G. W. Bodkin, R. D. Butt, M. F. Johnston

WORK STUDY BRANCH

A. J. G. Hughes, B.Sc.(For.), M.I.For., Head of Branch
R. O. Smith, M.A., M.M.S.: St. J. G. D. Bland-Flagg, M.M.S., M.J.R. Ingoldby.

Field Teams:		*Centre*
North Scotland	R. G. Muhl (Leader): R. A. Sandilands 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. Tyres: K. A. Russell, J. B. Spencer	Ae, Dumfries
Office:	Mrs K. Howat	
East England	M. N. Haworth, B.Sc.(For.) (Leader) P. B. Lane, N. Head	Santon Downham, Thetford
Southern England	D. Howard (Leader): T. P. Edge, B.Sc.(For.)	Brockenhurst
Wales	A. T. Jones, B.Sc.(For.), D.M.S., M.I.For., (Leader): A. C. Thompson, B.Sc.(For)., B. S. Hicks: D. H. Jones, W. J. Parkin, B.Sc.(For.), C. J. Pearce, C. J. Roberts	Brecon and Dolgellau
Special Duties	J. A. Drummond, B.Sc.(For.)	Ae, Dumfries

FIELD SURVEYS BRANCH

K. P. Thallon, M.A., M.I.For., Head of Branch

FIELD SURVEY SECTION

A. I. D. Horne, B.Sc.(For.), Dip.For.Sur., M.I.For., G. M. L. Locke, B.Sc.(For.) *(Edinburgh)*

Foresters stationed at Alice Holt:
D. Case, J. C. Proudfoot, M. D. Whitlock

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

Foresters stationed throughout Scotland:
R. F. E. Barlett, J. Straiton: J. Boluski, N. Bousfield, F. W. E. Burlton, A. R. Brown, D. G. Caird, D. J. Collins, J. Davidson, G. R. Dunbar, D. E. Ellis, R. Evans, J. C. Findlay, H. Gillen, J. A. McIntyre, I. R. McNicol, H. Schneider, M. R. T. Spernagel, A. A. Tait, G. Taylor, D. S. Whitaker, P. J. Williams.

MENSURATION SECTION

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

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

CENSUS SURVEY SECTION

W. T. Waters, N.D.F., J. Harrison, B.Sc.

Foresters: A. C. Miller, R. W. Twallin

DRAWING OFFICE *(Edinburgh)*

K. F. Ball
G. D. Bull, G. M. Challis, P. D. Finch, Mrs L. E. Marshall, A. Pearson: D. B. Armstrong, K. R. Fergus, Miss M. F. Innes, Mrs E. Mann, B. H. Miller, D. S. Mitchell (Asst Photographer), Miss A. M. Selbie, Miss V. M. Stupple, R. Venables: R. H. Beck, Miss E. McKeen, Miss S. Murchison

STATISTICS AND COMPUTING BRANCH (with Section at NRS)

R. S. Howell, Head of Branch
R. C. Boswell, B.Sc., M.I.S., G. J. Hall, B.Sc., I. D. Mobbs, A.I.S., K. Rennolls, B.Sc., M.Sc., Miss J. Smyth, B.Sc.: R. M. A. Gill, B.Sc., M.Sc., A. J. Peace, B.Sc., S. Pickett, B.Sc., M.Sc.

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
Leading Research Worker: M. Little, B.A.

COMMUNICATIONS BRANCH

O. N. Blatchford, B.Sc.(For.), M.I.Inf.Sc., Head of Branch

RESEARCH INFORMATION SECTION

O. N. Blatchford, B.Sc.(For), M.I.Inf.Sc., Head of Section
P. J. Langley, M.A.: Mrs C. W. Collins, B.Sc. (Librarian)

PHOTOGRAPHY SECTION

I. A. Anderson, F.I.I.P., Head of Section
G. L. Gate, J. Williams (Graphics Officer), Miss M. Trusler

PUBLICATIONS SECTION

K. W. Wilson, B.Sc.(For.), M.I.For., Head of Section

WOOD UTILIZATION BRANCH

J. R. Aaron, M.A., M.Sc., F.I.W.Sc., F.I.For., Head of Branch

ADMINISTRATIVE STAFF

HEOs:	Mrs D. R. Harper *(Branch A)*, R. Murray *(Branch B)*
EOs:	Mr K. A. Fielding *(Estabs)*, S. Hankin *(Stats)*, L. W. Thomas *(Office Services)*, M. G. Wheeler *(Finance)*
COs:	Mrs K. S. Butcher *(Office Services)*, Miss C. I. Derrick *(Estabs)*, Mrs M. Greenwood *(Seeds)*, Mrs W. B. Groves *(Estabs)*, Miss G. B. Hayden *(Communications)*, J. G. Jackman *(Wildlife/Site Studies)*, Miss J. R. Lacey *(Finance)*, Mrs P. A. M. Pharo *(Silviculture)*, W. E. Powell *(Field Surveys)*, Miss L. M. Raggett *(Estabs)*, Mrs D. Steel *(Work Study)*, Miss C. A. Woods *(Communications)*, Mrs C. A. Yeomans *(Finance)*.
CAs:	Mrs J. N. R. Burbidge *(Work Study)*, Mrs M. Butt *(Communications)*, Mrs H. M. Caddick *(Seeds)*, Miss L. J. Caless *(Entomology/Finance)*, Mrs M. Foster *(Silviculture)*, Mrs L. Gower *(Office Services)*, Miss S. M. Haywood *(Field Surveys)*, Mrs K. J. Kapszul *(Office Services)*, Mrs S. M. Locke *(Estabs/Pathology)*, Miss M. N. Pasquet *(Estabs)*, Miss S. J. Worman *(Communications)*
Photoprinter II:	Miss E. A. Hill
Senior Supt/Typist:	Miss M. Hopkin
Specialist Typists I:	Mrs L. D. Birchall *(Communications)*, Mrs A. H. Clements *(Stats)*
Specialist Typists:	Mrs E. L. Allen, Mrs J. G. Anderson *(Pathology)*, Mrs B. Dickinson, Mrs R. J. Hales *(Work Study)*, Mrs J. Richardson, Mrs E. A. Walters
Telephonists:	Mrs O. Ambler, Mrs J. M. Plant
Messengers:	D. M. Chandler, F. C. Tompkins
Gardener:	M. Philp
Workshop:	H. R. Butt, A. N. Butler
Handyman:	L. A. Vickery

Other HQ Staff

MECHANICAL ENGINEERING DIVISION *(Alice Holt)*

W. J. Muddle: W. S. Mackenzie, T.Eng.(CEI), M.I.M.G., Tech.E.

STAFF AT NORTHERN RESEARCH STATION

SILVICULTURE BRANCH (NORTH)

J. Atterson, B.Sc.(For.), M.I.For., Head of Branch
R. Lines, B.Sc.(For.), F.I.For., P. Biggin, B.Sc.(For.), M.I.For., K. F. Miller, B.Sc.(For.), M.I.For., R. McIntosh, B.Sc.(For.), M.I.For., P. Tabbush, B.Sc.(For.), M.I.For.

Research Foresters:		*Centre*
Special Projects	J. Hunt: J. G. Whyatt	Northern Research Station
North Scotland Region	J. C. Keenleyside	Newton, Grampian
North Scotland Area	W. G. Paterson: C. E. S. Fleming, R. J. Wallace	Lairg, Highland
North East Scotland Area	C. H. Blackwood: G. R. Menzies, D. Yeats	Newton
North West Scotland Area	N. Mackell: D. S. Coutts	Fort Augustus, Highland
Central Scotland Region	J. H. Thomson	Northern Research Station
East Scotland Area	A. H. Reid: C. D. Rider	Perth, Tayside
South East Scotland Area	M. K. Hollingsworth: 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	J. D. McNeill: D. J. Furness, J. Stannard	Kielder, by Hexham, Northumberland
South West Scotland Area	F. S. Smith: P. Harrison	Mabie
North East England Area	K. A. S. Gabriel: R. E. J. Howes	Wykeham, Scarborough, North Yorkshire
Wales Region	G. Pringle	Betws-y-Coed, Gwynedd
North Wales Area	Vacant	Betwys-y-Coed
South Wales Area	N. P. Danby: A. A. Gardner	Brecon, Powys

SITE STUDIES BRANCH (NORTH)

D. G. Pyatt, B.Sc.(For.), Ph.D., Head of Branch

Laboratory: A. R. Anderson, Miss S. E. Reid, B.Sc.

GENETICS BRANCH

R. Faulkner, B.Sc.(For.), 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.: C. J. A. Samuel, B.Sc., Ph.D., J. G. S. Gill, B.Sc., M.I.For.

Research Foresters: C. McLean: R. B. Collins, I. J. M. Dawson *(Westonbirt)*, M. T. T. Phillips *(Newton)*, G. C. Webb *(Westonbirt)*: W. J. Dyce *(Newton)*, R. E. Stuart
Laboratory: Miss C. M. M. Baldwin

PHYSIOLOGY BRANCH

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

Research Forester: C. Walker, B.A., Ph.D.
Laboratory: Miss J. Baxter, Miss M. Brown, K. Clifford, B.A., Miss H. M. Dougall, B.Sc.

PATHOLOGY SECTION (of Branch at Alice Holt)

D. B. Redfern, B.Sc., Ph.D., Head of Section
S. C. Gregory, M.A., Ph.D., Miss G. A. MacAskill, H.N.D.

Research Forester: J. D. Low

ENTOMOLOGY SECTION (of Branch at Alice Holt)

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

STATISTICS AND COMPUTING SECTION (of Branch at Alice Holt)

D. H. Stewart, B.Sc., M.I.Biol., F.I.S., Head of Section
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