

REPORT ON

FOREST RESEARCH

1980

FORESTRY COMMISSION



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REPORT ON
FOREST RESEARCH

for the year ended
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INTRODUCTION

By D. R. JOHNSTON

Director of Research and Development

Alternative species

A number of relatively unfamiliar species are being considered for use in Britain. The performance of the genus *Eucalyptus* in Britain was reviewed during the year and trial plots of various species and origins of *Nothofagus* were established on a range of different sites throughout the country.

A range of origins of Red alder is now under test on infertile and exposed sites and other exotic *Alnus* species are being studied prior to further experimental introductions. *Picea engelmannii* is showing wide origin-variation in upland experiments, the most successful origins being comparable with Sitka spruce. The hybrid between Sitka and White spruces is also showing good early performance on acid peatlands in northern Scotland.

Wind stability

Work was started on topographic modelling and wind-tunnel testing in conjunction with automatic anemometer recording at Glentroot Forest in order to improve the windthrow hazard classification throughout the British uplands. New methods of cultivation for long-term plantation stability were tested in conjunction with current research on the physiological factors governing root development in spruce and pine.

Vegetative propagation

A satisfactorily high rate of rooting success is now being achieved with Sitka spruce cuttings in simple polythene houses, and a start has been made in the study of variation and stability of clonal characteristics. The possible gains in growth rate and tree form by selection and propagating from young trees, and the necessary safeguards for the use of clones are now being assessed.

Biochemical analysis

Analysis of terpenes from trees in the native Caledonian pinewoods in Scotland has made it possible to characterise constituent populations as an aid to genetic conservation of these pinewoods. A joint E.E.C. research programme for the biochemical characterisation of Douglas fir by mono- and sesqui-terpene and iso-enzyme analysis was established with biochemical laboratories in France and Germany.

Wood research

An objective of the Forestry Commission is to produce the highest practicable proportion of timber of structural grade quality. The Forestry Commission has commissioned the Princes Risborough Laboratory to undertake an investigation into the factors which cause Sitka spruce sawn timber to be rejected as structural grade timber by a stress grading machine. The results of this investigation will influence future research and management.

Aerial survey

A Cessna Skylane was acquired during the year for the aerial photography required for the census. Flying was restricted mainly to equipment testing and camera calibration. Adverse weather conditions during the winter were severely limiting so that operational sorties were only possible during the final weeks of the year.

These operational flights clearly demonstrated the advantages of having an aircraft immediately available when weather conditions are suitable for photography.

Contract work

The preliminary stages of two contracts were completed during the year. These were a Department of the Environment contract concerned with the reclamation of deep mining spoil heaps and a Department of Energy contract to investigate the possibilities of growing biomass for energy from fast-growing coppice crops. A research contract was awarded by the EEC to several member countries to undertake research into Dutch elm disease, the principal partners being Holland which is responsible for tree breeding, and Britain which is studying the biology of the fungus and the behaviour of the vector.

A five year contract on arboriculture research undertaken for the DOE has entered upon its final year.

Visitors

A total of 440 visitors came to Alice Holt Lodge, and 580 to the Northern Research Station. Distinguished visitors included Dr R E Buckman, Head of the USDA Forest Service Research.

The Executive Board of the International Union of Forest Research Organisations (IUFRO) visited the Northern Research Station.

Visits and Conferences

Sixteen conferences abroad were attended by members of staff and 11 visits were made to overseas research organisations. Fifteen conferences were attended in this country.

Awards to staff

British Empire Medals were awarded to Leading Research Worker E. Watts, Silviculture South (Westonbirt) and to Leading Research Worker A. G. R. Legge, Silviculture North (Newton).

C. Walker (Physiology) gained his Ph.D. (Iowa State University) and R. M. A. Gill (Statistics) his M.Sc. (University of York).

Miss J. Webber (seconded to Pathology from Southampton University) received her Ph.D. (University of Aberystwyth).

Staff changes

Transfers in: J. C. Harrison (Forest Officer I) from South West England Conservancy to Field Surveys, Malvern. R. G. Muhl (Forest Officer II) from East England Conservancy to Work Study. J. L. Keenleyside (Chief Forester) from West Scotland Conservancy to Silviculture North, Elgin. P. B. Lane (Head Forester) from East England Conservancy to Work Study, Thetford.

J. C. Findlay (Forester) from West Scotland to Field Surveys, Newton Stewart. W. G. Parkin (Forester) from North East England Conservancy to Work Study, N. Wales. C. D. Rider (Forester) from East Scotland Conservancy to Silviculture North, Perth. R. E. Stuart (Forester) from West Scotland Conservancy to Genetics. G. L. Gate (Senior Photographer) from Ancient Monuments to Alice Holt. R. E. Warn (Forester) from North West England to Silviculture South, Dean. J. E. Applegate (Principal) from H. Q. to Alice Holt. R. Murray (Higher Executive Officer) from H. Q. to Alice Holt. B. W. Cann (Executive Officer) from Headquarters to NRS.

Transfers out: T. C. Booth (Forest Officer I) from Silviculture North to North Scotland Conservancy. H. B. Painter (Head Forester) from Field Surveys to South West England on promotion. K. E. Wallis (Head Forester) from Silviculture South to East England Conservancy. T. J. Davis (Forester) from Silviculture South to North Wales Conservancy. P. F. Jefferson (Forester) from Work Study to North Wales Conservancy. J. D. Lindsay (Forester) from Silviculture North to East Scotland Conservancy. T. Lees (Executive Officer) from NRS to HQ.

Promotions: A. M. Fletcher (Genetics) to Principal Scientific Officer. D. G. Pyatt (Site Studies North) to Principal Scientific Officer. K. Rennolls (Statistics) to Senior Scientific Officer. M. Jukes (Entomology) to Higher Scientific Officer. F. R. W. Stevens (Silviculture South) to Head Forester. R. A. Sandilands (Work Study, Inverness) to Head Forester.

Resignations: Miss J. M. Davies (Principal Scientific Officer) Entomology. Miss T. K. Evans (Senior Photographer). These two lady members of staff had been at Alice Holt Lodge since the early Fifties. Mrs. H. A. Steele (Scientific Officer) Pathology, NRS. G. D. Bell (Scientific Officer) Statistics, NRS. B. G. Miller (Scientific Officer) Statistics, NRS. K. D. Rushforth (Higher Scientific Officer) Silviculture South.

New appointments: A. J. Peace (Scientific Officer) Statistics. N. C. Henderson (Scientific Officer) University of Sussex/Pathology. Miss F. M. Barnby (Scientific Officer) Pathology.

Retirements: N. E. Stutter (Principal) A&FO, Alice Holt. Miss E. J. Johnson (Executive Officer), Establishments. D. A. Cousins (Chief Forester) Westobirt.

PART I

The Work of the Forestry Commission

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SEED

Research

Nursery Experiments

Following the observation of the beneficial effects of a sand cover on the germination of small seeded conifer species (see *Reports* 1978, 1979) experiments were extended to *Alnus cordata*, *Alnus glutinosa*, *Betula pendula* and *Betula pubescens*. The treatments investigated were prechilling and no prechilling of seed, raked and unraked beds at sowing and sand and grit as seedbed coverings. Identical experiments were laid out in irrigated and unirrigated areas of Headley Nursery. All species differed in their individual reactions to the treatments. On the whole prechilling gave better germination (except for *A. glutinosa*); germination was better in unraked than raked beds; *Betula* species germinated better under sand than grit but *Alnus* species germinated better under grit. Irrigation was beneficial to germination of *Betula* species but not *Alnus* species and increased the height of most treatments by about 10 per cent at the end of the season. The most outstanding result was the consistent loss of 40 per cent of the seedlings between mid and end of season. Pathology Branch were unable to identify any causal organisms.

Further experiments were carried out to investigate dates of sowing, prechilling and seedbed condition on germination and survival of Sitka spruce in an irrigated and unirrigated area of Headley Nursery. Due probably to the cold, moist spring there was little effect of irrigation and prechilling on plant numbers until the fifth sowing on 31 May. By the end of the season plants from prechilled seed and plants grown under irrigation were at least 10 per cent higher than plants grown without seed prechilling and irrigation. The biggest treatment effect was related to the seedbed conditions at sowing. Raked seedbeds gave at least 36 per cent more plants in mid season, and at least 30 per cent more plants at the end of season than unraked seedbeds. This agrees with results obtained last year but is in marked contrast to the findings for *Alnus* and *Betula* species.

Broadleaved Seed Pretreatment

Work has continued on determining effective presowing treatments for some of the more deeply dormant broadleaved species. Techniques, which promote satisfactory germination within the first year of sowing, have been discovered for most of the species studied. However, the great variability between seed lots in their pretreatment requirement means that exact recommendations cannot be made.

The seed of most broadleaved species requires either a period in warm, moist conditions followed by a period of prechilling treatment, or a moist, prechilling treatment alone (e.g. *Crataegus monogyna* and *Nothofagus obliqua* respectively). Mixing the seed with an imbibing medium rather than leaving them to pretreat 'naked' increases the efficacy of both warm and prolonged cold treatments and so decreases the necessary pretreatment time. Sandy soil/peat and sand/peat mixtures are superior to sand alone.

Time of collection studies have shown that *Acer campestre* seed collected and sown at the red/green stage gave greater percentage germination than untreated mature seed. However, the seedlings were small and lacking vigour,

having developed from immature embryos. Seed collected when fully mature and then pretreated with three weeks warm and 17 weeks cold treatment germinated well and produced normal seedlings.

The seeds of *Sorbus* species should be extracted from their fruits as soon after collection as possible. Seed sown in the autumn without being dried at all gave almost total germination in the following spring. Dried *Sorbus* seed required 2–4 weeks warm plus 12–16 weeks cold treatment to produce good germination from a spring sowing.

Although potentially effective, concentrated sulphuric acid is a dangerous chemical to use for overcoming the hard-seeded dormancy of legumes. Hot water soaks can be employed but must, like acid, be calibrated beforehand. Experiments have been carried out in conjunction with the Site Studies Branch aimed at breaking the hard-seededness by mechanical scarification. Various apparatuses have been used, including a sieve shaker, a test-tube shaker, a gem grinder, a revolving drum with internal paddles and an end-over-end shaker for soil analysis. Various abraders have been employed including silicon carbide, sharp grit particles, carborundum paper and broken-up carborundum chips. So far nearly 100 per cent abrasion of the hard seed coat has been most efficiently carried out using the end-over-end shaker and the revolving drum in conjunction with marble-sized carborundum chips.

A. G. GORDON, D. C. WAKEMAN, D. C. F. ROWE

Service

There has been a large increase in the total weight of broadleaved seeds dispatched by the Seed Branch in the last year, whereas the conifer supplies have stayed more or less at the same level. Despite a below average cone crop in Britain there has been a good response to a drive to increase home collection and 606 hectolitres in total (comprising 256 hl Scots pine, 215 hl Lodgepole pine, 9 hl Corsican pine, 95 hl Japanese larch and 31 hl of others) were collected. Four and a half hl was obtained from private estates. The increase in requirements for conifer seed in their country of origin has again resulted in shortfalls in our desired importations. Unless home seed production is increased substantially there is a grave danger that planting stock of the desired origin and species will soon become unavailable.

A. G. GORDON

FOREST RESEARCH
SILVICULTURE (SOUTH)

Plant Production

Seedbed Herbicides

Pre-emergent and post-emergent treatments were carried out with bifenox, chlorpropham, cyanazine, dinitramine, ethofumesate, hexazinone, methabenzthiazuron, napropamide, prometryne and terbuthylazine. Napropamide and terbuthylazine were the most promising compounds.

Pre-emergent tests were carried out with several herbicides in mixture with diphenamid. Chlorthal-dimethyl was tested separately for pre-emergent weed control.

Broadleaved Trees in Paperpots (Polythene Greenhouse)

A mixture of two gibberellins (GA₄/GA₇) at concentrations from 50 to 200 ppm caused unacceptable malformed growth of beech. Oak continued to grow well but the increase in height growth was minimal.

Three formulations of the slow release fertiliser 'Osmocote' were tested on four broadleaved and two conifer species in paperpots. No obvious differences were observed.

An organic extract of seaweed which reputedly improves growth, was tested but no differences were obvious for the range of concentrations tested on six species.

Four broadleaved species were sown at four different dates and hardened-off for 0, 4 and 8 weeks before removal to a forest site for planting. Forest performance of paperpot plants was better than plants taken from an ordinary nursery, but unhardened plants were killed in the summer months, only those given eight weeks hardening-off surviving adequately. A 12-week indoor growing period appeared to be too long, allowing plants to grow too tall.

W. J. McCAVISH

Vegetative Propagation

Studies of softwood cutting methods, using overhead automatic mist, were extended to 44 deciduous species, cultivars and trial clones. Some 30 of these were included in medium-term greenhouse experiments to investigate the effects of type of substrate, time of cutting insertion and the application of growth substances in solution on root initiation. Studies were continued to determine the best methods of propagating new clones of Leyland cypress and other × *Cupressocyparis* hybrids.

J. JOBLING

Lowland Silviculture

Nothofagus

Survival of *Nothofagus obliqua* and *N. procera* planted in 1979 in provenance experiments in southern England averaged over 90 per cent. Two sites were planted in late May, but survival was still over 75 per cent.

Some lots of *N. obliqua*, planted in 1978 at Flaxley, have grown over 100 cm and several *N. procera* over 130 cm. The *N. procera* from Nuble have recovered from winter damage and are of average height.

Fast Growing Pines

The provenance experiment of *Pinus muricata*, sown in 1979 at Headley nursery (Hampshire), shows that seed lots from Humboldt County are slower growing than those from further south in California (mainly Mendocino County). Smaller differences occur between origins of *Pinus radiata* in another experiment.

At Cannock Forest (Staffordshire) 5-year old trees were damaged during 1978/79 winter. Results confirm nursery experience reported last year that *P. radiata* suffered the most damage, and Humboldt County *P. muricata* the least.

G. TULEY

Eucalyptus

Following the severe winter of 1978/79 the opportunity was taken to review the potential of eucalypts in British silviculture. Severe damage or death of all species occurred where temperatures fell to below -18°C (Plate 1). Such exceptional temperatures were recorded in narrow valleys in S.W. England in January 1979, but over most of Britain minimum temperatures averaged -8°C . to -12°C . and caused little damage to *Eucalyptus gunnii*, *E. pauciflora* ssp. *niphophila* and *E. perrineana*. Damage to other species varied but several little-known ones survived well; *E. glaucescens*, *E. gunnii* ssp. *archeri* and *E. pauciflora* ssp. *debeuzevillei*.

A few small trials are being laid down to compare seed origins of *E. gunnii* and the growth of *E. glaucescens*, *E. gunnii* and *E. gunnii* ssp. *archeri* with other fast-growing broadleaves *Alnus cordata*, *Nothofagus obliqua*, *Populus trichocarpa* and *Pterocarya* \times *Rhederana*.

Nutrition on Freely Drained Soils

The six-year assessment of a fertiliser experiment in second rotation Corsican pine, growing on a shallow brown/grey sandy loam over chalk drift in the Mundford area of Thetford Forest, showed significant responses to potassium in height growth and especially survival probably due to improved frost tolerance. This is the first indication of a response to fertiliser by Corsican pine at Thetford, though improved growth of Scots pine seedlings with potassium was seen in 1948 experiments. The shallow calcareous soils around Mundford could be expected to be more potassium deficient than deeper soils elsewhere in Thetford.

J. EVANS

Forest Weed Control

Herbicide Screening in the Nursery

Terbuthylazine (a grass herbicide) and cyprazine (a heather herbicide) were screened, both on broadleaved and conifer species. Rates tested were 2, 4 and 8

kg ai/ha for both, applied in April, May and June; and June, July and August respectively.

Control of Grasses and Herbaceous Broadleaved Weeds

Testing of hexazinone continued in lowland Britain. A repeated treatment gave good weed control without harming Corsican pine or Sitka spruce, but *Tsuga* showed some damage. *Dactylis glomerata*, *Calamagrostis epigejos* and *Deschampsia caespitosa* were well controlled, as were all soft grasses present, by 1.8 and 2.7 kg ai/ha (2 and 3 kg product/ha of a 90% w/w powder).

Terbutylazine gave good grass control at 4 and 8 kg ai/ha applied both in spring and at mid-summer. Grass species controlled were *Dactylis glomerata* and *Deschampsia caespitosa*. *Calamagrostis epigejos* was not controlled.

A new granule containing both atrazine and dalapon (CS25H) gave promising results controlling *Arrhenatherum elatius* (false oat) without damaging CP. The 10%/10% w/w granule formulation was tested at 4/4 and 8/8 kg ai/ha (40 and 80 kg product/ha). Atrazine on its own failed.

Control of Bracken

Glyphosate at 0.54, 0.81 and 1.08 kg ae/ha gave good control of bracken after July and August treatments the previous year. Controls with asulam at 2.0 kg ae/ha was slightly better and less damaging on DF and SS.

Control of Deciduous Woody Weeds

Glyphosate at 0.54, 0.81 and 1.08 kg ae/ha gave good control at the middle and high rates whether applied in July or August. Triclopyr amine gave good, and triclopyr ester excellent, control of deciduous woody weeds. NS was unharmed by triclopyr and slightly damaged by glyphosate.

Control of Gorse and Broom

Glyphosate at the dates and rates mentioned above gave poor control of *Ulex gallii*, no control of *Ulex europaeus*, and only moderate control of broom. Triclopyr amine gave excellent control of broom at 0.9, 1.8 and 2.7 kg ae/ha, but only moderate control of *Ulex europaeus*. Triclopyr ester gave excellent control of *Ulex gallii* at rates of 1.2, 1.8 and 2.4 kg ae/ha.

Control of Heather

Two humus iron podsol sites were tested, one with a high annual rainfall and one with a low annual rainfall. Glyphosate at 0.54, 0.81 and 1.08 kg ae/ha gave poor control at all three rates on the low rainfall site and excellent control on the high rainfall site. 2, 4-D treatment behaved in a similar manner. 'ULVA 8' application gave better control than 'Herbi' application at both sites.

Cyprazine and atrazine were tested at 2, 3 and 4 kg ai/ha and 4, 6 and 8 kg ai/ha respectively on a lower greensand site. Cyprazine gave excellent kill at rates of 3 and 4 kg ai/ha in both July and August. Atrazine control was much poorer even at 8 kg ai/ha.

Arboriculture – Department of the Environment Contracts

Nutrition of Amenity Trees

Results of the foliar sampling carried out in 1977 and 1978, from an avenue of Common limes at Avington (Hampshire), have given good indications of the within and between season variation of macronutrients (N, P, K, Ca and Mg). The variation in foliar N concentration during 1977 is shown in Figure 1. These results, together with those obtained from other lime trees in which foliar macronutrients were monitored over 4 years, show that a representative measure of a tree's nutrient status can be obtained by sampling at almost any position on the tree crown, provided that clean, undamaged, fully expanded leaves, which have been exposed to full sunlight, are taken.

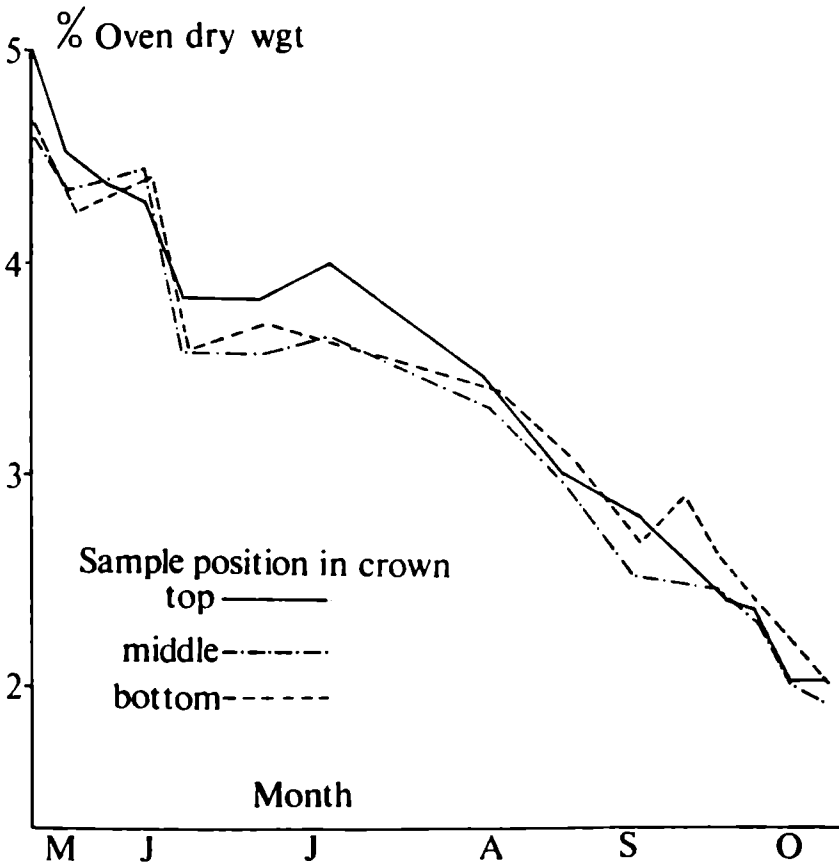


Figure 1. Change in foliar N concentration in 30 common limes at Avington, Hampshire during the summer 1977.

The collection of foliar samples in order to build up an index of the range of macronutrient concentrations in amenity species was continued. The species sampled in 1979 were walnut, Horse chestnut, London plane and False acacia.

Motorway Planting

The season-of-planting trials have been extended with plantings of beech on an M4 site in South Wales. Results from the Esher (Surrey) and Newmarket (Suffolk) experiments, comparing trees grown in Japanese Paperpots with bare rooted stock do not indicate significant advantages from the use of container stock. Although the initial height of the Japanese Paperpot stock used was greater, growth rate and survival were not significantly better than for well-handled, bare rooted stock planted during the normal planting season (October–April). Further experiments to measure the effects of competition by grass sward on tree growth have been carried out in the polythene greenhouses. Another trial to monitor the soil temperature and moisture under different sward control treatments has been established at Alice Holt.

Urban Planting

The experiment to measure the effect of different planting-pit backfills for street trees in Islington has continued. Losses through vandalism have been remarkably few.

Production of Amenity Stock

A further trial of potassium iodide as a defoliant was carried out in October at Hillier Nurseries at Romsey (Hampshire). Silver birch transplants were successfully defoliated by both low and medium volume applications, and with rates down to 0.75 kg ai/ha.

An experiment to assess the effect of undercutting standards one year before lifting was started at Hillier Nurseries at Ampfield. The species being used are sycamore, Box elder (*Acer negundo* L.) and ash 'Westhof Glory'.

H. INSLEY, J. B. H. GARDINER

Arboriculture Advisory and Information Service

A total of 2,045 enquirers (a 36.6 per cent increase on last year) sought answers to 4,048 questions during the year. Damage to trees and mature tree maintenance were the predominant topics of concern, while growth of trees continued to be a major interest of the general public.

Eleven Arboriculture Research Notes were prepared covering interim results from Department of the Environment research contracts, and a range of subjects from 'English Elm Regeneration' to 'The Effects of Trees on Television Reception'.

A two-day seminar, 'Research for Practical Arboriculture' was organised in February at the Lancashire College of Agriculture, Preston. The seminar covered research undertaken for the Department of the Environment, and included papers from other sources. The high attendance, particularly from local authority officers, indicated the interest in the subject and emphasised the importance attached to continuing arboricultural research and the Advisory Service.

D. PATCH, K. D. RUSHFORTH, F. R. W. STEVENS

Colliery Spoil

An investigation lasting 18 months to determine methods of improving the survival and growth rates of trees on reclaimed colliery spoil, by studying tree

root development in relation to the physical and chemical properties of the spoil, was concluded at the end of September 1979. At the beginning of February 1980 work was started under a fresh contract, expected to last five years, to study a wide range of silvicultural problems on regraded heaps. To date seven experiments have been started.

J. JOBLING, F. R. W. STEVENS

Short Rotation Coppice - Department of Energy Contract

Work commenced on a contract to establish experiments to provide data on species, spacing and optimum rotation for short rotation coppice.

M. L. PEARCE

Arboriculture - Other

Rural Arboriculture

Oak (*Quercus petraea*) transplants (1+1's), acorns, larger nursery stock (1+1+2's) and container-raised plants were protected after planting by several designs of single tree shelters. The shelters tested in 1979 at Alice Holt Forest (Hampshire) are shown in Plate 2. There were considerable increases in growth of transplants and container-raised trees with some of the shelters (see Table 1). Temperatures in excess of 48°C., very high humidities and oak mildew did not cause serious problems but some designs delayed leaf-fall. Although this is a single experiment on one site in one season it does appear that shelters can improve survival and growth, protect trees from deer and rabbits and make chemical weed control easier and safer. In 1980 additional designs, new materials and a range of species will be tested.

G. TULEY

TABLE 1

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

	Size at planting	Height and diameter at end of year in different designs of shelter (B = Control)						
		A	B	C	D	E	F	G
Transplants (1+1's)								
Height (cm)	22.0	-	22.1	25.6	29.7	29.6	50.7	35.6
Stem diameter (mm)	4.07	-	4.98	5.27	5.48	5.68	5.63	5.98
Container-raised plants								
Height (cm)	14.8	82.0	21.2	22.9	41.1	47.4	61.4	-
Stem diameter (mm)	2.47	7.86	5.32	5.04	5.20	5.50	5.68	-

Figures are mean values adjusted for initial differences between treatments. The end of year differences are significant at 1% level except for stem diameter of transplants.

Dendrology and Arboreta

Dendrology

During the year 158 estates, collections and gardens were visited to measure specimen trees. Ninety-three of these were first visits, the remainder were for updating the records. Specimens measured and entered in the National Tree Register were 4,889, of which 3,468 were first entries and 1,421 were remeasures. The Register now contains the dimensions of 50,964 trees of 1,361 species and 786 varieties and cultivars. Growth records over longer periods include 890 specimens found and remeasured from 2,535 noted around 1906 by Elwes and Henry, and 2,726 found and remeasured from 4,843 given in 1931 in the Report of the Conifer Conference. These show very interesting variations in growth for different species in different regions.

Westonbirt

The Native Tree Collection and the Hillier Cherry Glade have had their main plantings completed. The John White Willow Collection has been greatly expanded and now includes 150 plants of 48 species, 50 varieties and 25 hybrids, all planted beside a ride on the east side of the southern half of Silk Wood. This is now the national collection of this genus.

The western half of Silk Wood has been given a new system of rides, taking advantage of features remaining from earlier fellings and replanting but designed to take new collections, glades and features.

Bedgebury

Planting in the autumn was again not possible because of continued wet weather, but was carried out in spring when additions were made to many generic collections, notably the pines and junipers as well as the dwarf conifer collection. As the building of the new visitor centre has been postponed indefinitely, the old kennels building, extensively renovated and adapted as a schoolroom, has been equipped as a small centre and shop with various displays including a comprehensive collection of cones.

A. F. MITCHELL

SILVICULTURE (NORTH)

Production of Planting Stock

Herbicides on Transplants

In studies to test the tolerance of Lodgepole pine and Sitka spruce transplants when sprayed with glyphosate, height increment and damage were found to be related to date and rate of application. Lodgepole pine was more sensitive than Sitka spruce, July and particularly September applications even at 0.5 kg ae/ha were quite damaging. On Sitka spruce, rates of 0.5 and 1.0 kg ae/ha when applied in July and September, damaged plants only slightly and, in very weedy conditions, this could be considered acceptable. May applications were very damaging on both species whereas November applications up to 2.0 kg ae/ha caused only a very slight depression in height growth.

In similar experiments to test the tolerance of transplants to overhead sprays of hexazinone damage, levels were high.

Experiments continue on the use of herbicides to remove *Rumex acetosella* and *Equisetum arvense* from amongst Sitka spruce transplant lines. Glyphosate at 1.0 kg ae/ha sprayed inter-row in July gave very effective control of *Rumex*. MCPA at 2.0 kg ai/ha sprayed inter-row in July gave moderate control of *Equisetum*.

Cloches on Seedbeds

Experiments continue attempting to find a cloche technique suitable for Sitka spruce. The 1979 growing season lacked periods of hot weather so that even clear polythene cloches produced good results without the scorch damage which has occurred in previous years. In one experiment the mean height of cloched seedlings was 7.2 cm as compared with a conventional uncovered seedbed mean of 3.6 cm. White polythene gave a small improvement in numbers compared with clear. 'Seep-hose' irrigation run along the centre of the seedbeds throughout this experiment seemed to make little difference, again perhaps because it was not a dry season.

Vegetative Propagation

A series of 22 forest experiments, 13 with Sitka spruce and 9 with Hybrid larch, have now been planted to compare cuttings with transplants on a complete range of sites.

P. BIGGIN

Planting

Spraying transplants with HCH

Spraying transplants with HCH (2% 'Gamma-col') in the nursery before lifting, as an alternative to the dipping of plant tops in HCH, protected plants effectively against weevil attack after planting at Glenbranter Forest (Strathclyde).

Dipping in HCH was shown to have a depressing effect on height growth compared to dipping in water or spraying with HCH both at Glenbranter, and in a similar experiment at Dalnacallan Forest (Dumfries & Galloway) where there was no weevil attack.

Spraying trials in the nursery using a dye showed that the pattern of distribution of spray can be altered considerably by varying the spray technique. Fan jets mounted on droppers with the spray fan horizontal and directed at the plants were found to give the most effective coverage of the base of the plants. A double pass gave even more effective coverage. Further experiments using such techniques with HCH, particularly testing lower rates, are required.

P. BIGGIN

Species Trials

Provenance Experiments with Black pine (Pinus nigra)

Between 1960 and 1966, forty-seven lots of various forms of Black pine were planted in the central Pennines, on four sites where air pollution by smoke and

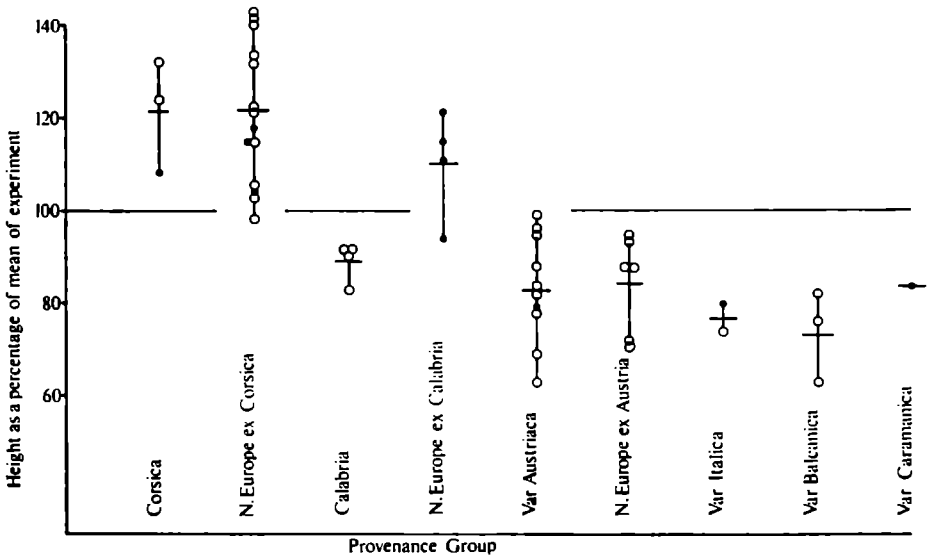


Figure 2. Height at 10 years of *Pinus nigra* provenances on air polluted sites in the Pennines.

sulphur dioxide was considered to affect growth of conifers. Some came direct from Corsica or the European mainland (Switzerland to Turkey), others from plantations in Britain, France, Belgium or Denmark. Heights at 10 years have been expressed as a percentage of the mean of each experiment (Figure 2). The overall mean height for each provenance is shown as an open circle for those represented in only one experiment, and as solid circles for those represented twice or more. The five tallest provenances were all from plantations in northern England or Denmark, and were all ex-Corsica. This illustrates the benefits of home collection of seed with this species.

Seed origins of Lodgepole pine (Pinus contorta)

Experiments with 24 origins of Lodgepole pine at Rumster and Glengarry Forests (Highland) and Strathardle Forest (Tayside) were assessed at 10 years. The Rumster site, near Wick, is on a very exposed deep peat bog. Considerable site \times provenance interaction occurred, with origins from Coombs, Vancouver Island and Shelton, Puget Sound showing very poor growth at Rumster, while at the other sites they ranked fourth and sixth respectively. Origins which had a higher relative ranking at Rumster were Mt. Ida, and two lots from the Skeena River (Kispiox and Cedarvale), all in British Columbia. Several origins are growing at a rate equivalent to GYC 16 in the Glengarry experiment.

A data bank is being prepared, based on 236 seed lots. Height data are converted to GYC, allowing comparison of trees of different ages on over 50 sites. Together with stem form, this should help to improve recommendations for choice of origin in different site regions and soil types.

Flushing of Grand fir (Abies grandis)

Stage-of-flushing was assessed in 1977 and 1978 on 24 origins of Grand fir at Speymouth Forest (Grampian) and Dunkeld Forest (Tayside). Differences between origins were significant at the 0.1% level on each occasion, most of the variation occurring between geographical groups. Coastal lots from Vancouver Island and S. Oregon flushed earlier than those from both east and west of the Cascade Mts. There was little correlation between flushing and height growth. However, those from above 1200 m were last to flush and also grew slowly while one from Matlock, in the southern foot-hills of the Olympic Mts, also flushed very late, though it was the tallest.

Seed origins of Norway spruce (Picea abies)

The results of the IUFRO experiments with Norway spruce at Drummond Hill Forest (Tayside) and Minard Forest (Strathclyde) were reported at a conference in Romania (see Appendix I and Plate 3). The magnificent Carpathian seed stands were visited while at this conference.

Arboreta

Many *Eucalyptus* spp. in the Kilmun Arboretum (Strathclyde) suffered severe foliage browning during the hard winter of 1978/79. *E. parvifolia* was undamaged, *E. archeri*, *E. gunnii*, *E. coccifera* were only slightly damaged but several *E. johnstoni* died.

The Crarae Arboretum on the shores of Loch Fyne was leased to Sir Islay Campbell for recreational use in conjunction with the adjacent Crarae Gardens. The scientific value of the Arboretum will be preserved by the Forestry Commission maintaining the records for each plot.

R. LINES

Cultivation*Ironpan Soils*

Existing experiments indicate that responses to deeper and more complete cultivation (S60/T90/m/I 0.8) does not give increases in yields during the first rotation commensurate with the cost of treatment. One reason is the early time at which trees show nitrogen deficiency symptoms. A new experiment at Teindland (Speymouth Forest, Grampian) was designed to investigate this aspect of cultivation of heathlands. Each cultivation treatment plot will be split to investigate the effects of inter-row cultivations and additions of 2, 4-D or nitrogen fertilizer.

Cultivation of Restocking Sites

Trials have taken place during 1979 in which a Caterpillar D6 LGP (low ground pressure) tractor has been used to pull a double mouldboard plough (D60/T90/t) over restocking sites which previously carried stands of Sitka spruce. This treatment was one of four in a new experiment laid down in

Falstone Forest (Northumberland). The soil type, a peaty gley, has a high water table after clearfelling giving traction problems. Brush left from Sitka spruce does not readily snap under tracks of tractors but becomes quickly entangled in any implement pulled through these sites. The experiment compares three ploughing techniques (a winged ripper -/T90/t, a moleplough -/M90/t, and a deep double mouldboard plough - D60/T90/t) with a treatment consisting of drains at 18 m with spoil mounds in between and a control, and also compares planting in March and May.

A further experiment on a peaty gley restocking site was established at Torridge Forest (Devon) where plots with and without mounds are compared. In addition three types of plant treatments are compared, normal transplants planted in March, transplants stored in a cold store and planted in June and seedlings raised in paperpots and planted in June. Difficulties in planting through Sitka spruce brush are to be investigated. Finally the effect of total weed suppression is compared with normal weed control methods which are restricted to the immediate surround of a tree.

D. A. THOMPSON

Nutrition

Establishment Phase

Prescriptions for the fertilizer treatment of Sitka spruce up to the canopy-closure stage will shortly be published for a wide range of upland soils. Monitoring of long-term experiments on the effect of different fertilizer regimes on the yield of Sitka spruce and Lodgepole pine continues and a new series of experiments is planned for restocking areas. A new experiment was established to examine liming as a means of overcoming the phosphorus fixation problem in the basalt-derived soils on the west coast of Scotland.

Pole Stage

Results of pole-stage fertilization experiments in Sitka spruce continue to be unpredictable and foliar analysis, as practised at present, does not provide a reliable indicator of possible responses. Results from Lodgepole pine and Scots pine experiments have been more promising. A good correlation has been established between foliar nutrient content and growth in pole-stage Scots pine stands, enabling fairly accurate predictions of fertilizer response to be made.

Tissue Analysis

Monitoring of seasonal variation in foliar nutrient levels in Sitka spruce and Lodgepole pine at two sites continues. An investigation has begun into the distribution of nutrients within the foliage of pole-stage Sitka spruce stands, with respect to crown position and age of needle, to see if a better diagnostic technique can be developed for identifying deficiencies and predicting fertilizer response.

Analysis of the nutrient content of buds proved to be of little value but preliminary investigations of bark analysis have suggested that this might be a useful alternative to foliar analysis.

Forest Weed Control

Heather Control

Trials with the 'Herbi' controlled-droplet applicator have shown that it can be used to extend the heather spraying season since the larger droplet size results in less drift, and consequently less damage, than the 'Ulva' when applied during the growing season. However, rates of 2, 4-D must be increased by 30–50 per cent to achieve effective heather kill.

Trials with glyphosate have shown it to be effective against heather and experiments are in progress to determine the optimum rate and time of application for both peat and mineral soils.

Aerial application of glyphosate was carried out on a trial basis in South Scotland Conservancy, and results were promising enough to allow planning of a further trial in 1980.

Objections have been raised by Regional Water Authorities to the application of 2, 4-D in reservoir catchment areas. Trials carried out with Strathclyde Water Authority and The Clyde River Purification Board suggest that run-off of 2, 4-D into adjoining water courses is likely to be very slight and should not give rise to any problems of water taint.

R. McINTOSH

Wind

Topographic Influences on Wind Structure

Comparisons of topographic models of part of Wauchope Forest (Borders) with actual wind data recorded on site, illustrate acceptable levels of correlation in both mean wind speed and turbulence intensity between the wind tunnel and field data. This work was carried out under contract by Environmental Science Research Unit (now, Environmental Aerodynamics Group) at Cranfield Institute of Technology between 1977 and 1980.

Equipment to capture wind data has been installed in Glentrool Forest (Dumfries and Galloway). The very broken topography in this forest is expected to influence wind structure more drastically than the gently rolling topography of the Border forests studied previously. A scaled topographic model of the study area at Glentrool Forest has been assessed in the wind tunnel at the Department of Aeronautics at Bristol University, and results will be compared with field data to be assembled during the 1980–81 winter at Glentrool. The primary objective is to improve the 'topex' system of exposure assessment, particularly in its application to the Windthrow Hazard Classification.

Windthrow Hazard Classification

Validation of the Windthrow Hazard Classification in the Border forests indicates that the predictive capability of the system is good, with actual onset of windthrow occurring typically at ± 2 metres from the predicted top height, and at some forests at top heights consistently closer than $\pm \frac{1}{2}$ metre. The system requires further checking on a wider range of sites, particularly on rougher terrain where greater deviations are apparent. Additional data from

tatter-flags studies are providing bases for changes in the wind zones, particularly in parts of central and southern Scotland.

Measurement of Wind and Exposure

Use of tatter flags has increased, and their application in defining upper planting limits and improved wind zonation continues. Trials of prototype gust counters produced acceptable reliability and accuracy under field conditions, and it is proposed to deploy these instruments in an experiment to compare stand damage levels with detailed wind measurements. A battery-powered chart recorder which monitors both wind speed and direction has been constructed and tested, and is now installed as part of the Glentroot instrumentation.

Influence of Thinning on Windthrow

The series of thinning experiments in the Border forests, Wales and northwest England has yielded little additional information, but overall confirm the increasing risk of early onset of windthrow from line and chevron thinning, through selective thinning to non-thin. In addition, line thinning, particularly in combination with close-spaced ploughing, tends to produce rapid extension of windthrow following onset. A new series of experiments is planned covering a wider range of stands and sites, and incorporating different timings and intensities of thinning.

Extension of Windthrow

Work to date on the rate of spread of windthrow shows an extremely wide variation in response, which is related to the complex interaction of stand characteristics, silvicultural treatment, soil type and wind regime. Several Border forests covering a range of stands and site conditions have been selected for study. Preliminary analysis of aerial photographs will identify stands where windthrow is spreading at different rates, and will be followed up by detailed ground survey to determine stand and site factors which are influential in determining differential extension of this damage.

K. F. MILLER

SITE STUDIES (SOUTH)

Foliar Analysis

Service

The number of foliage samples presented for analysis was about 5,000, a considerable (and welcome) decrease compared with the previous two years. There has however been a large increase in other types of samples, such as litter and wood, and also in the elements to be analysed.

Methods

The Spectraspan III has shown itself capable of determining trace elements in plant material, for which there is an increasing demand and development of methods for several elements is continuing. A photographic system to record the emission spectrum is nearing completion. This method is useful when the analytical requirement is not clear and will be the first stage in establishing differences between samples. An automatic sampler is being adapted for use with the Spectraspan which will reduce the amount of operator involvement. The Transdata 309 (*Report* for 1979) has markedly improved the data handling; programs are being developed to make optimum use of the analytical results.

A. WILLSON

Soil Analysis

The dependence of the concentration of 'extractable' elements on solution-soil ratio and time can be interpreted in terms of simple mechanisms involving the reactions within the soil and the interaction between the solution and the soil. For potassium there is no evidence that reactions within the soil contribute to the measured concentration unless they are extremely fast, $t_{\frac{1}{2}} < 1$ minute, which seems unlikely. In contrast the reactions within the soil are very important for phosphate. The results suggest that a series of consecutive, reversible reactions exist in which the form of P estimated, using the normal Bray 2 conditions, is in equilibrium with another form whose concentration is many times larger. The existence of parallel reactions, i.e. the extractant dissolving increasingly less soluble forms of phosphate, is not supported by the results. The relationship between these different forms of phosphate and tree growth is to be investigated further. Results suggest that Ca, Al and Fe have much more complex reactions and it is not possible at present to establish which forms of these elements are being estimated using extractants.

A. WILLSON

Effects of Trees on Sites

Thinning and spacing trials

A repeated study of the development of soil conditions in response to thinning intensity has confirmed the result (*Report* for 1979) that light thinnings minimise litter accumulation under Sitka spruce. Parallel investigations into the accumulation of litter in response to spacing have suggested a similar pattern: planting intervals of 1.5–2 m reduced litter accumulation by 10–15 per cent compared with either close spacing (1 m) or wide spacing (2.5 m).

Whole-tree harvesting of Sitka spruce

Studies are continuing of the likely nutrient loss from sites at which forest residues as well as stem-wood are harvested. Sitka spruce crops of GYC 10 and less are currently being analysed; these will be compared with the GYC 12 and 16 crops mentioned in the *Reports* for 1978 and 1979.

M. ANDERSON, K. G. SHUKER

Lowland Production Forestry—On Derelict Land

Reclamation methods

During 1979 further trials were made of the winged tine sets mounted on a Caterpillar D8 (300 hp) tractor to loosen compaction caused by earth movers such as box-scrapers and bulldozers. Although soils loosened by tining in 1976 have firmed up somewhat, they are still loose enough for normal rooting. Experience on various restored sites has confirmed our view that a slope of 4–5° is necessary to induce water movement through soil. The easiest way to produce this slope is to make large ridges 30–40 m across, 1.5–2 m high in the middle, and cross-rippled to 750 mm with winged tines. The ridges themselves slope along their length to give a gentle fall in the gullies between them. These slopes and dimensions are a compromise between the constraints of erosion and stagnation. The aim is to remove by gravity all water present in the spoil at tensions lower than field capacity. The configuration recommended for porous sites is shown in Figure 3.

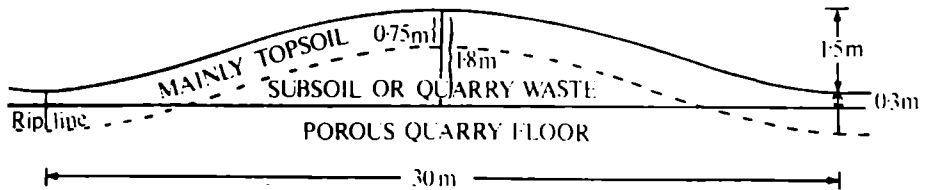


Figure 3. Recommended land form for restoration over porous sands. Ridges ripped across by Caterpillar D8 with multi-shank ripper, tool points at 750 mm. Vertical scale 2 x horizontal.

The Branch has been consulted about the covering of domestic waste tips in preparation for tree planting. Ridge patterns as described above for normal restoration are recommended, but it is essential to have at least 1 m thickness of inert fill over the sealing cover. This allows tining to 750 mm, which should provide both adequate rooting depth and storage of 100–150 mm of available water.

Spoils and nitrogen

Many surface workings lack topsoil, so that tree species other than alders and *Robinia* are slow-growing due to nitrogen deficiency. A range of herbaceous or shrubby legumes are therefore being tried, but these need treatment for hard seed-coat dormancy (as does *Robinia*). Of two commonly recommended treatments, the hot water soak is not reliable and the concentrated sulphuric acid soak is not only dangerous but also requires pilot time trials for each seed lot.

Abrasion techniques are therefore being tried in the hope that seed so treated can be stored dry, ready for sowing. This work is described further in the Seed Branch Report (p9).

Seeds of *Lupinus arboreus* and *L. polyphyllus*, *Lathyrus sylvestris* and *L. latifolius*, *Galega officinalis*, and commercial strains of *Melilotus* and *Trifolium* species are in stock for field trials.

D. F. FOURT

Upland Production Forestry

Characterisation of Site Properties from Borehole Data

Daily borehole readings from a drainage trial at Crychan Forest (Powys) were modelled descriptively (Rennolls, Carnell & Tee, 1980). The results were statistically analysed and it was found that only in the most intensively drained plots was the drainage rate of saturated profiles significantly different. Examination of a functional model showed that the absence of a larger drainage effect was due to a combination of the thin layer of permeable soil and site slope, even though this was only 2–4°. There was no change in soil transmissivity due to crop/drainage interactions.

The model parameters were found to relate to conventional soil physical parameters and there was good comparison between hydraulic conductivity measured by the auger hole seepage method (Boast & Kirkham, 1971) and conductivity derived from the model parameters.

R. CARNELL

Amenity Forestry and Arboriculture

Work during the year has been restricted to advice and assistance to Silviculture Branch projects.

W. O. BINNS

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 been several enquires about yellow-tipped foliage, mainly in young conifers. Foliar analysis confirms magnesium deficiency, but the condition is believed to be induced by poor physical conditions in the rooting zone rather than by low soil magnesium.

At the enquiry into proposed deep mining in the Vale of Belvoir (Leics), Bedfordshire County Council proposed that the spoil be used to fill up their vast areas of worked out brickpits. Forestry is one possible land use; the spoil would be formed into ridges with some clay waste mixed in with the surface layers of shale to reduce the effects of the moderate pyrite contents. Because of the lack of topsoil, a woodland consisting mainly of alders has been suggested, with a small proportion of other broadleaves and a few Corsican pine.

D. F. FOURT

Enquires concerning water use by trees have increased following the dry period of 1975–1976. To fill an evident information gap, an Arboricultural Leaflet entitled *Trees and Water* will be published in 1980.

W. O. BINNS

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SITE STUDIES (NORTH)

Classification and Improvement of Upland Soils

Clay and Ironpan Soils

The experiment at Falstone Forest comparing the effects of Sitka spruce and Lodgepole pine stands, planted in 1952, on the properties of a peaty gley has continued for three years. Beneath Lodgepole pine the soil was dried more deeply and intensely than beneath Sitka spruce, although the difference was less marked in the wet summer of 1979 than in 1977 and 1978.

Analyses of the composition of the soil air showed that in 1978, under the trees, 30 cm depth of soil was well aerated at all times, whereas under *Molinia* grassland the soil was not consistently well aerated even at 15 cm. Under Lodgepole pine summer drying was sufficient to aerate the soil for 3 months duration at 60 cm depth, and for 2 months at 90 cm. Under Sitka spruce aeration showed only short-term improvement at these depths.

When the soil was rewetted in the autumn the water table returned to the same depth (about 35 cm) under pine and spruce, compared with about 15 cm under the grass. The effect of the pine in drying and aerating the subsoil does not therefore seem to produce a permanent improvement in the structure and hydraulic conductivity of the soil.

A study of soil physical conditions has begun at Birkley Wood, Falstone Forest, in a stand of Sitka spruce planted in mixture with Scots pine in 1916 and now about 27 m top height. According to the windthrow hazard classification of Booth (1977) the site has a hazard class of IV and windthrow would be normally expected to begin at a top height of 16 m. Only a few individual trees have so far been blown down, so the stability of the stand is of great interest. The soil appears to be a typical peaty gley on clayey till derived from Carboniferous rocks and the evidence, so far, from exposed root systems and the soil moisture regime, is that rooting is as shallow as usual on such soil. The trees appear to have particularly wide-spreading root systems, with thick buttress roots close to or at the surface extending for up to 4 m.

Deep Peats

'Irreversible drying' of peat which takes place after afforestation (Pyatt and Craven 1979) is the progressive reduction in the water holding capacity of the material. The process is being studied in the laboratory using samples of different kinds of peat taken from planted and unplanted sites.

A preliminary account of the work on the classification of peatlands by physical and chemical properties has been published (Pyatt, Craven and Williams 1979). The existing classification is effective in predicting the contents of N, P and K in the peat using the presence and vigour of 'indicator' plants in the pre-planting vegetation.

D. G. PYATT

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FOREST GENETICS

Testing

Pollinations

Three of six programmes of single-pair matings between widely separated populations of Lodgepole pine have been completed. Additional effort has been directed towards improving selected populations and at the same time establishing seedling orchards to provide seed for commercial planting purposes. The first two origins selected for improvement were Queen Charlotte Islands (QCI) and Burns Lake, British Columbia (BC). A programme of 160 single-pair matings was completed in a privately owned stand of Burns Lake origin at Meallmore, south of Inverness (Highland), and 76 crosses within a seed stand of QCI material at Neroche (Devon). Pollen was collected from a further 100 trees of the QCI material for use in the 1980 hybridization programme and from 120 trees of Sonora Island, BC origin at Wykeham (Yorkshire), for the production of provenance hybrids with a Southern Interior BC source in 1980. A similar hybrid has shown exceptional promise in earlier tests planted in 1965.

The quantity of female flowering in Sitka spruce was moderate in the tree banks at Wauchope (Borders) and Ledmore (Tayside) where 34 crosses were made using pollen collected from grafts established in an unheated polythene tunnel-house. Twenty-one specific crosses were made between clones selected for good general-combining-ability on the basis of half-sib progeny tests, and now established in the first clonal seed orchards. Grafts of clones included in a population study flowered well and 84 specific crosses were made to provide families for special heritability studies.

Forest Progeny Tests

Sitka spruce and Lodgepole pine progeny testing continued with replications on three sites. A further 124 open-pollinated families of Sitka spruce and 80 families of Lodgepole pine derived from single-pair matings between south (Washington) and north (Alaskan) coastal populations were planted. A hybrid larch progeny test to compare 22 families, derived from European larch plus trees crossed with a 10-parent Japanese larch pollen mixture and raised in outdoor progeny beds, was also established. This experiment parallels the 1978 polyhouse early-test of the same families, and will enable comparisons to be made between the early-test results and forest-grown plants raised by more traditional methods and measured at intervals over several years.

Methods of assessing stem straightness in Scots pine and Sitka spruce progeny tests were reviewed. The standard method has been to count the number of internodes displaying a bend on each tree; no account being taken of the amplitude of each bend. This method successfully identifies only the extremes of the range and on subsequent checks was found to have poor repeatability particularly in the middle range of values. A totally subjective score of tree form, confined to families of superior vigour, is now being field tested.

Breast-height diameter was assessed in a 26 year-old progeny test of Sitka spruce, and a strong correlation was found between this measurement and height at both 6 and 3 years ($r = 0.86$ and 0.87 respectively, both significant at $p = 0.001$). This is an encouraging result and supports present practice of making selections from progeny tests within the first 10 years. Height and volume have since been measured and it is planned to collect wood samples in order to investigate juvenile-adult correlations for wood density, early- and late-wood percentages and perhaps fibre lengths.

Nursery Progeny Tests

The design and layout of nursery experiments, in which the progenies of selected trees are raised prior to forest-stage planting, have been modified in order to equate block size and isolate blocks on separate nursery beds, despite variation in the available numbers of families and seedlings per family.

Seed Production

Flowering Studies

The effect on flowering of removing $\frac{1}{4}$, $\frac{1}{2}$ or $\frac{3}{4}$ of the crowns of 24 year-old Scots pine grafts in an orchard is being studied in a new experiment at Spye Park, Savernake Forest (Wilts. and Hants.). Collecting cones from tall grafts is difficult and most of the easily accessible lower branches bear predominantly

male flowers. It is hoped that heavy crown-pruning will promote a much higher proportion of more easily accessible female flowers nearer to the ground and so prolong the effective life of the orchard trees.

Seed Orchards

Liasion with Conservancy staff continued and additional clonal Sitka spruce and seedling Lodgepole pine orchards were established at Coed Preseli Forest (Dyfed). The first stage of a new Hybrid larch orchard was planted at Torridge Forest (Devon). Grafts or seedling progenies for the orchard programme are raised within the Genetics Branch and planted by Conservancy staff, to a plan designed and developed by Genetics staff. Subsequent maintenance of the orchards, crop estimates, and cone collections are the responsibility of the local Conservancy staff which is advised by Genetics staff annually.

Seed Stands

Twenty-two seed stands, including seven Japanese larch and six Scots pine stands, were added to the National Register during the year. Fifteen applications for the registration of stands for seed collection were refused. Ninety-five stands were re-inspected; as a result of selective fellings and the poor management of some younger stands, 13 were withdrawn from the Register. Multi-origin seedling seeds stands of *Nothofagus procera* and *N. obliqua* were established at the Kinver (Staffs.) section of Wyre Forest.

Biochemical Variation

Genotypic variation within and between many of the relict populations of native Scots pine in Scotland has been studied by monoterpene analysis of shoot cortical resin and isoenzyme analysis of seed endosperm. Monoterpene analysis has enabled the native pinewoods to be divided into a small number of biochemically distinct groups, the most distinctive being a north-western group of populations with Shildaig as the most outstanding population. Other regions included northern, south-western, and central groups, central Speyside, and outer Speyside with eastern Deeside. In several cases a high degree of variation was detected between different locations, for example, within the largest woodlands, Abernethy, Glentanar, and especially Glen Affric. The degree of similarity between any pair of sites was indicated by cluster analysis and principal coordinate analysis of the monoterpene data, which together with the regional divisions are recommended as guidelines in the selection of material for replanting existing native woodlands in order to preserve the genetic integrity of the remnant populations. Because of the highly localised clustering of biochemically related genotypes, the mother-trees selected should be spaced well apart from each other within the area to be sampled. Isoenzyme analysis is as yet incomplete.

Data Base

Work is now at an advanced stage of preparation for the mounting of a computer-based data-bank of all tree breeding records of all species. The system, referred to in the *Report 1979*, will use the IDMS package available on the ICL 2980 computer at the Edinburgh Regional Computing Centre.

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

TREE PHYSIOLOGY

Vegetative Propagation

Micropropagation

Mature embryos from Sitka spruce seeds of known parents have demonstrated a varied response to different types of cytokinin, added to the agar induction medium, both within and between crosses. The embryos were induced into callus growth on a medium containing cytokinin and auxin, and numerous short shoots were formed on these calluses after transfer to a hormone-free agar medium (Plate 4). However, the larger shoots suppressed the development of surrounding smaller shoots. Outgrowth of the smaller shoots was promoted by sequential harvesting of the larger shoots and in some instances up to thirty shoots over 2 cm long have been harvested from individual cultures, with development of the calluses still occurring. Rooting of the short shoots produced from culture has proved to be difficult though not impossible on agar under sterile conditions (Plate 5). However, shoots that have been grown to a length of 4 cm on the sterile medium have been successfully rooted like normal stem cuttings under mist.

A. JOHN

Flower Induction

Flowering of Sitka Spruce

Applications of the hormone mixture Gibberellin $A_{4/7}$ in 1978 produced a variety of results. A single injection into the main stem of mature cuttings stimulated the production of male and female strobili, with the greatest effects at the highest application rates (Figure 4). The experiment extends previous research in which $GA_{4/7}$ stimulated flowering in mature grafts following repeated applications to the branches or buds. However, the other experiments frequently gave no stimulation of flowering, and these experiments included both mature grafts which have previously flowered, and trees from a diallel cross experiment which have responded favourably to $GA_{4/7}$ treatment in previous years. It is a common though little reported feature of experiments with $GA_{4/7}$ on the *Pinaceae* that the treatment is not always successful, particularly in years when the level of flowering in untreated plants is low, although the hormone usually enhances flowering in good flowering years. The research is continuing with fundamental work to investigate the main environmental factors responsible for flower induction and the physiological changes which take place within the plant. Observations on root activity are being made to study the role of the root system.

Flowering of Larch

The European larch which were winched to the horizontal position in 1978 have remained alive and have again flowered in 1980. There was considerable bark damage and the response could be due to ringing or the gravimorphic effect. Additional trees were winched over in 1979 with less bark damage and these have also produced male and female strobili in 1980. The experiments

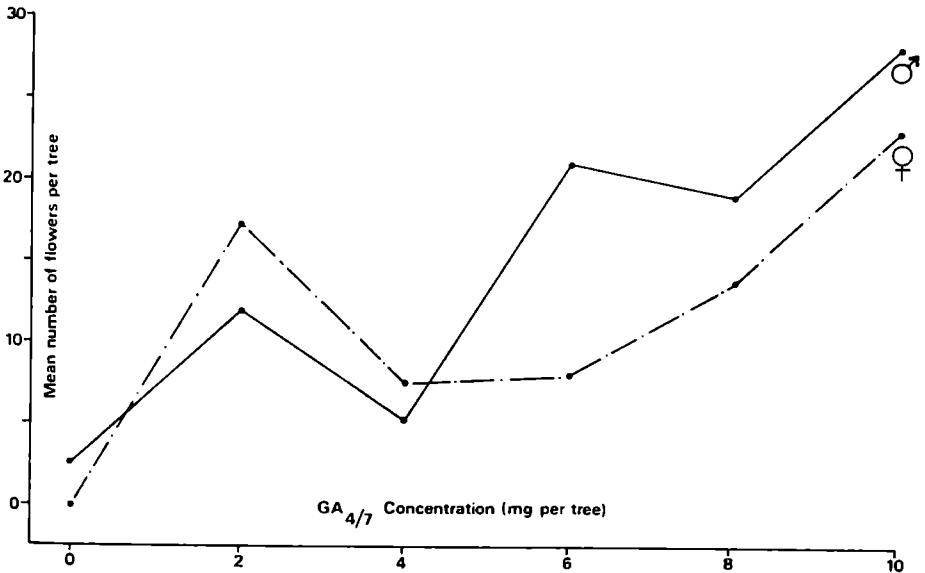


Figure 4. The effects of a single injection of GA_{4/7} into the main stem of mature Sitka spruce cuttings on induction of male and female strobili.

thus support the idea that this is a useful technique which makes the branches accessible for both the application of experimental treatments and controlled pollinations.

Grafted clones of European, Japanese and Hybrid larch are being used to investigate the effects of chemical and physical treatments in flowering.

J. J. PHILIPSON

Establishment After Planting

Further work on the first symptoms of planting shock in Sitka spruce seedlings showed that, when actively growing seedlings were transplanted under growth room conditions, transpiration decreased over a period of a few days, indicating progressive closure of the stomata. Detailed measurements of leaf water potential showed that the closure occurred in the complete absence of water stress; indeed, transplanted seedlings commonly had a higher leaf water potential than undisturbed controls.

Transplanting also caused an abrupt cessation of root extension. Root growth was resumed after a variable period, often from the original root apices, and the transpiration rate gradually recovered. Closure of the stomata apparently occurred in response to some message from the disturbed root system. Preliminary work, in which detached shoots were stood in vials of xylem sap extracted from transplanted and from undisturbed control seedlings, suggested that the sap from transplanted seedlings caused closure of the stomata. The work indicates that after transplanting, water loss from the shoot is under partial control by the root system. The precise nature of the damage to the root caused by transplanting is not known, but is under investigation.

M. P. COUTTS

FOREST PATHOLOGY

Fomes annosus (Heterobasidion annosum)*Spore Infection of Lodgepole Pine and Sitka Spruce Stumps*

In inoculation experiments, stump infection in Lodgepole pine and Sitka spruce was extremely variable both within and between sites. In mixed crops of both species, Sitka spruce stumps were generally less susceptible to infection than those of Lodgepole pine, particularly in terms of the proportion of the stump cross-sectional area occupied. Of 120 stumps of each species inoculated the proportion of stumps infected was 50 per cent for spruce and 61.7 per cent for pine. The respective figures for the cross-sectional area occupied were 9.4 per cent and 23.3 per cent.

The bark on a proportion of stumps of both species remained alive for at least two years after felling, particularly on peat soils, due to the presence of root grafts with neighbouring trees. This was more common in Sitka spruce than Lodgepole pine. There was some evidence that infection occurred more frequently in living Sitka spruce stumps than in those which died rapidly after felling.

A significant negative correlation of infection with average annual rainfall suggests that stump infection in Sitka spruce may be limited by high rainfall.

D. B. REDFERN

Dutch Elm Disease*Variation in Ceratocystis ulmi*

The centre of origin of Dutch elm disease and the full extent of the variation in the fungus need to be established before resistant elm material can be introduced with confidence. Recent work has shown that the aggressive strain of *C. ulmi* occurs as two distinct races, a Eurasian (EAN) and a North American (NAN) race (Brasier, 1979). The two races are morphologically different in culture. Mating studies show that they are genetically distinct. The NAN race shows an exclusively westerly and the EAN a predominantly easterly distribution indicating that the recent outbreaks of disease in Europe and south west Asia are of dual origin. The NAN race was almost certainly imported from North America into Britain in the late 1960s and into France, Holland and Germany, probably via Britain, in the early 1970s. The EAN race has probably migrated from Italy, central Europe or from further east.

A survey in Moscow and Volgograd in the USSR in August 1979 yielded only the EAN race, confirming the probable link between the Volgograd disease outbreak of 1967 and that occurring in the Caspian area of Iran in 1970. An extensive survey in Italy in September 1979 showed that both races were present between Milan and Naples with the EAN race predominant. The non-aggressive strain was scarce in the north but increased southwards. It was the only strain present in most of Sicily with the exception of Palermo where the NAN race appeared to be a recent arrival.

C. M. BRASIER

Elm Regeneration

In the majority of the plots set up to monitor the survival of elm regeneration (Report for 1979), the young suckers are still healthy and overall the disease level only increased from 11.2 per cent to 14.3 per cent during 1979. Over half of the 30 plots have less than 10 per cent of trees diseased. Feeding wounds in twig crotches caused by elm bark beetles were uncommon, indicating low populations of *Scolytus* spp. in the areas.

Fungicide Injection

Encouraging results were obtained with high volume curative injections of 'Arbotect 20-S', a fungicide containing thiabendazole hypophosphite (TBZ). Trees with very early symptoms were treated in July and disease development was halted in the majority. Larger scale field trials with Arbotect are planned for 1980.

B. J. W. GREIG

Peridermium pini

A survey in 1979 of Scots pine crops 30 to 60 years old in Thetford Forest (Norfolk and Suffolk) showed a mean incidence of 7.6 per cent of trees with stem lesions caused by *Peridermium pini*. There has been a marked increase in the incidence of *P. pini* in Thetford in the past 15 years, as less than 1.0 per cent of trees were found to be diseased in a survey in 1964.

B. J. W. GREIG

Beech Bark Disease

Disease Development

A survey was initiated, jointly with the Entomology Branch, to follow the development of the disease and its symptoms with time. Eight long-term observation plots, each with about 400 trees, were established in beech plantations in south-east England. A range of site types, and stages in disease development is represented. A detailed assessment on individual numbered trees was made and will be repeated annually for at least eight years. Data will be analysed to reveal temporal and spatial patterns of disease development on individual trees and within each stand.

The simple concept of insect infestation followed by fungal infection provides an insufficient basis for developing models for disease prognosis or for management of disease stands. This survey has been designed to provide models of this type.

Chlorotic Beech Survey

The survey at Arundel Forest (West Sussex) showed a close spatial relationship between the chlorosis and the distribution of microscopically divided chalk in the A1 soil horizon. A comparison between the incidence of beech bark disease on either side of the newly defined soil boundary confirmed preliminary findings, based on the visible chalk/no chalk boundary, that bark necrosis, unlike insect infestation, was more prevalent in the chalky zones.

E. J. PARKER, D. LONSDALE

Advisory Services

Alice Holt Lodge

Six hundred and fifty one enquiries were received excluding those on Dutch elm disease.

An extremely cold winter followed the very mild autumn of 1978, and various forms of suspected cold injury to trees became evident in the spring and summer, the two most notable being death of bark on Lombardy poplars in east England and dieback of Scots and Corsican pine in the region from Cheshire and Staffordshire to Nottinghamshire. The poplar damage varied from complete death of trees to death of small patches of bark on twigs and branches, and there was some evidence suggesting that premature defoliation by the fungus *Drepanopeziza populorum* (imperfect state of *Marssonina populi-nigrae*) had predisposed trees to this injury. The dieback of pines occurred in vigorous 5 to 30-year-old plantations and resembled Brunchorstia dieback caused by *Gremmeniella abietina*. However, only *Cenangium ferruginosum* was isolated from diseased shoots, and there were other differences from Brunchorstia dieback, viz. the failure of adventitious shoots to form below the point of dieback and the absence of a yellow colour in the xylem. *C. ferruginosum* is a common saprophyte occasionally recorded as parasitic on weakened pines. There were outbreaks of Brunchorstia dieback in north Wales and in Lincolnshire, a coincidence that increased the risk of confusing the two types of damage.

Spring 1979 was the fourth coldest and second wettest of the century, conditions that were followed by and probably favoured severe outbreaks of shoot blight of London plane, caused by the fungus *Gnomonia platani*, and of leaf blotch and withering of Horse chestnut, caused by the fungus *Guignardia aesculi*.

In the autumn, needle discoloration and dieback of young Corsican pine developed in several parts of Thetford Chase, East Anglia. Initially affected needles were mainly on the lower parts of the 1979 shoots and were orange-pink in colour. Lammas shoots, abundant on some trees, were killed or severely injured, and necrosis of stem tissues, generally starting about the middle of 1979 shoots, subsequently developed. *Cenangium ferruginosum* was most commonly isolated from stem lesion margins, but the primary cause of damage was probably a succession of unusually severe frosts in mid-September.

J. N. GIBBS, C. W. T. YOUNG, R. G. STROUTS

Northern Research Station

One hundred and forty-one enquiries were dealt with during the year. Only six enquiries concerning Dutch elm disease were received although reports have indicated that the disease continued to be prevalent in the areas where it has already been recorded.

The most numerous enquiries involving damage by living agents were those seeking advice on decay and identification of the fungi responsible. *Fomes annosus* (*Heterobasidion annosum*), *Meripilus giganteus*, *Phaeolus schweinitzii* and *Coriolus versicolor* were among the fungi identified. *F. annosus* was also found to be responsible for the death of conifers making this the single most common pathogen dealt with.

Brunchorstia pinea (*Gremmeniella abietina*) was the second most frequently encountered fungus and, as in 1978-79, it was responsible for damage to both Corsican and Scots pine.

The winter weather of 1978-79 was exceptionally severe in northern Britain and was responsible for direct injury to trees. The most notable form of damage was the widespread foliage browning of pines which became apparent in several forests during early summer. In North Scotland Conservancy, Lodgepole pine in particular displayed a striking red-brown discoloration which, in one stand at least, was distinctly worse on the south side of the crown. Many affected side-shoots failed to flush despite retaining live buds, and shoot dieback was also frequently observed.

Climate was the most frequently recorded abiotic cause of injury during the year. However, there were also numerous reports of damage arising from the misuse of chemicals (chiefly herbicides) and from cultural malpractice.

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

Arboriculture, Department of the Environment Contract

Decay in Amenity Trees

Laboratory and field trials on the effect of chemicals on the callusing of wounds have indicated that preparations containing thiophenate methyl or the closely related carbendazim have a strong stimulating effect. The action is biochemical and not by the prevention of desiccation, as is the case for bitumen and latex paints.

Field trials were laid down to observe the early stages of colonisation of beech stubs following applications of different chemicals. None of the treatments was able to halt bacterial or fungal growth for more than a few weeks, apart from one product, 'Santar' (mercuric oxide), which prevented microbial growth for one to three months. Many of the products were phytotoxic and produced necrotic streaks in the wood, which eventually became colonised by micro-organisms.

Laboratory tests had indicated that several micro-organisms might be suitable for the biological control of decay fungi (see *Report* for 1979) and during 1978/79 these were field tested. Results were promising, especially with *Trichoderma viride* which, after 10 months, was recovered from over 90 per cent of wounds into which it had been inoculated and in 75 per cent of these wounds it was the only fungus present.

P. MERCER

Tree Seed Pathology, Overseas Development Administration Contract

Seeds of tropical pines (principally *Pinus caribaea* and *P. oocarpa*) and potentially important hardwoods (*Cedrela odorata*, *Cordia alliodora*) native to Central America are being screened to determine their mycoflora, and to note incidental pests. Particular attention is given to those potentially damaging fungi and insects for which there is an increasing danger of seed-borne dissemination across international boundaries.

Seed lots of *P. caribaea* from Honduras, which had performed badly under nursery conditions, were infected by virulent isolates of the fungus *Botryodiplodia theobromae*. Certain fungi usually considered to be saprophytic (*Aspergillus niger*, *Trichoderma* spp.) were associated with stunting of young tropical pine seedlings radicles. Sometimes death of the host resulted.

MRS A. A. REES

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FOREST ENTOMOLOGY

Population studies

The Pine Sawfly, Neodiprion sertifer

The attraction of the Pine sawfly *Neodiprion sertifer* to the propionates and acetates of the alcohol 3, 7-Dimethylpentadecan-2-ol was tested on field populations in southern England, Wales and Yorkshire. A good response by males to one of the acetates was obtained, supporting previous laboratory studies based on electroantennogram responses (Jewett *et al* 1976). Pheromone traps baited with this acetate may be useful in monitoring populations of *N. sertifer* in forests at risk.

*C. LONGHURST, D. J. BILLANY

The Web-spinning Larch Sawfly, Cephalcia lariciphila

In 1979 there was a 60 per cent reduction in the area defoliated in South Wales. Reductions in sawfly populations have been attributed, at least in part, to the parasite *Olesicampe monticola*. In South Wales, severe defoliation has persisted only in Ebbw Forest (Gwent). However, small new outbreaks were reported at Irfon Forest (Powys and Dyfed), and also at Crychan where *C. lariciphila* was first found in 1974.

In the Forest of Dean the sawfly has spread into new areas, and there are signs of resurgent populations in areas previously showing a decline.

D. J. BILLANY

The Pine Beauty Moth, Panolis flammea

In 1979, no new outbreaks occurred outside the areas covered by the chemical control programme. In areas with a high risk of Pine beauty attack (*Report* for 1979), pupal surveys were done in autumn 1979 and are likely to be repeated annually. Results show a need to spray 800 ha in Naver (Highland) and

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Bareagle (Dumfries and Galloway) Forests in June 1980. A decision to spray a further 540 ha in Naver and Shin Forests will be based on egg counts to be made in May 1980.

Pheromone traps which attract male *P. flammaea* are being used to obtain relative population estimates in 35 forests in Scotland and the north of England, where pupal counts in autumn 1978 were very low. The traps were supplied by the Chemical Entomology Unit of Southampton University. Population monitoring by pheromone traps is less labour-intensive than pupal surveys, but estimates of population size appear to be less accurate. Also, since eggs hatch shortly after flight activity ceases, the information comes too late for planning large-scale control operations in the same season. However, pheromone trapping may provide a useful early warning for apparently low risk areas which could be followed up by pupal survey and/or egg counts where necessary.

J. T. STOKLEY

The Pine Looper Moth, Bupalus piniaria

As in previous years, 48 separate forest units were sampled for overwintering populations of *B. piniaria*. In each forest the number of compartments sampled was proportional to the total area of pine at risk. Sample transects of 10 circular 0.25 m² plots were taken through forest compartments between January and March.

Throughout Britain, pupal populations overwintering in 1979/80 were generally low. Overall, 20 units showed an increase in the highest compartment pupal density. Pupal densities at Cannock (Staffs) which were highest last year, declined and this year pupal densities (12 per m²) were highest at Roseisle (Laird of Moray, Grampian).

R. M. BROWN

The Felted Beech Scale, Cryptococcus fagisuga

Clonal differences in severity of attack by *C. fagisuga* on beech scions has been observed in seed orchards in southern England. The differences appeared to be largely due to genetically controlled resistance. However, stock/scion incompatibility may have produced changes in the scions of some trees that were favourable for growth and development of *C. fagisuga*.

D. WAINHOUSE

Host Plant Susceptibility

The Green Spruce Aphid, Elatobium abietinum

During the dormant season 1978/79 the foliage of selected Sitka spruce (*Picea sitchensis*) provenances was sampled to follow changes in amino-acid composition during the period when they are most susceptible to attack. Intensive sampling was done during both bright and overcast weather to decide on the most appropriate sampling conditions.

In the field, differences in susceptibility of several species of *Picea* to *E. abietinum* have been observed. A laboratory experiment is in progress to compare growth rates of this aphid on 16 species of *Picea* to determine their comparative suitability as host plants.

Other Aphids

Previous records of *Mindarus obliquus* have been confined to *Picea engelmannii*, *P. glauca* and *P. sitchensis* (Carter and Eastop, 1973). Marked differences in susceptibility of *Picea* species to attack by this aphid were seen for the first time in 1979. In a silvicultural experiment at Rheidol (Dyfed) to assess growth of spruce species at high elevation, the new shoots of *P. albertiana*, *P. glauca* and *P. engelmannii* which have glaucous foliage were attacked by large colonies of *M. obliquus*. *P. × lutzei*, *P. glenhii* and *P. spinulosa* which have green foliage appeared to be unattacked. These observations may be important in selection of spruce species for planting at high elevations.

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

Biological control

Cephalcia lariciphila

Infestations of *C. lariciphila* in South Wales were sampled for parasites as in previous years. No new parasite species were found.

D. J. BILLANY

Rhyacionia buoliana

The chemical E-9-dodecenyl acetate (E9DDA) was used experimentally to disrupt mating of the Pine shoot moth, *Rhyacionia buoliana*, infesting Lodgepole pine at Kilveyhill, Coed Abertawe (W. Glamorgan). Over a 27 day period mating frequency was reduced by 95 per cent. A field trial is planned for 1980 using Conrel fibres to dispense E9DDA in 27 ha of Lodgepole pine at Kilveyhill.

*C. LONGHURST, D. J. BILLANY

Gilpinia hercyniae

Under a seven year biological control programme with the Commonwealth Institute of Biological Control, the final consignment of parasites specific to *G. hercyniae* was received in January 1979.

Populations of the sawfly in the collecting areas in mainland Europe were higher than in the previous year, and 1600 *Gilpinia* sp. cocoons were received of which 10–30 per cent were parasitised.

Releases of parasites were again made at Rheidol Forest and Coed Sarnau (Powys) against natural populations of *G. hercyniae* larvae. In these areas larval populations were higher than in 1978.

D. J. BILLANY, C. I. CARTER

Chemical control

The Pine Beauty Moth, Panolis flammea

Clearance under the Pesticides Safety Precautions Scheme for ultra-low volume (ULV) aerial application of fenitrothion to 3200 ha of Lodgepole pine was given on condition that half the normal dose (i.e. 150 g ai/ha) was used for

*Chemical Entomology Unit, Southampton University

areas close to habitations, and that there was further monitoring of possible effects on humans and the environment.

In the second half of May, egg counts were made in all blocks in the provisional spray programme of 3500 ha (*Report for 1979*). Low egg counts were obtained in 300 ha which were subsequently excluded from the final programme. Spraying was completed by mid-June, and assessments of larval mortality and subsequent pupal surveys showed that good control was achieved in all except two small blocks. One of these received a 'half-dose' application, and the other reduced amounts of insecticide applied as part of an experiment to determine the minimum effective dose.

Environmental monitoring was concentrated at the Elchies block of Craigel-lachie Forest (Grampian), with some additional investigations carried out elsewhere by River Purification Boards. The findings confirmed those of 1978, showing that there was high retention of spray droplets by the forest canopy, with little deposition of the insecticide elsewhere in the environment.

As in 1978 Professor R. J. V. Joyce*, advised on spraying technique. In addition, the Ecological Physics Research Group, directed by Professor G. W. Schaefer*, worked on a model for ULV aerial application of insecticide to forest crops.

J. T. STOAKLEY

The Pine Looper Moth, Bupalus piniaria

In autumn 1978, locally severe defoliation of P65 Lodgepole pine occurred in the Flanders Moss section of Achray Forest (Central) and overwintering pupal densities of up to 27 per m² were found.

Estimates of over 4000 eggs per tree were obtained in the following July in the worst affected area. After completion of egg-hatch on 22 August 1979, 72 ha were sprayed by helicopter with diflubenzuron at a rate of 75 g ai in 20 litres of water per ha. A larval kill of over 90 per cent was obtained by 27 September. The average overwintering pupal density in the sprayed area was 0.3 per m².

Diflubenzuron has not previously been used in British forestry.

D. BARBOUR

Elm Scolytids

Chemical Attractants for Scolytus scolytus (F).

During 1979, 12 further field experiments were done to study the behaviour of *S. scolytus* and to investigate potential attractants.

A trial with Elm billets infested with one or both sexes of *S. scolytus* confirmed that males produce the aggregation pheromone and that females, both mated and unmated, do not contribute to aggregation. When both sexes were present, high numbers of females boring into the billets reduced the attractiveness of the male-produced pheromone.

A sticky trap consisting of a simple plastic fin design was developed and proved highly effective in testing potential chemical attractants.

The alcohol 4-methyl-3-heptanol is produced by males and its importance in aggregation behaviour was confirmed. There was a significant linear response

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of the log-transformed catch of *S. scolytus* on sticky traps to the log release rate of 4-methyl-3-heptanol. A release rate of 800 $\mu\text{g}/\text{day}$ attracted large numbers of *S. scolytus*.

Several host-derived volatiles were tested as possible synergists of 4-methyl-3-heptanol; useful data were obtained and further trials will be performed this year.

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

Advisory Services

Forestry Commission staff sent 105 enquiries to Alice Holt and 43 to the Northern Research Station. The number of private enquiries received was 176 at Alice Holt and 26 at the Northern Research Station.

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WILDLIFE MANAGEMENT

Management of Deer, Squirrels and Other Mammals

A method of determining herd structure in Red deer populations, based on the age and sex of killed animals, has been further developed to include density. This provides a basis for making management decisions and is currently being tested in field conditions. Monitoring Red deer reproductive performance continues and more time is being given to assessing the occurrence of mortality, other than by shooting, although this appears to be by far the greatest factor in woodlands. Rumen contents are being analysed for nitrogen and ammonia as well as for qualitative and quantitative floristic content. This work is being pursued jointly with the Institute of Terrestrial Ecology to provide information linking plant phenology with reproductive performance, nutrition and forest structure.

Indirect methods of assessing Roe deer populations have included counts of pellet group frequency, scrapes and fraying stocks. Investigations of night-shooting have suggested that in some areas this is an essential method of controlling deer in vulnerable plantations. Monitoring reproductive performance in relation to age in southern forests suggests that culling by shooting

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alone rarely takes off the available surplus of Roe deer, and further investigations of other mortality factors and dispersion are being undertaken.

Grey squirrels have been successfully bred in the two enclosures. A further enclosure for both rabbit and Grey squirrel research has been completed but is not yet stocked. Warfarin bait in bar form was found to be unacceptable to squirrels. Investigation of the possibility of using a technique for determining warfarin resistance in rats and squirrels is being undertaken with the Ministry of Agriculture. The annual Squirrel Questionnaire shows the status of both Red and Grey squirrels in Commission forests. The Red squirrel continues to decline slowly in Wales and East Anglia. The long term research project in Thetford Forest (Norfolk) suggests that the Red squirrel population is maintaining itself at present.

Analysis of the Mammal/Bird/Damage Questionnaire has suggested that while pine-martens are holding their own and probably increasing their range in Scotland, the polecat in Wales is decreasing. This may possibly be correlated with the increased reports of mink.

Management of Birds

Comparisons of the birds associated with restocking and afforestation have been made for one season as has the influence of maintaining a proportion of trees beyond their normal economic life. In both cases it appears that the structural diversity of the habitat is a major influence.

Damage Assessment and Evaluation

Damage surveys were made in north and west Scotland to look further at the impact of Red and Roe deer and sheep. Methods of incorporating the recommended damage assessment technique into deer and other wildlife management plans are being investigated. Grey squirrel damage on private estates throughout central Scotland was assessed at the request of the Scottish Woodland Owners Association. This showed that sycamore was the most vulnerable species particularly in the 10–20 year age class. There was some indication of an intensification of damage in recent years. The damage assessment system itself has been tested for the effects of using different assessors, and varying the size of the sample group. Investigations of the effects of bark stripping and browsing damage on the individual tree continue.

Chemical and Mechanical Repellants

Two manufacturers have produced pre-production batches of 25 mm × 50 mm rabbit netting and lightweight 31 mm hexagonal mesh netting. These are being tested for situations where the requirement is short-term protection, and fences require either a short life and low initial cost, or are permanent with an option for recovery and re-use.

The 75 mm diameter polyethylene biodegradable mesh guard is now produced with a square mesh which gives the guard greater rigidity, and overcomes the stability and packing problems encountered with diamond mesh guards. These are effective in preventing roe and rabbit browsing. The larger 25 mm × 35 mm mesh guard has been effective in preventing damage to large standard amenity trees in forest, paddock and street.

No new chemical repellants were tried during the year.

Wildlife Management Techniques

Methods of forest management for conserving rare reptiles and amphibia are being investigated. Initially a survey of potential sand lizard and smooth snake sites in a forest in south-west England has been undertaken.

The use of structural diversity for evaluating the conservation status of the Commission's woodlands on a compartment or sub-compartment basis continues.

Game Resource Evaluation

The status of the woodland grouse species is being investigated. There is some evidence of a decline in both blackgame and capercaillie numbers recently but whether this is a short-term fluctuation or part of the longer-term decline noticed through much of Europe, has yet to be determined.

J. J. ROWE

ENGINEERING SERVICES

Maintenance of Electro-mechanical Services

A wide range of maintenance services carried out during the year included work on the thermo-gradient plate and germination tanks in the Seed laboratory.

Further development was required on the Inductive Loop Detectors installed in the New Forest (*Report*, 1978), which suffered from excessive moisture.

The installation of a complete cable system throughout Alice Holt Lodge for the new PRIME 400 computer was successfully completed.

W. H. HINSON

FIELD SURVEYS

FIELD & SITE SURVEYS

Field Surveys

Fifty-nine thousand and eight hundred hectares were surveyed during the year against a planned programme of 84,500 ha.

Five thousand one hundred and sixty-two man days were employed, giving a mean output per man-year of 2700 ha, which, although rather less than last year, is nevertheless, reasonably satisfactory and implies a survey cycle of rather less than 15 years.

Additional tasks undertaken by the survey teams included reconnaissance site surveys in England and Wales, data base updating and forecasts, the census and elm survey. Miscellaneous tasks, particularly training, technical meetings, special surveys and projects for Conservancies and Headquarters Divisions, together absorbed 2841 man-days.

Site Surveys

The four foresters employed full time on site surveys were reinforced by two survey assistants, and completed 6400 ha of full forest surveys and 9600 ha of preplanting surveys. In addition to this, 3775 ha of forest were covered by Field Survey foresters in Wales.

MENSURATION

Field Survey teams completed the measurement of 212 permanent sample plots including the setting up of a number of new thinning experiments, absorbing 1427 man days.

Within the section itself, work concentrated on a few major projects all of which are now nearing completion.

The assortment forecasting programme is now working but requires a few minor refinements.

Tree volume tables were produced for Thetford Forest. Aerial volume tables were produced for the Census. A programme to enable field staff to make tariff calculations on a hand calculator was produced which should save a considerable amount of their time. Check runs on tariff data at Alice Holt are, however, likely to continue.

MSI hand-held data terminals were successfully tried in the collection of sample plot data and their use will be extended.

The new series of yield models to replace Booklet 34 are very nearly ready for publication.

DRAWING OFFICE

The Census dominated Drawing Office work during the year, involving the preparation of 1:50 000 scale maps from Conservancy records, and the marking up of woodland sheets for digitising. The completion of Field and Site Survey final maps and the introduction of new mapping procedures has suffered in consequence of this and staff shortages.

The Air Survey Sub Section was established with a CPI stereoplotter as the principal piece of specialist equipment. This instrument produces accurate, draft, forest detail maps for aerial photography which leads to faster ground completion of the survey. A detailed index of up-to-date air photo cover was built up over the year and provides a rapid reference system for most FC requirements. It has also aroused a good deal of interest amongst outside bodies.

CENSUS

The year was taken up with training courses, a pilot survey of non-woodland trees, a repayment survey of the Isle of Man and the completion of the survey of Berkshire.

MSI hand-held data terminals were introduced for all data collection and the system is working well with only minor problems.

The Drawing Office output of 1:50 000 sheets for digitising by Laser Scan Laboratories Ltd is up to schedule, and the contractors output covered the major part of England and Wales.

The flying programme was substantially delayed by technical problems in the aircraft equipment and camera system and by the weather but a start was made towards the end of the year.

There is no doubt that when the aircraft is in the air it covers a large area of ground. There have also been delays in the production of aerial photography by outside sources.

At the end of the year, field work was well in hand in seven counties.

If the field work is to be completed by March 1982, there is no doubt that the regular Field Survey teams will be involved in the census to a far greater degree than was originally envisaged.

K. P. THALLON

WORK STUDY

Forest Management: Method Study

Further trials with the Dondi rotary ditcher, mounted on a more powerful tractor, confirmed the potential of this machine on peaty soils. An Excavator ditcher commenced trials to test its suitability on harder soils and clearfell areas.

A Fobro transplant lifter/bundler was tested at Rogate nursery, where, despite modification and advice from the manufacturer, it failed to lift conventional transplants successfully. The lifter is primarily designed to handle 500–600 mm stock.

An examination of techniques for treating clearfell lop and top in pine forests, before manual or machine replanting, was undertaken to determine an economical and silviculturally sound practice.

Fire-fighting techniques based on water additives were examined. After successful trials with foam, teams in selected forests were provided with foam equipment to test the technique in wildfire conditions particularly as a protective barrier to oncoming fires. A survey of other fire-fighting equipment including hoses, pumps and protective clothing was also undertaken.

Forest Management: Servicing and Continuous Review

Field trials of the Herbi controlled drop applicator modified to produce a measured dose spot treatment were successfully concluded using selective herbicides. An investigation into the application characteristics of a wider range of herbicides including non-selective (which require crop tree guarding) was also initiated.

The Lockinge Ulvamast, tractor-mounted, controlled drop applicator, successfully used for lowland grass control was given preliminary trials for upland heather control where it showed promise. The concept of a low cost, simplified tractor-mounted, controlled drop applicator was examined for use in forests with limited weeding programmes.

A survey of protective equipment for herbicide spraying including face shields, respirators and gloves supplemented previous work on protective clothing.

A comprehensive review of clearing saws was undertaken but the Husqvarna 165R, in regular use, is still recommended with the Husqvarna 140R accepted for lighter weeding conditions. The review also examined alternative clearing saw blades, the nylon 'Trimmy' head proving satisfactory in soft weeds.

Several tractor-powered mechanical weeding/cleaning machines were evaluated. Most were efficient in specific conditions but all had limitations. To ensure optimum application of this category of equipment, a specification for tractor/weeder systems was proposed based on work and site conditions.

Forest Management: Work Measurement

Studies have been carried out nationally and a Standard Time Table on replanting will be issued before next planting season.

Harvesting and Marketing: Method Study

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

- County 774 Skidder
- Mini Bruunett 578F Forwarder
- Holder A60 Skidder
- Massey Ferguson MF 1200 Skidder (as modified)
- Gremo TT8 H Forwarder
- Kockums 822 Skidder
- Smiths Timbermaster (Cable Crane) Winch
- Sifer SS 103B Processor
- Roadless Logmaster Skidder

In particular, the Kockums 822 GP thinnings processor was tested and found very suitable for first thinnings and smaller sized clear fellings. Good results were achieved in both systematic and selective thinnings. Measuring attachments to enable 2, 3 and 4 metre pulpwood to be processed proved successful.

A comparison of forwarder and skidder systems on clearfelling sites was undertaken. Direct costs were similar for both systems, but the shortwood operation did have an advantage with less unproductive time. A similar study on early thinnings indicated cost savings with the shortwood system while work on later thinnings is uncompleted.

Harvesting and Marketing: Servicing and Continuous Review

A full examination of harvesting aid tools concluded with a comprehensive report which was issued nationally to all forests.

A survey of cable crane logging areas in North and West Scotland and North Wales Conservancies, the three major cable crane areas, was completed. This indicated that 97 per cent of the areas could be harvested by a cable crane with a range of 450 metres. Future programmes were examined showing a potential increase of 50 per cent in cable crane harvesting in these regions over the next decade.

Work on chokers and choker hooks was formalised in a report, but ongoing trials of alternative captive hooks designed to accept polypropylene chokers show promise. Alternative polypropylene chokers are also being tested.

Several chainsaws have been tested for noise and vibration. The Husqvarna 444SG, 480CD and the Jonsereds 452 EVS models were added to the approved list. Further trials of guide bars and chains to determine minimum kickback characteristics have continued.

Harvesting and Marketing: Work Measurement

The following Standard Time Tables were published during the year:

Thinning—Scots and Corsican Pine

Extraction of Tree Lengths by Falstone Skidder

Extraction of Systematic Thinnings by Holder A55F Skidder

Extraction of Clearfell or Windthrow by Timberjack Skidder

National studies have been completed on thinning European and Japanese Larch, clearfelling European and Japanese Larch, thinning Douglas Fir and thinning Sitka Spruce. Standard Time Tables will be issued shortly.

Forest Authority

The use of the Rapco data collector has been extended and Time Study Instructions for several activities were reviewed. Enlargement of the computer-based data bank continues.

Safety

Draft Forestry Industry Safety Guides have been reviewed and comments submitted. Regular regional meetings of Work Study, Safety Officer and Education and Training Branch have taken place to co-ordinate the approach of the Branches towards safe working techniques.

Training

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

A. J. G. HUGHES

STATISTICS AND COMPUTING

Data Preparation and Computing

Validation of the Sample Plot data punched by a bureau was completed and its transfer to magnetic tape at the Rutherford Laboratory continues over the link with the IBM 1130. The considerable contention between users of the IBM 1130 was relieved in October by the transfer of the COPE terminal from Headquarters. After lengthy deliberations and with the help of the Central Computer and Telecommunications Agency (CCTA) a PRIME 400 computer was chosen to succeed the IBM 1130 as the main in-house machine at Alice Holt. This machine was delivered in the last hour of the year. To help to ensure that the new computing system effectively meets demands made upon it a Computer Users' Group, on which all branches of the R & D Division at Alice Holt are represented, has been established.

Many years' data from Lodgepole pine provenance experiments throughout Britain have been collected into a data bank at the Edinburgh Regional Computing Centre. The initial purpose is to investigate growth patterns of provenances in different regions using yield class to standardize comparisons.

Statistical Service to Research and Development Projects

Advice on experiment and survey design, analysis and the interpretation of results continued to take up most of the statisticians' time. With continued staff vacancies the service inevitably suffered but easier access to the programming package GENSTAT from Alice Holt through the link with the Rutherford Laboratory brought considerable benefit, particularly in the analysis of results from complex statistical designs.

Statistical Service to External Units

Assessment areas were randomly selected for the 1980 deer-damage survey and a re-spacing project was analysed—both for South Scotland Conservancy.

There has been direct collaboration with the Unit of Invertebrate Chemistry and Physiology, Sussex University, on field experiments in the Dutch elm disease aggregation pheromone project.

Programming Service, General

The yield forecasting system programs were further modified and the retrieval routines were generalised to increase their flexibility.

Lack of two programmers throughout the year has held up the development of many programs.

Programming Service, Mathematical/Statistical/Technical

The emphasis this year has been on programs for the Census of Woodlands and Trees. The first programs written were to analyse the data of the pilot survey to give guidance on sample sizes. Programs to provide the desired estimates and tabulations from the full survey are under development.

Statistical, Mathematical and Computing Methods

Methods were developed for optimal sample selection for the woodland and tree surveys in which the sample design is complex and subject to constraints, and for which complex estimates are required.

The validity of deer damage sampling methods with respect to their robustness, bias and precision has been studied. Parametric models of small mammal growth suitable for the common field capture methods have been investigated.

Jackson's Structured Design Method for computer program design as promoted by CCTA was investigated and found to offer significant advantages as a means for improving programming standards.

Data Capture and Associated Computing

MSI hand-held terminals have been used to record data for the national census of woods and trees and for many experiments. The census data are printed at field sites and then transmitted by the public telephone network to Transdata CX400 microprocessor-based floppy-disk terminals at Alice Holt. The resulting files are then transmitted to the UNIVAC 1108 at the UCC bureau,

London, where they are subjected to validation and initial summary programs. When the PRIME computer is installed this link will be made via the PRIME in synchronous mode over a leased line. The PRIME computer will also make the CX400 experimental data files generated by transmission from the MSI terminals easier to operate on.

R. S. HOWELL, D. H. STEWART

COMMUNICATIONS

RESEARCH INFORMATION

Library

New books acquired totalled 160 and subscriptions taken out for 14 new journals. Loans from Library stock were 5,811 with a further 700 items borrowed from other libraries. Approximately 2,000 photocopies were provided instead of loans, and the total number of loan requests satisfactorily dealt with was in the region of 8,500.

Liaison

The Oxford System of Decimal Classification for forestry (ODC) has always been used in the library and in many Branches, for indexing and retrieval purposes. Recently, following new developments in information handling, there has been considerable confusion over the present and future use of ODC. A Working Party set up at an international IUFRO Meeting (Subject Group 6.03) carried out a world-wide survey of forestry information centres. A good response revealed that ODC is still very much alive and in use in 62 per cent of such centres. Work is now in hand to expand and update this very successful and well-proven system.

O. N. BLATCHFORD

PHOTOGRAPHY

Aerial Photography

Much of the year has been spent in devising, installing, and testing an intergrated system of photography and print production for use in the current Census.

The twin-cameras mentioned in the 1979 *Report* have now been fitted to a Cessna FR182. The right-hand front seat is removed from the aircraft and the fixed part of the camera mount is attached to the seat rails. The moveable part of the mount carrying the cameras is aligned with the pilot's seat. This slides laterally. Thus the cameras can be pushed outboard into a fairing in the starboard main door for photography, or withdrawn into the cabin to change film magazines, etc.

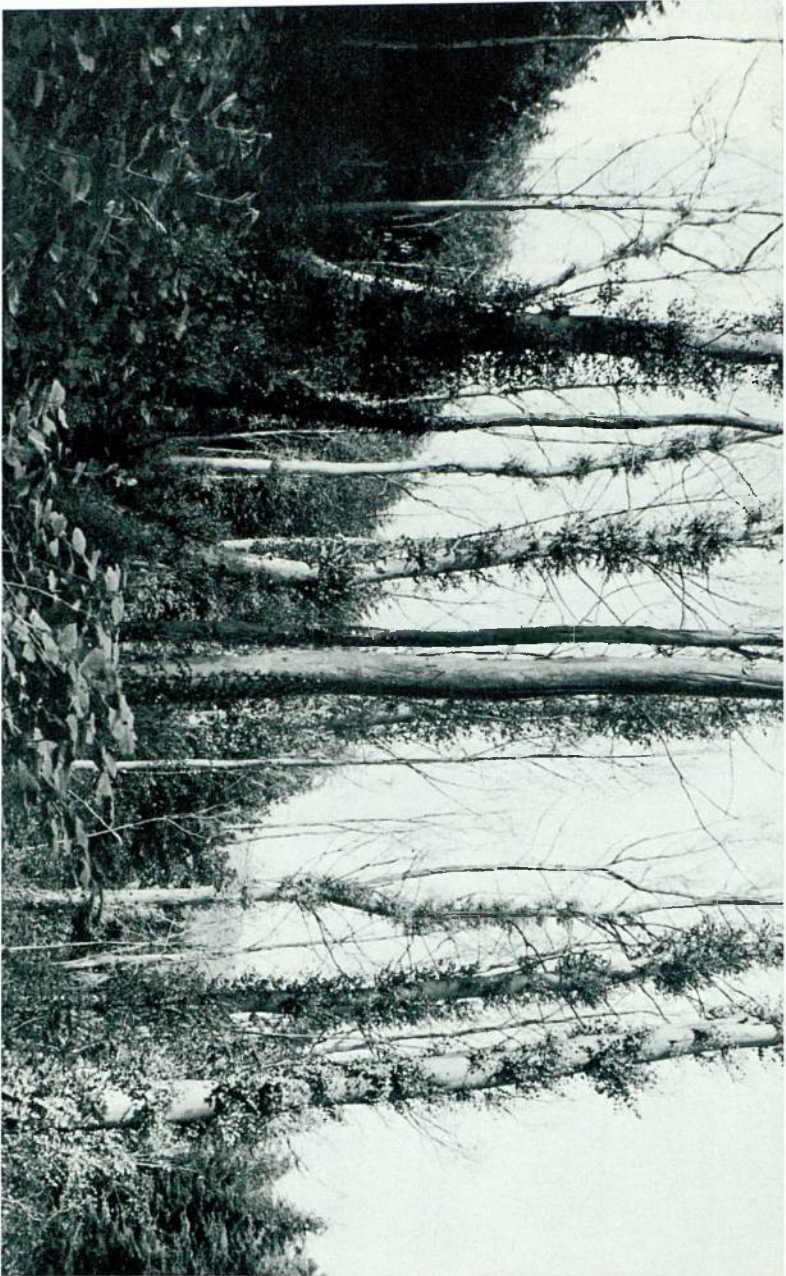
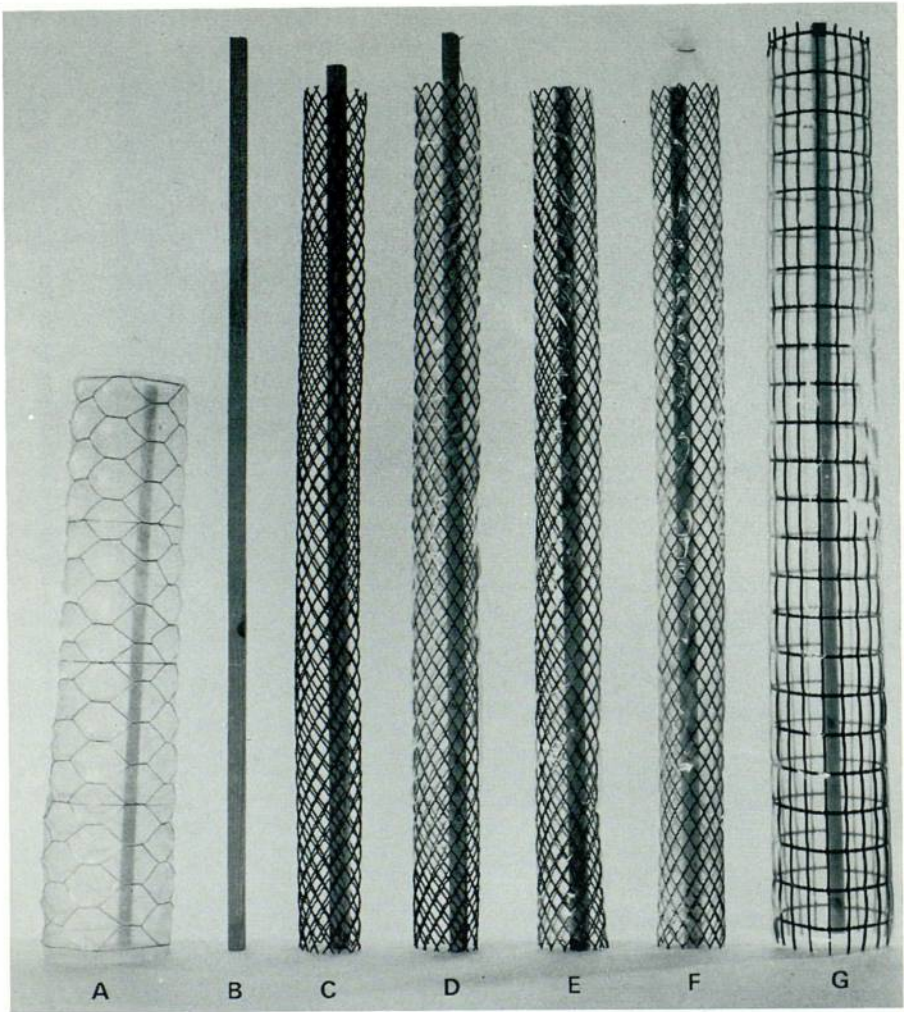


Plate 1

Twenty-five year old *Eucalyptus gunnii* in Cornwall showing vigorous production of epicormics following crown death by extreme cold (-18° C) in January 1979 (p.11).

(A9999)



(D6557)

Plate 2

Designs of Single Tree Shelter in which oak were grown in 1979 (p.15)

- A - Wire reinforced polythene 15 cm diameter and 0.8 m tall.
- B - Control tree marked by a stake.
- C - Biodegradable individual tree guard 7.5 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 15 cm diameter, 1.2 m tall with polythene tube cover 1.2 m long with no gap at base.

(Note: photograph has been taken in a studio so that all shelters could be shown in one photograph – there are no trees in the shelters).



(N4293)

Plate 3

Norway spruce seed origins in six plant plots at Minard (Strathclyde) aged 11 years. Foreground: *TIMIRJAS*, near *TOMSK*, *USSR* (0.98 m tall). Behind: *KLINGENBRUNN*, *BAVARIA* (2.1 m). Background: *KNITTELFELD*, *AUSTRIA* (3.9 m) (p.19).

(A. John)

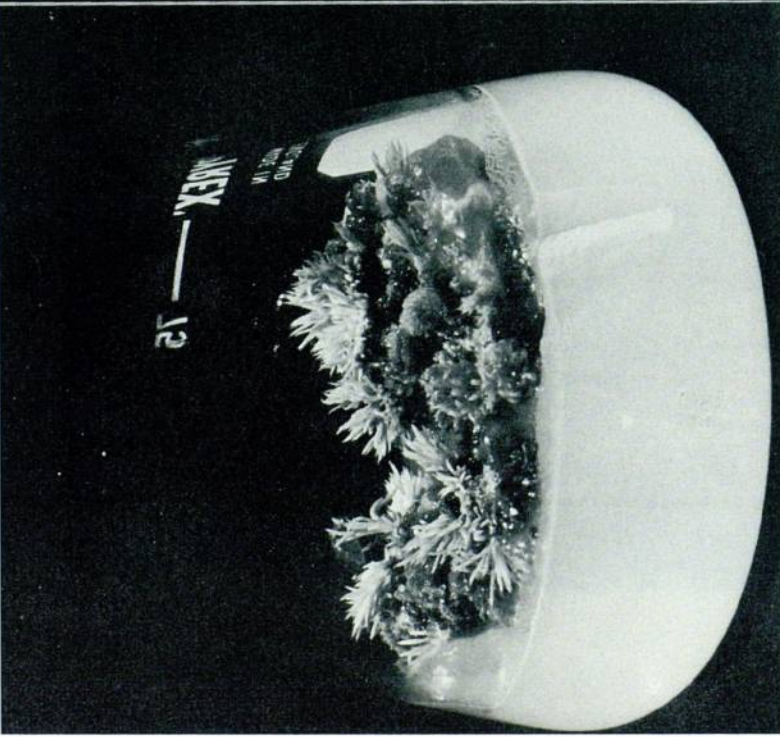


Plate 4

Micropropagation of Sitka spruce (560 x 1088) on hormone-free agar medium after callus induction and shoot initiation on agar containing 10^{-8} M BAP, 5×10^{-6} M IAA and 5×10^{-6} M IBA (p.30).

(A. John)

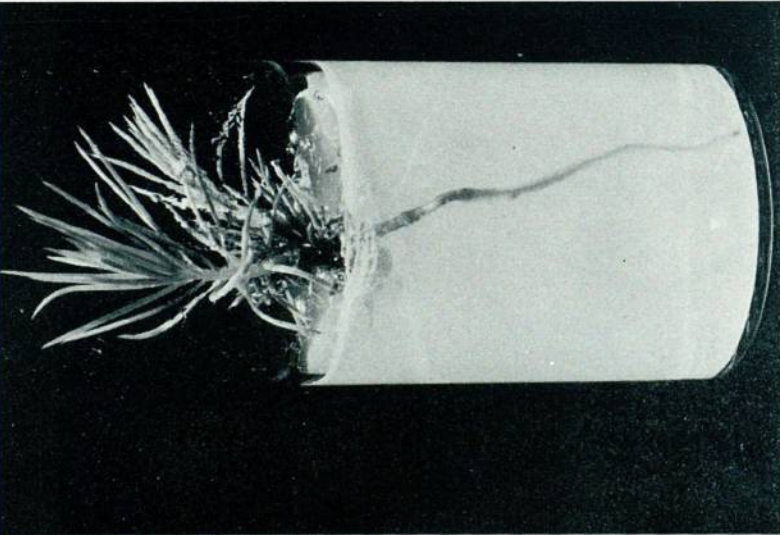


Plate 5

Vigorously growing plant reduced by micropropagation, with root extending in to the hormone-free agar. (p.30)

Shutter speed priority is attained by use of automatic diaphragms on the lenses. A control unit on a 'wander lead' (so that it can be used by pilot or observer) serves both cameras. This gives pre-selection of time interval, simultaneous or independent operation of each camera, etc.

A standard print size of 10" x 10" is used. Printing is done on an electronic enlarger with a scanning light source and the resulting rolls are developed in a continual automatic processor.

After some initial mechanical snags the system is proving reliable and relatively trouble-free.

Advisory Services

The reduction in staff resulted in a marked reduction in the range of services provided, particularly in the amount of photography. Nevertheless, a full advisory service was maintained together with a limited amount of printing.

I. A. ANDERSON

PUBLICATIONS

Whilst the Section has prepared many items for publication during the year progress through printing houses has sometimes been delayed by industrial action. Titles published were:

Reports

Fifty-ninth Annual Report of the Forestry Commissioners 1978-79 (£5.75)
Report on Forest Research, 1979 (£3.00).

Booklet

No 38 — Common Trees (revision) by A F Mitchell and J Williams (20p).

Forest Record

No 120 — Pine Beauty Moth, by J T Stoakley (75p).

Leaflets

No 12 — Taxation of Woodlands (revision 1980) (50p)
No 72 — Forest Drainage Schemes, by D A Thompson (55p)
No 74 — High Seats for Deer Management, by J J Rowe (80p).

Arboricultural Leaflets

No 5 — Common Decay Fungi of Broadleaved Trees, by D A Burdekin (£2)

Occasional Papers

Three more titles in this new series were prepared and published:

No 3 — Tree Planting on man-made sites in Wales, by K F Broad (£1.50)
No 4 — Control of Pine Beauty Moth by Fenitrothion in Scotland, edited by A V Holden and D Bevan (£2.50)

No 5 — The use of Chemicals in the Forestry Commission, edited by O N Blatchford (50p). This replaces the earlier publications entitled *Chemical Control*, Supplement to *Entopath News*.

Policy and Procedure Papers

No 5 — Softwood Sawlogs – presentation for sale.

Other Publications

A short guide, *About Westonbirt* by John White, was designed and published for sale at the arboretum. The trees at Westonbirt were the main features of a Forestry Commission calendar, *Trees for all Seasons, 1980*, with which the Section was involved in design and publication.

The Section has been responsible for the design and printing of papers being prepared for the Commonwealth Forestry Conference to be held in Trinidad in 1980, when they will be published.

K. W. WILSON

OTHER HEADQUARTER DIVISIONS

PLANNING AND ECONOMICS

Guides to Management

Owing to a major increase in work in support of other Headquarters' Divisions during the year, the amount of research carried out was small and this year's report is correspondingly short.

The main study carried out was on the merits of respacing. This showed that, with given mensurational assumptions on total volume yield and diameter increment, the critical element in the appraisal concerns the rate of price change with tree size and wood quality. The conclusion emphasises the need for careful appraisal of factors influencing price now and in the future.

Management data were used to analyse operating costs of machinery and costs of harvesting. These studies provided proof of the inherent difficulties of econometric studies based on material compiled for different purposes such as management control. The assessment of regional variation in an aggregate index of machinery cost is now established as a routine. A study of variation in harvesting cost with tree size, terrain and other factors, was undertaken in order to find out whether available sample costings data provided a better basis of analysis than other routes. Imperfections in the data, from sampling through to completion of records, indicated that unless great discipline is exercised the empirical approach, however desirable in theory, is not in practice such a rewarding one when applied to business data. Experience suggests, in this field at any rate, that work study data provide a more satisfactory basis, so long as the predicted results are adjusted to conform to actual achievement.

A. J. GRAYSON

HARVESTING AND MARKETING

Power Transmission Poles

The experimental work of the joint project with the Electricity Council in which attempts are being made to improve the permeability of spruce through the stimulation of bacterial activity by spraying with or immersion in water continued. Further creosoting trials using a full-cell process of pressure treatment were undertaken. Subsequently some of the poles were tested to destruction in bending by three-point loading at the Laboratory of the Timber Research and Development Association.

In the preservation trials where the poles were subjected to a full-cell pressure treatment process, satisfactory retentions and radial penetration were achieved in Norway spruce. However, in Sitka spruce, although the retentions reached the level of 115 kg/m³ prescribed in British Standard 1990 Part 2 (Wood Poles for Overhead Lines), fewer than 10 per cent of the poles achieved the target penetration of one-third radius.

The poor radial penetration in Sitka spruce is probably due to the low proportion of the more permeable sapwood. It is difficult to detect the extent of the sapwood in dried spruce poles, and it has become customary to assume that it extends for one third of the radius. It was therefore decided to undertake a small survey to check the validity of this approximation. Cross-section discs were sampled from fresh felled poles at five forests, the heartwood/sapwood boundary was traced by the use of pH indicators and the extent of the sapwood was recorded at 12 points per disc. The results have indicated that while there is substantial variability in the proportion of sapwood, the mean in a single disc can be as low as 12 per cent of the radius, and at individual points it can descend to 9 per cent. It is therefore unrealistic to use the value of 33 per cent as a standard for assessing the penetration by creosote.

The data from the strength testing were not available by the end of the year.

The Utilisation of Bark

Two more units began the production of pulverised bark, and three more organisations began marketing the product, two of them specialising in the use of bark for equestrian purposes.

J. R. AARON

PART II

Work done for the Forestry Commission by Other Agencies

FOREST SOILS

NUTRITION AND FOREST SOILS

By H. G. MILLER

The Macaulay Institute For Soil Research, Aberdeen

Study of tree growth in relation to the input and movement of nutrients in early thinning-stage stands of Sitka spruce continues (*Report for 1973*). During the past year a further two of the six experiments reached the end of the planned initial five years of intensive study. Only two experiments now remain in this stage (those at Kershope and Kilmichael Forests), although the earlier experiments are all being refertilised to provide further information on the pattern of response to applied fertiliser nitrogen, phosphorus and potassium in such stands. Response during the initial stage was significant at five of the six sites, but at none was it at all large. Consideration of the processes of input and retention of rain and wind-borne nutrients in relation to the uptake, accumulation and release of nutrients by tree stands, based on models developed earlier (*Report for 1979*), has led to the suggestion that there are three distinct nutritional stages in the life of a coniferous forest: (i) the establishment phase, during which the input and retention of atmospheric nutrients is at its least pronounced (because for much of the time the trees are small and are not fully occupying the site) but during which nutrient demands rise to their maximum (because the canopy is being constructed): (ii) after canopy closure, when the only net immobilization is in structural tissues and humus, so nutrient demand is low at a time when the capture and retention of nutrients from the atmosphere is very efficient: (iii) a late rotation stage when excessive immobilization in the trees and humus may lead to nitrogen deficiency and site deterioration. On this basis it could be expected that response to fertiliser is liable to be disappointing during stage (ii), but application of nitrogen during stage (iii) may be very rewarding, as would the application of any limiting nutrient at stage (i). Indeed, in many respects the most effective use of fertilisers in forest management is to reduce the time until canopy closure, a time during which the trees are most at the mercy of soil supplies of nutrients.

As trees have evolved efficient processes for the capture and retention of nutrients in rain and in atmospheric aerosols and gases, and as these same processes will effect the interrelation with atmospheric pollutants, they are being studied in some detail (Miller, 1979; Miller and Miller, 1979; Miller and Cooper, 1979). A particular methodological problem has been the apportionment of the gain in weight of an element found in rainwater beneath trees into the separate contributions from crown leaching (part of the cycle internal to the ecosystem) and the wash down of material trapped from the atmosphere on

crown surfaces (a net input). A regression technique developed in earlier work on pine (*Report for 1976*) led to the design of special gauges for the present study in spruce, and trials with early results from these suggest that the modified technique provides a robust and sensitive answer to the problem (Lakhani and Miller, 1980).

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HERBICIDES

EVALUATION OF HERBICIDES FOR FOREST USES

by D. J. TURNER, W. G. RICHARDSON, and I. D. CLIPSHAM

*Agricultural Research Council Weed Research Organisation, Begbroke Hill,
Yarnton, Oxford*

Herbicide research at WRO with pot-grown crop and weed species is a first step towards the development of new weed control methods. Some new products have been examined but this year emphasis has been given to follow up studies with herbicides of known potential, already discussed in previous reports.

Herbicides for Weed Control in Seedbeds

The ideal herbicide for seedbed use would control all commonly occurring weeds but have no effect on germinating seed or emerged seedlings of conifer or broadleaved crops. Diphenamid, now generally used, is tolerated well by tree seedlings but is insufficiently active against important weeds such as chickweed (*Stellaria media*), sheep's sorrel (*Rumex acetosella*) and *Polygonum* species. In conifer seedbeds, other products may give better results, either

alone or in mixtures with diphenamid. Napropamide, terbuthylazine and a group of nitrophenyl ethers are of particular interest. In field trials carried out by Forestry Commission research staff 0.5 kg/ha terbuthylazine or 4 kg/ha napropamide gave good weed control without injuring Japanese larch, Douglas fir, Sitka spruce or Corsican pine. These herbicides are, however, probably too damaging to be used in broadleaf seedbeds.

Herbicides for Transplant Lines and Young Plantations

Further tests were conducted with alloxymid and trifop-methyl, new herbicides which have novel and very specific activity against grasses. As expected, neither had much effect on crop species, even at very high rates. July applications of 1 kg/ha trifop-methyl were highly toxic to pot-grown purple moorgrass, *Molinia caerulea*, particularly when extra surfactant or emulsified oil was added. Earlier application in April effectively controlled creeping soft-grass, *Holcus mollis*. Unfortunately, the commercial future of this herbicide is uncertain. Alloxymid, now available commercially, appears to be much less active. It may find use in seedbeds or transplant lines but is unlikely to control well-established perennial grasses.

Addition of a surfactant, Ethomeen T25, considerably increased glyphosate activity against *Holcus mollis* and *Molinia caerulea*. The product increased injury to oak, beech and birch but in contrast to other additives did not greatly affect conifer crop tolerance. Some representative results are summarised below. Glyphosate was applied in 200 l/ha of spray as the commercially-formulated product, 'Roundup'.

Effect of added Ethomeen T25 surfactant on glyphosate activity. Weights of new growth after 1 year as percentage of control.

Treatment	Sprayed 26/3/78		Sprayed 18/7/78	
	<i>Holcus mollis</i>	<i>Sitka spruce</i>	<i>Molinia caerulea</i>	<i>Sitka spruce</i>
0.5 kg/ha glyphosate as Roundup, no added wetter	62	—	19	—
Plus 0.5 per cent Ethomeen T25	19	—	4	—
1 kg/ha glyphosate as Roundup, no added wetter	0	69	6	100
Plus 0.5 percent Ethomeen T25	0	72	1	74

FOREST ZOOLOGY

LONG-HAIRED FALLOW DEER

By R. H. SMITH and ELIZABETH JOHNSON

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It now seems almost certain that long hair is a genetically determined character. Fawns reared away from Mortimer Forest have developed long hair (Smith *et al.*, 1977) while most animals at Mortimer Forest are normal, ruling out an environmental cause. The possibility that Border Disease virus is responsible for long hair has been eliminated by running antibody tests on blood samples from long-haired and normal deer; we are grateful to Miss J. Sands of the MAFF Central Veterinary Laboratory, Weybridge for performing the tests.

Five of the crosses set up in forest enclosures in September 1978 (Smith and Johnson, 1979) produced fawns the following summer. The table shows the phenotypes of the offspring and parents with their identifying code numbers. It is not certain which doe is the mother of which fawn in enclosure 4.

Enclosure	Buck	Doe	Fawn
1	L 11 Short	L 1 Long L 14 Short	L 28 Long L 26 Short
4	L 25 Short	L 8 Intermediate L 16 Short L 15 Intermediate L 18 Long	- - L 30 Short L 29 Long
Museum	L 23 Short	L 2 Long L 3 Short	L 27 Long -

The deer were caught up and moved between enclosures in September 1979, with the exception of L8, L23 and L25 which were released into the forest. Most of the crosses now set up are like-by-like since the production of a fawn unlike both parents will show immediately that the fawn's character is recessive. The crosses set up in a New Forest (Hampshire) enclosure between the long-haired buck L9 and four New Forest does were unsuccessful; hounds entered the enclosure early in 1979 and killed one doe, and the remaining three does produced no offspring. New Forest crosses are being repeated this year.

The doe fawn L19 (Smith & Johnson, 1979), which at birth appeared to have traces of long hair in her ears and tail and was initially classified as intermediate, has shown no trace of long hair in subsequent coats. Since her parents, L9 and L18, are both long-haired, this provides evidence that long hair is genetically dominant and suggests that the parents are heterozygotes and that L19 is homozygous for short hair alleles. The assignment of long hair to a dominant allele at a single locus must be regarded as provisional until more complete breeding data are available.

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

REPRODUCTION IN THE GREY SQUIRREL

by A. J. TAIT and ELIZABETH JOHNSON

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The two squirrel enclosures provided by the Forestry Commission at Alice Holt Forest (Hampshire), each of approximately 700 sq metres (·07 ha) have been successful in allowing breeding to occur. In enclosure A, which housed 4 females and 3 males, one female was found with a single young in April 1979. This same female produced a second litter of 4 in July 1979, at which time two other females produced litters of 3 and 4 young. In enclosure B, which housed 3 females and 3 males, two females gave birth.

Since autumn 1979 both enclosures have contained parous females, but only one (Enclosure A) has contained an adult male. This should enable us to determine whether the initiation of oestrus in adult females requires the presence of an adult male. Present indications are that an adult male is the sexual trigger, since a female in enclosure A came into oestrus in February 1980 and may now be pregnant, whereas females in enclosure B have remained in anoestrus. This investigation is being carried out by Miss G Webley (F.C./S.R.C. CASE student). After successfully raising an antiserum to testosterone, Miss Webley is continuing with the measurement of blood hormone levels throughout the reproductive cycle.

During the summer breeding season (1979) laboratory trials with an anti-androgen were begun in order to investigate the feasibility of its use as a male reproductive inhibitor. After encouraging results were obtained by injection, feeding trials were begun with wheat coated with the antiandrogen in latex. This investigation was brought to a halt when control squirrels showed testicular regression in July. Immediate investigation of field animals revealed that testicular regression was widespread in Alice Holt Forest and in the males of the enclosures. These observations provide further evidence that testicular regression is a regular phenomenon following the breeding season. Regular live trapping in the Forest since that date has shown that male squirrels remained in a regressed state, with small abdominal testes, until 31 March 1980, when the first squirrels with large scrotal testes were trapped.

In enclosure A, where artificial feeding is practised, the male squirrels showed regressed testes in July, but had returned to full scrotal testes by December 1979. This provides further evidence that the prolongation of sexual regression through the winter, which workers in this laboratory have observed

in 1972/73, 1977/78 and 1979/80 depends on environmental factors such as food supply. By the use of the forest enclosures as controlled environments it will be possible to test these hypotheses further and to investigate the internal pathways through which the regulation occurs.

FOREST RODENT POPULATIONS

By J. GURNELL

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Since the spring of 1975 a series of intensive trapping studies have been in progress to obtain long-term information on communities of forest rodents of a fundamental and an applied nature. This work has centred on a nine hectare oak woodland at Alice Holt Forest (Hampshire) and it has clearly demonstrated that the survival and fecundity schedules of squirrels, Bank voles, Wood mice and Yellow-necked mice are closely linked to the size of the annual tree seed crop. For example, following the very large seed crop in the autumn of 1976 there was a high recruitment of young squirrels from the subsequent spring breeding period. This together with high immigration and a 98 per cent overwinter survival, resulted in the 'foraging-trappable' squirrel population in the wood approaching 170 animals in the summer of 1977. This high density population did not breed at this time and, following the very poor seed crop in the autumn of 1977, there was no spring breeding in 1978. As a result, the squirrel population returned to a level of approximately 65 animals in the summer of 1978. Densities of mice plus voles over the study period to-date have also varied widely, ranging from 161 individuals per hectare in March 1977 to 5 individuals per hectare in May 1978.

A complementary three-year programme of research into the ecological genetics of these rodent populations was initiated in October 1978 by a Forestry Commission/NERC CASE student (D. J. Lord). This work involves the analysis of blood protein enzymes using starch-gel electrophoresis; the blood samples are obtained from live animals in the field. The work is designed to obtain information on genetic variation in rodent populations and to investigate whether there is any relationship between such variation and, for example, survival, breeding and winter food availability.

In October 1979 a University of London post-graduate student, with the financial backing of the Forestry Commission (Miss C. I. Knee), started investigating the energy-flow basis to the rodent population/winter food interactions already being studied. Food balance studies in metabolic cages are being carried out at Westfield College (on mice and voles) and at Alice Holt (on squirrels). It is hoped that a large squirrel enclosure will become available this summer in which food consumption, activity and temperature relationships of the animals will be studied; similar work on mice and voles in small enclosures is already in progress. Another line of research associated with this studentship involves the study of the movement of mice and voles into and out of the oak wood in relation to its 'rodent carrying capacity'. It is hoped to develop this work in the future with observational and telemetric studies.

In addition to these studies in an oak woodland, a broader joint study with the Forestry Commission is in progress and concerns trapping studies of mice and voles in 14 different areas at Alice Holt at different times of the year. All these closely related lines of investigation are designed to look into the dynamics of communities of rodents over a long time period in a well-defined woodland area. These studies also assess the relationships of the animals in such an area with those in the overall complex patchwork of habitat-types found typically in afforested areas in southern England.

SOCIAL ORGANISATION AND ECOLOGY OF SIKA DEER

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

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The aim of this three-year study is to establish some of the fundamental factors of behaviour and ecology of Sika deer (*Cervus nippon*). Five main areas of research are defined: an analysis of social structure, social behaviour, use of habitat; food and feeding behaviour, and interactions with other large herbivores. While intensive fieldwork is centred on the New Forest, ancillary data are being collected from other forests (particularly Wareham Forest in Dorset). Data from culled animals are also being collected from five forests in Scotland.

Analysis of material from culled animals provides information on sex and age-structure of the populations, as well as on diet (rumen analysis) and reproductive activity. Population structure and fecundity may be compared between areas. Direct observation in the New Forest and Wareham provide a more detailed analysis of social structure (in terms of group sizes and structures within the overall population), social behaviour, feeding behaviour and habitat use. In the first year of the study, while cull data are being accumulated for later analysis, studies have concentrated for the most part on field observation.

Regular watches of set areas, with transects walked or driven through a representative series of vegetation types, are providing a great deal of data on the pattern of usage of each vegetational community. Watches are carried out at all times of day and night and are repeated on a monthly basis. Preliminary analysis of the data suggests marked diurnal and seasonal rhythms in activity. While yielding data primarily on habitat usage, these watches are also providing information on social behaviour and feeding behaviour. Further information on diet may be derived from analysis of rumina from culled animals, and from faecal analysis. Collections of faeces are made monthly from fixed sites and, linked with measurements of faecal accumulation, provide a further method for assessing relative habitat occupancy.

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

GREY SQUIRREL SPATIAL DYNAMICS

By B. A. C. DON

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There have been several detailed investigations carried out on the local population dynamics of the Grey squirrel (*Sciurus carolinensis*), both in its native U.S.A. and in Britain. These studies have tended to concentrate on high density populations, generally found in mature broadleaved woodlands. Although there are obvious advantages in such a research strategy, these studies have failed to yield certain answers directly relevant to the squirrel damage problem, since:

- i they effectively minimise, and hence ignore, any fine-scale habitat heterogeneity,
- ii regional heterogeneity is not considered, and
- iii the habitats selected as study areas are generally not those in which extensive squirrel damage is expected.

The present research project aims to consider population dynamics through the framework of habitat, concentrating in particular on low density, damage-prone areas. Work is being carried out on an extensive basis (survey work in Forestry Commission woodlands) and intensively (live trapping in Wytham Woods, Oxfordshire), although the latter has received most attention so far.

The importance of habitat quality in determining mean abundance, reproductive performance, and movements is being considered on two spatial scales. The differences which exist between one woodland block and another may be termed macro-heterogeneity, the process unifying the dynamics of such study units being long-range movements or dispersal. It has been found that differences do exist in the rate and timing of dispersal between high and low density areas, and dispersal is viewed as the most important agent by which low density habitats become possibly over-saturated at the time when damage occurs. Dispersal is currently being examined more closely by means of radiotelemetry, and removal trapping techniques.

Within any woodland block, there is obviously micro-heterogeneity, or patchiness, the quality of patches changing with season. Squirrels may track such changes by trivial activity shifts, apparent from examining the detailed structure of home ranges through time, and by looking at the dispersion of population activity as revealed by trapping. Results so far indicate that seasonal changes occur in the degree of 'spacing out', i.e. evenness of activity distribution within an area.

The aim of the extensive survey is to characterise objectively what constitutes 'good' and 'poor' squirrel habitat. In so doing, the findings from the intensive research programme may be generalised for management purposes. A good correlation has been found to exist between the density of dreys (leafy nests built by squirrels) and the density of squirrels in the same area. Thus drey counts can be used as an index of squirrel abundance, having several advantages over live-trap enumeration:

- i drey counts are relatively quick, requiring little expertise or field equipment,
- ii biases from unequal trappability effects are overcome, and,

iii drey counts tend to measure the general carrying capacity of an area, rather than a density estimate at one time.

Future work on the extensive programme will involve surveying a wide range of habitat types. Drey counts will be related to habitat parameters using multivariate techniques, generating predictive relationships from existing forest inventory data.

FORESTRY ENTOMOLOGY

BIOLOGY OF SCOLYTID BEETLES IN RELATION TO DUTCH ELM DISEASE IN NORTHERN ENGLAND

By S. G. KIRBY,

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Since the work of Beaver (1966), little research has been carried out into the ecology of *Scolytus scolytus* and *S. multistriatus* as vectors of Dutch elm disease (D.E.D) in the British Isles. Although the elms of southern England have been decimated over the last ten years a significant proportion of the northern England population still remains and major losses seem to be held south of a line from the Ribble to the Humber. The effect of marked temperature differences, topography, elm type and the possible interaction of other organisms remains obscure and such information will be of considerable importance in deciding the strategy of future D.E.D. control programmes in the region.

The 1979 season's work employed Beaver's experimental technique to follow the development of beetle populations within infested logs. The major differences centre around the use of three elm types (*Ulmus procera*, *U. glabra* and *U. carpiniifolia* var. *sarniensis*) in the north as opposed to the use of only *U. procera* in Beaver's Oxford-based work. The present experiments are, of course, taking place during an epidemic rather than pre-epidemic phase involving the aggressive strain of the pathogen *Ceratocystis ulmi* as opposed to the non-aggressive form prevalent during the early 1960's.

Experimental sites have been established to determine the influence of the latitudinal differences outlined above on the two Scolytid species involved and to review the relative importance of each as vectors of D.E.D. in the north. Disc samples have been removed from infested logs each month since the initial attacks started in early July of last year. Four separate sites (Wirral, St. Helens, Worsley, Hyde) have been monitored using all three elm types and two (Northwich and Exeter) using *U. procera* only. This will allow a comparison of northern and southern England before and during the epidemic phase of the disease.

Statistical analysis of the 1979 season data is not yet complete. There are, however, a number of conclusions already evident.

- i *S. scolytus* is by far the most common of the two vectors in the north of England.

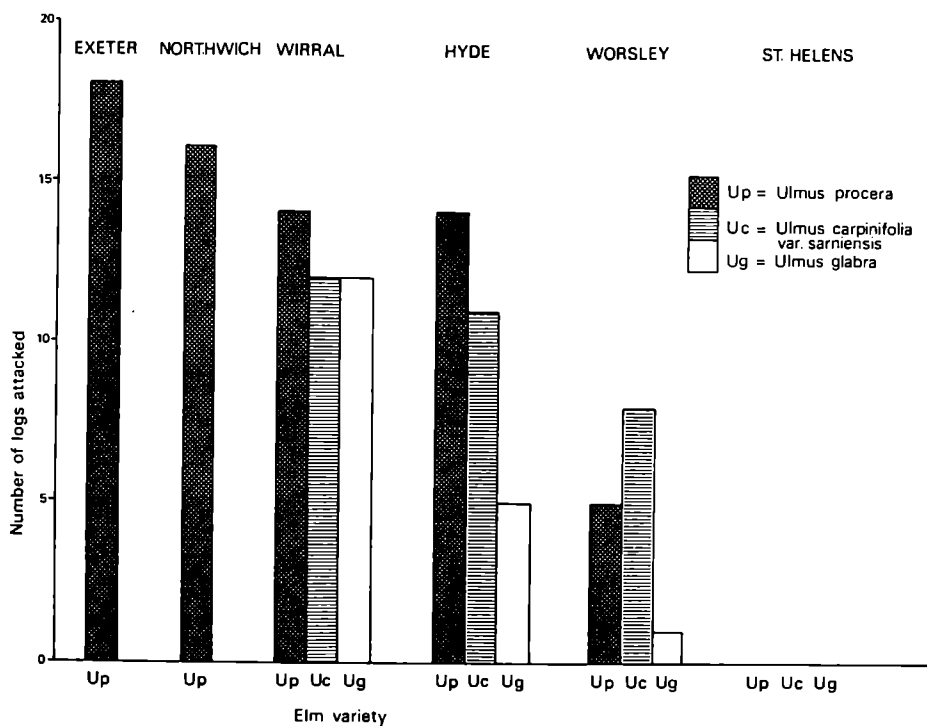


Figure. 5 Histogram showing the relative attack of different elm types by *S. scolytus* and *S. multistriatus* in different experimental sites.

- ii When provided with a choice of elm types and for low density infection, *U. procera* is more heavily attacked than *U. glabra* or *U. carpiniifolia* var. *sarniensis*. (See Figure 5).
- iii There is a bias towards beetle attack in the shaded areas of test logs
- iv Maturation feeding is not obligatory for the first (spring) and possibly the second (summer) emergence.
- v A large proportion of mature *S. scolytus* larvae form chambers up to 1.0cm into the wood whereas the majority of *S. multistriatus* larvae pupate between the inner and outer bark layers. Thus cold winters may have a more severe effect on the latter species. Also even debarked timber may present a source of emerging beetles. This is still somewhat open to question for it is not yet clear whether these mature *S. scolytus* larvae are able to pupate and subsequently emerge from these 'sub-bark chambers' or whether they require an additional nutrient input at the onset of more favourable conditions. If the latter is true they may still move outwards to pupate between the outer and inner bark layers,

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TIMBER UTILISATION JOINT RESEARCH PROGRAMME ON BRITISH-GROWN TIMBER

By T. HARDING

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The joint programme of research has continued but has been adversely affected by staff shortages and sickness during the past year. This has resulted in only modest progress being made in the forest management practices area. Significant progress has been made on the sawmilling work and the project to assess the strength properties of Douglas fir has commenced.

Evaluation of Forest Management Practices

This study sets out to determine the effect of silvicultural practices on wood properties and, in the period under review, has been concerned mainly with the effects of rectangular plantings where differences in growing space within and between rows might be expected to lead to the development of a crown with an oval outline and an associated effect on stem cross-section shape.

This has been examined in 20 year-old Sitka spruce from a single site at Weem, Perthshire, where trees had been planted in three patterns:- 3.7 x 0.9, 2.8 x 1.2 and 1.8 x 1.8m between and within rows respectively. There was no evidence for planting pattern having an effect on stem cross-section shape, although eccentricity of the pith, which appeared shortly after planting and persisted thereafter, was present in the plots at all three spacings and was attributed to exposure rather than planting patterns.

There was a greater incidence of larger knots in the rectangular compared with the square plantings and, though knot size is related to stem size in trees of uniform age, this relationship differs between plots and at different heights in the trees. At lower levels in the stem, knot sizes in trees planted on the square were smaller than those in trees of comparable sizes in the rectangular plantings. This difference tended to disappear at a stem height of about 6m but, at this height in the Weem trees, knot size for a given stem diameter was appreciably larger than at the same diameter lower in the tree.

Previous work in this area has aimed to identify changes in individual wood characteristics (e.g. density, knots, etc) under different growth regimes, and the significance of these has been interpreted for various wood properties. However, for Sitka spruce, one of its most critical attributes is its performance in machine stress grading. The relative and combined effect of these characteristics on the process is not fully understood. Work is being undertaken to resolve this problem.

A discussion of the background to this area of work has been published (Brazier, 1979).

Conversion, Processing and Utilisation of British-grown Timber

Work to develop a practical computer-controlled conversion aid for British sawmills has continued throughout the year. Trial runs of the log profile scanner together with off-line processing of the accumulated data showed that

an improvement of about 5 per cent in log conversion yield could be obtained in the two mills studied. These trials have provided useful experience in data handling for the complete on-line system under development.

A micro-processor with the required speed has been purchased to enable on-line processing of data, and current work is directed at devising appropriate programs for its operation. This may involve modifications to the experimental model. The instructions which emerge from the micro-processor for converting the cant can be handled in a number of ways but for the purpose of demonstration the output will be fed to a log alignment aid. It is proposed that this should take the form of two servo-positioned laser lines with which the resaw operator can line up the cant to achieve the desired conversion. Equipment to demonstrate the practicability of the development is under construction.

In preparation for a study of bandsaws and the improvement in accuracy which can be obtained using new high-strain equipment, a visit has been made to North America by a member of the Laboratory. This included machine developers and a number of mills using such equipment, and an account of the visit will be produced as a BRE Information Paper. The main part of the project on sawmilling accuracy will follow on the completion of the work on computer-aided conversion.

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BRAZIER, J. D. (1979). Never mind the trees, what about the wood? *Building Research Establishment Information Paper IP 12/79*. Princes Risborough, BRE.

APPENDIX I

Publications by Forestry Commission Staff

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

ANDERSON, M. A. (1979). The development of plant habitats under exotic crops. In *Ecology and Design in Amenity Land Management*, Ed. Wright, S. E. and Buckley, G. P. Wye College, Kent, 87–109.

Recent work on the natural development of plant communities and exotic forest crops is reviewed. The control which a forester can exert over the flora of his plantations by choosing particular tree species is examined in a range of lowland forests. After 50 years, crops tend to develop a ground flora of about 20 flowering-plant and fern species, which are listed; this is essentially an oakwood community. Plant species are classified according to the relative importance of light intensity and litter quality in controlling their occurrence and abundance under a variety of trees.

ATTERSON, J. (1979). Current fertilizer use in plantations. In *Ecology of Even-aged Forest Plantations*, Ed. Ford, E. D. *et al.*, Cambridge, ITE, 313–323.

A brief review of the use of fertilizers in plantation forestry throughout the world. Nitrogen and phosphorus are the two main nutrients used, typically at rates of 150 kg N and 50 kg P per hectare. High input: high yield versus low input: low yield is a choice plantation managers can make, and research should supply the answers. Further research is required on species, varieties and clones which can grow satisfactorily at low nutrient levels. As the relative costs of N and P fertilizers are likely to rise, accurate advice on response and on the economics is essential. To obtain this more research is required on fertilizer regimes and on methods of application.

BELL, G. D. and FLETCHER, A. M. (1978). Computer organised orchard layouts (COOL) based on permuted neighbourhood design concept. *Silvae Genetica* 27 (6), 223–225.

COOL is a computer program which produces seed orchard layouts based on the permuted neighbourhood design concept. The program is flexible, coping with irregular areas, up to 100 clones, varying numbers of ramets per clone, and hybrid orchards. It is easy to use, being controlled by a set of English command words, and can be operated without specialised statistical or computing knowledge. The use of COOL should eliminate much of the hard work involved in designing seed orchards.

BEVAN, D. and CARTER, C. I. (1980). Frost proofed aphids. *Antenna* 4, 6-8.

A brief account comparing the frost resistance of the Green spruce aphid *Elatobium abietinum* and the vetch aphid *Megoura viciae*. The body surface of *E. abietinum* is water repellent and under a scanning electron microscope can be seen to be coated with wax filaments that hold off condensing water and prevent inoculative freezing down to temperatures of -8°C or so. *M. viciae* is more easily wetted and usually dies when the air temperature falls below 0°C .

BINNS, W. O. (1979). The hydrological impact of afforestation in Great Britain. In *Man's Impact on the Hydrological Cycle in Britain*, Ed. Hollis, G. E., Geo. Abstracts, Norwich, 55–69.

Britain's new forests lie mainly in high rainfall areas, important for water supply. Forests reduce water yield substantially because they have a lower albedo, intercept precipitation and evaporate this intercepted water very rapidly, due to the rough and deep canopy. Heavy thinning and short rotations increase yield somewhat. Ploughing and roading increase the rate of runoff and pollute water, such effects persisting for many years. Phosphate from fertilisers can get into streams and if it reaches reservoirs may cause problems for water authorities. The effects of forestry on hydrology should be taken into account in land acquisition and forest management.

BLATCHFORD, O. N. (1979). The value of ODC for information retrieval now and tomorrow. *Mitteilungen der Bundesforschungsanstalt für forst-und Holzwirtschaft* 127, 171-175.

The Oxford System of Decimal Classification for Forestry has been used by the author for retrieval purposes when searching several files. On-line searches of computer data bases have a

major advantage of using sequences of letters, i.e. words or wordstems regardless of any classification system. However, a search by words only does not satisfy the information needs of users because of terminological ambiguity of words and results often are disappointing. Numerical systems using the hierarchy of decimals for subject control avoid these failures. The ODC has proved its value as the only internationally accepted classification system for 25 years and should not be discarded.

BOSWELL, R. C. and EDWARDS, P. N. (1979). Use of the Kolmogorov-Smirnov Two-Sample Test in a forest sampling context. *Mitteilungen der Forstlichen Versuchs- und Forschungsanstalt* 91, 75-78.

A simple to calculate test is used to determine whether two samples of trees, taken for volume estimation, do in fact represent the same population.

BRASIER, C. M. (1979). Dual origin of recent Dutch elm disease outbreaks in Europe. *Nature* 281 (5726), 78-79.

New Dutch elm disease outbreaks have occurred in Britain (1970) Holland (1972), France, Germany and Italy (1973), Ireland (1977) and Denmark (1978). Evidence is presented that there are two races of the aggressive strain of *Ceratocystis ulmi*, a Eurasian (EAN) race and a North American (NAN) race. The two races show certain morphological differences and low inter-fertility.

In a survey in 1978 US, Canadian, UK, French, Dutch, Austrian and Swiss isolates were exclusively of the NAN race whereas Italian, Danish, Bulgarian, USSR and Iranian isolates were exclusively of the EAN race. It is suggested that recent outbreaks of Dutch elm disease in Western Europe are of dual origin: through the importation of the NAN race of the aggressive strain from North America into the UK in the 1960s, and into France, Holland and Germany, probably via Britain, in the early 1970s; and through migration of the EAN race from Italy, central Europe or from further east.

BRASIER, C. M. [& AFSHARPOUR, F.] (1979). The aggressive and non-aggressive strains of *Ceratocystis ulmi* in Iran. *European Journal of Forest Pathology* 9 (79), 113-122.

Two hundred and seventy-eight sample isolates of *Ceratocystis ulmi* were obtained from the Caspian Forest area. Without exception, they fell into either the aggressive or non-aggressive strains of *C. ulmi* on the basis of growth rate and colony morphology. These characters were again correlated with pathogenicity.

The aggressive strain occurred from Astara on the Russian border to Chachkam, 600 km further east. Only the non-aggressive strain occurred in the extreme east of the area at Golestan. The data suggests that the aggressive strain entered Iran relatively recently from the Russian border area, and that recent disease outbreaks in Iran and Russia may be related.

BURDEKIN, D. A. (1979). In the wake of Dutch elm disease. *GC & HTJ* 186 (18), 39-42.

A number of examples of tree diseases are described in order to illustrate the range of conditions and circumstances which can influence disease outbreaks. Comments are made on the measures which can be taken to control or ameliorate the damage caused.

BURDEKIN, D. A. (1979). *Common decay fungi in broadleaved trees*. DOE/FC Arboricultural Leaflet 5. H.M.S.O.

This leaflet includes a detailed description of the fruit bodies of fungi commonly causing decay in broadleaved trees and of the associated decay. Colour photographs of the fruit bodies and decay accompany each description.

BURDEKIN, D. A. (1979). Oak wilt. *The Garden* 104 (10), 427.

In this brief article the risks of introducing oak wilt into Britain from the USA are reviewed and it is concluded that a total ban on the importation of oak wood from North America is not justified.

BURDEKIN, D. A. (1979). Beetle and fungus - the unholy alliance. In *After the Elm*, Ed. Clouston, B. and Stansfield, K., Heinemann, 65-79.

This chapter includes sections on the following: The early history of Dutch elm disease in Europe and North America, symptoms and life cycle of the disease, spread through roots and by transport of logs, origin of the current epidemic in Europe, control measures, including sanitation felling and selection and breeding of resistant elms, other tree diseases and a section on the future outlook.

CHRISTIE, J. M. and LINES, R. (1979). A comparison of forest productivity in Britain and Europe in relation to climatic factors. *Forest Ecology and Management* 2 (2), 75–102.

Using national yield tables as a basis, the growth of Scots pine *Pinus sylvestris* L., Lodgepole pine *Pinus contorta* Douglas ex Loud., Norway spruce *Picea abies* (L.) Karst. and Sitka spruce *Picea sitchensis* (Bong.) Carr. have been compared. From the trends of height growth with age and the levels of total volume production the paper attempts to relate the differences in growth in the various countries to climatic factors.

In the first part broad comparisons are made between the climatic types in Britain with those of Northern Europe and N.W. America, and in the second part the productivity of each species is examined separately and tentative conclusions are offered for the observed differences. In general forest productivity in Britain is shown to compare very favourably with that in N. Europe and N.W. America.

CLARKE, P. J. (1979). Support systems for private forestry in Great Britain. *Journal of Forestry* 77 (9), 592–595.

Written for the American *Journal of Forestry*, the article traces the development of the support arrangements for private forestry since the second world war. The current schemes are described in some detail and reference is made to the consultation procedures. The article also describes briefly the fiscal arrangements for encouraging the establishment of woodlands by private owners.

COUTTS, M. P. (1979). Trees and buildings (3). The physiological characteristics of trees and damage to buildings by root activity. *Arboricultural Journal* 3 (6), 413–419.

The paper reviews those features of growth which enable roots to exploit the soil in the vicinity of buildings. Features of root activity discussed include growth rate and the extent of tree root systems, the direction of growth, and compensatory growth in response to uneven conditions in the soil. Attention is paid to the ability of the roots of certain species to tolerate unfavourable conditions, and the growth of roots into shrinkable clays is discussed. Factors which affect water use by the tree, such as control over water loss by the stomata and cuticle, are also considered with a view to the selection of tree species for town or garden planting.

COUTTS, M. P. and PHILIPSON, J. J. (1980). Mineral nutrition and free root growth. In *Mineral Nutrition of Fruit Trees*, Ed. Atkinson, D. *et al.*, Butterworths, 123–136.

The paper presents field observations on the effect of nutrient deficiencies on the overall growth of the root system, and glasshouse and growthroom experiments which isolate the direct effects of mineral nutrition on the growth of individual roots, from effects mediated by changes in shoot growth.

CROWE, DAME SYLVIA (1979). The value of small woodlands to landscape and society. *Parks* 4 (1), 5–7. (Dame Sylvia Crowe was Landscape Consultant to F. C. 1963–76)

Whatever the visual and social benefits of woodlands, perhaps their greatest contribution is the conservation of wildlife and their beneficial effect on the health and fertility of the land as a whole.

Thus choice of species is all important. While timber value largely governs the species in large timber-producing forests, there is a wider choice for smaller, often non-commercial, woodlands. Indigenous species and those most conducive to wildlife can be given preference, for small woodlands are multi-purpose and their function is far wider than that of pure timber production.

DAVIES, E. J. M. (1979). Back to the drawing board. Re-thinking coniferous silviculture. *Scottish Forestry* 34 (1), 43–47.

Examines six factors which are causing existing silviculture and management practices to be re-examined for forests in the wetter parts of the Scottish Uplands, viz chemicals — fertilisers and weedkillers, site survey results, greater knowledge of the principal species used, Sitka spruce, the decreasing net returns from harvesting small-sized trees, the results of the windthrow hazard classification for Forestry Commission areas in South Scotland, and finally the increasing area at risk from catastrophic windblow.

Outlines a simple high fertiliser input regime for Sitka spruce and its estimated NDR.

DAVIES, E. J. M. (1979). High input prospects. *Scottish Forestry* 33 (2), 120–132.

Against the background of practical management of Forestry Commission forests in West and South Scotland Conservancies, advocates a simple tree-farming silviculture involving high inputs of fertiliser.

Reviews previous silvicultural practice in Scotland and outlines the regional silviculture he believes should now be adopted, based upon the results and conclusions of fertilising 84,000 ha of plantations and shaped to meet the three major problems likely to bedevil Scottish forestry — deer, wind, and the increasing use of heavy machines which may damage the forest and its soils.

Gives an example of a high input regime for both thin and non-thin systems.

DAVIES, E. J. M. (1979). The future development of even-aged plantations — management implications. In *Ecology of Even-aged Forest Plantations*, Ed. Ford, E. D. *et al.*, Cambridge, ITE, 465–480.

This paper argues that British foresters have been slow to emulate good agricultural practice and outlines the standard regime-based silviculture that has been evolved in the South Scotland Conservancy.

It is suggested that with higher inputs of fertiliser, timber yields may be greatly increased to considerable economic advantage. It stresses the need for further research as being a matter of urgency.

EDWARDS, P. N. and GARFORTH, M. F. (1979). Systematic and selective thinning: choice of method for the first thinning. Prepared for FAO/ECE/ILO Joint Committee on Forest Working Techniques and Training of Forest Workers. Seminar on Mechanisation and Techniques of Thinning Operations, Nancy, August 1979.

Economic analyses for 3 species, ignoring the problem of windthrow, suggest that selective first thinning is not generally justified within the range of prices assumed except for certain species in which diameter increment is markedly reduced by systematic thinning. Systematic first thinning increases windthrow risk more than does selective first thinning. In those parts of Britain where crop instability is particularly high it is likely that more emphasis will be placed on reducing the costs of selective first thinning than on increasing the use of systematic methods.

EDWARDS, P. N. and GRAYSON, A. J. (1979). Respacing of Sitka spruce. *Quarterly Journal of Forestry* 73 (4), 205–218.

Wider spacing reduces the merchantable yield of wood. There is no reason to believe that respacing carried out at an early stage will produce any different results from the total yields and assortments of crops initially established at wide spacings. When account is taken of the costs of respacing and the effects of lower log quality on price, it is found that the most profitable spacings achieved through the respacing are close to those of recent planting.

EVANS, J. (1979). The effects of leaf position and leaf age in foliar analysis of *Gmelina arborea*. *Plant and Soil* 52 (4), 547–552.

Analysis of macro- and micro-nutrient content of leaves of *Gmelina arborea*, a deciduous tree widely planted in the lowland tropics, was undertaken to determine the effects of leaf position within the crown and leaf age in relation to time of flushing on foliar nutrient levels. Within the crown, foliar nitrogen, phosphorus, zinc, and boron levels decreased, and calcium and iron levels increased, with increasing amount of leaf shading. Evidence of a genuine trend of declining nitrogen and potassium levels with increasing leaf 'age' is presented, the fact of which will greatly complicate sampling procedures.

FAULKNER, R. (1979). The exploitation of genetic variation by selection and breeding. In *Ecology of Even-aged Forest Plantations*, Ed. Ford, E.D. *et al.*, Cambridge, ITE, 99–117.

A review paper dealing with plus tree selection; multiple trait selection; selection indices; indirect selection; heritability values and their limitations; responses to phenotypic and genotypic selection; juvenile-mature correlations; inter- and intra-specific hybrids; and clonal planting material.

FORREST, G. I. (1979). Monoterpene variation in Lodgepole pine (*Pinus contorta*) and Scots pine (*Pinus sylvestris*). *Proceedings of the Conference on Biochemical Genetics of Forest Trees, Umea, Sweden 1978*. Swedish University of Agricultural Sciences, Report 1, 136–150.

The natural range of Lodgepole pine was divided into 15 regions on the basis of the monoterpene composition of the shoot cortical resin. Provenance material of unknown origin may then be allocated to one of these regions from the monoterpene analysis of a sample of some 25 trees. Introgression with Jack pine (*Pinus banksiana*) was evident from the monoterpene data beyond the zones of distributional overlap and natural hybridization of the species. Preliminary sampling of relict Scots pine populations in Scotland has shown a high degree of genotypic variation and population differences in biochemistry.

FOURT, D. F. (1979). Winged tines and restoration of gravel pits. *Saga Bulletin* 11 (3), 4, 12.

Increased cultivation intensity on restored gravel workings improved survival and early growth of pines. Two staggered passes of a three-tine assembly towed by a 320 hp crawler tractor, working to 800 mm depth, were needed to achieve full loosening. The attachment of horizontal wings to the tine shanks, each 355 mm wide and set at 25°, enables the full cultivation effect to be achieved in one pass.

FRANCIS, G. J. (1979). Future use of British Timber. *Scottish Forestry* 33 (4), 258–265.

A review of potential wood production in Britain to the mid 1990s. An assessment of future developments in the use of British timber in the main industry sectors of sawmilling; pulp, paper and board; wood based panels. A general review of the prospects for the industrial use of wood as a source of energy and chemicals.

GARFORTH, M. F. and WHYTE, R. (1979). NDR—an attempt to clear the mist. *Forestry and British Timber* 8 (5), 39–40.

A discussion of the advantages and problems of applying the concept of discounting to forest investment appraisal.

GIBBS, J. N. (1979). Measures to prevent oak wilt from reaching Europe. In *Plant Health*, Ed. Ebbels, D. L. and King, J. E., Blackwells, 103–112.

The status of *Ceratocystis fagacearum* in an infected tree is discussed in relation to the possible transmission of oak wilt to Europe. Only logs and sawn wood are considered to pose a significant risk, and the effects of various treatments of the wood on the survival of the pathogen are considered. As long as existing regulations are adequately enforced they should be sufficient to exclude the disease.

GIBBS, J. N. [HOUSTON, D. R. and SMALLEY, E. B.] (1979). Aggressive and non-aggressive strains of *Ceratocystis ulmi* in North America. *Phytopathology* 69 (11), 1215–1219.

Examination of the culture morphologies and growth rates of 300 isolates of *Ceratocystis ulmi* collected during 1977 from a range of locations in Eastern and Central North America revealed that all but one could be readily assigned to the two strains ('aggressive' and 'non-aggressive') originally defined in Britain. A sample of 70 isolates collected in 1970 and maintained on autoclaved elm twigs at -20°C also was classified similarly. In the North Central States of the USA the aggressive strain was predominant, but in northern New England and the adjacent provinces of Canada, and in a small sample from Kansas, the non-aggressive strain was detected more frequently. Available evidence indicates that the aggressive strain is migrating into the northeast and this phenomenon is discussed in relation to current theories on the origins of the two strains of *C. ulmi*.

GIBBS, J. N. (1980). The role of *Ceratocystis piceae* in preventing infection by *Ceratocystis fagacearum* in Minnesota. *Transactions of the British Mycological Society* 74 (1), 171–174.

In Minnesota, the *Pesotum* state of *Ceratocystis piceae* (Munch) Bakshi (syn. *Graphium rigidum*) is found on sporulating mats of *C. fagacearum* (Bretz) Hunt, the cause of oak wilt. Inoculation experiments showed that if *C. piceae* was introduced with *C. fagacearum* to wounds on healthy *Quercus ellipsoidalis* E. J. Hill it had no influence upon development of oak wilt, but if it was introduced 24 h before *C. fagacearum* it prevented infection. When the delay between inoculation of the two fungi was 2 or 6 h, intermediate results were obtained. Natural colonization of wounds by *C. piceae* may be at least partly responsible for the fact that wounds remain suitable infection courts for *C. fagacearum* for only a few days after they have been made.

GIBBS, J. N. and BRASIER, C. M. (1980). Further studies on MBC (Carbendazim) tolerance in *Ceratocystis ulmi*. *Annals of Applied Biology* 94, 308–310.

Three hundred and twenty seven wild isolates of *Ceratocystis ulmi* from Europe, North America and Iran were tested for tolerance to 0.5 ppm MBC. None of these isolates were naturally tolerant of the fungicide.

GORDON, A. G. (1979). *Use and supply of forest seed in Chile*. Santiago, Corporacion Nacional Forestal, Documento de Trabajo 16, 52pp.

The report, which covers sources of seed, processing, testing and research, describes the present situation in Chile, identifies a number of problems and makes recommendations for their solution. Included in the appendices are lists of orthodox and recalcitrant native Chilean species from the point of view of seed storage and preliminary recommendation for testing them by Tetrazolium or embryo excision techniques.

GORDON, A. G. (1980). A look at fluid drilling for forestry. *Farm Contractor* **49**, 58-59.

The fluid drilling technique is described. Forestry Commission experience with conifer seeds is compared with that gained in horticulture with fluid drilled seeds. It is concluded that at present fluid drilling has little potential in British forest nurseries.

GRAYSON, A. J. (1979). British experience in the provision of information for yield planning. Prepared for FAO/ECE Joint Working Party on Forest Economics and Statistics, *ad hoc* Meeting on Forest Resource Assessment, Geneva, May 1979.

The information needed for market planning and other purposes, notably planning provision of roads and harvesting labour and machinery, is the annual cut over a period of 20 years detailed by location, species and assortment. The information needed to determine the cut falls under 3 heads:-

- a) knowledge of the effect on volume yield and the quality of wood of different regimes, in particular thinning treatment;
- b) knowledge of the existing resource and its growth potential;
- c) a management objective.

The main gain in the more economic use of the resource concerned is likely to come from more careful appraisal of management options.

GRAYSON, A. J. (1979). Information needs in relation to environmental roles. Voluntary Paper prepared for FAO/ECE Joint Working Party on Forest Economics and Statistics, *ad hoc* Meeting on Forest Resource Assessment, Geneva, May 1979.

Different needs call for different information in order to plan the use of land including forest land. Where the supply of traded goods, such as wood and wood products, is concerned, international comparability of data on likely supply and demand is most desirable. Where the supply of environmental services is concerned, it is usually the case that the data needed for planning will be determined within a country and, indeed, within defined areas within the country.

GREIG, B. J. W. (1979). English elm regeneration. *Timber Grower* **73**, 22-24.

In many areas elms are producing prolific regeneration which at present has a generally low level of Dutch elm disease. This note reviews the status of this regeneration in relation to the disease and comments on possible treatment of the growth.

GREIG, B. J. W. and GIBBS, J. N. (1980). Strategic cuts. *GC & HTJ* **187** (10), 21-24.

Reviews experience with sanitation felling programmes to control Dutch elm disease and describes recent research on fungicide injection, bark beetle pheromones and natural control by *Phomopsis oblonga*. These new research developments may make it possible to restrict future losses.

HOLMES, G. D. (1979). The future of British and European forestry. *Timber Grower* **71**, 12-17.

Address to the Annual General Meeting of the Timber Growers Organisation in 1979 outlining developments in world and European forestry strategy and the factors affecting the formulation of forestry policy in Britain and especially means of reconciling afforestation with other calls on the available land.

HOLMES, G. D. (1979). An introduction to forestry in upland Britain. In *Ecology of Even-aged Forest Plantations*, Ed. Ford, E.D. *et al.*, Cambridge, ITE, 7-19.

Discusses the influence of upland forestry on soil, water, flora and fauna and the reconciliation of the needs of silviculture, environmental management, and operational efficiency and the importance of sound knowledge based on research on the forest ecosystem as a basis for management decisions.

HOLMES, G. D. (1980). Relating forestry to farming. In *Forestry and Farming in Upland Britain*, Forestry Commission Occasional Paper 6, 207–226.

A paper presented to the British Association in Edinburgh in September 1979 as part of a Symposium on Land Use in the Uplands. Discusses the scale and location of forestry development in the uplands and means of reconciling the interests of farming and forestry.

[BRAZIER, J. D. and] HOWELL, R. S. (1979). The use of breast-height core for estimating selected whole-tree properties of Sitka spruce. *Forestry* 52 (2), 177–185.

The use of a breast-height core for estimating wood density of the whole stem has been examined for British-grown Sitka spruce (from nine sites). Regression equations have been derived for stem lengths to 7 cm and 18 cm top diameter (ob) and the precision of the estimates determined for both between- and within-site comparisons.

INSLEY, H. (1979). Planting dead trees. *GC & HTJ* 185 (21), 20–23.

Damage to broadleaved trees is discussed in relation to experiments carried out under the Department of the Environment arboriculture research contract. Height growth of *Tilia cordata* and *Platanus x hispanica* standards was improved by branch pruning at planting. Moisture loss from the roots of broadleaved seedlings was found to depend upon root morphology and to be related to subsequent survival and height growth. Moisture loss was reduced by polythene wrapping. Samples of plant material delivered by the trade in 1978 showed that up to 10 per cent had lost more than half their original moisture content between lifting and delivery.

INSLEY, H. (1979). Roe in the New Forest—history, heads and freaks. *Deer* 4 (10), 510–515.

The origins of the New Forest roe population are explained and occurrences of unusual antler types and antlered females are described.

[DIETRICHSON, J. and] LINES, R. (1978). Recent advances from international co-operation in species and provenance selection within the temperate region. In *Third World Consultation on Forest Tree Breeding, Canberra, March 1977*, Canberra, CSIRO, 113–126.

Experiments with introduced species and provenances have shown that indigenous seed sources are not always the most profitable in temperate countries. International co-operation is essential for species and provenance trials. Examples are given of recent international experiments with *Picea abies*, *Pinus contorta*, *Picea sitchensis*, *Populus trichocarpa* and *Larix* spp. Trials are planned as range-wide, short-term studies, using juvenile-mature correlations where possible, or more intensive experiments investigating regions of optimum potential. A good understanding of adaptability is required for introduced species, based on their phenological and physiological variation. Tree breeding programmes should be based on these trials.

LINES, R. (1979). Airborne pollutant damage to vegetation—observed damage. In *Sulphur Emissions and the Environment*. Proceedings of Symposium of Society of the Chemical Industry, London, May 1979, 234–241.

Records of damage to forests by air pollution, especially sulphur dioxide, extend for more than 50 years in N. America and more than 100 years in Europe. Some of the areas worst affected are the Rhine-Ruhr in the German Federal Republic, Northern Bohemia and Silesia, Poland. Many research investigations have been carried out over the last 30 years. Long range transport of pollutants has been studied under a cooperative OECD programme. Forests form an effective sink for pollutants, intercepting 50–100 kg S per ha/annum. Sulphur is an essential nutrient and airborne sulphur can be useful on S deficient soils. The relative quantities of sulphur and other nutrients in foliage can help in diagnosing injury. Trials of different species and provenances in the Central Pennines have shown large differences in susceptibility on sites where pollution is believed to be high.

LINES, R. (1979). Natural variation within and between Silver firs. *Scottish Forestry* 33 (2), 89–101.

Of the 30 species of Silver fir which grow in Britain, only five are planted on a forest scale. *Abies alba* was the earliest introduction and the results of trials with 26 seed origins on four sites show that the best were from Calabria, Czechoslovakia, S. Poland, the Black Forest and the Swiss Juras. Comprehensive trials with *Abies grandis* were planted later (1974) and nursery results of the 1976/77 IUFRO trials with 36 lots are given. It appears that there are very wide differences between origins in growth rate; many earlier seed imports are now believed to have been of inferior type.

LINES, R. (1979). Results of the IUFRO 1964/68 experiments with *Picea abies* in Scotland after 11 years. In *Proceedings of the IUFRO Joint Meeting of Working Parties on Norway Spruce Provenances and Norway Spruce Breeding, Bucharest 1979*, Escherode, F.R.G., Lower Saxony Forest Research Institute, 41–50

The IUFRO Norway spruce seed origin experiments in Scotland contain 400 sources planted on two sites. Results are presented for mean height, diameter and the ratio of height to diameter eleven years after planting. Growth of the best origins has been very fast (GYC 24) whereas with some, which have been commonly used in the past, the rate has been much slower. Diameter growth generally followed the pattern for height, but with some notable exceptions and the distribution was more confused. The ratio of height to diameter emphasised this variation, with a marked tendency for northern origins to have slimmer stems, while those from the Alpine group had greater diameter growth in relation to their height. Comparison of height at 11 years with earlier assessments after 3 and 6 years shows some changes, though the same broad pattern applies.

LOFTHOUSE, M. *et al.* (1979). Forestry Commission/HGTAC Technical Note — The Huntley applicator. *Forestry and British Timber* 8 (12), 37.

LONSDALE, D. (1979). Beech bark disease: one disorder or several? *The Ecologist* 9 4/5, 136–138.

Following the 1976 drought, many beech trees in Britain developed disorders in which drought stress, often in combination with old age, seemed to predispose the trees to bark necrosis of the type associated normally with beech bark disease. The relationships between the different forms of 'beech bark disease' are discussed. There seems to be no justification for fearing that the post-drought damage represents the epidemic spread of any pathogen.

LONSDALE, D. (1979). Beech bark disease — unjustly feared. *GC & HTJ* 186 (18), 13–15.

Beech bark disease and related disorders are discussed and are contrasted to Dutch elm disease in its epidemic form. Guidance is given for identifying various bark conditions in beech and for taking action where appropriate.

LONSDALE, D. (1979). Archéologie et santé des hêtres. *La Recherche* 10 (105), 1137–1138.

(In French). An account of the relationship between foliar chlorosis of beech and patterns of disturbance of chalk soils by ancient cultivation is given. The relevance of the relationship to beech bark disease research and forestry is discussed.

LONSDALE, D., [CUNLIFFE, C. and EPTON, H. A. S.] (1980). Possible routes of entry of *Phytophthora erythroseptica* Pethyb. and its growth within potato plants. *Phytopathologische Zeitschrift* 97 (2), 109–117.

Inoculation experiments at the Cryptogamic Botany Laboratories, Manchester University, showed that zoospore and mycelial inocula could cause infection of host roots, stolons and stem bases. Immature daughter tubers became infected due to progression of the fungus from the initial infection site but, if inoculated directly without wounding, they remained healthy while, in some cases, becoming a site for oospore formation and thus a potential source of carry-over if used as seed tubers.

McCAVISH, W. J. (1980). Goodbye to hand weeding in forest nurseries. *Forestry and British Timber* 9 (3), 20–22.

The effect of diphenamid, nitrofen and oxyfluorfen on reducing the cost of weeding in forest nursery seedbeds is important, as hand weeding is the most expensive routine operation in the nursery. Other herbicides tested more recently, such as napropamide and terbuthylazine, have considerable potential for weed control in conifer seedbeds.

Propyzamide is useful for controlling *Rumex acetocella* with winter applications to stood-over transplanted beds. Simazine still remains the recommended treatment applied immediately after transplanting, followed by ground moistening if necessary.

Diphenamid continues to be the most useful seedbed herbicide for conifers and some broad-leaves.

MacIVER, I. F. (1979). Forestry in Central Scotland. *Forestry* 52 (1), 91–100.

An introduction to the general area visited by the Institute of Foresters of Great Britain and Northern Ireland in September 1979. Brief descriptions are given of the variable history, geology and climate of the area, which included hill sheep farming, highly productive arable farming as well as concentrated industrial activities. Details are given for both the Forestry Commission plantation areas and Private Woodlands in respect of annual planting programmes, annual timber production volume, current and forecast, and the employment directly attributable to the forests.

MACKIE, J. (1979). The further development of afforestation in South-West Scotland. *Scottish Forestry* 33 (2), 137–141.

The text of a speech to the Royal Scottish Forestry Society, S.W. Region. Covers briefly the history of forestry in the area and looks ahead to a possible increase in production and better integration with agriculture.

MERCER, P. C. (1979). Attitudes to pruning wounds. *Arboricultural Journal* 3 (6), 457–465.

An historical summary of attitudes to the treatment of pruning wounds and a discussion of the various factors which could affect callusing and decay, such as time of wounding, shade and aspect of wounds and the response of the host. The use of chemical and biological control measures is discussed.

MERCER, P. C. (1979). Phytotoxicity and fungitoxicity tests for tree wound paints. *Annals of Applied Biology* 91, 199–202.

To assess quickly the wide range of potential treatments for pruning wounds, phytotoxicity and fungitoxicity tests were devised. The phytotoxicity test was based on the growth of poplar callus and the fungitoxicity test on the inhibition of fungal growth on wood strips. Results of field tests were in broad agreement with the laboratory phytotoxicity tests.

MITCHELL, A. F. (1979). Growth rates of Leyland cypresses. *The Garden* 104 (11), 451–2.

MITCHELL, A.F. (1979). The National Tree Register. *The Garden* 104 (9), 384.

[HOUSTON, D. R.,] PARKER, E. J. and LONSDALE, D. (1979). Beech bark disease: patterns of spread and development of the initiating agent *Cryptococcus fagisuga*. *Canadian Journal of Forest Research* 9 (3), 336–344.

Three years after artificial infestation with *Cryptococcus fagisuga* onto individual *Fagus sylvatica* trees, secondary colonization was generally restricted to within 1 m from points of introduction. In young plantations patterns of beech scale infestation were related to distance from large old relic trees, to prevailing wind directions for the insect's larval dispersal period, and to site topography.

The continuous spread of *C. fagisuga* in North America since its introduction in about 1890, and consequent beech bark disease development, suggests a majority of *F. grandifolia* are highly susceptible to infestation, so that environmental factors are relatively unimportant in the disease complex.

[HOUSTON, D. R.,] PARKER, E. J., [PERRIN, R. and LANG, K. J.] (1979). Beech bark disease: a comparison of the disease in N. America, Great Britain, France and Germany. *European Journal of Forest Pathology* 9 (3/4), 199–211.

Recent multi-national investigations into beech bark disease, an often lethal malady of *Fagus* spp., support the concept that the disease complex occurs when bark, infested by the scale insect *Cryptococcus fagisuga*, is infected and killed by fungi of the genus *Nectria*.

Callused bark wounds offer spatial niches for *C. fagisuga*, and protective coatings of bark algae or lichens (especially *Lecanora conizaeoides* in southern England) encourage infestation on young trees. Limited encrustations of the fungus *Ascodicheaena rugosa* are a physical barrier to colonization, especially on the lower trunk. Moribund trees are rapidly degraded by other insects and white rot fungi.

PATCH, D. (1978). Advice, information and the future. *The London Gardener*, 16–21.

A review of the events leading to establishment of arboriculture research funded by the Department of the Environment. An outline is given of the resultant advisory and information facilities available to arboriculturists.

PATCH, D. (1979). Lime trees and bees. *British Isles Bee Breeders' Association News* 17, 28–30.

A summary of information in literature relating to Lime (*Tilia* spp.) and bees, highlighting the existing confused knowledge about the effect of lime trees on bees.

PATCH, D. and STICKLAND, R. E. (1979). Tree climbing. *Arboricultural Journal* 3 (7), 532–535.

A court directive, and publication of the Forest Industry Safety Guide (FSC 18) *Tree Climbing and Pruning*, emphasised the need for workers climbing trees to be 'secured to prevent falling'. This article describes equipment and techniques which could be adopted to meet this need.

PHILIPSON, J. J. and COUTTS, M. P. (1979). The induction of root dormancy in *Picea sitchensis* (Bong.) Carr. by abscisic acid. *Journal of Experimental Botany* 30, 371–80.

The naturally occurring plant hormone abscisic acid, applied at 10^{-4} M, inhibited elongation and induced dormancy in roots of Sitka spruce cuttings growing in solution culture. The dormancy was characterised by superficial browning which progressed towards the root tip and by the development of a layer of lignified and suberized cells around the root apex. The dormant roots remained alive and resumed growth on transfer to ABA-free solutions. The possible role of ABA in inducing root dormancy under adverse conditions is discussed.

PHILLIPS, D. H. (1979). British forestry—the problems of alien diseases and pests. In *Plant Health*, Ed. Ebbels, D. L. and KING, J. E., Blackwells, 87–102.

Now that Britain is a member of the European Economic Community its plant health legislation must be based on the EEC Plant Health Directive 77/93/EEC. Broadly this Directive singles out those pests and diseases likely to cause damage to the most important plants (including trees) grown in EEC Member States. Evaluation of alien pests and diseases of trees is discussed. The alien tree pests of most importance to Britain are listed, with comments on their likely mode of entry, and the steps prescribed to prevent their entry are given.

PRATT, J. E. (1979). *Fomes annosus* butt rot of Sitka spruce. I. Observations on the development of butt-rot in individual trees and in stands. *Forestry* 52 (1), 11–29.

In a study of *Fomes annosus* butt rot in 484 Sitka spruce trees, 23 to 50 years old from 27 sites in Great Britain, three stages of rot (decay, incipient decay and stain) were observed. The heights and the volumes of rot columns appeared to vary with tree size and age. Increases of 5–7 cm yr⁻¹ in the height of rot columns in the stems were estimated. Columns of rotted wood occupied an average 9% of the volumes of the trees which contained them. The incidence of butt-rotted trees on different sites was found to be highly variable (7% to 68%) and unpredictable.

PRATT, J. E. (1979). *Fomes annosus* butt rot of Sitka spruce. II. Loss of strength of wood in various categories of rot. *Forestry* 52 (1), 31–45.

The influence of *Fomes annosus* on the strength (moduli of rupture and elasticity) and density of Sitka spruce wood was assessed using small (150 mm x 10 mm x 10 mm) samples cut from zones of decayed, incipiently-decayed and stained wood from 18 naturally-infected trees. Neither stained nor incipiently-decayed wood appeared to be significantly weaker than healthy wood, but decayed wood was reduced in strength by 26% (mod. of rupture) and 39% (mod. of elasticity). Surprisingly, no significant reduction in density of wood in any of the various categories of rot was detected.

PRATT, J. E. (1979). *Fomes annosus* butt rot of Sitka spruce. III. Losses in yield and value of timber in diseased trees and stands. *Forestry* 52 (2), 113–127.

Average losses per tree of 22% and 33% of volume were sustained by rejection of butt lengths of Sitka spruce containing decay or incipient decay in 484 trees from 27 plantations. Consequent losses in value in these plantations were found to be closely associated with the incidence of butt-rotted trees. A method was devised for predicting losses in value, using the incidence of butt-rotted trees and the current price/size curve. A computer-simulated sawmilling study suggested that losses in revenue might be reduced by about 10% if butt lengths containing rot were converted into pallet boards rather than being rejected in the forest.

PYATT, D. G. and CRAVEN, M. M. (1979). Soil changes under even-aged plantations. In *Ecology of Even-aged Forest Plantations*, Ed. Ford, E. D. et al., Cambridge ITE, 369–386.

Most of the soils of upland Britain are affected by waterlogging but afforestation reduces the supply of rainwater to the soil because of evaporation from the canopy. In some ironpan soils the presence of the tree crop cures the waterlogging, in others preliminary breakage of the pan by cultivation is necessary. In gley soils with low permeability of the deeper layers the effect of spruce crops is small and other more tolerant species must be studied. Deep blanket peats are highly humified and undergo progressive drying with the development of large shrinkage cracks and much improved drainage and aeration.

PYATT, D. G., CRAVEN, M. M. [and WILLIAMS, B. L.] (1979). Peatland classification for forestry in Great Britain. In *Proceedings of the International Symposium on Classification of Peat and Peatlands, Finland 1979*, International Peat Society, 351–366.

Samples taken from 194 peatlands throughout upland Britain were subjected to physical and chemical analysis to check the effectiveness of the present classification based mainly on vegetation in predicting the potential for afforestation. Peatlands with natural irrigation ('flushing') carry *Juncus* or *Molinia* and have higher concentrations of N, P and K than non-flushed or eroded peatlands which carry *Sphagnum*, *Calluna*, *Eriophorum* or *Trichophorum* species. There are also differences in moisture content, bulk density and fibre content. Concentrations of Ca and Mg are not clearly related to the vegetation type. The concentration of Na varies geographically.

[WILLIAMS, B. L., COOPER, J. M. and] PYATT, D. G. (1979). Some effects of afforestation with Lodgepole pine in rates of nitrogen mineralization in peat. *Forestry* 52 (2), 151–160.

Rates of mineral nitrogen production and carbon dioxide evolution in incubated samples from the upper 300 mm of peat beneath Lodgepole pine (*Pinus contorta* Dougl) have been compared with those for adjacent unplanted areas at each of six sites in the north of Scotland. Under both aerobic (moist) and anaerobic (waterlogged) conditions, rates of mineral nitrogen production at 30°C are strongly influenced by peatland type and sampling depth. Peat from beneath the tree crop showed a more rapid production of mineral nitrogen during the early stages of aerobic incubation and a significantly lower rate of carbon dioxide accumulation than peat from unplanted sites.

RATCLIFFE, P. R. and ROWE, J. J. (1979). A golden eagle (*Aquila chrysaetos*) kills an infant Roe deer (*Capreolus capreolus*). *Journal of Zoology* 189, 532–535.

Describes eagle taking healthy roe kid.

RENNOLLS, K. (1979). A contribution to the mathematics of top height. *Mitteilungen der Forstlichen Versuchs- und Forschungsanstalt* 91, 187–195.

A commonly used definition of 'top height of a forest stand' is presented and an approximate analysis is made to determine the size of plot to be used for unbiased top height estimation. The bias resulting from the use of a 'wrong sized' plot is also calculated. The results obtained are in general agreement with those of Fries (1974) and Matérn (1976). In order to overcome inadequacies in the definition of top height an alternative definition is suggested and methods of estimating it are considered.

RENNOLLS, K. (1979). Particular generalizations of Matérn's hardcore competition model. *Mitteilungen der Forstlichen Versuchs- und Forschungsanstalt* 91, 121–126.

Two generalizations of Hard Core competition models are introduced and some results on their second order characterization are given.

RENNOLLS, K. and HALL, J. (1979). The boundary effects on the moments of nearest neighbour distances for points randomly distributed in a circle. *Mitteilungen der Forstlichen Versuchs- und Forschungsanstalt* 91, 197–205.

The difficulties that arise when distance methods are used on points in a bounded region are discussed. An integral formula is derived for the moments of the distance from a sample point to the s^{th} nearest of the points of a Poisson process falling into a domain D , subject to the constraint that there are at least s such points. Numerical integration is then used to calculate the mean and variance of the distance to the closest point when D is a disc, and the results are compared with those of Persson (1970). Using results of Donnelly (1978) on the mean and variance of mean nearest neighbour distance in the binomial case, the expectation and variance of the mean nearest

neighbour distance is calculated for the 'restricted Poisson' situation. Some comments are made on other possible ways of overcoming the problems discussed.

ROWE, J. J. (1979). *High seats for deer management*. Forestry Commission Leaflet 74.

Describes use and availability of various high seat designs.

SAMUEL, C. J. A. and JOHNSTONE, R. C. B. (1979). A study of population variation and inheritance in Sitka spruce. 1. Results of glasshouse, nursery and early forest progeny tests. *Silvae Genetica* 28 (1), 26–32.

The juvenile height growth of 116 families derived from open-pollinated seed collected from a random sample of trees in a 34-years-old plantation of Sitka spruce of Queen Charlotte Islands origin has been studied in a nursery, glasshouse and forest tests on three sites. Annual estimates of heritability up to the sixth year are not outstandingly high. The results are discussed in relation to the reliable interpretation of juvenile assessments, the gains to be expected from a number of methods of breeding and modifications to the breeding strategy for the species.

SEAL, D. T. (1979). Making the most of Britain's upland forest areas. *Timber Trades Journal* 310 (5374), 29.

SEAL, D. T. (1980). Making the most of Britain's upland forests. In *Forestry and Farming in Upland Britain*, Forestry Commission Occasional Paper 6, 77–98.

This paper, originally presented to the 1979 Meeting of the British Association for the Advancement of Science, explains the reasons for the design of older plantations established in the uplands for wood production. The even-aged structure and the use of a diminishing number of coniferous species in pure stands have advantages for economic production of industrial wood but conflict with growing demands on upland forests for wildlife conservation, landscape improvement and opportunities for public recreation. The special treatment of land beside water-courses in future forests is seen as the key to future design and the best means of reconciling wood production with the other functions expected of upland forests.

[MATTHEWS, J. D., LAST, F. T. and] SEAL, D. T. (1979). The way ahead in research and practice. In *Ecology of Even-aged Forest Plantations*, Cambridge, ITE, 529–539.

This paper brings together some of the main concepts from the IUFRO Meeting in Edinburgh in September 1978. A systems approach to forest research is recommended as a means of reconciling the widely different components of the permanent, productive forest. The value of age diversity within blocks of plantation, increased knowledge of soil fertility and means of its maintenance, and the identification of improved tree types and conservation of genetic resources for future use are advanced as important future concepts. Nutrition of plantations is seen as an important area for future research and development.

SMALL, D. (1979). Forest for all seasons. *Geographical Magazine* 51 (9), 620–628.

The author describes the history and structure of the New Forest that has changed in role from a Royal Hunting ground to a provider of timber, agriculture and tourism. He describes in detail the greatest conservation and recreational project ever undertaken in Great Britain and shows the complexities of multiple land use management in the 1980s.

SMALL, D. (1980). Recreational potential of the upland forests. In *Forestry and Farming in Upland Britain*, Forestry Commission Occasional Paper 6, 135–159.

The author reviews statutory, climatical and topographical features of the upland forests, with particular reference to Scotland. He uses the research data provided by the STARR series and planning studies.

He analyses the characteristics of the visitor and his requirements from the countryside. He suggests that future recreational development be approached with caution and advocates future development nearer to main centres of population.

STERN, R. C. (1979). Wildlife conservation in woodlands. In *Hampshire Federation of Young Farmers' Clubs Yearbook 1980*, 48–51.

Describes the active conservation measures the Forestry Commission undertakes in its forests in South-East England. The importance of having the basic information about the wildlife con-

tent—particularly the vascular plants—is stressed. There is a need for staff at all levels to have some understanding of conservation needs and liaison with responsible naturalists is desirable.

STICKLAND, R. E. and BILLANY, D. J. (1979). A use for the crossbow in forestry entomology research. *Quarterly Journal of Forestry* 73 (4), 242–244.

A system for hoisting 'Delta' pheromone traps; baited with adult virgin *Cephalcia lariciphila* females up to the crown level of larch trees was developed to study the behavioural responses of male *C. lariciphila*. The system used a crossbow and a fishing rod which enabled the traps to be erected quickly and obviated the need to climb the trees. The procedure has potentially a wide application in research, arboriculture and general forestry where it is necessary to get a line into the crown of a tree quickly and safely. A safe code of conduct is outlined.

STOAKLEY, J. T. (1979). *Pine Beauty Moth*. Forestry Commission Forest Record 120.

The Pine beauty moth, *Panolis flammea*, is an indigenous species associated with Scots pine, *Pinus sylvestris*, but in Britain no outbreaks are recorded for this host. In 1973 *Panolis* larvae were found in Caithness and Sutherland on Lodgepole pine, *Pinus contorta*, and in 1976 and 1977 severe outbreaks occurred in Naver Forest, Sutherland, resulting in tree death. An account of the biology and chemical control of this pest is given.

TABBUSH, P. (1979). Roe deer control and restocking in the Border forests. *Scottish Forestry* 33 (4), 290–294.

With reference to experience in the Forestry Commission's Kielder District (39 963 ha of plantation) costs and benefits of fencing against roe deer are considered against a background of poor success with restocking. The criteria which lead to the decision on fencing are explored and it is found that given current relativities, benefits may often exceed costs, particularly if fencing is considered when making the initial felling plan.

TANDY, C. R. V. (1979). Designing an attractive but productive forest. *GC & HTJ* 186 (22), 25–27.

This is a journalist's report of the paper on Landscape Design of Hill Forests which was given verbally to the British Association in Edinburgh 1979. (Contents abstract below).

TANDY, C. R. V. (1980). Landscape design of hill forests. In *Forestry and Farming in Upland Britain*, Forestry Commission Occasional Paper 6, 121–133.

Only since 1963 has the idea been accepted that forests could be *designed*. The change in the Commission's role, since 1918, to include recreation and conservation has both assisted the work of the designer, and created new problems. It is the task of the landscape designer to meet the constraints set by land, climate, working conditions and production policy, and yet achieve an end-product which is satisfying visually, provides recreation, loses very little productive timber, meets the needs of farmers, and conserves wildlife. In the upland forests of northern Britain the opportunities and the problems in this work are at their maximum.

THALLON, K. P. (1979). Yield planning and control. Report of 18th Discussion Meeting, Edinburgh. *Forestry* 52 (1), 1–10.

This meeting was well arranged for its presentation of the problems in balancing supply and demand of roundwood in Great Britain and particularly for choice of speakers.

A review of timber trends and prospects for Europe in the world context was followed by papers outlining the methods and principles employed by the Forestry Commission on yield forecasting. These are based upon management of uniform plantations. The justification for irregular forests and the problems faced by management, and possible solutions to yield forecasts and control in these situations, concluded the first day.

The second day was devoted to examining consumers' problems and those of the forest managers in achieving the forecasts in terms of harvesting the yield and selling it.

THALLON, K. P. (1979). Aerial photography in a national tree and forest inventory of Great Britain. In *Forest Resource Inventories*, Vol. I, Fort Collins, Colorado State University, 372–383.

This paper outlines the way in which aerial survey methods are to be employed in the Sample Survey of Trees and Woodlands of Great Britain that is currently in progress. The objective is to substantially reduce the quantity of ground collected data while at the same time improve the

precision of the results. The system that has been adopted involves two sampling levels and although simple in operation, the statistical analysis of the data is complex.

It is estimated that the total costs of the system will be 46% of an equivalent survey based solely on ground sampling.

THALLON, K. P. (1979). Uses of a stand data base for forest management. In *Forest Resource Inventories*, Vol. I, Fort Collins, Colorado State University, 506–513.

This paper presented a description of the Forestry Commission Inventory, yield model construction and forecasting systems as applied to a computer Data Base.

The present outputs of management aids is described. Proposals for the expansion of the data base to that existing, but unsatisfied management information needs, is outlined with some indications of further development.

TOLEMAN, R. D. L. (1979). Site classification. In *Ecology of Even-aged Forest Plantations*, Ed. Ford, E.D. *et al.*, Cambridge, ITE, 23–37.

If consistent, rational silvicultural decisions are to be made when establishing even-aged plantations, a site classification is essential. It must be readily understood and be applicable by forest managers, and should be based on soil and climatic factors which limit production when compared with the requirements of species.

The ultimate objective of a site classification must be to produce a site yield guide incorporating silvicultural proposals designed for the target yield to be achieved. Such a guide may take a considerable time to devise, as the long term effects of site modification and improvement will only be apparent over several rotations.

THOMPSON, D. A. (1979). *Forest Drainage Schemes*. Forestry Commission Leaflet 72.

One of the main problems on many of the soils being afforested in Great Britain is excessive soil water. Solutions adopted were based on agricultural practices and consisted of open drains. Over the years, argument and experimentation have revolved around the depth and spacing of drains for different soil types. Also forest ploughing has evolved from suppressing weeds and providing a turf into which the tree could be planted, to the point where plough furrows give very intensive drainage of the upper soil layers. This leaflet is concerned with open ditch schemes superimposed on ploughing and commonly called cross-draining.

THOMPSON, D. A. (1980). Restocking problems in France. *Scottish Forestry* 34 (1), 35–42.

Aspects of restocking discussed with CNRF, AFOCEL and CERMAS are described. The problems, particularly of drainage, in establishing Norway spruce on gley soils in NE France are discussed, and results of experiments in Limosin on using Douglas fir for restocking old Chestnut coppice are described. The ease with which machinery can be used on the gentle terrain of Les Landes is considered to indicate possibilities for future mechanisation on other site types. Speculations are made as to the usefulness of research into restocking with Atlantic cedar in SE France in explaining poor performance of trees on gleys in upland Britain.

WAINHOUSE, D. (1979). Dispersal of the beech scale (*Cryptococcus fagi* Baer) in relation to the development of beech bark disease. *Bulletin de la Societe Entomologique Suisse* 52, 181–183.

Cryptococcus fagi Baer., the primary pathogen in beech bark disease, disperses passively on air currents to find new hosts. There are steep aerial density gradients of dispersing larvae from individual infested trees, from which they disperse a mean distance of 10.3 m in a mean windspeed of 0.75 m per second. Greatest aerial densities occur at a height of 1 to 3 m but a few larvae are carried by up-currents above the canopy and so have a greater potential range of dispersal.

The efficiency of deposition of larvae is inversely proportional to tree diameter. The size of the adult population that developed on trees close to a heavily infested 'source' tree was not proportional to the number of larvae deposited on them, suggesting heterogeneity in susceptibility of the trees to attack.

WINTER, T. G. (1979). *Torymus druparum* Boheman (Hym., Torymidae) in seeds of *Pyrus communis* L. *Entomologist's Monthly Magazine* 114, 24.

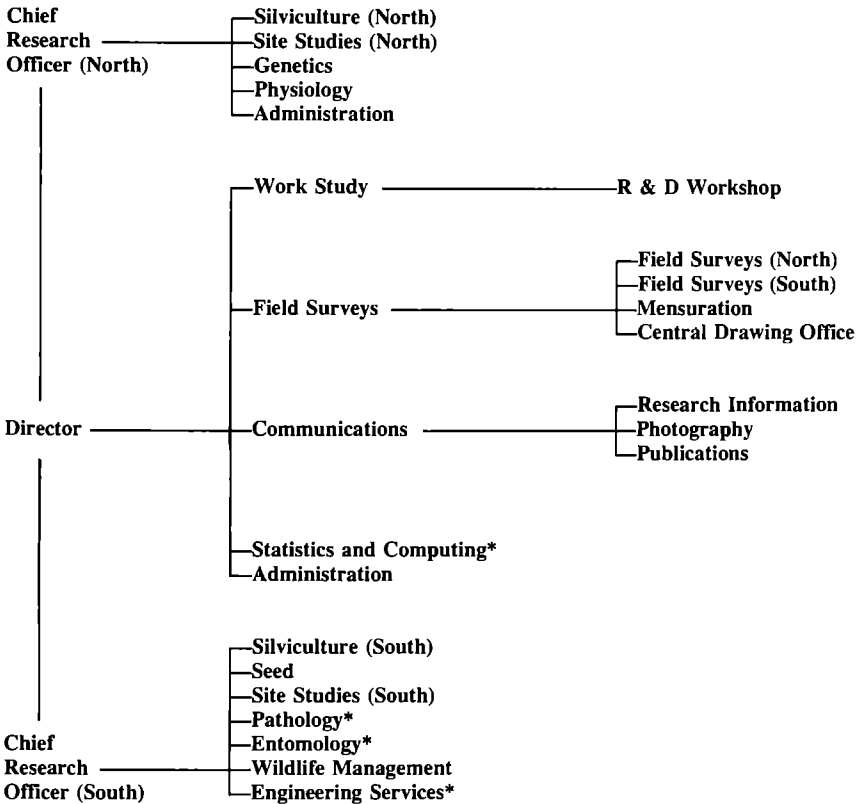
The seed wasp *Torymus druparum* is reported for the first time from *Pyrus communis* seed. This species is usually found in the seeds of *Malus* and *Sorbus* species, especially *S. torminalis*.

WINTER, T. G. (1979). Observations on the biology and some larval parasites of *Rhyacionia duplana logaea* Durrant (Lepidoptera: Tortricidae) in Scotland. *Entomologist's Gazette* **30** (4), 257-265.

Observations on the biology of *R.d. logaea* were made from larvae collected on *Pinus contorta* in Scotland. Laboratory breeding of this insect proved difficult but the number of pairings were increased using a specially developed mating chamber. The ovum is described, and the effect of temperature on the incubation period is discussed. The description of larval behaviour includes details of resin tent construction and the removal of frass from the mine. Larvae leave the mines to pupate but pupae have not been found in the field. Four species of parasites were reared from the larvae collected in Scotland.

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 1980

The main centres for research and development are:

FORESTRY COMMISSION RESEARCH STATION

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

FORESTRY COMMISSION NORTHERN RESEARCH STATION

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

Some staff engaged in research and development 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), Aylebury, 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*)

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

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

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

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

STAFF AT ALICE HOLT LODGE

SILVICULTURE (SOUTH)

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

ARBORICULTURAL ADVISORY SERVICE (Department of the Environment)

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

*Research Foresters:**East England Region*

P. W. W. Daborn	<i>Centre</i>
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

SITE STUDIES (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 S. A. Wright: Miss C. A. Howard, Miss D. V. Kitson,
 Mrs D. A. Waddell

PATHOLOGY

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:

C. W. T. Young, 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 S. A. Kirk, Miss T. C. Osborne, Mrs M. K. Rawlings,
 Mrs A. A. Rees, B.Sc.: A. Jeeves, K. G. Crump.

ENTOMOLOGY

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.

Research Foresters:

R. M. Brown, C. J. King, D. J. Billany.

Laboratory:

N. J. Fielding, Miss J. F. A. Nichols, B.Sc.

* Seconded from University of Surrey

** Seconded from the University of Southampton

† On secondment to ARC Unit of Invertebrate Chemistry and Physiology, Brighton.

WILDLIFE MANAGEMENT

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

A. G. Gordon, B.Sc.(Agric), Ph.D., Head of Branch
Laboratory: D. C. Wakeman: Miss B. L. Nelson, Miss K. Spriggs:
 D. C. F. Rowe, B.Sc.
Seed Store and Extractory T. A. Waddell: L.H. Crumplin, C. Lallemand.

ENGINEERING SERVICES

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

WORK STUDY

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

Machinery Research and Development

R. B. Ross, M.I.Mech.E.
 W. S. Mackenzie

<i>Field Teams:</i>		<i>Centre</i>
North Scotland	M. Lofthouse, B.Sc.(For.) (Leader) R. G. Muhl: R. A. Sandilands F. W. Hayes, B. G. Allison	Smithton, Inverness
<i>Office:</i> Borders	Mrs V. Mackenzie (Typist) A. Whayman, M.B.E., M.M., M.I.For. (Leader)	Ae, Dumfries
<i>Office:</i> East England	J. D. A. Tyres: K. A. Russell, J. B. Spencer Mrs M. Park M. N. Haworth, B.Sc.(For.) (Leader)	Santon Downham, Thetford
Southern England	P. B. Lane, L. A. Cohen, N. Head D. Howard (Leader): R. N. Gossling	Brockenhurst
Wales	A. T. Jones, B.Sc.(For.), D.M.S., M.I.For. (Leader) D. G. Davies, N.D.F., M.I.For.: B. S. Hicks, W. J. Parkin, B.Sc.(For.) C. J. Pearce, C.J. Roberts	Brecon and Dolgellau
<i>Special Duties</i>	J. A. Drummond, B.Sc.(For.)	Ae, Dumfries

FIELD SURVEYS

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, M. D. Whitlock

Foresters stationed throughout England and Wales:

A. C. Dover, M.I.For.: P. A. V. Burke, E. B. Cordery, N. C. Day, E. C. C. Gardner, D. Hammond, H. Oram, B. D. Pattern.

Foresters stationed throughout Scotland:

R. F. E. Bartlett, J. Straiton: J. Boluski, N. Bousfield, F. W. E. Burlton, A. R. Brown, D. G. Caird, J. Davidson, G. R. Dunbar, D. E. Ellis, R. Evans, J. C. Findlay, H. Gillen, J. A. McIntyre, 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, A. L. Cooper: D. B. Armstrong, Miss V. Colgan, G. H. Hunter, Miss E. Baillie, R. H. Beck, K. R. Fergus, Miss M. F. Innes, Miss V. M. Stupple, Mrs L. E. Marshall, Miss E. McKeen, Miss S. Murchison, R. Venables.
D. S. Mitchell (Asst Photographer)

STATISTICS AND COMPUTING

R. S. Howell, Head of Branch

I. D. Mobbs, A.I.S.**, K. Rennolls, B.Sc., M.Sc, R. C. Boswell, B.Sc., M.I.S.,

G. J. Hall, B.Sc., A. J. Peace, B.Sc., Miss J. Symth, B.Sc.: R. M. A. Gill, 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

COMMUNICATIONS

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

RESEARCH INFORMATION SECTION

O. N. Blatchford, B.Sc.(For.), A.I.Inf.Sc., Head of section

P. J. Langley, M.A.: Miss C. W. Bradshaw, 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

**Seconded: Pay Research Unit

ADMINISTRATIVE STAFF

HEOs:	Mrs D. R. Harper (<i>Branch A</i>), R. Murray (<i>Branch B</i>)
EOs:	Mrs K. A. Fielding (<i>Estabs</i>), S. Hankin (<i>Stats</i>), L. W. Thomas (<i>Office Services</i>), M. G. Wheeler (<i>Finance</i>).
COs:	Mrs K. S. Butcher (<i>Office Services</i>), Miss C. I. Derrick (<i>Estabs</i>), Mrs M. E. Douglas (<i>Field Surveys</i>), J. Ellison (<i>Entomology</i>), J. Empson (<i>Pathology</i>), Mrs M. Greenwood (<i>Seeds</i>), Mrs W. B. Groves (<i>Estabs</i>), Miss G. B. Hayden (<i>Communications</i>), Mrs P. J. Holcombe (<i>Work Study</i>), J. G. Jackman (<i>Wildlife/Site Studies</i>), Miss J. R. Lacey (<i>Finance</i>), Mrs P. A. M. Pharo (<i>Silviculture</i>), S. Potheary (<i>Communications</i>), W. E. Powell (<i>Work Study</i>), Miss L. M. Raggett (<i>Estabs</i>), Miss C. A. Woods (<i>Communications</i>), Mrs C. A. Yeomans (<i>Finance</i>).
CAs:	Mrs J. N. R. Burbidge (<i>Work Study</i>), Mrs M. Butt (<i>Communications</i>), Mrs M. Foster (<i>Seeds</i>), Mrs. L. Gower (<i>Office Services</i>), Miss S. M. Haywood (<i>Field Surveys</i>), Mrs B. A. Maisey (<i>Office Services</i>), Mrs S. M. Locke (<i>Estabs</i>).
Photoprinter II:	Miss E. A. Hill
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