REPORT ON

FOREST RESEARCH

1977

FORESTRY COMMISSION

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Cover picture:
An oblique aerial view of severe defoliation by Pine Beauty moth, *Panolis flammea*, on Lodgepole pine at Naver Forest (Highland). The Pine Beauty is indigenous to Britain and occurs commonly on pines, but this is the first time it has attained pest status. (p. 34)

FORESTRY COMMISSION

REPORT ON FOREST RESEARCH

for the year ended
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The abbreviated title of this Report is:
Rep. Forest Res., Lond. 1977

Corrigenda to Rep. Forest Res., Lond. 1976

Page 36, line 19. For 2,000 ha read 1,000 ha.

Page 38, lines 19 and 22. For *Olesicampa montizada* read *O. monticola.*

Page 40, line 3. For *Longaea* read *Logaea.*

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ACKNOWLEDGEMENTS

The cover picture and plates are from the Forestry Commission's Research photographic collection. The diagrams were supplied by the respective authors and prepared for publication by the Commission's Research Photography Section.

INTRODUCTION

By D. R. JOHNSTON
Director of Research and Development

Arboriculture

The planned staff have now been recruited for the Department of the Environment contract for arboricultural research. The first leaflet of the new arboricultural series has been written and was published in May 1977. A small contract to appraise the problems and results of tree planting on restored opencast coal sites has been commissioned by the National Coal Board.

Accommodation

Work on an extension to the new wing at Alice Holt Lodge was completed early in the year. The new building has improved the working conditions for staff previously housed in deteriorating huts and also provides accommodation for the new work on arboriculture.

Deer Research

A joint programme of research on Red deer in Scotland has been agreed with the Red Deer Commission and the Institute of Terrestrial Ecology.

EEC Symposium of Forest Biochemists

The Chief Research Officer (North)—D. T. Seal—chaired an EEC Symposium of forest biochemists in Brussels in January 1977.

International Exchanges

Dr R. D. Houston from the North-eastern Forest Experiment Station of the USDA Forest Service at Upper Darby, Pennsylvania, returned to the United States after spending a year with the Pathology Branch studying Beech bark disease.

Dr J. N. Gibbs (Pathology) has gone to the North Central Forest Experiment Station at St Paul, Minnesota, to study oak wilt, for twelve months from March 1977.

Professor J. H. Borden, from Simon Fraser University, Vancouver, British Columbia, joined the Entomology Branch. He has initiated studies into the pheromone chemistry of *Scolytus scolytus* (a vector of Dutch elm disease) in collaboration with the Unit of Invertebrate Chemistry and Physiology of the Agricultural Research Council.

Awards to Staff

J. D. Low (Chief Forester, Pathology (N)) and B. J. W. Greig (Head Forester, Pathology) were awarded the 1976 Silvicultural Prize of the Institute of Foresters for their recent papers in *Forestry*. Mr Greig also became a Member of the Institute of Foresters.

D. G. Davies (Forester, Work Study) gained his National Diploma of Forestry and was accepted as a member of the Institute of Foresters.

Visitors

Six hundred and sixteen people visited Alice Holt Lodge, coming from 23 countries. They included a visit from the International Plant Propagators Society, the Timber Growers' Organisation Technical Sub-Committee, the Institute of Foresters' Silvicultural Group and the National Forestry Committee for England.

There were 151 visitors to the Northern Research Station, including parties from the Scottish Landowners Federation, the Association of Applied Biologists and the Forestry Commissioners.

Visits and Conferences

Staff attended 17 conferences overseas (including the IUFRO Congress, four other IUFRO meetings, and several European meetings), and a further 10 in this country. Several staff also toured various countries as advisors and on fact-finding visits.

Staff Changes

P. N. Edwards (District Officer II) became Mensuration Officer in place of G. J. Hamilton who transferred to East Scotland Conservancy.

Transfers in: A. J. G. Hughes (District Officer I, Work Study) transferred from North Wales Conservancy. H. Insley (District Officer I, Arboriculture) was transferred on promotion from South East England Conservancy. G. Tuley (District Officer I, Silviculture South) on promotion from East Scotland. K. W. Wilson (District Officer I, Publications) from South East England Conservancy. R. C. Melville (District Officer II, Wildlife) transferred from North Wales Conservancy. D. Elgy (Head Forester, Silviculture South) transferred on promotion from East Scotland Conservancy. J. Hunt (Head Forester, Silviculture North) on promotion from South Wales Conservancy. L. A. Cohen (Executive Officer, Work Study), transferred from South East England Conservancy.

New Entrants: D. Patch (Senior Scientific Officer) to Arboricultural Advisory Service, Silviculture South. K. Rennolls (Higher Scientific Officer) to Statistics and Computing. C. Shuttleworth (Photographer) Field Surveys, Central Drawing Office.

Transfers out: R. D. L. Toleman (District Officer I, Site Surveys) to South Scotland Conservancy. G. J. Hamilton (District Officer I, Mensuration) to East Scotland. K. Broad (Head Forester, Silviculture South) to South West England. J. Howarth (Head Forester, Physiology) to North East England. L. A. Howe (Head Forester, Silviculture South) to South East England. E. V. Rogers (Head Forester, Work Study) to East England Conservancy. R. J. Reid (Head Forester, Work Study) to South Wales Conservancy.

Promotions: Dr C. M. Brasier (Pathology) and Dr A. G. Gordon (Seed) to Principal Scientific Officer. J. J. Philipson (Physiology) to Higher Scientific Officer. D. A. Barbour (Entomology North) and G. D. Bell (Statistics and Computing North) to Scientific Officer. D. Bruce, Miss V. Colgan and Miss L. E. Smith (Field Survey, Central Drawing Office) to Cartographic Draughtsman. P. W. W. Daborn (Silviculture South) and L. A. Tee (Wildlife) to Chief Foresters. D. G. Davies (Work Study, Dolgellau), T. R. Sawyer (Work Study) and H. W. Pepper (Wildlife) to Head Forester. F. S. Smith (Silviculture North) was transferred from Silviculture South on promotion to Head Forester.

Retirements: H. L. Edlin (District Officer I, Publications). R. M. Ure (Chief Forester, Silviculture South). Miss S. B. Page (Executive Officer, Silviculture South). R. D. Duncan (Executive Officer, Work Study). R. H. M. Taylor (Clerical Assistant, Work Study). F. J. M. Awdry (Pathology).

Deaths: H. L. Edlin, formerly Publications Officer at Savile Row and Alice Holt Lodge.

M. Baggs, formerly on the Alice Holt garden staff.

PART I

The Work of the Forestry Commission

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* No progress is reported during the year.

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SEED

Research

Scots Pine Seed Orchard Extraction and Germination Trial

Differences in the yields of seeds per hectolitre of cones collected have been obtained from individual ramets within clones from a polycross seed orchard. So far no logical explanation has been found. The screening of progeny tested clones for their high seed yield and ease of seed extraction has continued. Four-fold differences in yield of seeds per hectolitre of cones have been observed which would have important influences on the production of seed from established seed orchards.

Nursery Experiments

Because of the drought conditions which persisted from March to September 1976 at Headley Nursery where no irrigation plant was available, the yield of seedlings in all five seed experiments laid out was very far below normal and made any conclusions very questionable. The results did show, however, that despite the drought prechilled seeds gave better germination than unprechilled seed, that Research sowing techniques gave double the germination of Conservancy techniques and that Western hemlock seeds germinated more fully under sand than under grit as a seedbed cover. All experiments will be repeated with irrigation available in 1977.

Survey of Nursery Productivities

The survey of Conservancy nursery productivities by year, species and site has now been completed. In an effort to explain the extremely variable results obtained, calculations have been made of the estimated soil moisture deficits from March to August. They have shown that moisture deficits capable of limiting germination and/or growth have built up in all nurseries at some stage during all years. Large deficits in April and May appear to be correlated with poor germination. In 1976, estimated moisture deficits exceeding 150 mm of water existed for several weeks at several nurseries for which the final germination totals were greatly reduced. Characteristically, *Pinus* species did not suffer as badly as spruces, firs and larches. Where irrigation was available and regularly used the germination and growth of seedlings was well above average.

Germination Studies using a Thermo-gradient Bar

Further seed lots of both conifer and broadleaved species have been studied. Results have shown that there are surprisingly small variations in the germination—temperature response curve for origins of the same species from widely differing latitudes. With minor variations in position, all lots studied have had very sharp cut-off points at both low and high temperatures. The sharp cut-off is considerably reduced by prechilling the seeds. However, these temperature responses may have important implications when raising container stock. The germination temperature normally used for this has been found to be very close to the cut-off point for many seed lots. These results could also explain the improved germination of non-dormant seeds in cold seedbeds after prechilling.

Invigoration of Conifer Seeds with Polyethylene Glycol (PEG)

Because of evidence from other workers contradictory to last years results, further trials were carried out on a much wider range of species and origins, using several alternative PEG treatment techniques. Some of these did in fact produce a further stimulation of laboratory germination over that which could be achieved very much more simply by prechilling. Different seed lots were stimulated by different treatments. One lot of northern Swedish Scots pine benefited particularly from the treatment. Because of the critical nature of the successful treatments it does not seem that they will ever become of commercial importance in Great Britain, however their effect in open nursery conditions will be studied in 1977.

Nothofagus Germination Studies

The laboratory and field germination of *Nothofagus* spp. has been unreliable but chronic shortages of seeds have prevented detailed studies. A plentiful crop of seeds of *N. obliqua* from home sources and *N. procera* from Chilean and home sources provided a useful opportunity to begin a study. The results have been reported in detail elsewhere (Gordon, 1977). They have shown that a soak in Gibberelic acid (GA_3) has overcome almost all germination problems of these species.

GA_3 has now been used on seeds of 40 different lots of another 13 species of *Nothofagus* from South America, New Zealand and Australia. Where comparisons were possible the GA_3 treatment improved the germination of all seed lots. The use of GA_3 for nursery sowings is being studied in 1977.

International Seed Testing Association

As leader of the Germination Group of the Forest Tree Seed Committee, the reporter carried out a postal debate on several important issues left unresolved from the Forest Tree Seed Workshop (see *Report* for 1976 p. 8). The results were put in the form of proposed changes to the Rules and Annexes of Chapter 5 of the International Rules for Seed Testing. These will be discussed and voted on at the ISTA Congress in Madrid in May 1977.

Service

The Branch has again provided a supply of home collected and where necessary, imported seeds of the main conifers for Conservancy nurseries and the private trade, acting as agents for Forest Management Division in this respect. It has again supplied broadleaved seeds to Conservancies and to private nurseries against firm orders. It has also continued to carry out its duties as the Official Forest Seed Testing Station.

There was heavy flowering in almost all tree species in 1976, following the warm dry summer in 1975. The heaviest crop was in Sitka spruce from which, after Registration of suitable stands of Queen Charlotte Islands origin, 1560 hectolitres of cones were collected. From these, 1833 kg of seeds were extracted which was very close to the target of 2000 kg. Conservancy staffs are to be congratulated on their efforts. Although coning was prolific on several other species, the heaviest crops did not occur on Registerable stands. As a result, collections and extracted seed of Douglas fir, Japanese larch and Hybrid larch were well below target. Coning in the pines was not so prolific reflecting the two year cycle of their coning. However the target of Skeena River origin Lodgepole

pine was collected, along with half of the Scots pine. No Corsican pine cones were collected.

Collections of broadleaved species were reasonably successful, far more being collected than ever before since Registration began. The total requirement of Pedunculate oak was satisfied by home collections (mainly from private estates); approximately half of the Sessile was also collected. Although fruiting in beech was exceptionally heavy, many seeds failed to develop fully and the quantity collected was well below target. Requirements of Sessile oak and beech were made up by importations.

There were few conifer importations last year. One hundred kg of Grand fir raised the stocks to three years' requirements. Limited quantities of South Coastal (Long Beach) Lodgepole pine were bought in. Small importations were made from three sources of the same species from within the Southern Interior zone of British Columbia. World demand far exceeded supply for this provenance as well as for Sudeten larch, for which no seed at all was obtained.

Supplies of conifer seed to the Forestry Commission for the 1977 sowing season were almost identical in total to the 1976 season; much more Japanese larch was sown with a compensating reduction in the quantity of Sitka spruce. Supplies of conifer seed to the trade showed an overall increase of 20 per cent over the 1976 season. Sales of most species showed slight increases but Scots pine and Corsican pine sales showed large increases and European larch and Western hemlock small decreases. Substantial quantities of surplus seeds were again sold abroad, although they totalled only half of last year's sales. Full details of seed supply and procurement, which used to be published annually in this *Report* are available on request from the Principal Seeds Officer.

A. G. GORDON

REFERENCE

GORDON, A. G. (1977). Raising *Nothofagus* seed. *Forestry and British Timber* **6** (3), pp. 20-21.

SILVICULTURE (SOUTH)

Plant Production

Seedbed Herbicides (Open Nursery)

Diphenamid and nitrofen gave safe and good pre-emergent weed control on Lodgepole pine. Post-emergent weed control was less successful. Rates tested were 4, 6 and 8 kg ai/ha.

Trifluralin (0.4, 0.6, 0.8 and 1.0 kg ai/ha) a pre-sowing herbicide gave safe and good weed control on Lodgepole pine.

The following species showed good tolerance to pre- and post-emergent treatments of diphenamid and nitrofen at 4 kg ai/ha: Sitka spruce, Lodgepole pine, Norway spruce, Corsican pine, Scots pine, Douglas fir, Japanese larch, European larch, Grand fir, beech and Sessile oak.

Propyzamide (1.0 and 2.0 kg ai/ha) was successfully used on overwintering Sitka spruce and Lodgepole pine seedlings.

Nutrition of Broadleaved Seedlings

Slow release nitrogenous fertilisers (5 gms element N/m^2) gave no improvement over nitrochalk.

Conifer Seedlings in Paperpots (Polythene Greenhouse)

Corsican pine did not respond to underheating to produce taller plants, due to a warm spring and hot summer. Different levels of liquid top-dressing did not affect growth. The incorporation of horticultural vermiculite into the "Irish Moss Peat" medium reduced seedling height and initially yellowed the foliage.

Corsican pine, Lodgepole pine, Scots pine, larches, Sitka and Norway spruce and Douglas fir were successfully raised in Paperpots, but Western hemlock, Red cedar, Grand and Noble firs were not. Gloquat at 15 mls/m^2 under the trays did not prevent rooting-through. Ethrel "E" at 1,000 ppm applied to run-off did not induce artificial hardening-off.

Broadleaved Seedlings in Paperpots and Containers (Polythene Greenhouse)

Raising broadleaves from seed in Paperpots in a polythene greenhouse confirmed the rapid growth of seedlings (see Table A). Neither removing the Paperpots before potting on nor the addition of extra nutrients had a beneficial effect.

1+0 seedlings brought in from the open nursery and grown on in the polythene greenhouse showed varied results (see Table A, column 2), and it is doubtful whether the greater growth of birch and oak compensates for the extra space required by the larger pots. Growing seed in Paperpots is the better polythene greenhouse method.

TABLE A

HEIGHT GROWTH OF BROADLEAVED SEEDLINGS AND 1+0'S IN POLYTHENE GREENHOUSE

Species	(1) From seed in polyhouse (cm) 33 weeks	(2) 1+0's seedlings brought into polyhouse (cm) 36 weeks
Beech	54	49
Birch	116	202
Sycamore	104	116
Oak (Sessile)	30	49

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

Conifers in Paperpots

Corsican pine, Sitka spruce and Lodgepole pine Paperpot seedlings, raised in enriched carbon dioxide atmospheres, were planted in the forest. After one full growing season the Corsican pine are proving superior to 1+1 transplants in both height and survival for both planting dates tested (autumn 1975 and spring 1976). The Sitka spruce survival was similar, and autumn planted Paperpot stock remained taller while spring planted Paperpot stock was outgrown by 1+1 transplants. Autumn planted Lodgepole pine Paperpot stock suffered sheep damage giving worse survival than 1+1 transplants as did spring

planted stock. Both spring and autumn planted Paperpot stock remained taller.

Differences in height growth associated with lighting, additional top-dressing and CO_2 enrichment shown during the greenhouse phase were less obvious after planting out.

Broadleaved Species in Containers

One series of broadleaved species experiments compared a Paperpot with a Spencer-Lemaire pot planted at three different dates June 1974, October 1974 and April 1975 included the following species:

Quercus robur, *Fagus sylvatica*, *Acer pseudoplatanus*, *Acer platanoides*, *Alnus incana* and *Betula pendula*. Only birch and alder gave satisfactory height growth. Pot type and planting date had little effect on any of the species tested.

Another series compared a Paperpot with a Paperpot potted on into a "Whalehide amenity" pot (0.75 litre) or a "Whalehide rose" pot (4.0 litre). After one season "amenity" pots gave the best growth on a surface-water gley site while "rose" pots gave the best growth on a reclaimed gravel pit site. "Rose" pots were planted later in the season, and plants in them remained the tallest.

W. J. McCAVISH

Vegetative Propagation

Experiments were carried out to compare the ease of rooting of semi-hardwood cuttings, and the behaviour after bedding out of rooted cuttings, of different clones of the spontaneous bi-generic hybrid Leyland cypress × *Cupressocyparis leylandii*. The accumulated evidence suggests that in controlled conditions, while the rate of root initiation and development may show little variation overall, some clones clearly grow faster and have a better stem and crown shape than other clones during their years in the nursery.

Since the vigour and appearance of the nursery plants directly affect their saleability, the importance of clonal selection in the first place cannot be over emphasised. Three recently released clones and two clones that have been known for some years but hardly ever propagated were used in the experiments.

Methods of raising broadleaved species and cultivars from softwood cuttings under mist were again studied. London plane, *Platanus* × *hispanica*, and Small-leaved lime, *Tilia cordata*, were the main trees worked on. A test carried out during the winter on hardwood cuttings of London plane disclosed that this type of material roots readily in heated beds at 21°–24°C.

J. JOBLING

Lowland Silviculture

Native Broadleaves

Research into the silviculture of native broadleaves is directed towards reducing the high establishment costs and shortening the time taken to produce high value products.

Intensively raised containerised planting stock (1 m whips in approximately 20 weeks) has been used to establish experiments at very wide spacing (11 m^2). Maximum amelioration of fewer planting positions, plus minimal disturbance of plants and therefore little or no check, are being investigated to see whether they enable plants to keep clear of vegetation regrowth.

Enhanced rates of radial growth of oak have been obtained by early heavy crown thinnings on existing pole-stage crops. Positive NDR calculations are predicted for rotation ages 80-100 years from this "free-growth" treatment, and a publication of the results of this work is now available (Jobling and Pearce, 1977).

M. L. PEARCE

Exotic Broadleaves

To date *Quercus palustris*, *Q. frainetto*, *Alnus rubra*, *A. cordata* and *Fraxinus americana* have been raised intensively and planted out on cleared broadleaved woodland sites to see if they have any advantages over our native species.

Intensive provenance experiments using imported and home collected seed of *Nothofagus obliqua* and *N. procera* have been started to obtain as much information as possible about the variation within the species. Larger seed lots are to be sown in spring 1977 in the open nursery for conventional provenance experiments.

G. TULEY, M. L. PEARCE

Fast Growing Pines

Recent work at Cannock Chase suggests that both *Pinus radiata* and *P muricata* can be established from either Japanese Paperpot (JPP), 1+0 or 1 u 1 stock provided that plants are well rooted and not more than 30 cm tall. Plants lifted during February and early March were cold-stored until soil temperatures rose to around 10°C. The JPP stock were December sown to reach 10 cm for planting in May/June. The development of heavy crowns by both species on richer sites and after complete ploughing renders them liable to wind-rock. *P. muricata* in particular can develop a very bushy base with many branches on the lowest metre of stem. A trial has been established to see if movement of humus by ploughing followed by planting in bare mineral soil will lead to more satisfactory initial growth. Growth in 1976 was impressive and survival of trees planted during the drought in May and June was good except in dense vegetation, and was improved where shallow ploughed.

G. TULEY, D. F. FOURT

Forest Weed Control

Screening of Herbicides

1+0 transplants of alder, Horse chestnut, sycamore, birch, beech, rauli (*Nothofagus procera*), gean, oak, Lodgepole pine, European larch, Grand fir, Noble fir, Red cedar, Lawson cypress, *Pinus muricata* and *Pinus radiata* showed good crop tolerance of propyzamide at 2 and 4 kg ai/ha.

Glyphosate at 0.5, 1.0 and 1.5 kg ae/ha was applied in early March, early June and August to Corsican pine, Lodgepole pine, Sitka spruce, Norway spruce, Douglas fir and Japanese larch. Spruces were relatively unaffected by any treatments, but pines lost a little height growth in the early March treatments. Japanese larch was seriously affected by June treatments but less so by March and August treatments. March treatment of Douglas fir caused reduced height growth at 0.5 kg ae/ha and some deaths at 1.0 and 1.5 kg ae/ha, but later treatments had no such effect. All species except Norway spruce showed some signs of chlorosis or reduced height growth.

Half of the plots received ammonium sulphate additive which can enhance the herbicidal effect. Height and survival were unaffected by it but the health of Japanese larch and Douglas fir deteriorated.

Krenite at 2.1 and 4.2 kg ai/ha was applied in August and September to 1+3 plants of Corsican pine, Scots pine, Sitka spruce, Norway spruce, Douglas fir, Western hemlock, Hybrid larch, Red oak and beech. Oak and beech were severely affected and barely flushed the following spring. Conifer survival was unaffected though health and height of Japanese larch and Douglas fir were impaired.

Control of Grasses and Herbaceous Broadleaved Weeds

Glyphosate at 0.5 and 1.0 kg ae/ha was applied in early spring and mid-summer at medium and low volume, with and without ammonium sulphate additive.

All grasses except *Calamagrostis epigejos* were fully controlled for a whole season. The *C. epigejos* produced some regrowth by mid-season after spring applications. The additive improved grass control.

The survival of 1+1 Sitka spruce, Corsican pine and Douglas fir was unaffected. Health and height of a three year old Sitka spruce crop was improved greatly by the early spring application. Medium volume gave better control on all but *Calamagrostis epigejos* on which low volume applications were more effective.

Suspension concentrates of propyzamide, atrazine and "Holtox", an atrazine/cyanazine mixture, were tested at low volume.

Rates tested were:

Propyzamide 0.5, 1.0, 1.5 and 2.0 kg ai/ha
Atrazine and Atrazine/cyanazine 2.0, 4.0, 6.0 and 8.0 kg ai/ha

Propyzamide at low volume was as effective as at medium volume. Atrazine and atrazine/cyanazine were not; Atrazine at low volume required an additional 2 kg ai/ha to remain equally effective while atrazine/cyanazine was not as effective as the medium volume application, at any of the low volume rates.

W. J. McCavish, F. S. Smith

Arboriculture—Department of the Environment Contracts

Advisory and Information Service

The Arboricultural Advisory and Information Service has been established at Alice Holt Lodge as part of the contract awarded to the Forestry Commission by the Department of the Environment. During the period January 1976 to March 1977 this service answered by letter, telephone or site meetings 512 enquiries.

The unusually dry summers of 1975 and 1976 produced a spate of enquiries (18 per cent of the total) requesting information relating to the legal implications of trees, and the effect of tree roots, on buildings constructed on shrinkable clay subsoils. Most of these queries came from private individuals.

Other frequent problems which were raised by the private sector, local government and consultants, were the selection of tree and shrub species and the inhibition of fruit formation in *Aesculus hippocastanum*. Mature tree maintenance and stump removal have also generated a number of enquiries.

D. Patch, F. R. W. Stevens

Production and Establishment

A trial of mulch materials, applied to newly planted trees, was started in 1975 on a site beside the A.12 trunk road at Kelvedon, Essex. This indicated that loose bark mulches probably gave the most effective weed suppression, but that the various materials required more detailed testing. A new trial has been started on the A.3 Ripley by-pass in Surrey.

Tests of planting methods are being made with stock raised in Japanese Paperpots.

Container grown and bare root stock are being compared on a topsoil covered rubble embankment at Aldershot, Hampshire, and mulches on destructured clay at Milton Keynes, Buckinghamshire. The effects of the exceptional drought of 1976 on this type of clay is shown in Plate 1.

H. INSLEY, J. B. H. GARDINER

Coal Tip Review

A research contract was started in early October for the Department of the Environment, to study the reclamation of colliery spoil heaps with special reference to the establishment of trees and other woody vegetation on regraded materials. The work involves the examination of coal tips, a review of the relevant literature, and direct contact with research workers and field practitioners. The contract terminates at the end of September, 1977.

J. JOBLING

Arboriculture—other

Difficult Man-made Sites

A small research contract was also begun for the Opencast Executive of the National Coal Board, to appraise the problems and results of tree planting on restored opencast coal sites. This study involves field surveys and discussions with practitioners.

Further progress was made in the review of tree planting on filled sand and gravel workings. Particular attention was given to the serious problem of domestic refuse disposal in old pits, and useful discussions on the subject were held with several local authorities.

J. JOBLING

Dendrology

During 1976, 97 estates were visited, 26 of them in Northern Ireland. Fifty-eight of these were first visits and 39 were to bring up to date measurements taken in earlier years. Trees measured were 3137 of which 996 were re-measurements and 2141 were new trees added. The card-index now includes 40,798 trees of 1,300 species. Conifers continue to increase their lead over broadleaves in the number of specimens measured (24,785 against 16,013) and fall further behind in the number of species (276 against 1024). There are now listed 250 cultivars of conifer and 449 of broadleaved trees. Of the 2405 trees on the cards derived from Elwes and Henry (1902-1912) 807 have been found and remeasured. Of the 4419 conifers listed in the Report of the Conifer Conference of 1931, those found and remeasured now total 2531. These remeasurements give a valuable insight into the growth of old and young trees over quite long periods to supplement the short period increments from second and third visits since 1954.

Westonbirt, Gloucestershire

Work was started on the building of a Visitor Centre and is progressing well. Improvements in the access road and to exclude cattle from the car-park area are working well. Gales removed many trees during the winter but only two were important specimens. Lightning exploded a Giant sequoia in the Downs and heavy fragments did a little damage in the Arboretum.

There has been extensive planting in general, and a glade of cherry species and cultivars was started with three trees each of 20 clones as a gift from Mr H. G. Hillier, after whom the glade is named. A glade of species native to the British Isles has been planted with about one third of the final total of trees and an understorey of native shrubs will be added before it is complete. The trees are arranged in an approximation to the order in which they colonised these islands. A sturdy 2m one-year seedling of *Nothofagus procera* was ceremonially planted by the Duke of Beaufort and the Consultative Committee of the arboretum near the car-park to commemorate the Queen's Silver Jubilee year.

Bedgebury, Kent

New plantings have taken in a large sloping area of good soil where tender species are being established under a light cover of birch and Sweet chestnut. The extension to the collection of Lawson cypress cultivars across the stream from this has been increased and is making good progress.

A. F. MITCHELL

REFERENCE

JOBLING, J., and PEARCE, M. L. (1977). *Free growth of oak.* Forestry Commission Forest Record 113 (London: HMSO, 50p).

SILVICULTURE (NORTH)

Production of Planting Stock

Seedbed Herbicides

Diphenamid (at 4 kg ai/ha) has been tested for 2 years as a post-emergent herbicide. Sitka spruce and Lodgepole pine seedbeds were treated at any time during emergence without seedling damage, but weed control was not as effective as with pre-emergent spraying. Seedbeds of Scots pine, European larch, Japanese larch and Norway spruce can be treated at the same rate before seedling emergence and after full extension of the first needles.

Nitrofen and RH2915 were tested as pre- and post-emergent herbicides on Sitka spruce and Lodgepole pine seedbeds and found to be almost as effective as diphenamid; no seedling damage was observed.

Herbicides on Transplants

Propyzamide is being tried on Sitka spruce and Lodgepole pine transplant lines. Results are promising but further trials are necessary.

Preliminary trials with glyphosate indicate that it may also have potential.

Seedbed Cloches

An experiment at Newton (Laigh of Moray Forest, Grampian) showed that seedlings large enough for lining out could successfully be grown under cloches on unsterilised ground provided the edges of the cloches were buried, thus preventing any loss of moisture in the hot weather. High humidity seemed to protect the seedlings from scorch damage in hot weather. Cloches were left on for as long as 16 weeks without damage.

Partial Sterilisation

Damage attributed to the use of dazomet in 1975 was again noted in the 1976 season. Trials with different rotovation treatments for gas release gave no improvement.

Container Plants

User trials were carried out in North (Scotland) Conservancy with Sitka spruce on afforestation and reforestation sites, and Lodgepole pine on afforestation sites, with F408 Paperpots containing 20 cm plants. In spite of plants being soft and the planting followed by drought, initial survival was good.

Vegetative Propagation

A polythene greenhouse specifically designed for experiments on large-scale vegetative propagation of commercial conifers was completed. A programme of experiments on Hybrid larch has highlighted the main problems, viz. accurate control of irrigation and humidity, weaning and transplanting of rooted cuttings, control of *Botrytis* and careful handling (see Plate 2).

P. BIGGIN

Planting

Plant Spacing

Three new spacing experiments with Sitka spruce have been established, on moderate to severely exposed upland sites. Spacings up to 3 m × 3 m both square and rectangular are being tested, to examine the effects of mutual shelter and vegetation suppression. Long-term effects on timber properties will also be examined.

P. BIGGIN

Restocking gley soils

A meeting at Kielder North Forest (Northumberland) in October with Conservancy staff, attempted to identify the main cause of failure in restocking gley soils and suggest remedies. Two aspects of failure, survival and slow early growth, are inter-related, but initially poor survival is the major cause for concern. Guide lines were given for plant size, condition, and handling and liaison between nursery and planting forest. Position and depth of planting were emphasised as being important on gley soils after clear felling, when the water-table rises close to the surface. Control of damaging fungi, insects and mammals are essential. Ploughing to improve survival is expensive and can be avoided if sensible care is taken on the lines given above. Only when frost and weevil damage are likely to be persistent can ploughing immediately after clear-felling be justified.

D. A. THOMPSON

Species Trials

Seed Origin (formerly Provenance)

Sitka spruce. After three years there is already a broad seed origin/site interaction among the IUFRO collection. On the most southerly site at Wilsey Down, Kernow Forest (Cornwall), the Oregon origins from latitude 42½° N are outstanding, while some of the Alaskan ones are less than half as tall. At the most northerly site at Rumster Forest near Wick (Highland), the Alaskan origins are taller than those from Oregon. Seed origins which have grown well on all sites include those from Queen Charlotte Islands, BC, which on the majority of sites have grown taller than those from Washington. This unexpected result does not seem to be due to frosting of the Washington provenances, and current shoot growth of the Queen Charlotte Islands origins (on the Scottish sites) is superior to the Washington origins.

Lodgepole pine. Fifteen experiments containing the same group of up to 87 seed origins and planted in 1969, 1970 or 1971 were assessed for height after six years. These ranged from a Breckland sand at Thetford Forest (Norfolk and Suffolk) to an exposed infertile bog at Rumster Forest (Highland). Differences in height growth between sites were marked. The seed origins were divided into 9 geographical groups and the results are shown in Figure 1. Although the coastal origins from Washington and Oregon are outstanding for vigour, several of them performed badly at the most testing site at Rumster, and the most southerly origin in this group (Mendocino, California) failed completely above 57° 30′ N, i.e. north of Inverness.

R. Lines was re-elected Chairman of the IUFRO Working Party on *Pinus contorta* seed origin. (See Appendix I for publications.)

Douglas fir. The experiments with about 20 Washington and Oregon seed origins from commercial collections (Bonded Manning Seed) at Glentress Forest (Borders and Lothian) and Culloden (Laiken) Forest (Highland), were assessed at 20 and 23 years respectively. Differences in top height were small. Total volume showed much larger seed origin differences, with Elma outstanding at 314 m^3/ha (≡ GYC 20).

The IUFRO Douglas fir experiment planted in 1970 at Craigvinean Forest (Tayside) was assessed at six years. The tallest individual seed origin was from Enumclaw in the North Cascades, Washington, the best group from the Pacific Coast of Washington, comprising Forks, Naselle and Cathlamet.

Grand fir. The experiments planted in 1974 at Speymouth Forest (Grampian) and Dunkeld (Tayside) are beginning to show distinct seed origin variation.

The IUFRO seed collection comprising 22 seed lots from Washington, Idaho and Oregon together with one Scottish lot (originally from Vancouver Island) was sown at Fleet Nursery (Dumfries and Galloway). Mean heights varied highly significantly, ranging from 7-8 cm for low elevation seed sources on the Olympic Peninsula near Seattle to less than 4.5 cm for many of the origins to the east of the Cascades. Twelve further IUFRO seed lots collected in 1976 have been sown in 1977 to supplement gaps in the collection.

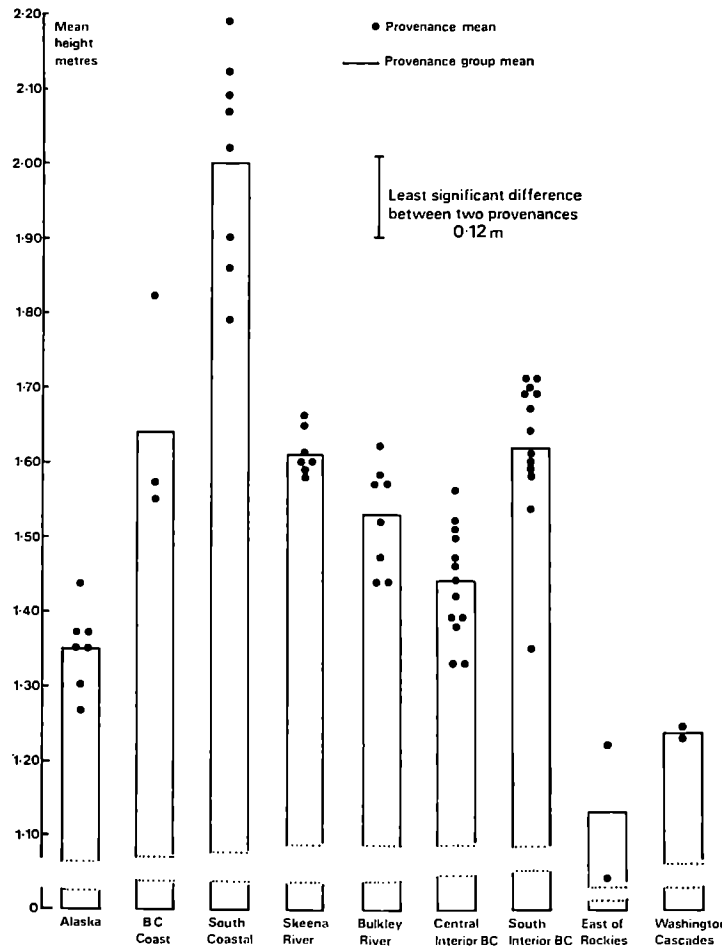

Figure 1: Mean heights at 6 years of 63 origins of Lodgepole pine growing on 13 sites. Significance based on p=0·05.

Nothofagus. A recent large collection of *Nothofagus* seed includes six seed origins of *N.obliqua* and 16 origins of *N.procera* covering the native range from 36°-41°S. These will be used in experiments throughout Britain together with five seed lots collected from British stands.

An experiment planted in 1955 at Buchanan Forest (Strathclyde and Central) has now been thinned twice and at age 20 *N.procera* had a top height of 15.3 m and *N.obliqua* 14.5 m. By comparison, *Fagus sylvatica* had a top height of only 8.6 m and was not ready for thinning. Severe squirrel damage occurred some years ago on the beech while neither of the *Nothofagus* was affected.

Polluted Sites

For many years the prospect of commercial afforestation in the central Pennines was bleak, partly due to air pollution. In recent years, growth has improved dramatically on some sites, particularly on Sitka spruce near Halifax.

A trial plantation, using intensive cultivation on a peaty iron-pan soil and carefully chosen species and seed origins, was planted in 1972 near Ripponden. This has now grown sufficiently well to justify a larger-scale trial to be planted in 1977 on a more difficult deep-peat site of low fertility.

Concern about possible fluorine damage from the aluminium smelters at Fort William and Invergordon prompted further investigations around the sites. Samples of spruce foliage from Leanachan Forest (Highland) near Fort William showed a good correlation between those taken in October 1973 and those taken in October 1975. The correlation between the concentration of fluorine in the foliage and the distance from the smelter was highly significant. The relationship can be expressed in the equation:

$$\text{Mean (1973-1975) log (F concentration in ppm)} = 2.26 - (0.21 \times \text{distance in km}).$$

R. LINES

Cultivation (including Drainage)

Deep Peats

A theoretical study of the potential increase in drawbar pull and traction, by using apical or semi-circular track plates in place of normal grouser plates, predicted an increase of at least 14 per cent on peat soils. Practical trials indicated increases of approximately 30 per cent.

Continued development of the D60/-/t plough has achieved the objective of producing a 0.6 m deep furrow with planting distances across the furrow of 2.1-2.2 m on the majority of deep peat soils.

Rotary Mouldboard Ploughs

Development of a new rotary-mouldboard plough for gley soils was commissioned by Forest Management Division. A specification for a powered, trailed plough was finalised and sketch drawings produced by members of staff at the Scottish Institute of Agricultural Engineering, Bush Estate (Lothians).

Ploughing Restocking Sites

Trials were carried out in Border forests using a mounted double-mouldboard plough (D60/-/m) to cultivate surface-water gley soils on which restocking had failed and a dense cover of *Deschampsia caespitosa* had developed. The tractor, a CAT D7, worked successfully during dry summer months to give 0.4-0.5 m deep furrows, 4 metres apart, and adequate suppression of weeds for normal planting methods to be employed.

D. A. THOMPSON

Nutrition

New nutrition experiments are still concentrating on quantifying the responses to N, P and K in Sitka spruce, Lodgepole and Scots pines in the thicket stage and older. They have only been placed on the major site region/soil/species combinations and with earlier experiments most of the major sites are now represented.

About 40 per cent of upland forest stands respond to fertilisers with basal area increments of 10-30 per cent over control in 4-6 years. Some earlier fertiliser-at-planting experiments which produced very few height responses have now been shown to have responded in basal area.

G. J. MAYHEAD

Forest Weed Control

Soil-acting herbicides such as propyzamide, atrazine and dichlobenil are applied in anticipation of weed growth and this could lead to over-weeding. Attempts are now being made to quantify the benefits of weed control. Four treatments are being examined in Sitka spruce: no weed control at all, minimal hand weeding if needed, minimal use of contact herbicide when a weed problem has arisen, and an anticipatory treatment with herbicide granules.

Experiments where five granular herbicides were applied in Sitka spruce areas in winter 1974/75, are being checked for tree damage. No significant damage to the trees at recommended rates or twice these rates has been noted.

Experiments have now shown that it is safe to plant Sitka spruce on herbicide-treated ground two months before or after the applications of propyzamide granules at 1.5 kg ai/ha (October to January inclusive), dichlobenil/dalapon granules at 2.4 kg ai/3.5 kg ai/ha (January to March inclusive), and chlorthiamid at 3.8 kg ai/ha (January to March inclusive).

G. J. MAYHEAD, J. H. THOMSON

Wind

Wind Flow Over Topography

In conjunction with the Environmental Sciences Research Unit, Cranfield Institute of Technology, equipment has been installed in part of Wauchope Forest (Borders) to measure variations in wind flow caused by the topography, and to compare the results with measurements taken over scaled models in a wind tunnel. Instantaneous wind speeds have been measured at five sites, and the data relayed by telemetry to a base site, to be recorded continuously on a seven-channel, magnetic-tape cassette recorder. In addition 20 "exposure" flags were erected to give a greater area cover and to enable the comparison of "exposure" flag results from a variety of aspects with wind tunnel results.

Two topographic models with a horizontal scale of 1 : 10,000 and vertical scales of normal and $\times$ 2.5 have been constructed, and aluminium oxide crystals are to be used to investigate the effect of surface roughness. Wind tunnel work has been restricted to the provisional testing of techniques owing to the lack of field data.

Assessment of Exposure

"Exposure" flag data from 66 sites gathered since 1973 was added to previously analysed data from 245 sites in Scotland and Northern England. The combined data were analysed and the five previously calculated regional tatter/altitude lines were confirmed and strengthened. The regions so defined were used as part of a national windthrow hazard classification scheme.

As the previous geographical distribution of "exposure" flags was on an *ad hoc* basis there are gaps in the regional coverage; data is also required for Wales and upland areas in South West England. Extension of afforestation onto exposed sites has led to an increased use of "exposure" flags to define planting limits. With the establishment of 32 new flag sites during the year, 131 Forestry Commission sites are now being assessed. Flags and mounts have been supplied to other research workers, including a special order for use in the Andaman Islands by a Royal Society sponsored expedition.

T. C. BOOTH

SITE STUDIES (SOUTH)

Foliar Analysis

Bark

Because it is difficult and expensive to sample foliage from the upper crown of large trees, alternative sites and tissues, such as bark (or rather phloem), have been considered from time to time. Although other workers have reported that nutrient concentrations in phloem are less well correlated with growth than are concentrations in the foliage, an investigation on Corsican pine at Wareham Forest (Dorset) was made in the winter of 1975/76. Statistical analysis has now shown that the correlation between nutrients in the phloem and several measures of tree growth, in a population with a wide range of heights and diameters, was not only surprisingly good, but for some nutrients was better than the correlation between nutrients in the foliage and the same measures of tree growth. A less intensive investigation into Sitka spruce in two Scottish forests also suggested that the method is worth pursuing. Accordingly a full investigation is planned for next year.

Service

Once again the number of samples sent in for analysis, at just over 6,500, was greater than in the preceding year, though still not as large as in 1973/74. Requests for calcium and magnesium determinations have however risen eightfold in four years; this is partly accounted for by the increasing proportion of broadleaved samples in the programme.

W. O. BINNS

Soil Analysis

The development of methods for analysing soil phosphorus, reported last year, is continuing.

A. WILLSON

Effects of Trees on Sites

Species, Mixture and Spacing Trials

A number of old experiments in the Welsh uplands have been sampled to quantify the effects on soil properties of different species and intensities of management.

Some intensive work on soil physics and water budgets of alder and Scots pine has been carried out in collaboration with the Institute of Terrestrial Ecology at Gisburn (Bowland Forest, Lancashire). The silvicultural assessment of crops in this experiment were summarised in last year's *Report;* the work in 1976 consisted of measurements on soil texture and bulk density by novel means. In collaboration with Dr B. P. Dash of the Department of Physics, Imperial College, London, attempts were made to determine and compare bulk density profiles by a seismic technique employing three geophone lines of 12 measuring points each. Shock waves were generated either by hammer blows, explosive detonators, or detonators plus a small charge. Independent measurements of bulk density were obtained by gravimetric and gamma-densitrometry techniques.

R. CARNELL, M. A. ANDERSON

Long-term Forest Plots

The nutrient analysis of the litter from the species plots examined by Ovington in 1953-55 has been completed. Results for mineral soils and species composition of the vegetation were outlined in last year's *Report*. N, P, K and Mg levels, as per cent of dry litter weight, have changed little in 20 years, except under larch in the Forest of Dean, where concentrations of P, K and Mg have increased by more than 30 per cent.

TABLE B
ELEMENTS ACCUMULATED IN THE FOREST FLOOR UNDER TWO ADJACENT CROPS IN THE FOREST OF DEAN, GLOUCESTERSHIRE

Species		Kilogrammes per Hectare Oven dry weight								
		N		P		K		Mg		Total Dry Matter
		L	F+H	L	F+H	L	F+H	L	F+H	
Larch	1955	62·3	532·0	3·16	22·1	3·8	19·0	3·2	23·7	34791
	1976	116·1	590·9	8·38	34·4	8·2	54·2	5·8	31.9	42025
Grand fir	1955	37·1	149·4	2·80	11·3	5·9	20·6	2·6	13·9	12240
	1976	47·9	128·2	3·20	9·9	3·5	17·7	1·9	8·7	9387

(L=litter; F=fermentation layer; H=humus)

Whole Tree Harvesting of Sitka Spruce

Work began during September on a two-year programme to estimate accurately the nutrient drain likely to result from harvesting all the live crown, as well as the stem-wood of Sitka spruce. Three stands on upland brown earths were sampled, and three more on peaty gleys will be tackled during 1977.

M. A. ANDERSON

Lowland Production Forestry

Gravel Workings

Less than 5 per cent of the 1+1 Corsican pine and *Pinus muricata* planted in 1976 in the cultivation/fertiliser trial at Bramshill (Hampshire and Berkshire), had died by mid-August and the experiment was then beaten-up with Paperpot plants. From October onwards the shallow tine treatments regularly showed standing water, while the deeply tined materials were softer and looser, although very wet. On the heavier soils nearby, ripping in July with a Caterpillar D8H and three tines left a very rough surface which slaked down well in the winter. Former silt ponds on the site were not ripped because their cover would not bear the tractor's weight.

Chalk Downlands

Nitrogen and potassium fertilisers continue to improve the growth of Corsican pine on shallow chalk soils on Salisbury Plain (Wiltshire) though the concentrations of N and K in the needles are still low, even with annual treatments.

Treatment with atrazine improved needle colour, but not, so far, height growth. The broadleaved species in this and other nearby trials were again frosted; shelter from the hardier pines seems necessary for success.

W. O. BINNS, D. F. FOURT

Upland Production Forestry

Soil Physical Properties

We have continued our intensive study of the drainage trial at Crychan Forest (Powys), measuring the depth of aerated soil from the corrosion of 360 steel rods inserted over the treated plots, and by measuring borehole water levels daily over an 80-day period. Oxygen flux and sulphide ion concentration have also been measured at 3-week intervals in the least and most drained plots. So far the borehole data has been successfully modelled as a first order auto-regressive time series. This has an advantage over previous methods of borehole data analysis since it uses the data more efficiently.

Next, we shall critically compare the coefficients from the time series with the data from the oxygen flux, sulphide ion, and steel rod measurements; the criteria for comparison will be the sensitivity of the parameters and the cost of measuring them.

Techniques for measuring soil physical properties are also mentioned above under "Effects of Trees on Sites".

R. CARNELL

Amenity and Arboriculture

Work during the year has been restricted to assisting Silviculture (South) with the analysis of foliage from broadleaved trees.

W. O. BINNS

Meteorology and Phenology

Routine observations have been continued during the year.

M. A. ANDERSON

SITE STUDIES (NORTH)

Classification and Improvement of Upland Soils

Indurated Soils

Assessments of diameter growth of Scots pine in relation to soil moisture have continued at Teindland (Speymouth Forest, Grampian). Rainfall was so low during the summer of 1976 that the soil became very dry in all treatments between late June and mid September.

In spite of this, there was a response to the small amount of water transferred from the "roofed" to the "watered" treatment. (Table C.)

Differences between watered and other treatments are significant at 1 per cent probability. Differences between roofed and control are not significant.

Half the replications of each treatment were given a standard dressing of NPK fertilizers during the preceding winter or spring but this did not produce a significant growth response.

TABLE C

DIAMETER INCREMENT (mm) AT 1m HEIGHT IN 1976

Mean diameter increment per tree	Treatment			
	Roofed	Trenched control	Untrenched control	Watered
Unadjusted	1·09	1·33	1·30	1·96
Adjusted	1·05	1·31	1·35	1·97
Numbers of trees	20	20	27	20

The adjusted values in Table C are the outcome of covariance analysis whereby increments were adjusted for the variation, between treatments, in the initial diameter of the trees. Little change from the unadjusted values resulted, and this reflects the fact that diameter increment in this crop is almost independent of tree diameter.

Gleys and Ironpan Soils

At Newcastleton Forest (Borders) the measurements of soil physical conditions and tree growth were completed with the third year's data. The low rainfall and high transpiration from mid June to the end of September promoted a greater degree of soil drying than in 1975. Drying in the subsoil of the ironpan soil was more intense than in the topsoil and surface peat. In the surface water gley suctions of at least 100 cm water occurred down to a depth of 60 cm. Roots extended during the latter part of this period, reaching at least 45 cm depth. The water table has since risen to about 20 cm depth and further observations should show how much dieback occurs during the winter. (See Aeration Status of Upland Soils, p. 52.)

Deep peats

The process of irreversible drying of peat under coniferous plantations is being studied at the Rimsdale block of Naver forest (Highland). The dry summer of 1976 caused further shrinkage of the peat and cracks about 5 cm wide developed beneath P59 Japanese larch, Scots pine and Sitka spruce. Severe defoliation of some of the Lodgepole pine stands by larvae of the Pine Beauty moth during July reduced transpiration and allowed the soil to make an earlier return to field capacity. The early work on this subject has been written up (see reference).

D. G. PYATT

REFERENCE

PYATT, D. G. (in press). The effect of afforestation on the properties of blanket peat. Report of the Scottish Peat and Land Development Association.

FOREST GENETICS

Testing

Pollinations

The systematic programme of artificial pollinations between widely separated populations of Lodgepole pine continued with crosses between Oregon and Alaskan provenances and between Oregon and Nass River, British Columbia provenances using a single-pair mating design. In order to investigate the mode of inheritance of vigour and stem straightness, a half diallel among eight parents (four "coastal" and four "inland") was carried out in the Lodgepole pine tree bank.

Heavy flowering occurred in the larch tree banks at Newton (Laigh of Moray Forest, Grampian) and Teindland (Speymouth Forest, Grampian) and the opportunity was taken to pollinate 143 European larch clones with a Japanese larch plus tree pollen mixture. Flowering in the Sitka spruce tree bank at Wauchope Forest (Borders) was good and 115 clones, many of which had previously been untested, were included in a programme using a pollen mixture based on Queen Charlotte Islands clones. In addition 47 Sitka spruce clones were crossed with a White spruce pollen mixture.

Forest Progeny Tests

Nearly 900 progenies from a variety of species were planted during the year. Five hundred and thirty of these were derived from eleven Corsican pine stands in Thetford Forest (Norfolk and Suffolk). In addition 124 Sitka spruce open-pollinated progenies from trees growing in North America were planted on five different sites; these trees were selected throughout the natural range of Sitka spruce, and are thus an important addition to the gene-pool in Britain.

The quantity of data now being collected from progeny tests is very large and will continue to expand for several years. Much effort is, therefore, being put into developing computer programs which minimise data handling and provide a fast analysis and easy-to-read results. One of the new programs handles the combined data from similar experiments on several sites and by joint regression analysis enables progeny $\times$ site interactions to be examined.

Using this program an analysis was carried out on 48 progenies planted on eight different sites throughout the country.

Seed Production

Plus Tree Selection

A notable feature of flowering on Sitka spruce in 1976 was the occurrence, in some forests, of trees under 15 years-of-age producing substantial cone crops and especially in Scotland. The opportunity was taken to select 300 young coning trees in Glentrool Forest (Dumfries and Galloway) from Queen Charlotte Islands origins. The main selection criteria was good stem and crown form, vigour without coarseness, and a crop of at least 50 cones. Adequate seed has been extracted to enable each tree to be progeny tested.

Flowering Studies and Pollen Collection

The study of flowering in Sitka spruce continued in conjunction with Dr P. B. Tompsett of Long Ashton (see page 55). A combination of $GA_{4}/_{7}$ and placing

the grafts in an unheated plastic-skinned house significantly increase both male and female flowering; even greater increases were obtained by application of $GA_4/_7$ in combination with GA_3 and GA_5. Several other gibberellin treatments are under test including GA_9 which showed promise in the 1975 trials.

In 1976 several spruce species flowered well and advantage was taken to make pollen collections from five White spruce (*Picea glauca*) populations to continue the programme of inter-specific hybrids started in 1969. Collections were also made from *P. koyamai*, *P. obovata*, *P. jezoensis*, *P. maximowiczii* and *P. likiangensis*.

Heavy flowering also occurred in Lodgepole pine and pollen collections were made from over 500 individuals to continue the programme of inter-provenance crosses.

Seed Orchards

The first of the new generation of commercial seed orchards of Scots pine and Hybrid larch were planted; each is 4 ha in size and consists of 40 clones. The clones have been selected on the basis of high performance in progeny tests and flowering studies. A permutated neighbourhood design was chosen since this restricts the amount of selfing and can be arranged to suit any number of ramets and clones. The main drawback to this design is its complexity and a computer program had to be developed to accommodate at least 150 clones.

The program accommodates constraints which restrict the choice of clones. Firstly to reduce selfing there has to be a treble ring of different clones (36) around each selected ramet to minimise self-pollination both before and after thinning. This is the maximum restraint possible when there are only 40 clones in the orchard. The design can be modified when a greater number of clones is involved. A second constraint limits the occurrence of the same two clones in adjacent positions in the horizontal, vertical and diagonal directions. Thirdly there is a limit to the number of times a clone can appear in the perimeter rows of the orchard. When used for hybrid orchard designs an additional built-in feature of the program allows every second clone to be of a different species or origin.

Seed Stands

Many requests were received for the registration of stands as seed sources. These were a direct consequence of the massive beech and oak masts and local but widespread and moderately heavy cone crops on Sitka spruce, Douglas fir and some larch throughout the country. A total of 1064 ha were inspected; the rejection rate was nine per cent. Most of the effort, directed at Sitka spruce originating from the Queen Charlotte Islands, British Columbia, resulted in the registration of 560 ha distributed over 200 compartments.

Two clonal Scots pine seed orchards were removed from the Register in view of the poor performance of a high proportion of their progenies in replicated progeny tests.

Biochemical Variation

Studies of the shoot resin monoterpene composition of Lodgepole pine have been extended to include about 100 provenances growing on several different British sites. The monoterpene composition was strongly correlated with geographic origin, and there were no important site effects. This work forms the

basis for the examination of provenances of unknown origin, and for the study of the genetic variability of populations. Resin analysis of a sample of 25 trees is usually sufficient to allocate that sample to a provenance or a provenance group on the basis of the monoterpene composition.

A preliminary investigation into a possible biochemical basis for resistance to *Fomes annosus* in Sitka spruce was carried out in a heavily infected population in Drummond Hill Forest (Tayside). Significant differences in monoterpene composition of the root cortical resin were found between infected and non-infected trees, as judged by the presence or absence of *Fomes* in radial cores taken from the lower stem. In particular, *Fomes* was absent from nearly all those trees in which α-pinene formed at least 35 per cent of the root resin monoterpene fraction.

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

TREE PHYSIOLOGY

Root Growth and Form

Research on the responses of tree roots to waterlogging was extended to examine oxygen transport in Lodgepole pine and Sitka spruce, using a reduced dye technique. A comparison between Lodgepole pine and Sitka spruce seedlings grown in freely drained soil showed that oxygen diffused out from the basal portion of the submerged roots in a characteristic pattern, and that oxygen was transported about twice as far in pine as in spruce. A different pattern was observed in Lodgepole pine roots which had been grown in waterlogged soil: oxygen was transported right to the root apex, and the first indication of oxygen diffusing out of the root was at the root apex rather than at the base. The maximum distance over which oxygen transport was detected in primary roots of pine was 36 cm.

When woody roots 1-3 cm in diameter were tested, oxygen transport was detected over mean distances of 30 cm in Sitka spruce and 50 cm in Lodgepole pine. The maximum distance of oxygen transport detected in Lodgepole pine was 77 cm. Experiments on the pathways of oxygen movement showed that in Sitka spruce, longitudinal oxygen transport was entirely confined to the tissues external to the xylem, whereas in Lodgepole pine oxygen was transported in the xylem as well as in the bark, and removal of the bark made no apparent difference to the distance over which transport occurred.

M. P. COUTTS, J. J. PHILIPSON

Vegetative Propagation

Further studies of softwood summer cuttings of Hybrid larch have demonstrated that the age of ortet from which cuttings are taken has a significant effect on rooting. Cuttings from ortets less than 3-years-old root well (circa 90 per cent) whereas cuttings from 17-year-old ortets root at a relatively low level, but rooting of this older material can be increased by hormone treatment (see table D).

TABLE D

ROOTING OF SOFTWOOD HYBRID LARCH CUTTINGS FROM 17-YEAR-OLD TREES AT FARIGAIG

Type of Treatment	Optimal hormone concentration		% rooting	
	IBA	NAA	Treatment	Control
2 hr aqueous soak	100 ppm	+ 0 ppm	52·0	24·0
24 hr aqueous soak	10 ppm	+ 5 ppm	52·0	26·7
1 sec alcohol dip	500 ppm	+ 500 ppm	56·0	25·3
Talc dip	1·0%	+ 0·01%	46·7	30·7

IBA = indole-butyric acid · NAA = Naphthalene acetic acid.

There would be advantages in using hardwood leafless cuttings of Hybrid larch for propagation, because of the difficulties with handling and transport of softwood, leafy cuttings. However, only a low level of rooting (circa 20 per cent) has been achieved with hardwood cuttings, using normal mist techniques.

Work to date suggests that the large scale propagation of Hybrid larch will involve the rooting of 1st and 2nd generation cuttings from ortets less than 3-years-old, under mist during the summer, with no propagation bed heating, and no hormone treatment.

A. JOHN, J. SIVILL

FOREST PATHOLOGY

Fomes annosus

Removal of stumps after felling of first rotation pine significantly reduce mortality by *F. annosus* in second rotation pine crops (Greig and Low 1975). About 100 ha of high risk areas are annually de-stumped in Thetford Forest (Norfolk and Suffolk) at a current cost of £90 to £100 per ha. Stump removal is achieved by a MF 450 S Excavator, followed by a Volvo 841 tractor, which pushes the stumps into rows 40 m apart, and levels the ground for planting.

B. J. W. GREIG

Killing in Lodgepole pine on Deep Peat Soils

In 1971, stumps of freshly felled Lodgepole pine were inoculated with *F. annosus* in previously unthinned, first rotation crops, approximately 10 m tall, growing on deep peat soils. Surrounding live trees were excavated and examined for infections during winter 1976/77. The proportion of trees killed or infected on five deep peat soils varied from 14-62 per cent. Figures at the upper end of the range were much higher than expected on a soil type with such a low pH (approximately 3.5) and can be compared with 71 per cent on a gleyed, but sandy, mineral soil with a pH of 4.6 which had previously been cultivated for agricultural use.

D. B. REDFERN

Dutch Elm Disease

Research on Ceratocystis ulmi

Following the discovery of the aggressive and non-aggressive strains of *Ceratocystis ulmi* (Gibbs and Brasier, 1973; Brasier and Gibbs, 1973) an examination of samples of *C. ulmi* from North America, Europe and Western Asia has confirmed the widespread occurrence of the two strains of the fungus and the virtual absence of other variants (Brasier and Gibbs, 1975a; Gibbs *et al*, 1975).

Studies in the laboratory of crosses between the two strains have been carried out with a view to investigating their origin, the genetic basis of pathogenicity and cultural characters in *C. ulmi*, the potential for emergence of new strains capable of attacking resistant elm varieties and the potential for decline of the aggressive strain in the present epidemic. A preliminary survey of the fungal population in Britain indicated that the non-aggressive strain occurred as both A and B mating types, whereas the aggressive strain was present only as the B type (Brasier and Gibbs, 1976). It therefore appeared that the aggressive strain could only mate in nature with the non-aggressive.

The progeny of the aggressive B and non-aggressive A type crosses were very variable in growth rate and other cultural characters. When inoculated into English elm they showed only weak pathogenicity comparable to that of the non-aggressive parent. It was concluded that pathogenicity was likely to be under polygenic control, and that the aggressive strain had not arisen from the non-aggressive by a simple mutation. If hybridization occurred frequently in nature, this could lead to a decline in the epidemic (Brasier and Gibbs, 1976) but there is now some evidence from laboratory studies of an inhibitory mechanism to prevent this (Brasier, 1977).

Other laboratory studies have shown that the B mating type aggressive strain can mutate to its A type and thereby avoid mating with the non-aggressive strain by mating with itself (Brasier and Gibbs, 1975b). This so-called "protoperithecial" strain is highly fertile and it has now been found in nature, adding support to the view that the aggressive and non-aggressive strains may be reproductively isolated and undergoing evolutionary divergence (Brasier, 1977).

Progeny of crosses between the protoperithecial aggressive A type and the non-aggressive B type showed a similar range of cultural characters to those in the previous crosses and confirmed the polygenic control of pathogenicity. The fact that the protoperithecial parent was used as the female and the non-aggressive as the male in these crosses indicates that a cytoplasmic factor such as a virus is not responsible for the weak pathogenicity of the non-aggressive strain or of the progeny (Brasier, 1977).

The population of *C. ulmi* in nature is being monitored to detect changes in the aggressive strain comparable to those already modelled in the laboratory and thereby to assess the future of English elm suckers now appearing in large numbers in southern Britain.

The possibility that strains of *C. ulmi* resistant to the elm injection fungicide MBC could occur naturally or under selection pressure from the fungicide (Brasier and Gibbs, 1975c) has been investigated, and a cytological comparison made of the aggressive and non-aggressive strains (Sansome and Brasier, 1973).

C. M. BRASIER

Surveys 1976

One survey covered the worst affected areas of southern Britain and was

directly comparable with its predecessors (see *Reports* for 1976 and earlier). A second extended into parts of Wales, Northern England and Scotland. Because of the low level of disease in most of these areas, the value of this survey lay primarily in the provision of information on elm populations, rather than on the number of diseased trees. In the original survey area it is estimated that the total of dying and dead non-woodland trees has now reached 5.9 million. If an allowance is made for disease in woodland and for trees felled because of disease, it is considered that some 9 million trees out of a total of 23 million have died since the start of the epidemic in the late 1960s (Anon, 1977). In the more lightly affected areas the distribution of the aggressive and non-aggressive strains of *Ceratocystis ulmi* has been monitored, and the position at the end of 1976 is shown in Figure 2. There does not seem to have been any major geographical

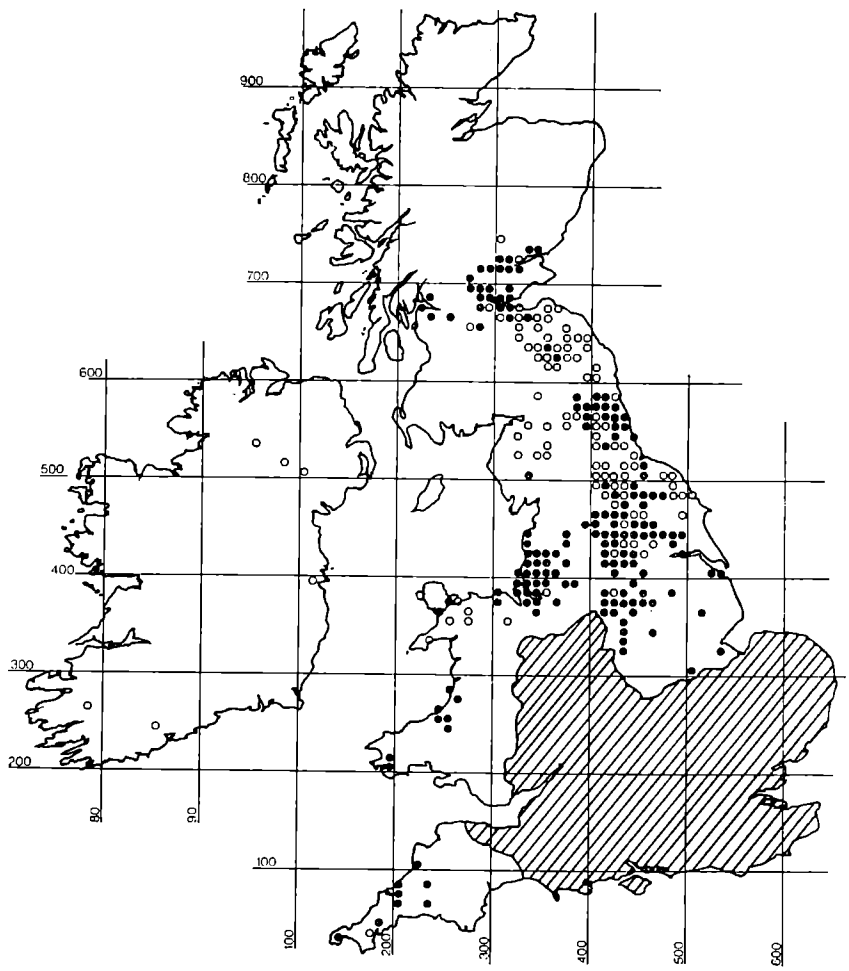

Figure 2: Dutch elm disease. Distribution (10 km square) of the two strains of *C. ulmi* to December 1976 except in main disease area (hatched).

○—non-aggressive strain only recorded

●—aggressive strain recorded

spread of the aggressive strain into North West England during the last year, but it appeared quite widely in the central lowlands of Scotland (see also Redfern, 1977).

J. N. GIBBS, D. B. REDFERN

Beech bark disease

Research on possible agents for the biological control of Beech bark disease was carried out under the direction of Dr D. R. Houston of the US Forest Service who was at Alice Holt Lodge on an exchange visit.

The first European record of the fungus *Gonatorrhodiella highlei* as a parasite of the pathogen *Nectria* on diseased beech was made at Micheldever Forest (Berkshire and Hampshire). Diseased areas of bark were subsequently inoculated with *G. highlei* at Bedgebury Forest (Kent and East Sussex) and it grew on the recently infected parts but fruit bodies of *Nectria* were not parasitized.

Assessments were also made of bark colonization by *Dichaena rugosa*, an apparently non-pathogenic, black, bark-inhabiting fungus, *Lecanora conizaeoides* a bark-inhabiting lichen and the Beech scale. The Beech scale commonly occurred on bark where the lichen was present but neither occupied areas of bark colonized by *D. rugosa*. Microscopical examination supported the hypothesis that this fungus provided a mechanical barrier to feeding by the scale.

D. LONSDALE

Decay in Amenity Trees

A sample survey of roadside oak, ash, elm and beech, blown down in the gale of January 2nd, 1976 was undertaken in the autumn of that year. A total of 176 windblown trees on sites throughout southern Britain were examined; in about 60 per cent of the cases, decay was a major contributory factor to windblow. The fruit bodies of nine different fungi were found associated with decay. The commonest were *Armillariella mellea* in rotten roots of all species, *Inonotus hispidus* in ash stems and boughs and *Ustulina deusta* in beech roots.

D. A. BURDEKIN

Advisory Services

Alice Holt Lodge

Four hundred and seventy-four enquiries were received at Alice Holt Lodge.

An unprecedentedly severe and widespread outbreak of Sooty bark disease of sycamore (*Cryptostroma corticale* on *Acer pseudoplatanus*) occurred, like previous outbreaks apparently consequent on the preceding year's hot summer. Potted and pole stage sycamore were inoculated with *C. corticale* on the 29th August 1975. Potted plants failed to flush or had wilted by the 6th July 1976. The xylem of the larger trees was extensively colonised by the fungus by the 22nd September 1976. The fungus was recovered from trees of both sizes. These are apparently the first successful artificial infections of living trees.

The hot 1975 summer, like 1959, was followed by many cases of fluxing, necrotic bark patches on birch (*Betula*), beech (*Fagus sylvatica*) and sycamore. Despite the suggestive symptoms, we detected no associated pathogen.

The remarkable 1976 drought caused widespread browning and premature defoliation of several species, notably birch, particularly on sands and clays and rocky slopes.

Leptoporus ellipsosporus (Pilat) Romagnesi was the apparent cause of a severe tubular stem rot in living *Cupressus macrocarpa* in Surrey and Warwickshire—the first record of this association.

Of 28 large, scattered, parkland beech in Hampshire, 15 dead, dying or still living trees bore fructifications of the stem and root rotting fungus *Ganoderma pfeifferi* while all the 59 oak there, listed as another main host of the fungus, appeared healthy. Little mention of this evidently serious beech parasite is made in the literature.

In June in Hampshire, a decaying pruning wound on a live Scots pine (*Pinus sylvestris*) bore fructifications of *Lentinus lepideus*. The same fungus, apparently hitherto recorded from living trees (not Scots pine) only in the USA, was isolated from two other severely decayed living Scots pine in Norfolk.

Collybia radicata was isolated from a decaying buttress root of a sickly birch in Essex, apparently the first certain record of this decaying a live tree.

In recent years we have seen many instances of severe root and stem rot of lime (*Tilia*) and beech caused by *Ustulina deusta*, invading usually via roots, sometimes via aerial wounds. This is another clearly serious pathogen which receives little prominence in the literature.

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

Northern Research Station

Two hundred and thirty-two enquiries were received; this represents a 47 per cent increase over last year and was entirely due to a marked increase in the incidence of Dutch elm disease in Scotland and northern England during 1976. The distribution of disease in Scotland and some factors which have affected its spread have been presented elsewhere (Redfern, 1977).

The most frequently recorded damaging agencies other than Dutch elm disease were climate (frost and drought) and cultural malpractice (misuse of chemicals and planting failure).

An unusual example of severe atmospheric pollution damage on mixed hardwood species over a limited area was found to be due to the emission of NaCl particles from the flue gas scrubbing mechanism of a nearby chemical incinerator.

Two possible minor pathogens which have not previously been recorded on elm in Britain, *Dothiorella ulmi* Verral and May and the conidial state of *Botryosphaeria quercuum* (Schw.) Sacc., were found associated with separate canker and dieback diseases of small branches. Pathogenicity trials are in progress with both fungi.

Large numbers of tubed seedlings in a polythene greenhouse were killed by toxic fumes from a wooden door treated with wood preservative.

During the summer, death of mature Scots pine near Grantown on Spey was associated with attack by the bark beetle *Ips acuminatus*, and development of the blue stain fungus *Trichosporium tingens* (Lagerberg and Melin) in the sapwood.

Coleosporium tussilaginis was recorded on *Pinus pinaster* needles for the first time in Britain (from Bareagle Forest, Dumfries and Galloway) and we are grateful to Mr D. M. Henderson (Regius Keeper of the Royal Botanic Garden, Edinburgh) for the identification. *Ganoderma lucidum* was recorded on a Douglas fir stump: this fungus usually occurs on broadleaved trees.

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

Plate 1—Silviculture South (p. 14)
Drought damage to an amenity tree planted on clay at Milton Keynes.

Plate 2—Silviculture North (p. 16)
Vegetative propagation of Hybrid larch in a polythene greenhouse at the Northern Research Station.

Plate 3—Wildlife Management (p. 38)
Warfarin hopper positioned out of reach of badgers on a raised wooden platform. Badgers tend to knock over hoppers and spill the bait.

Plate 4—R. H. Smith *et al.* (p. 57)
Hand-reared fallow deer from Mortimer Forest (Salop) photographed in May 1977. On the right are two long-haired fawns with long ear tufts, curly crowns and long fine coats. A normal fawn with short sleek coat is shown on the left.

Arboriculture, Department of the Environment Contract

Decay in Amenity Trees

A culture collection of organisms associated with decay has been started and now comprises 4-500 isolates. Preliminary experiments with the use of a pulsed electric current meter (Shigometer) to detect decay in standing trees have proved encouraging. Trials have been laid down to investigate the effect of various proprietary sealing and fungicidal products on pruning wounds. A study is being made, starting with beech, of the interactions and successions of micro-organisms within decayed wood with a view to interfering with these to produce biological control of decay.

P. C. MERCER

REFERENCES

ANON (1977). Dutch elm disease—1976 4. Results of 1976 Survey. 5. The situation in the lightly affected areas. *Arboricultural Journal.* **3**(2) 123-130.

BRASIER, C. M., and GIBBS, J. N. (1973). Origin of Dutch elm disease epidemic in Britain. *Nature* **242** (5400) 607-609.

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

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

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

BRASIER, C. M., and GIBBS, J. N. (1976). Inheritance of pathogenicity and cultural characters in *Ceratocystis ulmi:* hybridisation of the aggressive and non-aggressive strains. *Annals of Applied Biology* **83,** 31-37.

BRASIER, C. M. (1977). Inheritance of pathogenicity and cultural characters in *Ceratocystis ulmi:* hybridisation of protoperithecial and non-aggressive strains. *Transactions of the British Mycological Society* **68,** 45-52.

GIBBS, J. N., and BRASIER, C. M. (1973). Correlation between cultural characters and pathogenicity in *Ceratocystis ulmi* from Britain, Europe and America. *Nature* **241** (5389) 381-383.

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

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

REDFERN, D. B. (1977). Dutch elm disease in Scotland. *Scottish Forestry*, **31** (2) 105-109.

SANSOME, E., and BRASIER, C. M. (1973). Intracellular spore formation in *Ceratocystis ulmi. Transactions of the British Mycological Society* **61** (3) 588-590.

FOREST ENTOMOLOGY

Population Studies

The Pine Beauty Moth, Panolis flammea (see front cover)

In summer 1976 there was severe defoliation of Lodgepole pine (from 10-19 years old) of 120 ha at Naver Forest (Highland) and by March 1977 the trees were dead or dying. A further 60 ha were lightly defoliated, though huge populations of pupae were present.

An intensive pupal survey in autumn highlighted the abrupt change between severe and light defoliation, and gave some evidence that this may have been due to differences in host tree susceptibility, rather than to the distribution of *Panolis flammea* females.

The Pine Beauty occurs commonly on Scots pine but has not been recorded as a pest in Britain. Lodgepole pine is a new host and since areas reaching a susceptible age (10 years upwards) will increase, further outbreaks seem likely. A suitable method of monitoring populations is therefore needed and the possible use of pheromone-baited traps to attract adult males is being investigated, in cooperation with a biochemical team at Southampton University, as an alternative to pupal survey, which is laborious.

J. T. STOAKLEY

The Larch Bark Beetle—Ips cembrae

Analysis of contents of the hind-gut of *Ips cembrae* males showed the presence of two terpene alcohols, ipsenol and ipsdienol, which are known as aggregation pheromones. Two field experiments were carried out to test attraction of these substances by baiting traps with synthesised samples. In the first, when beetles were emerging from hibernation, there were four replications of the following treatments: ipsenol, ipsdienol, ipsenol plus ipsdienol, and unbaited control. Here beetle collection percentage clearly showed the importance of the two materials being together.

In the second experiment during August, traps were baited with ipsenol plus ipsdienol only to attract *Ips cembrae* from the new emerging generation.

In both experiments the sexes were attracted in approximately equal proportions. The results indicate the practicability of monitoring the presence of *Ips cembrae*, using traps baited with the two pheromones and suggest the possibility of using the method to reduce population size in suitable circumstances.

J. T. STOAKLEY

The Pine Looper Moth, Bupalus piniarius

A computer analysis was made of the long-term patterns of change in population numbers using pupal survey data. An approximately cyclic pattern of build-up and subsequent decline is found in those forests most liable to *Bupalus* outbreak. It seems that threatening populations such as those now reported at Tentsmuir Forest (Fife) arise when favourable weather coincides with the peak years of a cycle.

D. A. BARBOUR

Bupalus piniarius, Annual Pupal Survey

This year's survey of pupal counts has shown that more populations have increased than decreased. Tentsmuir has risen to a similar level as in 1957 when

a control operation was applied. At least 115 ha are above 30 pupae per m^2, while two compartments have counts of 69.

Alltcailleach continues at 9.2 but in Cannock, Wykeham, Langdale and Dalby at 17.2, 14.4, 14.0 and 13.2 respectively have increased to levels similar to Tentsmuir in 1976. Also pupal weights are greater than normal.

R. M. BROWN, D. J. BILLANY

The Web-Spinning Larch Sawfly, Cephalcia lariciphila Wachtl (= C. alpina Klug)

Infestations continue at the same level with one new outbreak at St Gwynno Forest (Mid-Glamorgan). Approximately 1200 ha on eighteen separate sites are now affected.

R. M. BROWN, D. J. BILLANY

The European Spruce Sawfly, Gilpinia hercyniae

There has been a general decline of the high sawfly populations in the affected areas of mid-Wales. This is due mainly to the naturally occurring virus which kills the larvae. Trees in some of the first areas to be defoliated are now recovering.

Endemic populations in south-Wales were higher, their success was probably due to the favourable weather in early summer.

The Unit of Invertebrate Virology continues the research on the virus epizootic of *G. hercyniae*.

D. J. BILLANY

Beech Scale, Cryptococcus fagi

Studies on the dispersal of first instar larvae in an unthinned P52 beech wood continued at Micheldever Forest (Berkshire and Hampshire), in 1976. Larvae were trapped with battery-operated suction traps. Hourly catches of larvae were compared with the mean hourly wind speed, humidity and temperature. Temperature seems to be the most important factor governing the aerial density of larvae within the forest.

Under the canopy, the distance dispersed by individual larvae depends mainly on the height of 'take-off' and wind speed. Traps were placed at a height of 1 m, at various distances downwind of a tree that was infested from near ground level to the lower canopy. Approximately 90 per cent of the total catch was within 4 m of the tree. Only trees adjacent to infested ones, therefore, are likely to be exposed to large numbers of immigrant larvae.

D. WAINHOUSE

Host Plant Susceptibility

The Green Spruce Aphid, Elatobium abietinum

A study on the phenological activity of Sitka spruce and the periods of susceptibility to *E. abietinum* has continued. Special emphasis is being paid to the changing amino-acid spectrum between different provenances of Sitka spruce. Although there were no observed major differences in amino-acid components during the winter, the seasons immediately before and after, when aphid attacks occur, showed distinct differences in arginine, glutamic acid,

phenylalanine and serine—compounds which have been variously linked with nitrogen metabolism and aphid performance.

As a parallel to this, the amino-acids in the leaves of *Acer palmatum* have been monitored in order to see which compounds coincide with the two distinct periods of growth and reproduction of the maple aphid *Periphyllus californiensis* (Carter, 1975). There appears to be a similar reciprocation between the concentrations of glutamic acid, proline and arginine in maple as there is in spruce at these two periods.

C. I. CARTER

Biological Control

The Web Spinning Sawfly, Cephalcia lariciphila Wachtl (= C. alpina Klug)

The ichneumon *Olesicampe monticola*, a parasite of *C. lariciphila* larvae, has been found only at Margam Forest (West and Mid-Glamorgan), but not in any of the other eighteen infestations. It is also the only parasite species that has been isolated from this sawfly.

A small field trial showed that *O. monticola* can be artificially established in an infestation.

A nematode occurs in cadavers of the prepupal overwintering sawflies. Preliminary investigations indicate that the nematode could be lethal to the sawfly when vectoring a bacterium.

Small mammal predation is being studied by a student at the University College of Wales, Cardiff. The Unit of Invertebrate Virology, Oxford, continues its work on larval viruses.

D. J. BILLANY

The European Spruce Sawfly, Gilpinia hercyniae

The importation of parasitised *Gilpinia* spp. collected in mainland Europe by the Commonwealth Institute of Biological Control, Delemont, Switzerland, is being continued. Some of the difficulties experienced in breeding out this material were overcome by the construction of two environmental chambers.

An adequate supply of host larvae at all stages of development was maintained throughout the parasite emergence period. However, attempts to breed up the parasite failed. The adult parasites were healthy and active, and showed interest in the host larvae, but mating and subsequent oviposition was not observed, and these larvae, having been bred through, did not produce parasites.

Field collected *G. hercyniae* larvae from several locations in England and Wales were not parasitised.

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

Chemical Control

Hylobius abietis and Hylastes spp.

It was found that a decrease in concentration of HCH as a suspension concentrate (Gammacol) occurred when dipping transplants as a protection against attack by *Hylobius abietis* and *Hylastes* spp. This was investigated for complete and partial dipping of plants using different tank sizes. Recommendations were made concerning how the concentration could be maintained.

S. G. HERITAGE

During the year, three field trials were established to further evaluate the systemic organo-phosphorous insecticide Thimet (phorate) applied to Japanese Paperpot grown seedlings. These trials were sited at Torridge (Devon) and Glenbranter (Strathclyde) using Sitka spruce seedlings, and Thetford (Norfolk and Suffolk) using Corsican pine seedlings. The insecticide in granular form was applied at two rates: 0.5 g a.i. and 0.75 g a.i. per plant on the ground surface close to the plant's root collar. Initial results, taken only from Glenbranter, show Thimet to have equal activity with the standard gamma HCH dipping treatment. Final results are expected in 1979.

C. J. KING, S. G. HERITAGE

Control of Beetles in Logs

Three tests were carried out using methyl bromide as a fumigant against bark beetle broods. Two of these, applied under controlled conditions against *Scolytus scolytus* larvae in elm and *Tomicus piniperda* larvae in pine, proved successful. The third, on large elm butts failed in field conditions of low temperature and high wind.

These tests, however, indicate that methyl bromide could be used at the dockside against imported timber pests where other methods, such as reshipment, burning or rapid processing, would not be suitable. In each case, methyl bromide was applied into timber stacks sealed in polythene sheeting, at the equivalent rate of 5 lbs a.i. per 1,000 cu. ft. and left for 24 hours before ventilating. Methyl bromide is extremely toxic and such application would always need to be made by a professional fumigating firm.

C. J. KING

Insects Following Wind and Fire Damage

Observations were made in pine forests at Cannock (Staffordshire) and Sherwood (Nottinghamshire) following the January 1976 gales. Scots pine areas produced prolific populations of *Tomicus piniperda* with heavy shoot pruning evident in adjacent pine stands by late summer. Corsican pine was markedly less suitable for this beetle's breeding requirements. Other pest insects, notably *Hylobius*, *Hylastes* species and *Pissodes* spp. weevils were also observed breeding in this material.

Large burnt areas of pine were also inspected for insect activity in Ringwood (Dorset) and Thetford (Norfolk and Suffolk). The majority of fires coming in the latter part of July and in August were too late to benefit *Tomicus* and *Hylobius* until 1977. The main coloniser of the smaller burnt pines were *Pityogenes bidentatus*, a harmless species normally breeding in thin barked stems and branches. This insect appeared to be closely associated with bluestain.

C. J. KING

Elm Scolytids

Scolytus scolytus

A programme of field and laboratory studies were initiated during 1976 into the behaviour and pheromone chemistry of *Scolytus scolytus*.

C. J. KING

Advisory Services

During the year 60 enquiries were sent to Alice Holt from Forestry Commission staff and 33 to the Northern Research Station. One hundred and fifty-five private enquiries were received at Alice Holt and 30 at the Northern Research Station.

REFERENCE

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

WILDLIFE MANAGEMENT

Management of Deer, Squirrels and Other Mammals

Red deer research began in coordination with the Red Deer Commission (aspects of practical deer management) and with the Institute of Terrestrial Ecology (factors governing dispersion and density of deer in woodlands). The Forestry Commission will establish the status and performance of red deer resident in forests, the extent and forecasting of damage and the necessary culling levels.

The annual Squirrel Questionnaire showed low grey squirrel damage levels and little change in range or abundance of red squirrels. Modification of the grey squirrel hopper involving a wire mesh floor in front of the tunnel did not significantly reduce the amount of wheat spilled. Of some 430 hoppers inspected 66 per cent showed no spillage (or wastage) and 16 per cent had less than 0·5 g spillage. The average amount of wheat spilled from the remaining 18 per cent was 14·6 g. (See Plate 3).

Management of Birds

Provision of carrion in winter to maintain condition and breeding status of scavenging birds such as ravens, buzzards and eagles was investigated. A time-lapse camera at one site showed crow, raven and eagle feeding activity. A correlation was found between fox feeding (nocturnally) and corvid activity. Granular herbicide treatment produced more diverse and successful breeding bird populations than mechanical or hand weeding in a restocked broadleaved woodland area with rapid growth of grass and herbs, but not in Breckland conditions. Stumps piled in rows for *Fomes* control produces suitable habitat for hole-nesting birds such as the dunnock, wren and stock-dove, but it is dubious whether slight increase in such common and adaptable species balances the additional problems of rabbit and deer management created by de-stumping.

A breeding bird study of a pond area with a history of angling usage and under increasing recreational pressure has highlighted the importance of zoning these high disturbance areas spatially by habitat alteration.

Chemical and Mechanical Repellants

Two of three experimental chemical repellant formulations effectively prevented winter roe deer browsing without phytotoxicty. Ultra low volume spray application of Aaprotect applied insufficient material to the trees to provide effective protection for more than 6–9 weeks. Summer damage by

rabbit, hare and roe deer was reduced on trees dipped in Aaprotect prior to planting in April. One winter's protection was then produced by spraying in October/November. Dendracol 17 is now supplied with a light-weight, simple hand sprayer to overcome earlier difficulties in spraying and cleaning. The new formulation is as effective as Aaprotect and may be cheaper to apply.

Individual tree protection devices have been reviewed. A light-degradable polythene net tube is under trials against deer browsing.

Several fencing materials have been appraised during the year. In the long-term durability experiment (comparing materials on coastal, industrial and "clean air" sites) disintegration of some wire components is occurring. Plastic coated wire netting is more durable than galvanised except on windy sites where it is more prone to mechanical damage at the points where the netting is attached to line wires. Bonded plastic coverings have lasted better than extruded coatings. Welded mesh netting at 4 years shows fewer signs of rust than did ring-lock woven field netting.

Damage Assessment and Evaluation

Annual checks on squirrel damage in a P51 beech crop severely damaged in 1972 showed no further damage and considerable occlusion of the wounds. Roe deer browsing in second rotation Sitka spruce in Kielder Forest (Northumberland) affected all types of planting outside a fenced area.

J. J. ROWE

ENGINEERING SERVICES

Design and Manufacture of Equipment

The visual Quiz Unit, tested by the Agricultural Show Unit, has been rebuilt using a Kodak Carousel projector with a magazine of 80 slides. The operating principles are identical to the description in last year's report.

A rotating Drum Seed Dryer, built to dry the seeds after they have been dewinged has been used this season, but will require slight modification.

An inductive loop was installed at Bere Forest (Queen Elizabeth Forest, West Sussex and Hampshire) to monitor vehicles using a car park. A seven day event counter was used to record the number of vehicles. Inductive loops will be used, on trial, in the New Forest (Hampshire) next year.

Two bays of the Cambridge Glasshouse have been equipped with benches and associated control gear. There are four benches (1 metre wide $\times$ 3 metres long) in each bay. The benches were built of aluminium alloy sections with a tray of galvanised steel mesh. This tray is covered with a heavy (2000 gauge) black polythene sheet and filled with sand or grit about 150 mm deep. Undersoil heating is by a 500 w heating cable in each tray and moisture provided by McPenny mist nozzles. Each bench is controlled independently for heat and mist, the controls being in a central console away from the spray.

Maintenance of Electro-Mechanical Services

Electrical supplies have been connected to two polythene tunnels and the potting shed. One poly-tunnel has been fitted with both heater and fan controlled from an aspirated screen and the other connected for ventilation only.

Maintenance of Existing Equipment

Maintenance of the seed germination trays, used in the Seed Laboratory, has been necessary this year due to the "furring up" of the 3-way valves. This equipment would benefit from a softer water supply and it is hoped to install a softener next year.

The mist controllers installed in the frames have given considerable maintenance problems during the past hot summer and the replacement of these units will be considered.

Engraving Service

Engraving work has increased considerably. Westonbirt alone have requested approx 2000 tree labels this year. Further work to investigate economic methods of producing tree labels is now necessary.

R. E. STICKLAND

FIELD SURVEYS BRANCH

FIELD SURVEY SECTION

Surveys

Preparations for the introduction of a new survey system based on air photography are advancing, perhaps rather more slowly than was originally anticipated. The search for a plotting instrument suitable for the Commission's mapping needs has narrowed the field to three or four and a final choice will be made in the near future.

Surveys have necessarily been delayed during the continuing preparations for the 1977 valuation and forecast. Staff shortages have also contributed to the programme falling short.

It is expected that arrears will be reduced as the new survey system gets underway.

Production Forecasting

The preparation of the Sub-compartment Data Base for the forecast has progressed very nearly to timetable. All staff are to be congratulated on the effort that has been put into the successful completion of this heavy task. The forecast computer programs have been successfully tested and the project should be completed on time.

Plans for the further developments of the Data Base to include all land holdings are in hand. Eventually it will be available as a general Management Information System.

MENSURATION SECTION

The updating of Sample Plot Measurement Summaries was completed, checked and copies for plots within their territories issued to Foresters i/c, District Officers and Conservators. In future, amendments will be issued each autumn.

A computer program is under development to simplify the production of yield models so that, on request, a yield table may be quickly produced to simulate any treatment regime that a forest manager may wish to apply.

The award of a NERC Studentship has been made for three years, to start October 1977 for research into computer modelling of individual tree growth. This is likely greatly to increase knowledge of the mechanics of tree competition, and hence of the effects of extreme treatments on forest growth rates.

The transfer of the numerous sample plot measurements to a computer data base is well underway. When complete, it will be used to develop, inter alia, regional and site type yield models, as well as for research into simpler measurement methods.

The tariff checking service available to field staff was well used and proved helpful as a check on technique.

The Assortment forecasting programme has been held up due to staff shortages so that the provision of this service to field managers will be somewhat delayed.

SITE SURVEY SECTION

The post of Site Survey Officer remains vacant and a reallocation of duties to Field Survey Officers has been necessary. Since most of the work is in Scotland, Field Survey Officer (North) has had to accept the major share of responsibility.

Basic surveys continue and a number of reconnaissance surveys to identify areas of windthrow risk for the production forecast have been completed.

DRAWING OFFICE

Productivity has been improved by the purchase of photo-reproductive equipment for the management of which a photographer has been recruited.

Work has begun on the introduction of air photo plot maps for field completion.

The identification of training needs for staff to be employed on this work is well in hand together with the design of appropriate courses.

K. P. THALLON

WORK STUDY

Forest Management: Method Study

Trials were undertaken to improve the traction of tractors when ploughing uphill on soft peat. Fitting apical track shoes to a Fiat 100 pulling a double mouldboard peat plough increased its output by 50 per cent.

A re-designed D60 plough has been given extensive trials in North Scotland and shows considerable promise in terms of output potential and silvicultural result.

Work on the construction and testing of the 6 × 6 hydrostatically powered rough terrain ploughing tractor has reached the stage where it and its associated plough have had their first, promising trials. Development of the control systems and the plough continues.

Research on vibrating ploughs and the cutting (hydraulically) of material which piles up in front of ploughs is being undertaken for the Forestry Commission by the National Engineering Laboratory at East Kilbride.

An assessment of Ursus deer fencing is nearing completion.

Work on controlled droplet applicators has been brought to a successful conclusion by the construction of tractor mounted equipment.

Forest Management: Servicing and Continuous Review

Modifications to the Huntly granule applicator to improve its performance in windy conditions brought the project to an end. Manufacturers are shortly to be appointed.

Trials of the highly successful McConnel flail weeder (which fits onto the front of a Holder tractor) were concluded. At the time of writing, there is some doubt as to whether the machine will be built commercially.

A Scrubmaster 66 tractor mounted brushcutter is undergoing trials in the New Forest (Hampshire).

Trials of a Husqvarna 140R lightweight clearing saw began at Savernake Forest (Wiltshire) and trials of a Husqvarna clearing saw fitted with a spraying attachment progressed.

Advice on rehabilitation of fire damaged areas has been given.

Forest Management: Work Measurement

An output guide dealing with planting on ploughed ground was produced.

Harvesting and Marketing: Method Study

The opportunity was taken to carry out method studies on windblown spruce, Douglas fir and pine in Wales, the Midlands and East Anglia. The Pika 52 processor was installed at Sherwood Forest (Nottinghamshire) to assist with windblow clearance.

Work on the Segem delimber, the Timberjack RW30 harvester and the Ösa 770 grabsaw fitted to a forwarder has been concluded. A French Sifer delimber and a Danish Stripper II delimber have been acquired and will shortly be tested.

Two forwarders have been tested, the Finnish Valmet 870CK and the Swedish Volvo TC860. Both were considered to be successful machines. The Valmet was used to extract timber over "less expensive" forwarder roads at Knapdale Forest (Strathclyde)—an exercise to keep road costs to a minimum. A brief appraisal of the British made TGT 6 × 6 forwarder was made.

To assess the advantages of radio-controlled winches and front wheel drive on a skidder, a Ford 5000 has been adapted and has undergone preliminary trials both in the borders (Scotland and Northumberland) and at Alice Holt Forest (Hampshire, West Sussex and Surrey). A new, safer, terminal pin has been developed for use with winch type skidders.

Hydraulic grapple cranes have been subjected to a fresh appraisal and recommendations made on the standardisation of controls.

A Bray front end loader was tested at Thetford Forest (Norfolk and Suffolk).

With the arrival of the Finnish Ahlström Karhula 312CS chipper in January, work on chipping forest residues began in earnest and samples of whole tree chips and chips made from branches and tops have been sent to potential

customers. Samples of stumps from Thetford Forest cut by chainsaw to simulate a Pallari Stumparvester, have also been supplied to potential customers.

A Cundey peeler fitted with a pneumatic hoist for loading was tested at Sherwood Forest (Nottinghamshire).

Harvesting and Marketing: Servicing and Continuous Review

Ten new chainsaws were tested during the year.

An evaluation of the Igland/Jones Mini Alp as a 1·5 tonne/600 metre range cable crane began in January.

Harvesting and Marketing: Work Measurement

A number of new and revised output guides and standard time tables have been produced during the year covering the following operations:

Clearance of windblown spruce, Douglas fir and pine

Preparation of produce for forwarder extraction

Thinning of Sitka spruce and Norway spruce

Clear felling of Douglas fir

Crosscutting at roadside

Peeling by Cundey peeler

Extraction by skyline winch.

Forest Authority

Trials of the Rapco data recorder continued and the machine emerged as a remarkably successful alternative to the stop watch bringing with it increased output, quicker analysis of data, greater accuracy, and reduced costs of work measurement. More machines will now be acquired.

With colleagues from Silvicultural branches, work on the rotary mouldboard plough and on the mechanisation of nursery operations has continued.

Safety Research

Noise and vibration levels of a number of chainsaws, portable clearing saws and other machines were measured.

Work has been done on assessing the noise at varying distances from the source made by machines such as chainsaws and mobile chippers working in the forest.

Draft Safety Guides have been monitored.

More explicit guidance on protective clothing and safety equipment is being written into all standard time tables and output guides.

Training of Forestry Commission Staff

Work Study appreciation courses are being organised for beat stewards throughout the country. So far, 13 such courses have taken place. Other courses have been run for management.

W. O. WITTERING

STATISTICS AND COMPUTING

Data Preparation and Computing

The transcription of sample plot data from paper tape was completed. The major project of the year was the processing of the 226,000 sub-compartment component records for the production forecast, of which 11 per cent were punched by our own staff and the rest under contract. Another Kode punch-verifier was ordered in preparation for the mounting of all pre-1968 sample plot records. The several on-going data processing tasks continued and some new ones (e.g. a register for arboricultural queries) were started.

Many of the special software packages available on the ERCC system have been applied. In particular, increasing use has been made of DSIGN and of the GENSTAT language.

Statistical Service to Research and Development Projects

Statistical and programming advice, experiment design and analysis continued to take up most of the branch's time. A new feature has been the growing importance of experiments in arboriculture.

Loss of strength due to *Fomes annosus* in Sitka spruce was estimated as the deviation of the observed strength in attacked stems from that to be expected on the basis of a regression equation for healthy stems. The data consisted of over 750 samples in various stages of decay.

A system giving a standardized analysis of time-study felling and thinning data has been introduced. It is planned to set up similar systems to standardize the analysis of cross-cutting and extraction studies.

Statistical Service to External Units

Data from a pilot deer damage survey is being analysed for South Scotland Conservancy. The results of the West Sussex hedgerow survey of elms and other species were analysed and reported to South East England Conservancy. A preliminary analysis was completed of a survey to estimate the specific gravity of home grown Douglas fir timber, as part of the Home Grown Timber Research Committee programme.

Programming, General

The new Production Forecasting system was completed and run. Forecasts were produced for each forest, district and conservancy.

Many routines for the graphical presentation of results have been written, in particular a selection of routines from the Middlesex Polytechnic PICASO system has been mounted and is being explored. A set of programs was developed to process the output of auto-analysers used for foliage analysis.

Programming, Mathematical/Statistical/Technical

A program was written to generate "neighbourhood" designs for seed orchards. Further developments were made to the DASMA statistical system. The remote-job-entry software was modified to allow the direct transfer of Fortran disk files to UCC. Some Assembler routines were written to improve the input and output routines available to Fortran programs.

Statistical, Mathematical and Computing Methods

Methods for the analysis of digitized pictures are being investigated and developed (e.g. soil profiles). A comparison has been made of different definitions of top-height in the hope that this may lead to improvements in mensurational practice. Short courses on elementary mathematics and statistics have been conducted for selected groups of R & D division staff.

Data Capture and Associated Computing

The Rapco magnetic tape time-recorder has performed well, especially in reducing turn-round time on data collection and analysis, and more machines are being ordered.

After trials a portable unit which encodes from keyboard to magnetic tape cassette and a transcription device automatically giving computer input were bought from Senodata Ltd. It is intended that systems based on this equipment will first be developed for breeding research.

D. H. STEWART, R. S. HOWELL

COMMUNICATIONS

All three Sections have been involved in the development of the new Arboricultural Advisory and Information Service. Research Information is collaborating in the development of additional current awareness services, Photography assisted with an exhibition at the Tree Council Conference, and Publications will be introducing a new series of advisory leaflets.

In August 1976 H. L. Edlin, Publications Officer for more than thirty years, retired, and it is sad to report that on Christmas Day he died suddenly. He was responsible for the development of the Forestry Commission's high quality and attractive series of publications, many of which he wrote or edited himself. In the mid-sixties he looked after the library as well. The profession has lost an extremely knowledgeable and able forester and writer; his colleagues will remember him as a kindly, helpful and ever-cheerful friend.

RESEARCH INFORMATION

Visitors

A number of overseas researchers visited the Station on their way to and from the IUFRO Conference in Norway.

Liaison

Following developments in the FAO Agricultural Information Service—AGRIS, a meeting was convened at Alice Holt Lodge of librarians and information scientists covering forestry and forest products in Great Britain. An excellent exchange of ideas and experiences led to the production of a provisional directory of information services in this country.

Library

One hundred and sixty four new books were acquired and subscriptions taken out for three new journals. Loans from library stock again reached a record

of 4,347, with a fruther 701 items borrowed from other libraries. Approximately 2000 items were sent out as photocopies in response to requests.

Information Services

The computer data-base now extends back to 1972 and, with a minor improvement in the search program, is providing a valuable and increasingly used facility.

O. N. BLATCHFORD

PHOTOGRAPHY

The difficulty in obtaining colour prints (from transparencies) to a consistent and acceptable standard from trade services continued to be a problem. A user processing trial of Cibachrome proved satisfactory in terms of cost, time and quality. Processing equipment capable of handling Ciba and other print and film materials, using one-shot chemistry, will now be installed. Initially this facility will be used for processing associated with aerial photography.

Aerial Photography

Increased use continues to be made of Supplementary Aerial Photography including, for the first time, as far as this Section is concerned, photography of urban areas. The object was to see if the progress of Dutch elm disease through a threatened area, could be monitored in this way. The first project was very successful, and the results have been used by the local authority, the Agricultural Research Council and ourselves. Further flights over the same and similar areas are planned.

In addition to the usual programme of flights for stock-mapping, disease and other damage, windblow and recreational surveys, there has been considerable involvement in the development of sampling and mapping techniques for specific purposes, e.g. survey of native Scots pine stands, Census of woodlands, Hedgerow survey, etc. A new twin-camera system for door or external pod mounting is at present in the design stage.

During the year a photographer has been appointed, and a process camera and automatic processor installed in the Field Surveys Drawing Office. This is a welcome advance and opens up the possibility of constructing photo-mosaics.

Photographic Library

Most of the work on the monochrome collection is now complete. Only the archive material and the re-printing of some reference prints which have been found to have strayed over the years remain to be dealt with.

I. A. ANDERSON

PUBLICATIONS

The following fourteen new priced publications were issued through Her Majesty's Stationery Office during the year. Previous issues are shown in *Sectional List No.* 31 available free of charge from Government Bookshops or the Forestry Commission, and in *Catalogue of Publications* from the Publications Section, Alice Holt Lodge, Wrecclesham, Farnham, Surrey.

Reports

Fifty-sixth Annual Report of the Forestry Commissioners, 1975–76. (£2·00).
Report on Forest Research for year ended 31st March 1976 (£1·90).

Bulletins

No. 55. Aspects of Thinning, edited by G. J. Hamilton (£2·50).
No. 56. Evaluation of the Contribution of Forestry to Economic Development, by A. J. Grayson (£3·00).

Booklet

No. 43. Forest Road Planning, by A. A. Rowan (75p).

Leaflets

No. 64. Control of Heather by 2,4-D, by J. M. Mackenzie, J. H. Thomson and K. E. Wallis (70p).
No. 65. Group Dying of Conifers, by D. H. Phillips and C. W. T. Young (30p).
No. 66. Guidelines to Forest Weed Control, by R. E. Crowther (35p).
No. 67. Rabbit Management in Woodlands, by H. W. Pepper (50p).
No. 68. Badger Gates, by Judith J. Rowe (15p).

Forest Records

No. 106. Mushrooms and Toadstools of Broadleaved Forests, by Roy Watling (£1·00).
No. 108. Tests on Round Timber Fence Posts, by J. C. Clarke and R. C. Boswell (£1·70).
No. 109. The Capercaillie, by C. E. Palmar (previously Leaflet No. 37) (50p).
No. 110. Conifer Bark: Its Properties and Uses, by J. R. Aaron (75p).

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

The pamphlet *Some Uses for Wood Residues* was produced for Harvesting and Marketing Division.

Research and Development Papers

No. 113. The Place of Forestry in Scotland, by G. M. L. Locke.
No. 114. Pinus contorta Provenance Studies, by R. Lines.
No. 115. Management and Administration of a Woodland Estate.

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

K. W. WILSON

OTHER HEADQUARTER DIVISIONS
PLANNING AND ECONOMICS

Policy

Forestry Taxation and Grants

As part of continuing work on the assessment of the financial effect of taxation arrangements for private woodlands, a number of analyses were carried out in connection with the work of an interdepartmental group on forestry taxation and grants. These included the preparation and use of computer programs indicating actual and discounted cash flows for a model hectare, passed from generation to generation over one crop rotation, and for a model forest containing stands of varying ages over one owner's life.

P. S. COLLINGS, A. J. GRAYSON

Regional Income and Output Multipliers

Traditionally forest economics has concentrated attention on the efficiency with which resources are used in tree growing. Quite apart from the efficiency aspect of any activity there is the economic impact it has on a region. An attempt has been made to assess the overall impact on regional income and output of investment in forestry and forest industries, in different regiona economic settings. The method used was that of input–output analysis. The existing information on regional input–output relationships is limited, and was accordingly supplemented by judgment in an attempt to characterise a range of stylised, but plausible, economic situations. The results indicated that, on the basis of comparison with alternative uses of resources, investment in wood processing industries does not rank particularly well as a means of generating regional income. In contrast forestry and, in particular, afforestation, does relatively well especially in less developed rural regions.

C. M. KELLY

Methodology for Assessing Land Use Integration

An investigation was carried out to see if a methodology could be developed for arriving at an optimum allocation of land between forestry and agriculture while at the same time achieving an integrated pattern of land use. The problem lent itself to the application of linear programming as a means of allocating land of different qualities to different land uses. Net discounted revenue for the whole area was used as the objective function to be maximised, with constraints set on the amount of land devoted to agriculture or forestry so as to ensure that some mix of land use was achieved. The initial application was on a single hill sheep farm, and it appeared that on this scale, and with plausible prices and discount rate, the tendency was for one or other land use to dominate. The reason for this result appears to lie in the dis-economies caused by reducing the scale of both farming and forestry below that ensuring efficient use of labour and other resources.

J. DEWAR

Forest Operations

Production Forecasting

A fundamental requirement in the review of the financial performance of the Forestry Enterprise over the first quinquennium since the financial re-

construction of 1972 (See Annual Report and Accounts of the Forestry Commission for the year ended 31st March 1973, London: HMSO, 1974) is the valuation of the estate existing at the end of the 5 years. The same cost and price weights are to be used as in the valuation of the estate existing at 1st April 1972. One element of the valuation is the assessment of future wood yields based on the application of the cutting regimes determined by Conservators and Headquarters, which results in agreed production plans. A more thorough appraisal of different cutting options has been carried out in the current round of forecasting and production planning, than in 1972, and it is expected that, as a result of more selective application of different cutting regimes, cutting plans will be more realistic.

J. DEWAR, A. J. GRAYSON

Investigations into the Variations in the Cost of Ploughing and Planting

In the course of management a great many costs are collected but few systematic attempts have been made to analyse variations in such measures of performance as unit costs and physical output per man or machine hour. Understanding the reasons for variation in costs can assist managers by drawing attention to factors which are controllable. A study was made of the costs of 51 ploughing and 52 planting jobs at 30 forests in North and West Scotland Conservancies. It was considered that more dependence could be placed on factors which appeared in regression equations for jobs in both Conservancies, rather than in the equation for a single Conservancy. Values of R^2, measuring the proportion of total variance explained by the combination of significant variables, ranged from 0·42 to 0·91. Spacing was found to account for 25 per cent of ploughing cost variation and 42 per cent of planting cost variation; type of plough (mounted or trailed) was less important than spacing for determining differences between Conservancies in ploughing costs, but more important for variations within Conservancies; and type of soil (hard or soft) had some limited effect on planting rates.

R. J. N. BUSBY, P. S. COLLINGS

Recreation

Pilot National Day Visitor Survey

As a preliminary to a national survey of day visits to Forestry Commission land in 1977, a pilot survey was carried out in North East England Conservancy during 1976. The survey covered car-borne visitors only. At sites designated master sites, a daily total of car entries was recorded using traffic counters. At both the master sites and many more sites (designated slave sites) stock counts of parked cars at a specified time were carried out on 4 days. All master sites were car parks whereas slave sites included such dispersed use sites as roadside verges. The main alteration in design necessitated by experience gained in the pilot survey was to increase substantially the number of road sections surveyed. Verge parking is an important component of total visits but occurs on only a small proportion of the total road frontage to Forestry Commission land. The main survey is intended to produce a national figure for numbers of visits and also of visitor hours, as well as Conservancy figures. The data will be used to relate use of Forestry Commission sites to recreational use of the countryside at large, to provide a basis for modelling use in relation to supply of facilities and to investigate use in relation to costs.

P. S. COLLINGS, R. Q. OAKES

TIMBER UTILISATION

The Use of Bark

The relatively new bark processing industry continued to expand with the setting up of new production units in Ayrshire, Suffolk and South Yorkshire. Although the main outlets were in horticulture and landscaping, it was noted that new markets were being developed in the horse-racing industry and for the manufacture of building blocks. The building blocks, made under patent in Somerset, consist of pulverised bark bonded with cement; they have good thermal and sound isulation properties.

A significant advance was made in the marketing of bark, at both wholesaling and retailing level, when one of the largest industrial concerns in Britain undertook the distribution and sale of horticultural bark. In consequence, it is possible, for the first time, to purchase bark in relatively small quantities in virtually all parts of Britain.

The investigation into the likely causes of phytotoxicity of fresh bark was restricted to a few gas–liquid chromatography analyses of oil extracted by distillation, but the findings were inconclusive.

A report of the development work during the past two decades was published under the title *Conifer Bark: Its properties and Uses*, Forest Record 110; and a paper on UK experience in the use of bark was presented to a United Nations Economic Commission for Europe Symposium on Extending the Use of Wood Residues.

J. R. AARON

PART II

Work done for the Forestry Commission by Other Agencies

FOREST SOILS

NUTRITION AND FOREST SOILS

By H. G. MILLER and B. L. WILLIAMS
The Macaulay Institute for Soil Research, Aberdeen

Nutrition

The project designed to investigate the relationship between tree growth and nutrient cycling in pole-stage Sitka spruce (*Report* for 1973) has continued with the establishment of the sixth, and final, experiment at Kilmichael Forest (Strathclyde). Nutrient movement in litter fall and in rainwater (throughfall and stemflow) is being followed in these experiments using equipment developed for the purpose (Miller, J. D. and Miller, H. G., 1976). In addition to the input of elements in rainfall, measurements are made of the total input including that in dry deposition and impacted aerosols, the latter being particularly important in forested areas. Analyses cover the usual major nutrients together with sodium and chloride, which reflect the influence of sea-derived aerosols, and fluoride, sulphate and pH, which are of interest in relation to pollution and the effects of "acid precipitation". A limited study is also being made of the input of insoluble particulate matter using X-ray fluorescence spectroscopy. Early results indicate that this is almost entirely soil-derived and, in terms of nutrition, its main importance is probably the introduction of small quantities of phosphorus.

Examination and publication of earlier results for pine continues. It has been shown (a) that the nitrogen content of recently fallen needle-litter is a good measure of nitrogen status (Miller, H. G. and Miller, J. D., 1976) and (b) that continued growth response after cessation of fertilizer application is due to nitrogen stored within the tree tissues (Miller, Miller and Pauline, 1976). The effect of drainage on the nutrition of Lodgepole pine on peat has also been examined (Boggie and Miller, 1976).

Nitrogen mineralisation in peat and mor humus

A study of the effect of the tree crop on the content and availability of nutrients in peat continues (*Report* for 1976). From determinations of exchangeable cations in both planted and unplanted peat, it seems that the higher acidity of peat from beneath Lodgepole pine is mainly due to an increase in the content of exchangeable hydrogen ions. This increase is not accounted for by exchange with base cations and is probably due to the formation of new acidic groups resulting from decomposition. Effects of the tree crop on nitrogen mineralisation are being studied in incubation experiments using samples of planted and unplanted peat from Naver Forest (Highland) supplied by Site Studies (North) Branch of the Research and Development Division.

A study of the effects of applications of nitrogen, phosphorus and lime on an acid mor humus, beneath pole stage Scots pine at Culbin (Laigh of Moray Forest, Grampian), continues. Effects of liming, carried out in 1968, are still evident, limed humus continuing to show higher pH values, calcium content and base saturation than controls. However, rates of CO_2-evolution and nitrogen mineralisation are similar in both limed and untreated humus despite the continuing differences in acidity.

REFERENCES

BOGGIE, R., and MILLER, H. G. (1976). Growth of *Pinus contorta* at different water-table levels in deep blanket peat. *Forestry* **49**, 123–131.

MILLER, H. G., and MILLER, J. D. (1976). Analysis of needle fall as a means of assessing nitrogen status in pine. *Forestry* **49**, 57–61.

MILLER, H. G., MILLER, J. D., and PAULINE, OLIVE J. L. (1976). Effect of nitrogen supply on nutrient uptake in Corsican pine. *Journal of Applied Ecology* **13**, 955–966.

MILLER, J. D., and MILLER, H. G. (1976). Apparatus for collecting rainwater and litter fall beneath forest vegetation. *Laboratory Practice* **25**, 850–51.

AERATION STATUS OF UPLAND SOILS

By K. A. SMITH

Edinburgh School of Agriculture

Soil aeration conditions in upland soils were studied for the second successive year, at sites in Newcastleton Forest (Borders). Gas and water samples were taken from sampling probes at 20, 35 and 50 cm depth in four soil types: brown earth, ironpan soil, surface water gley and peaty gley, and analysed for oxygen and carbon dioxide by gas chromatography (Dowdell *et al.*, 1972; Smith and Dowdell, 1974; Smith, 1976).

Results generally confirmed the observations made in the previous year (*Report* for 1975). There was a general decline in oxygen concentrations when soil moisture tensions and water table depths were increasing in early summer. This has been attributed to the effects of greater respiratory demand for oxygen outweighing the effects of improved permeability to air. During the prolonged dry period in July and August oxygen levels increased again, but declined at the end of September as the moisture tensions decreased. Thus it appears that at the end of the growing season the moisture content was the factor having the greatest influence on aeration.

Aeration was satisfactory throughout the brown earth profile; in the iron pan soil the aeration was again much better below the pan than above it, confirming the observations made in 1975. However, in the latter soil the oxygen concentrations above the pan were not as low as in the previous year. Very low levels of oxygen were recorded at all depths in the gley soils, with the duration of these conditions becoming greater with increasing depth. This is illustrated for the peaty gley in Figure 3.

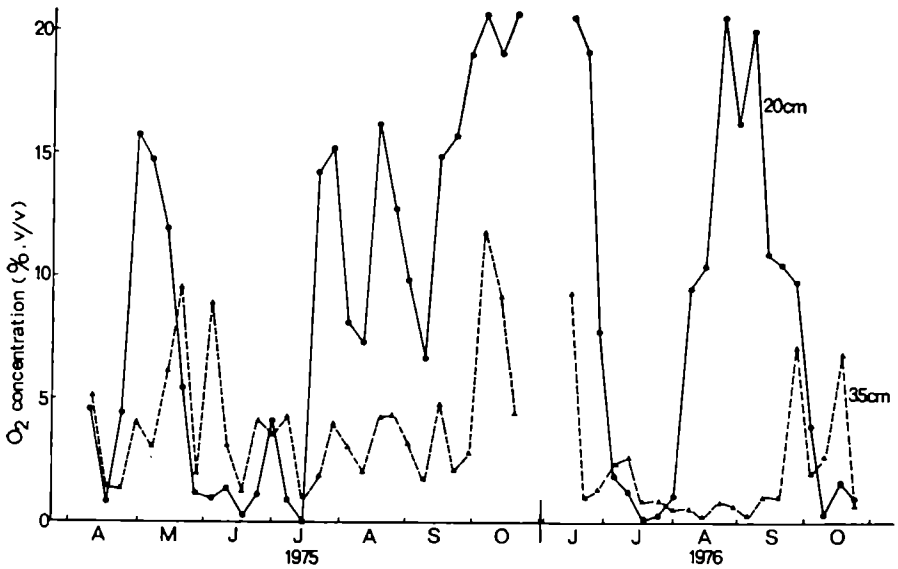

Figure 3: Oxygen concentrations at 2 depths in a peaty gley soil.

REFERENCES

DOWDELL, R. J., SMITH, K. A., CREES, R., and RESTALL, S. W. F. (1972). Field studies of ethylene in the soil atmosphere—equipment and preliminary results. *Soil Biology and Biochemistry* **4**, 325–331.

SMITH, K. A., and DOWDELL, R. J. (1974). Field studies of the soil atmosphere I. Relationships between ethylene, oxygen, soil moisture content, and temperature. *Journal of Soil Science*, **25**, 217–230.

SMITH, K. A. (1977). Gas-chromatographic analysis of the soil atmosphere. *Advances in Chromatography*, **15**, 197–231.

TREE PHYSIOLOGY

APPLICATIONS OF PLANT TISSUE CULTURE IN FORESTRY

By H. E. STREET and K. JUDITH WEBB

Botanical Laboratories, University of Leicester

The initiation of adventitious buds on the hypocotyl and cotyledonary regions of sterilised and excised embryos of *Pinus contorta* has previously been reported (*Report* 1976). Studies have since been extended successfully to cultures of *Picea sitchensis* embryos and seedling hypocotyls. Combinations of various concentrations of cytokinins and auxins have been employed in attempts to optimise the culture conditions for bud induction in both species under consideration. A high cytokinin to auxin ratio is required for the initiation of

"de novo" buds in both species. Results obtained indicate that *P. sitchensis* is less critical in its requirement for specific hormones than is *P. contorta*. The *P. contorta* embryos also exhibit a marked sensitivity to light immediately following excision.

The feasibility of using tissue culture for clonal propagation is supported by our findings that numerous "de novo" bud primordia may be formed from each explant under suitable culture conditions. Current work is being directed towards increasing the frequency and overall yield of shoot production. In *P. sitchensis*, the hormone additions to the medium can be adjusted to promote either direct formation of bud primordia from the original explant material, or initiation of a callus phase. Subculture of the explant, with its associated buds, into the same medium results in further bud formation. Bud induction may also be achieved from the undifferentiated callus by its transfer to a high cytokinin medium or by the application of a concentrated cytokinin solution directly onto the callus surface. This latter method has been reported for other gymnosperm cultures—specifically *Pseudotsuga menziesii* (Cheng, 1975). Direct application of the concentrated cytokinin, however, has the disadvantage that it frequently causes browning and subsequent death of the callus, although in some cases buds have been produced from the apparently necrotic callus.

Transfer of the cultures bearing buds to a low salt, hormone-free medium results in the extension growth of the buds. These may then be individually dissected out and further growth promoted prior to rooting the shoots by traditional sylvicultural techniques (carried out by the Northern Research Station, Roslin). Preliminary investigations indicate that the chromosome number of *P. contorta* plantlets produced by this method is at the normal diploid level.

Although complete plantlet regeneration is presently restricted to juvenile tissues in these species, the development of successful bud initiation media for these tissues may provide a basis for work using mature tissues, such as shoot segments, needle fascicle buds (in *P. contorta*) and meristems. A low percentage of mature tissues introduced into culture have survived to produce callus or axial extension but have, so far, not given rise to new shoot buds.

Studies on the control of xylogenesis in a new suspension culture of *P. contorta* are continuing. The conditions for the maintenance of the cultures have we believe, been successfully optimised. Regular fourteen day subculture has maintained the original rate of growth and tracheid production over twelve months without encountering the problems exhibited by the previous cell lines (*Report* 1976). It has also proved possible to exert a greater degree of control over the tracheid production of these cultures. The stock lines routinely contain 10–20 per cent tracheids. Manipulation of the mineral nutrition of the cultures can control tracheid production, decreasing the percentage of tracheary elements so formed to 0·5–5·0 or increasing it to 40–50.

REFERENCES

CHENG, TSAI-YING (1975). Adventitious bud formation in culture of Douglas fir (*Pseudotsuga menziesii* (Mirb) Franco). *Plant Science Letters* **5**, 97–102.

STREET, H. E., and WEBB, K. J. (1976). Tree physiology. Applications of plant tissue culture in forestry. *Forestry Commission Report on Forest Research* 1976, 58–59.

CONTROL OF FLOWERING IN SITKA SPRUCE

By P. B. TOMPSETT

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The discovery that gibberellin and cytokinin applications can enhance the flowering of Sitka spruce and the practical implications of this finding have been described in a previous *Report* (1976). Further hormone application experiments have been carried out and the results are reported below.

Treatments under Field Conditions

A number of growth regulators were applied from a 45-feet-tall platform to the upper branches of 47-years-old, fully mature trees at Brendon forest. The results showed that applications of a gibberellin $A_{4/7}$ mixture to these trees, under natural conditions, can significantly increase flowering. Contrasting results were obtained from an experiment on 23-years-old, sexually immature trees at Glentress forest; this younger material failed to respond positively, despite the use of various growth regulators at several concentrations. One further point of interest emerging from these studies is that gibberellin A_3 was shown to have no effect on the flowering of Sitka spruce. The fact that only gibberellin A_3 was used in previous attempts to induce flowering by gibberellins in spruce may explain the former lack of success. In a further experiment at the Wauchope Tree Bank, results were obtained which showed that the auxin naphthalene acetic acid can increase the ratio of male to female strobili.

Treatments in a Polythene House

Experiments on plants comprising 5-years-grafted scions on seedling rootstocks in a polythene house have confirmed the promotive effects of gibberellin applications on flower formation (Tompsett, 1977). Numbers were increased up to seven times for male strobili and up to eight times for female strobili; the growth inhibitors phosphon D and abscisic acid were shown to reverse the promotive effect of gibberellins. The presence of female cones reduced the length of vegetative shoots produced in the current year.

Taken as a whole, these results show that there is considerable potential for the use of growth hormones in the control of flowering of Sitka spruce. Further work on the types and concentrations of hormones required will ensure that this potential is fully realised.

REFERENCES

TOMPSETT, P. B. (1976). Control of flowering in Sitka spruce. *Forestry Commission Report on Forest Research* 1976, 61–62.

TOMPSETT, P. B. (1977). Studies of growth and flowering in *Picea sitchensis* (Bong.)Carr. I. Effects of growth regulator applications to mature scions on seedling rootstocks. *Annals of Botany* (in press).

HERBICIDES

RESEARCH ON USES OF HERBICIDES IN FORESTRY

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A range of herbicides has been applied to pot-grown crop and weed species, as a first step towards the development of new weed control treatments for use in forest nurseries, transplant lines and young plantations.

In a glasshouse experiment 45 compounds were applied pre-emergence to conifer and broadleaved crop species. Because of severe damping-off, useful results were obtained only with Corsican pine and oak. The study will be repeated in pots out of doors, in March 1977. However, from results with the two species, 6 herbicides have been chosen for further trial. These are HOE 29152 (a "double" phenoxy compound), "Velpar", chlornitrofen, napropamide, butam and Orga 3045 ("tetrapion"). Chlornitrofen, of particular interest, is as active against weeds as its analogue nitrofen but has no effect on the crop species. Orga 3045, related to dalapon, is much more active than the latter against weeds but did not injure Corsican pine and oak.

The full results of an outdoor pot experiment with well established conifers, oak, beech, heather and forest grasses sprayed in August 1976, will not be available until late 1977. However, some preliminary results are of interest. Velpar appears to kill broadleaved woody species, heather, *Calamagrostis*, *Deschampsia* and *Molinia* without affecting any conifer. Krenite and Dowco 290 are also inactive against conifers, but control many herbaceous weeds of forests.

In other pot experiments, ammonium sulphate has enhanced glyphosate activity against heather and the three forest grasses. Low volume application techniques also have this effect. As in other trials, cyprazine has effectively controlled heather. It is also active against *Molinia*, particularly when mixed with emulsified or solubilized oil. Most unfortunately this interesting herbicide has recently been withdrawn from the market by its makers. Its main use was for controlling annual grasses in maize.

FOREST ZOOLOGY

LONG-HAIRED FALLOW DEER

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

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A herd of fallow deer in Mortimer Forest (Salop) contains a proportion with long coats (Springthorpe, 1969). The investigation of this character falls into two parts;

A study of the inheritance of the character.
A quantitative characterisation of the coat together with an investigation of its physiological advantages or disadvantages.

Inheritance

It is most likely that long hair is genetically determined since short haired does may produce long haired fawns and *vice versa*, and long hair is not restricted to particular parts of Mortimer Forest. However, environmental causes must also be considered; these could be abiotic (e.g. deficiency or excess of a trace element) or biotic (e.g. a virus with a similar effect to that which causes Border disease in sheep).

Four large enclosures have been constructed in the forest so that controlled crosses can be set up. Thanks to the efforts of the Forestry Commission Rangers, four crosses were set up in September 1976; these were a long and a short haired buck each with a long and a short haired doe. The like by like crosses should be the most informative since a fawn unlike both parents would indicate that the fawn showed the recessive character and that the parents were heterozygotes showing the genetically dominant character. The first fawns will be born in June 1977, but it may take several years to elucidate the mode of inheritance of long hair because each doe normally produces only one offspring.

Coat and Physiology

Preliminary comparison of pelts from culled animals indicated that winter hairs of the long coated variety are finer as well as longer than normal. It seems desirable to investigate the insulating properties of the long coat compared with the normal coat. Is a long fine coat as good an insulator as a short coarse coat, particularly when wet? If not, long haired deer are likely to require more food in the winter months. Does a long coat allow efficient heat dissipation in summer?

In June 1976, two long haired and one normal fawn were obtained from Mortimer shortly after birth and hand reared at Reading University. Since January 1977 they have been housed in an outside enclosure (see Plate 4). A detailed study of the coat changes is in progress by taking regular samples of hairs. The body hairs of the long haired fawns were longer and finer than normal because they grew at a faster rate and for a longer time.

The long haired fawns also maintained a high proportion of growing hairs in their coats throughout the winter months, whereas the normal fawn had several clearly defined generations of winter hairs. Observations on the change to summer coat are continuing.

In order to assess the adaptability of the normal and long haired fallow to different environmental conditions, transmitters are now being fitted to the deer which will monitor their pulse, respiration and temperature.

REFERENCE

SPRINGTHORPE, G. (1969). Long haired fallow deer at Mortimer Forest. *Journal of Zoology* **159**, 537.

REPRODUCTION IN THE GREY SQUIRREL

By A. TAIT and ELIZABETH JOHNSON
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Hormone Changes in Female Squirrels

Hormone assays for plasma progesterone are being continued in order to obtain a complete picture of the changing hormone levels throughout the sexual cycle of female grey squirrels. The development of a method for collection of serial blood samples from the tail vein of captive squirrels has made it possible to study these changes in individual squirrels. The results from one pregnant female squirrel are shown in Fig. 4. After 20 days of gestation plasma progesterone rises sharply to reach a maximum value of 70 ng/ml by day 38. Levels of plasma progesterone then fall to a figure of 20 ng/ml at parturition. By 3 days post-partum the amounts of plasma progesterone have returned to the very low levels, 0·2 ng/ml, previously reported for anoestrous females (Tait & Johnson, 1976).

Histochemical studies on the corpus luteum of the ovary and the placenta are being performed in order to determine the site of production of the hormone during pregnancy.

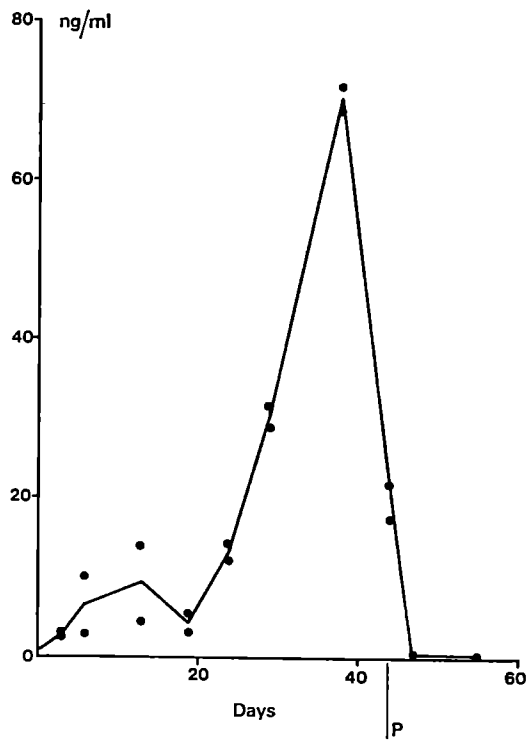

Figure 4: Plasma progesterone levels (nanogram/ml) of a female grey squirrel during pregnancy (P=day of parturition)

Testicular Activity and Regression in Male Squirrels

Histochemical techniques are also being used to determine more exactly the periods of testicular activity and regression in the male squirrel. Localisation of an enzyme, $\triangle^5$ 3β hydroxysteroid dehydrogenase, essential in the synthesis of the male hormone, testosterone, is being developed for a quantitative assay. The assay depends upon the production of a blue formazan within the cells containing the steroid dehydrogenase, when incubated with a suitable substrate. The enzyme activity is confined to the interstitial cells of sexually active testes, none being present in the seminiferous tubules.

REFERENCE

TAIT, A., and JOHNSON, E. (1976). Reproduction in the Grey Squirrel. *Forestry Commission Report on Forest Research* 1976, 62–63.

RECREATION

RECREATION ACTIVITY SUBSTITUTION IN SCOTLAND

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This study was sponsored by the Countryside Commission for Scotland, the Forestry Commission, the Scottish Sports Council and the Scottish Tourist Board as an input into the Scottish Tourism and Recreation Planning Studies (STARPS) being sponsored by these bodies. It was intended to provide insights into the way in which people may substitute one recreational activity (for which no, or limited, outlets are available) for another, where greater opportunities exist. Analysis was based on data from a number of surveys carried out by the Tourism and Recreation Research Unit: the Lanark and Greater Edinburgh Survey (1969), the ScottishTourism and Recreation Survey (1973) and a survey of areas in the Highlands and Islands affected by oil-related developments (1975). All these surveys provide information about participation in various types of recreational activity, and the socio-economic characteristics of participants.

The techniques of cluster analysis, supported by simple tabular analyses, were used:

(a) to define objectively groups of individuals who were similar with respect to their socio-economic characteristics, and to investigate the activities participated in by members of such groups; and
(b) to isolate groups of activities that tended to be participated in together, and to investigate the socio-economic characteristics of participants defined by such groups.

On the basis of the patterns revealed an attempt was made to infer which activities were more amenable to substitution, and to draw out the possible planning implications.

REFERENCE

TOURISM & RECREATION RESEARCH UNIT *Recreation Activity Substitution in Scotland* (TRRU Research Report No. 32) Edinburgh: TRRU, 1977.

SCOTTISH TOURISM AND RECREATION PLANNING STUDIES

By MICHAEL GEE

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The Scottish Tourism and Recreation Planning Studies (STARPS), sponsored jointly by the Countryside Commission for Scotland, the Scottish Sports Council, the Scottish Tourist Board and the Forestry Commission, were described in the *Report on Forest Research* 1976. The purpose of these studies was described as providing assistance in the evolution of outline planning strategies for sport, outdoor recreation and tourism for each region and island authority area in Scotland, coordinated within a broad national framework. The Dartington Amenity Research Trust (DART) have been engaged as consultants and their contract has been extended to cover the period from March 1975 to July 1977. The work has been divided into two stages.

Stage One

The first stage was described in the *Report on Forest Research* 1976. Two documents were produced:

Strategic Issues, which set out likely future situations and the implications, for the regions, of national policies.

Guide to the Preparation of Initial Regional Strategies. This guide is in two parts. The first sets out the concept of the Initial Regional Strategy, outlines the thought-process proposed for the preparation of a Strategy, and comments briefly on the subsequent process of adoption. The second describes in detail the technical work proposed, such as clarification of strategic issues, appraisal of both demand and supply and also impacts, together with formulation of aims, objectives and policies.

Stage Two

The second stage of the studies has been of a "planning" rather than "research" nature. It has involved the national agencies, together with their consultants, in assisting each region or island authority to produce strategies.

Every authority has agreed to produce a strategy for sport, outdoor recreation and tourism as part of the STARPS programme, and most are following the process set out in the *Guide to the Preparation of Initial Regional Strategies.* In addition to the production of this guide, the national agencies, together with their consultants, have convened a National Conference and a National

Technical Meeting; have established in each region a sequence of Coordinating Team Meetings and supporting technical meetings; and have distributed a series of Newsletters.

While the details of the work have varied between regions, most regions are producing "Situation Reports" which embrace the following elements:

(a) Statements on regional "Strategic Issues", (generally incorporating a response to the national policies set out in the Stage One "Strategic Issues" document as well as identifying major issues in the regions and relating these to recreation and tourism policy).

(b) Appraisal of the "impact" of recreation and tourism in the region in terms of society, economy or environment.

(c) Comparison of the demand for recreational and tourist activities with the supply of facilities. (This is perhaps the most novel aspect of the programme's work and has involved a considerable amount of data collection and analysis.)

The production of "Situation Reports" will constitute the most comprehensive region by region picture of the pattern of recreation and tourism in Scotland. The reports will form the basis of policy formulation and strategy preparation, and this final stage of the STARPS programme will involve the sponsoring national agencies in further close collaboration with the regional authorities. It is anticipated that around the start of 1978 a full set of strategies should be available.

TIMBER UTILISATION

JOINT RESEARCH PROGRAMME ON HOME-GROWN TIMBER

By T. HARDING

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

The Density of British-grown Douglas Fir

Stress grading studies on home-grown timber have shown that much improved yields at higher grade levels are obtained for Sitka spruce, Scots pine and Corsican pine when timber is machine graded, as compared with yields from visual grading. With Douglas fir, however, the scale of improvement over visual grading was substantially less. If, as seems reasonable, Douglas fir should behave in a similar fashion to the other home-grown timbers in giving

enhanced yields when machine graded, this suggests that either the timber used in the grading study, or that from which the grade stress levels in CP 112 were derived, was not representative. A density survey of Douglas fir sawlogs has been made to examine these possibilities.

For this purpose, the sawlog population at each of five different yield class levels, viz 10, 12, 14, 16 and 18 and over, was sampled in proportion to the extent to which it represented the outturn of sawlog material over the next five years. In all, 24 sites were sampled with six trees from each site. Sawlog density for each stem to a top diameter of 18 cm was determined, using discs cut at proportional lengths along the length. These gave an average (when weighted according to the proportion that each YC represents of the total proportion of sawlog trees) of 402 kg/m^3 based on an oven-dry weight and green volume. This compares with an estimated average of 409 kg/m^3 for the stress graded material (based on oven-dry weight and volume at 18 per cent moisture content) and an average of 447 kg/m^3 (based on green volumes and oven-dry weights) for discs from the trees, mainly thinnings, from which grade stress levels were derived.

The significance of this for grade stress levels is being considered.

Computer-aided Log Conversion for the British Sawmilling Industry

Theoretical work has been carried out using the computer-simulation model as an aid to improving the conversion yield of preferred sizes of sawn timber from sawlogs using two basic sawing patterns which are considered to be most applicable to British sawmilling. These are the cant-conversion process using a log carriage and resaw, and the double-slabbing process using a double bandsaw followed by split saw and resaws.

The work has shown the improvement which can be expected both in the overall conversion yield of sawn timber and also in the yield of sawn material from the core of the log. Improvements are most significant when bowed logs are being sawn and there are indications that some modifications might be required in the basic traditional cutting patterns to enable the benefits of computer aid to be realised.

Current research is concerned with the development of practical ways of implementing the concept of computer-aided sawmilling in a way which is suited to the home sawmilling industry, and cost benefit analyses are being carried out to establish the viability of the systems.

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

Simulated conversions have been carried out to assess the effect of varying amounts of bow on the conversion yield of board material sawn from logs 1 m and 1·2 m in length, and having a top diameter range of 12½ cm to 25 cm, when using a double-slabbing conversion technique.

Results show that board thickness does not have a marked effect upon the yield of sawn wood, but top diameter is highly significant both to the yield from straight logs and in its interaction with bow. For example, basing the bow measurement on its proportion of the log's top diameter, ten per cent bow on a 12½ cm top diameter log reduces the yield to 40 per cent, whereas a 35 per cent bow can be tolerated in a 25 cm top diameter log to give the same yield.

Machine Grading of Larger Sections of Timber

A co-operative test programme on machine grading of sizes up to a maximum of 7½ × 30 cm is in progress. A number of organisations are contributing and part of the programme will be carried out within the resources of the joint FC/PRL Programme. The test work is being shared between TRADA and PRL and comes under the overall control of PRL. Canadian hemlock, redwood/whitewood and British-grown Sitka spruce will be tested. In addition, attempts will be made to extrapolate from information currently available on smaller sizes of Scots pine, western white spruce and Douglas fir to produce computer program cards for the machine grading of larger sizes of these species without conducting a further test programme.

APPENDIX I

Publications by Forestry Commission Staff

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

AARON, J. R. (1976). *Conifer Bark: its properties and uses.* Forestry Commission Forest Record 110 (London: HMSO 75p).

Possible uses for bark are considered in the light of development work undertaken by the Forestry Commission on extractives during the 1950s and, more recently, on various horticultural applications. The latter has become a commercial reality and a number of organisations are now supplying bark to both professional and amateur growers throughout Britain. The preparation of bark for horticultural use to ensure the removal of harmful volatiles is covered in some detail.

AARON, J. R. (1977). Wood as a fuel. *Forestry '77, a Farm Contractor specialist annual,* 44–45.

The pros and cons of developing the use of wood as fuel in the light of the recent energy crisis. Attention is drawn to the disadvantages which include, the high labour requirement for the preparation of firewood, the unpredictability of the demand together with the relative infrequency of severe winters, the bulkiness in storage, and the risk of depriving established industrial uses of wood, as raw material.

Greater nett energy savings are achieved if wood is used to replace energy intensive products such as steel, aluminium and glass in building and civil engineering, than when it is used as a fuel.

AARON, J. R. (1977). *Some use for wood residues.* Edinburgh: Forestry Commission Miscellaneous Publication.

A short illustrated guide outlining the specifications and use of chipped wood for cattle and poultry litter, wood pulp fibreboard and chipboard production and fuel. Horticultural uses are also mentioned.

AARON, J. R. (1977). Feeding and mulching roses. *The Rose Annual* 1977, 86–88. St. Albans: Royal National Rose Society.

Describes the development work which was undertaken to launch bark as a horticultural commodity. Mentions how difficulties due to the presence of terpenes in conifer bark are overcome. Outlines the purposes of mulching and explains how these are fulfilled by bark. The desirability of adding a small quantity of nitrogenous fertiliser is also mentioned.

ALDHOUS, J. R. (1976). Lodgepole pine seed zones with reference to British requirements. In *Pinus Contorta Provenance Studies* (ed R. Lines) Forestry Commission Research and Development paper 114. 6–39.

Reviews botanical and site variation of Lodgepole pine in its native habitat and its relevance to commercial seed collections. Current seed zone maps in use in British Columbia, Washington and Oregon are related to the zonation used in Britain. Recommendations are made to adopt the British Columbian zonation in place of the current British one, because the latter gives insufficient attention to the major climatic subdivisions of the interior, in particular the Interior Wet Region.

Coast transition sites are recognised and their range extended into S.E. Alaska (Lynn Canal). An alternative subdivision of S.E. Alaska for seed collection purposes is also proposed.

The pattern of rapid adaptation to local sites is so pronounced as to cast doubt on the validity of the concept of distinctive archetypal "coastal" and "inland" populations, meeting and giving rise to intermediate forms in a few localities.

BARBOUR, D. A. (1976). Macrolepidoptera of Banffshire. *Entomologists Record* **88,** (1) 1–11. January.

A list of species found mainly in the Aberlour area in June 1968–October 1972.

BEVAN, D. (1977). La proteccion de un monte compatible con el manejo de uso multiple y el manejo de habitats para la conservacion de insectos en peligro de extincion. In *I Curso sobre manejo integrado de areas forestales de uso multiple*. Cazorla Instituto Nacional Para la Conservacion de la Naturaleza, May 1976, Monografia **13**, 7–25, (In Spanish).

Suggests a realistic basis for conservation measures for insects in danger of extinction within the overall management of a multiple-use forest.

BOOTH, T. C. (1976). The use of a wind tunnel model to locate areas of shelter in South Kintyre. *4th Symposium on Shelter Research*, (University of Warwick, September 1975). London: Ministry of Agriculture, Fisheries and Food, 55–59.

Summarises methods of assessing exposure, and describes in detail work done using a topographic model in a wind tunnel. Relative wind speed maps produced were later related to shoot growth for 1973 and 74. 1973 shoot growth related better to a mean of all wind directions (r=—0·82) than to westerly winds only (r=—0·57), although the biological symptoms indicated west as the most exposed. The use of data obtained was described for both research and advisory purposes. Discussion on the paper is also reported.

(ARMSTRONG, W.*), BOOTH, T. C., PRIESTLEY, P., and (READ, D. J.**) (1976). The relationship between soil aeration, stability and growth of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) on upland peaty gleys. *Journal of Applied Ecology* **13**, (2) 585–591.

The relationship between soil oxygen status and the growth and stability of Sitka spruce was investigated in a plantation showing early signs of windthrow. Soil anaerobis occurred in all but the top 10–15 cm of the profile in winter. The better aeration in the upper part of the profile was associated with reduced soil water potential. The largest and most stable trees occurred in areas which had slightly improved soil aeration. A cultivation treatment is suggested which might improve tree growth and stability in seasonally waterlogged areas.

BRASIER, C. M. (1977). Inheritance of pathogenicity and cultural characters in *Ceratocystis ulmi;* hybridization of protoperithecial and non-aggressive strains. *Transactions of the Britsh Mycological Society* **68** (1), 45–52.

The possibility that the low levels of pathogenicity shown by the progeny of aggressive × non-aggressive crosses of *Ceratocystis ulmi* (Brasier & Gibbs, 1976) are due to transmission of a cytoplasmic determinant from the non-aggressive parent was investigated. Protoperithecia produced by an isolate of the proto form of the aggressive strain were fertilized with conidia of the non-aggressive strain so that the female parent in the cross was known. Single ascospore progeny from the resulting perithecia had a normal growth-rate distribution, with a mean lying significantly below the parental mid-point. The progeny were highly variable in culture morphology and few could be classified in terms of the two parental types. When inoculated into English elm they caused only slight defoliation, followed by recovery. Even on the more susceptible Wych elm, none approached the protoperithecial parent in pathogenicity. This behaviour is comparable with that shown in the previous study (Brasier & Gibbs, 1976). It is concluded that a cytoplasmic determinant is unlikely to be involved in pathogenicity. It is suggested that this character is probably under polygenic control, and that the behaviour of the progeny reflects a degree of reproductive isolation between the parents.

When the numbers of mature perithecia resulting from the fertilization of a protoperithecial isolate with conidia of the aggressive and non-aggressive strains were compared, the proto × aggressive crosses were more than ten times as successful as protoperithecial × non-aggressive conidiations. These results suggest the existence of a mechanism which inhibits hybridization between the aggressive and non-aggressive strains of *C. ulmi*.

BRASIER, C. M., and GIBBS, J. N. (1976). Inheritance of pathogenicity and cultural characters in *Ceratocystis ulmi:* hybridization of aggressive and non-aggressive strains. *Annals of Applied Biology* **83**, 31–37.

When British isolates of *Ceratocystis ulmi* were surveyed for compatibility type, both A- and B- types were found in the non-aggressive strain, but only the B- type in the aggressive strain. Single ascospore progeny from crosses between compatible aggressive and non-aggressive isolates showed a near-normal growth rate distribution, with a mean lying between the parents. Many grew either faster than the aggressive or slower than the non-aggressive

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parent. The progeny were highly variable in culture morphology and could not be classified in terms of the parental types. When inoculated into English elm they showed a marked skewness towards low pathogenicity. None approached the aggressive strain in pathogenicity. It is concluded that the above characters are under polygenic control, and that the aggressive strain could not arise from the non-aggressive by a simple mutation. The results suggest that the two strains may be reproductively isolated.

BRASIER, C. M., and STROUTS, R. G. (1976). New Records of *Phytophthora* on trees in Britain. I. *Phytophthora* root rot and bleeding canker of horse chestnut (*Aesculus hippocastanum* L.) *European Journal of Forest Pathology* **6** (3), 129–136.

No *Phytophthora* diseases of *Aesculus* were recorded in Britain before 1969. Since then numerous Horse chestnut trees in various parts of southern England, with symptoms typical of *P.* root disease (sparse foliage, small chlorotic leaves and dieback), have yielded from their roots or the soil around them *P. megasperma* var. *megasperma*, *P. citricola* and isolates resembling *P. cambivora*. *P. citricola* was also isolated from the soil around fine roots of trees with leaf scorch. Trees with bleeding canker, a perennial disease killing bark of the stem and branches, yielded *P. cactorum* and *P. citricola* from the stem lesions and inoculations with these spp. reproduced the damage.

(WILLIAMS, S.,* VERMA, M. M.,** JINKS, J. L.,*** and) BRASIER, C. M. (1976) Variation in a natural population of *Schizophyllum commune*. II. Variation within the extreme isolates for growth rate. *Heredity* **37** (3), 365–375.

Two extreme dikaryotic isolates chosen from a large sample of localised population of *Schizophyllum commune* exhibited a considerable amount of genetical variation for growth rate, at the near ambient temperature of 20°C, and at the higher temperature of 30°C. The potential variation within these extreme isolates was greater than the variation observed in the whole sample. Regression analysis of the variation in growth rate, of the dikaryotic progeny of the extreme isolates on that of their component monokaryons, showed that the nature of gene action was not the same in these two stages of the life cycle.

The simple additive-dominance model of gene action was adequate to explain the variation in growth rate in both of the extreme isolates at both of the temperatures. The small deviations from this model could be accounted for by unequal gene frequencies due to small sample size, although a low incidence of non-allelic interactions could not be ruled out. Directional dominance for growth rate was detected in both isolates at the more normal temperature and it was opposing in direction in the two isolates. In the slow growing isolate the dominance was for faster growth and in the fast growing isolate it was for slower growth. This is expected for a character which displays overall ambi-directional dominance if isolates with more extreme growth rates than those recovered in the population sample are eliminated by stabilising selection. The dominance is temperature dependent, being ambi-directional in both isolates at the higher temperature.

Environmental heterogeneity, the buffering effects of directional dominance and genotype-environment interactions, and opposing selective forces operating on the monokaryotic and dikaryotic stages of the life cycle, are possible contributory factors to the considerable free and potential variability displayed in this small, localised population.

BURDEKIN, D. A. (1976). DED—A new analysis *G.C. & H.T.J.* **18** (25), 32–33, 17th December.

In this review of the present Dutch elm disease situation in Britain, it is emphasized that the disease is at a relatively low level in northern England and Scotland. Various measures, including sanitation felling and restrictions on the movement of elm logs, should help to contain its further spread.

CAMPBELL, D. (1976). Trees in the changing English landscape. *Journal of the Royal Agricultural Society of England* **137**, 34–41.

A historical review of the effect of man and agriculture on the trees in the landscape.

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CARTER, C. I. (1976). Forestry—pest control. In *5th Review of Insecticide and Fungicide Usage.* Monograph 19, British Crop Protection Council. 14–15.

Control of several insect pests is mentioned, and some general remarks on control problems are given.

COUTTS, M. P. (1976). The formation of dry zones in the sapwood of conifers. I. Induction of drying in standing trees and logs by *Fomes annosus* and extracts of infected wood. *European Journal of Forest Pathology* **6** (6) December, 372–381.

Infection by *Fomes annosus* leads to the formation of dry zones in conifer wood. During an investigation of the mechanism of drying it was found that water was withdrawn from infected parts of logs, into uninfected parts, probably by the release of hydrostatic tension. The tensions which exist in standing trees appeared to be maintained in logs and to cause movement of water when the sealed tracheid system became sufficiently damaged to allow entry of air. *F. annosus* apparently caused this type of damage by enzymatic lysis in the bordered pit. However, the extension of dry zones beyond infection seems to imply a further mechanism involving living xylem cells.

COUTTS, M. P. (1977). The formation of dry zones in the sapwood of conifers. II. The role of living cells in the release of water. *European Journal of Forest Pathology* **7** (1), February, 6–12.

Dry zones in conifer wood, characterised by gas filled tracheids, were induced by the injection of dilute solutions of various toxic chemicals followed by incubation at 10 or 20°C. The development of dry zones did not occur at lower temperatures nor with concentrated solutions, and was prevented or retarded in an atmosphere of nitrogen. These results are discussed in relation to the development of dry zones in infections by *Fomes annosus* and other fungi and in the formation of heartwood. It is postulated that the gradual death of ray cells alters their metabolism in such a way that gas emboli are evolved in adjacent tracheids; this can occur at sites of infection or at a distance under the influence of transportable or diffusible toxins.

COUTTS, M. P., and (ARMSTRONG, W.*) (1976). Role of oxygen transport in the tolerance of trees to waterlogging. In *Tree Physiology and Yield Improvement.* (ed. by M. G. R. Cannell and F. T. Last). London and New York: Academic Press. 361–385.

A review of oxygen transport in trees, in which factors affecting the oxygen balance of roots, and pathways of oxygen movement, are discussed.

COUTTS, M. P., and PHILIPSON, J. J. (1976). Plasticity of the growth of tree root systems in response to changes in the nutrient environment. In *XVI IUFRO Congress Proceedings, Division II.* 70–77.

Pinus contorta Douglas ex Loudon seedlings were grown in a glasshouse with their root systems divided between two contrasting nutrient regimes. Root growth was stimulated by the high nutrient concentration, resulting in uneven development of the root systems. In an experiment carried out in the summer, the low nutrient roots grew slowly for an 84-day period, but when the experiment was repeated in the winter, low nutrient roots became dormant.

After differential root growth had been induced, some of the plants were transferred to a uniform high nutrient environment, and changes in root dry matter accumulation and diameter were recorded. Roots which had previously been in the low nutrient solution responded to the uniform high nutrient environment by active growth, whether or not they had been dormant at the time of transfer.

COUTTS, M. P., and PHILIPSON, J. J. (1976). The influence of mineral nutrition on the root development of trees. I. The growth of Sitka spruce with divided root systems. *Journal of Experimental Botany* **27**, 1102–1111.

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

Root growth, assessed in terms of dry weight and diameter of both primary and woody

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tissues, was stimulated in the roots to which the nutrients were actually applied, whereas in the untreated roots on treated plants only the primary root diameter was enhanced. However, internal nutrient concentrations on *both* sides of the root system were related to the concentrations applied, though to a slightly lesser extent in the untreated roots. Thus, the nutrients which had been internally translocated to the untreated roots had little effect on their growth.

The localized stimulation of xylem production in the woody roots extended into the stem along a spiral pathway which was demonstrated by the movement of dye.

Possible mechanisms are discussed by which differential root growth is brought about by a localized supply of mineral nutrients.

COUTTS, M. P. and (RISHBETH, J.*) (1977). The formation of wetwood in Grand fir. *European Journal of Forest Pathology* 7 (1), 13–22.

The distribution, properties and origin of wetwood were investigated. Healthy dominant trees contained a central region of dead, water-soaked wood (wetwood) at the butt, which extended into the main roots and sometimes into the upper stem, comprising part of the normal heartwood. Wetwood was also formed in the sapwood in response to infection by *Fomes annosus* or injection of mercuric chloride. The water in wetwood had an internal origin and its accumulation depended on the physiological condition of the tree. Wetwood formation could be prevented by a phloem block and was preceded by withdrawal of water from localised regions in the sapwood: water later accumulated within these dried regions, although a peripheral zone of greatly reduced moisture content remained. Mechanisms by which water might move across this dry zone are discussed.

CROWTHER, R. E. (1976). *Guidelines to forest weed control.* Forestry Commission Leaflet No. 66. (London: HMSO, 35p).

A brief outline of weeding methods available and advice on factors influencing choice of method.

CROWTHER, R. E. (1976). The role of arboreta in Britain. In *Trees and Forests for Human Settlements* (ed. J. W. Andresen). IUFRO P1.05 Project Group on Arboriculture and urban Forestry, pp. 405–409. Centre of Urban Forestry Studies, University of Toronto.

In Britain the large number of arboreta which were planted in the 19th century, provided a fund of information on exotic trees. This role continues but their function as an amenity for the public is increasing. There are serious limitations to the contribution arboreta can make to the conservation of endangered species.

EDLIN, H. L. (1976). Recreation in the national forests, 1919–1976. *Parks and Recreation* **41** (6), 39–40.

A history of recreation in the Commission's forests, with notes on the formation of forest parks and recent developments.

EDLIN, H. L. (1976). *Natural History of Trees.* London: Weidenfeld and Nicolson.

EVANS, J. (1976). Plantations: productivity and prospects. *Australian Forestry* **39** (3), 150–163.

An increasing dependence is likely on fast-growing plantations in the tropics to meet the rising world demand for wood and wood products. With the use often of exotic species in pure stands grown on short rotations, a possible problem will be the maintenance of productivity in successive crops. This subject is reviewed in the light of experience elsewhere, the occurrence of a confirmed second-rotation decline in yield in South Australia and the author's research in Swaziland. So far there is insufficient evidence for assuming that declining yields will occur in successive rotations of plantations, but the possibility is very real on some sites. This must act as a warning against undue dependence on plantations, and to foresters that greater inputs of improved cultural practice, fertilizers and better genetic varieties may be needed as such forestry practice approaches "tree farming".

FERGUSSON, J. L. F. (1976). Forestry. In *The Soils of the Country around Perth, Arbroath, and Dundee* (*Sheets* 48 & 49) *with account of vegetation.* Chapter 9, 184–186.

FLETCHER, A. M. (1976). Seed collection north-west America with particular reference to a Sitka spruce seed collection for provenance studies. In *IUFRO Sitka Spruce International Ten Provenance Experiment—Nursery Stage Results* (ed. J. O'Driscoll), 2–20. Dublin:

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Dept. of Lands, Forest and Wildlife Services and XVI IUFRO Congress Proceedings, Division II. 1.46 (abstract only).

Background and reasoning for setting up a IUFRO programme for provenance seed collection and the scientific reasoning for evaluating seed lots are given. Natural distribution, details of the species discovery, the dimensions it attains and its introduction to Europe are described.

Background and basis of sampling is provided. Areas chosen for collection were divided into (a) commercially collectable areas, (b) collectable areas and (c) scientific areas. Only the very poorest phenotypes were rejected. A detailed description of trees and collection site were recorded, a sample form is included. Seed extracted in Vancouver Island was sent to Denmark for cleaning; seed testing was carried out in Norway.

FRANCIS, G. J. (1976). Operation windblow. *Forestry & Home Grown Timber* **5** (2) April/May, 10–11, 47.

A survey of the damage caused by the gales of January 2nd 1976.

GIBBS, J. N. (1976). Forestry—disease control. In *Summary of the 5th Review of Insecticides and Fungicide Usage*. Monograph 19, British Crop Protection Council. 16.

A short note on the control of *Fomes annosus*, Dutch elm disease and *Armillariella mellea*.

GIBBS, J. N. (1977). Dutch elm disease—1976. A review of Dutch elm disease control programmes in England, Wales and the Channel Islands—Autumn 1976. *Arboricultural Journal* **3** (2), 110–114.

The attempts being made to control Dutch elm disease by sanitation felling are discussed, with special reference to the situation in East Sussex, Brighton and Jersey.

GIBBS, J. N., and BRASIER, C. M. (1976). Combating Dutch elm disease. *Country Life* **CLIX** (4113) 29th April.

A number of different measures, depending upon the particular circumstances, which can be taken to combat Dutch elm disease. These include sanitation felling, especially in the north and west of Britain, the control of root transmission, the possible use of fungicide injection techniques for high value amenity trees and, in the longer term, the planting of resistant elm cultivars. The future of large numbers of healthy English elm suckers arising in place of felled elms is discussed.

GORDON, A. G. (1977). Seeds for saplings. A critical look at their use and misuse. *Forestry '77, a Farm Contractor specialist annual*, 10–11.

The article outlines British legislation on the marketing and tests of forest seeds and spotlights its implications on nursery production. The most important of these is the likely increase in price for seeds of improved genetic quality. This in turn should lead to nurseries taking more care to improve the reliability and productivities from their nurseries. Finally the article reviews the supply position of conifer and broadleaved tree seeds, and suggests that more home-produced seeds should be collected and used.

GORDON, A. G. (1977). Speeding dormancy break in hardwoods. *GC & HTJ* **181** (3) 30–31. 21st January.

Some hardwood tree species have seeds which are very dormant and require lengthy periods of seed treatment to produce any germination. A technique whereby this dormancy was rapidly overcome was demonstrated at the 1976 Chelsea Flower Show. The article described and illustrates the technique, which involves excising viable embryos, incubating them under controlled conditions and pricking out the germinating seedlings into containers under glass. Plants over one metre high were produced in six months. The commercial possibilities of the technique are discussed.

GORDON, A. G., (SALT, G. A.*, and) BROWN, R. M. (1976). Effect of pre-sowing moist-chilling treatments on seedbed emergence of Sitka spruce seed infected by *Geniculodendron pyriforme*, Salt. *Forestry* **XLI** (2), 143–151.

Burial of seed in moist sand for several weeks during winter (pit stratification) and early sowing have been common practices in forest nurseries for breaking dormancy of conifer seed. However, in the experiments reported here the emergence of Sitka spruce was greatly reduced

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when seeds naturally infected by Geniculodendron pyriforme, were moist-chilled for 6 weeks in a stratification pit or in moist sand in a refrigerator at about 4°C. Reduction in emergence was less when seed was refrigerated without sand (naked), and negligible when the seed was treated with thiram or captan before chilling. Sowing 6 weeks early produced erratic results, often giving fewer but larger seedlings. Moist-chilling of seed did not increase total emergence but normally made it 1–2 weeks earlier so that the seedlings were larger by autumn. Addition of extra water to the seedbeds did not increase emergence or growth, even in a dry season.

GRAYSON, A. J. (Editor) (1976). *Evaluation of the contribution of forestry to economic development.* Forestry Commission Bulletin 56 (London: HMSO, £3·50).

Reports on meeting of IUFRO working party S4.05.01, including papers in full with summaries in English, French and German.

GRAYSON, A. J. (1976). The relevance to forest policy of evaluation of environmental benefits. In *Papers presented to the Symposium on forests and Wood—their role in the environment.* Part III. 177–188.

In considering the question of environmental benefits and changes in them as a result of changes in forestry practice, it is obviously useful to have methods of weighing them in money terms. Decisions on the appropriate mix of goods and services should thereby be improved and a basis established for any subsidy needed to compensate owners for loss of money income.

Cost-benefit analysis has grown in power and competence in recent decades but some of the greatest difficulties which this form of economic evaluation faces are found in the field of environmental effects. Cost-benefit analysis by itself is not a sufficient basis for decision-making even if the economic difficulties can be overcome. Attention must be paid to the effects of continued or changed management on the distribution of benefits between different income groups.

The economic analysis is only as good as the physical data on which it is based whether these refer to hydrological effects, ecological effects or recreational visit numbers. Continued work on the observation of effects and modelling is needed. Most of all, the aim of the economic assessment is to provide a reasoned basis from which informed discussion can go forward.

GREIG, B. J. W. (1976). Inoculation of pine stumps with *Peniophora gigantea* by chainsaw felling. *European Journal of Forest Pathology* **6** (5), October. 286–290.

By adding oidia of *Peniophora gigantea* to the lubricating oil of a chainsaw Scots pine stumps were automatically inoculated as the trees were felled and gave comparable results in terms of abundance of *P. gigantea* and control of *Fomes annosus*, as conventional inoculation of stumps after felling.

GREIG, B. J. W. (1976). Host plants of *Fomes annosus* in Great Britain. *Transactions of British Mycological Society* **66** (3) June, 517–519.

A list of 74 hosts of *F. annosus* in Britain is presented which includes 22 species not previously recorded in this country.

GREIG, B. J. W. (1976). Biological control of *Fomes annosus* by *Peniophora gigantea. European Journal of Forest Pathology* **6** (2), April, 65–71.

Experimental inoculation of pine stumps with *P. gigantea* reduced infection by *F. annosus* in first rotation crops and was as effective as chemical stump treatments. In severely diseased pine crops, *P. gigantea* reduced, but did not eliminate, *Fomes annosus. P. gigantea* is produced commercially and is used in many pine forests in Britain.

GREIG, B. J. W., and GULLIVER, S. CLARE (1976). Decays in oak in the Forest of Dean. *Quarterly Journal of Forestry* **LXX** (3) July, 157–159.

Decay in large, mature oaks felled for veneers was mainly due to *Polyporus sulphureus* and *Polyporus frondosus.* These two fungi have not previously been regarded as major causes of butt-rot in oak.

GREIG, B. J. W. and PRATT, J. E. (1976). Some observations on the longevity of *Fomes annosus* in conifer stumps. *European Journal of Forest Pathology* **6** (5) October, 250–253.

The longevity of *F. annosus* was assessed in 3 investigations, which showed that the fungus could remain active in stumps for periods of 16 to 62 years.

HAMILTON, G. J. (1976). The Bowmont Norway spruce thinning experiment 1930–1974. *Forestry* **XLIX** (2), 109–121.

Various effects of four different thinning treatments, after a period of 44 years, are outlined and discussed. In particular, there was found to be no significant difference between C, D, and LC grades in total volume production. The D grade thinning is shown to be the most favourable from an economic viewpoint.

HAMILTON, J. M. (1977). Forestry Commission fire losses: 1976. *Forestry '77, a Farm Contractors specialist annual*, 13–14.

A comparison of the exceptional losses of 1976 with other years. The special conditions leading to these losses are noted and conclusions are drawn about future measures.

HOLMES, G. D. (1976). International researchers meet in Oslo. *Forestry and British Timber* **5** (5), October, 18–20.

A report on the XVI IUFRO Congress.

HOLMES, G. D. (1977). Whole-tree marketing. *Forestry and British Timber* **6** (1) January/February, 48–50. and *Timber Trades Journal* **299** (5228), 20 November 1976, 56–59.

Reviews the prospects for further utilization of wood and logging residues, including chipper harvesting, whole-tree chipping and reduction of waste in industry.

HOLTAM, B. W. (1976). Forestry practice in Britain is applied terrestrial ecology. *Commonwealth Forestry Review* **55** (2), No. 164, June. 123–127.

Destruction of Britain's forests during 4,000 years had severe ecological effects, but plants and animals had time to adapt to a denuded landscape. In only 50 years foresters, through applied ecology and supported by sustained research, have created on deserted, impoverished land, new forests to restore a part of Britain's plundered forest wealth. Plants and animals are adapting to the new forests which, in addition to growing wood at three times the rate of former forests in more fertile environments, provide our richest wildlife resource for centuries. Patience is necessary: prospects for greater enrichment through continued research are great.

HOWARD, D. J. (1976). Holder Cultitrac A55F forestry tractor and McConnell inter-row weeding flail. FC/HGTAC Technical Note No. 24. *Forestry and British Timber* **5** (4) August/September, 45–46.

Inter row weeding in plantations with this machine is described, together with terrain limitations. Description of the equipment centres on the McConnell weeder. Dimensions and weights of the outfit are tabulated. Working costs and outputs in grasses, light woody weeds and heavy woody weeds are predicted at various row spacings.

INSLEY, H. (1976). Amenity tree research—a new move in the Forestry Commission to extend research on arboriculture. *Arboricultural Journal* **3** (1) September, 54–57.

Outlines the Forestry Commission's research programme in arboriculture up to the end of 1976 and mentions the formation of an advisory service for trade and professional users.

INSLEY, H. (1976). Deer and the visitor to the New Forest. *Deer (Journal of the British Deer Society)* **3** (10), July, 542–545.

JOBLING, J. (1976). Populus: uses, cultivation and diseases. In *Trees and Shrubs Hardy in the British Isles* (by W. J. Bean). *8th rev. ed.* Vol. III N-Rh. 294–298. London: John Murray.

Briefly reviews site requirements, choice of variety, wood production and the main diseases.

JOHNSTON, D. R. (1976). The reorganisation of forestry research in Britain. In *Management of Forestry Research for Results*, Proceedings of the first meeting of IUFRO Subject Group S6.06. 80–85.

Outlines the reorganisation of the Forestry Commission's Research and Management Services Divisions, which produced the new Research and Development Division in 1974.

JOHNSTON, D. R. (1976). The application of research results in forestry. *Commonwealth Forestry Review* **55** (4) No. 166, December. 335–340.

An applied research programme should be based primarily upon the requirements and possibilities of management and the users should be involved, according to the Rothschild concept, in the formulation of research programmes. Applied research is probably best carried

out by the national forest authority with a periodic interchange of some staff between research and management. Research findings should be published in two series, one for other research workers and one, in as clear and straightforward a form as possible, as operation guides for field managers.

JOHNSTON, D. R. (1976). Forestry in a changing world. *Forestry* **XLIX** (1), 29–44.

A review of the position of forestry in the context of increasing population and decreasing forest area. New methods of fuller production from existing resources are examined, and the conclusion is reached that although prices will increase, there will be no shortage of supply. The forestry situation in south-east England is also examined with regard to the problems of multiple use of the available forests.

LEWIS, A. B., and LINES, R. (1976). Provenance of *Picea sitchensis* (Bong.) Carr. IUFRO "Top Ten" provenances. Great Britain (North). First year results. In *IUFRO Sitka spruce International ten provenance experiment—nursery stage results.* (Ed. J. O'Driscoll), Dublin: Dept. of Lands, Forest and Wildlife Service, pp. 90–105. Also XVI IUFRO Congress Proceedings, Division II, p. 153 (abstract only).

Seed characteristics were not well correlated with germination rate or seedling height growth: long seeds had most cotyledons. Germination rate strongly influenced seedling height. Height was not correlated with latitude of origin. The percentage of late season (21 August–29 October) growth was significantly correlated (inversely) with latitude and even more strongly correlated with October minimum temperature at seed source.

LINES, R. (1976). *Bibliography on international provenance experiments begun in* 1938 (revised to 1975). Forestry Commission Research and Development Paper 76.

Lists 114 publications about the IUFRO series of experiments begun in 1938 with *Pinus* and *Picea* and in 1944 with *Larix*, together with the background to these trials.

LINES, R.(1976). The effects of a shelter fence on tree growth in south-west Scotland. In *4th Symposium on shelter research*, (University of Warwick, September 1975). London: Ministry of Agriculture, Fisheries and Food, 46–54.

Describes an experiment at Penninghame Forest in which a moderately exposure-sensitive provenance of Lodgepole pine responded to an artificial shelter screen (plastic mesh) by a growth increase of up to 56 per cent. Tree growth and tatter rate of adjacent flags were well correlated (r=0·87). There was no clear interaction between different fertiliser (NPK) and exposure effects. The Netlon ¼″ shelter screening stood up well to exposed conditions. Discussion on the paper is also reported.

LINES, R. (Editor) (1976). *Pinus contorta provenance studies.* Meeting of IUFRO Working Party on *Pinus contorta* provenance S2.02.06. Scotland 1974. Forestry Commission Research and Development Paper 114.

Report of a IUFRO Working Party meeting on provenance of *Pinus contorta* in September 1974. Sessions included (a) accounts of the species in its native range (J. R. Aldhous and K. Illingworth); (b) detailed morphological studies (M. G. R. Cannell and S. Thompson); (c) a discussion on assessments in this series of trials; (d) reports on provenance trials, using IUFRO and earlier seed collections, from Scandinavia (S. Hagner, S. Fahlroth, P. Krutzsch and J. Dietrichson,) the Netherlands (W. Kriek), Ireland (J. O'Driscoll and P. S. Savill), Canada (K. Illingworth) and Britain (R. Lines). The discussion meeting was followed by a four day tour in N. Scotland and extracts from the tour notes are included.

LINES, R. (1976). The development of forestry in Scotland in relation to the use of *Pinus contorta.* In *Pinus contorta Provenance Studies*, Forestry Commission Research and Development Paper 114. 2–5.

LINES, R. (1976). *Pinus contorta* provenance experiments in Britain. In *Pinus Contorta Provenance Studies*, Forestry Commission Research and Development Paper 114, 107–109.

LINES, R. (1977). Variation in flowering forest trees. *Quarterly Journal of Forestry*, **LXXI** (1), January 7–15.

The abundant flowering of trees in 1976 has drawn attention to this aspect of forestry. Trees vary in the age at which they commence flowering and this is related to their status as pioneers or successor species. Sitka spruce can play both roles. Variation in flowering exists at all levels from generic differences down to that between individual trees. Natural selection

has favoured early flowering in some ecotypes to match flowering times and to study coning behaviour of individual clones. Various treatments can affect flower production and reduce delays, which are particularly serious in the spruces.

(BURLEY, J., WOOD, P. J. and) LINES, R. (1976). A guide to field practice. In *A Manual of Species and Provenance Research with Particular reference to the Tropics.* CFI Tropical Forestry Papers No. 10. 83–107. Oxford: Commonwealth Forestry Institute.

Covers the planning, layout, control and assessment of nursery and forest stages of species and provenance trials with emphasis on practical techniques and the way to overcome difficulties and reduce experimental error.

(CANNELL, M. G. R.,* THOMPSON, S.** and) LINES, R. (1976). An analysis of inherent differences in shoot growth within some north temperate conifers. In *Tree Physiology and Yield Improvement.* (Ed. M. G. R. Cannell and F. T. Last). London & New York: Academic Press. 173–205.

Inherent variation in shoot growth is considered in terms of (a) shoot apices, (b) sub-apical meristems, (c) needles and (d) sites where new lateral apices can form. The periods and rates of initiation of stem units at the shoot apices often determine shoot lengths. Sizes of apical domes reveal potential initiation rates. When all stem units are pre-formed, inherent differences in shoot elongation phenology can reflect differences in numbers within winter buds. But some genotypes may extend stem units more than others. This tendency may not be linked genetically with stem unit production. Pine needle growth is influenced by climate of current and previous year and can compensate for poor activity in meristems. Differences in branch frequency are as important as absolute numbers.

(DIETRICHSON, J. (Editor) *et al.* and) LINES, R. (1976). The *IUFRO provenance experiment of* 1964/68 *on Norway spruce. (Picea abies* (L) Karst). A joint voluntary paper with height data from 8 countries. IUFRO Paper of Working Party S2.02.11. As: The Norwegian Forest Research Institute. 14.

Mainly tabular statements of the location of 38 experiments in 8 countries (including Scotland) and height of trees 6 years after planting (10 years from seed). 1100 provenances are included in the total range. Most experiments contain 100–400 of these; some the full number. Results are expressed as a percentage of the mean height of each "block" of 100 provenances, which is also given. Scottish results are similar to those in Continental experiments.

(KRAUS, J. F.,† and) LINES, R. (1976). Patterns of shoot growth, growth cessation and bud set in a nursery test of Sitka spruce provenance. *Scottish Forestry*, **30** (1), January, 16–24.

Patterns of shoot growth cessation, bud set and flushing were studied in 64 provenances of Sitka spruce from the IUFRO collection. From growth curves and statistical analyses growth cessation was shown to be very highly correlated with latitude of seed origin, suggesting strong photoperiodic control, thus confirming earlier tentative observations. Bud set followed the same pattern as growth cessation but the interval between the two was narrower in the southern provenances. There were no significant differences between provenances in growth cessation within the seven latitudinal groups except for the most northerly one. Separate analyses were made within one group to compare the behaviour of provenances from the Queen Charlotte Islands and from the mainland interior with others of similar latitude. Those from Queen Charlotte Islands were highly variable in bud set, though the mean was similar to that of the group, whereas the interior sources were significantly earlier in setting buds. Individual provenances showed variation in flushing though no overall pattern could be determined.

LOCKE, G. M. L. (1976). *The place of forestry in Scotland;* a basis for local authority planning. Forestry Commission Research and Development Paper 113.

This paper was prepared for submission to the Standing Committee on Rural Land Use in 1975 and was subsequently issued to all Regional Authorities in Scotland to assist them in the formulation of their Regional Reports and other Local Authority plans. The contents are in three parts. First, a discussion of the objectives of the various bodies concerned with the growing, harvesting, marketing and utilisation of timber in Scotland; second, the present status of forestry in the country, the potential for further development and the possible constraints involved and the third, a suggested forest strategy for the future.

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MACKENZIE, J. M., THOMSON, J. H. and WALLIS, K. E. (1976). *Control of heather by 2,4-D.* Forestry Commission Leaflet 64 (London: HMSO, 70p).

Problems arising from heather in conifer plantations are discussed. Prescriptions are given for medium volume, low volume and ultra low volume applications of 2,4-D esters to kill heather in plantations, using knapsack sprayer, mistblower and ultra low volume equipment respectively.

MAYHEAD, G. J. (1976). *Forest fertilising in Great Britain.* Proceedings of the Fertiliser Society, No. 158.

The quantity and distribution of Forestry Commission and private woodlands in upland Britain is given and an estimate made of the occurrence of soil types within these areas. Factors affecting tree growth are listed and the economics of forest fertilising discussed. Standard fertiliser regimes may appear extravagant, but because of delays in responses, can compare favourably with fertilising by prescription from foliage samples. The major fertilisers in use at present are listed along with their recommended rates. Research has confirmed that broadcast fertiliser application is adequate and most fertilisers are now applied by helicopter. Most fertiliser has previously been used in the establishment phase but it is beginning to appear that large areas of pole-stage crops may benefit from added nutrients. Quantities of Forestry Commission areas fertilised so far are given and an estimate is made of total fertiliser demand in these and private sectors at normality. There is little evidence of fertilisers adversely affecting either the environment or wood quality.

(WHITE, R. G.,* WHITE, M. F.* and) MAYHEAD, G. J. (1976). *Measurement of the motion of trees in two dimensions.* Institute of Sound & Vibration Research, University of Southampton, Technical Report No. 86.

Several methods for the analysis of tree vibration characteristics are described. Acceleration data derived from strain gauge accelerometers with associated instrumentation are satisfactory and damping ratios may be calculated with the log decrement method. The fundamental mode was dominant in all sway tests although other modes of vibration were present. The tree crown is responsible for a large part of tree damping but considerable energy absorption occurs in tree-to-tree contact with adjacent trees.

MERCER, P. C. (1976). Further work on U.L.V. spraying of groundnuts in Malawi. *Pest Articles and News Summaries* **22** (4), 520–521.

Report of a continuation of ultra low volume spraying of fungicides to control *Cercospora* leafspot of groundnuts. An attempt was made to work out the most suitable and economical spray regime.

MERCER, P. C. (1976). Effect of defoliation on yield of two groundnut cultivars in Malawi. *Oleagineux*, **31** (2), 69–72.

Effects of natural and artificial defoliation were compared in bunch and runner groundnut cultivars in Malawi.

MERCER, P. C. (1977). A pod rot of peanuts in Malawi. *Plant Disease Reporter*, **61** (1) 51–55.

A pod rot of groundnuts in Malawi is described and its link with pale kernels established. The cause of the disease appears to be senescence coupled with attack from a variety of fungi, primarily *Fusarium oxysporum* and *F. solani.*

MERCER, P. C. (1977). Control of peanut pod rot in Malawi. *Plant Disease Reporter*, **6 1** (1), 55–59.

Groundnuts in Malawi suffer a severe pod breakdown or rot as they mature. Results indicate that control of *Cercospora* leafspot will help to reduce the incidence of pod rot.

MERCER, P. C. (1976). Ultra low volume spraying of fungicides for the control of *Cercospora* leafspot of groundnuts in Malawi. *Pest Articles and News Summaries*, **22** (1), 57–60.

High increases in yield of pods, kernels and haulms of groundnuts were obtained in Malawi by the use of u.l.v. formulations of a systemic and a contact fungicide to control *Cercospora* leafspots.

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MERCER, P. C. (1976). A wilt disease of groundnuts in Malawi. *Pest Articles and News Summaries*, **22** (2), 275.

A wilt disease of groundnuts in Malawi is described. *Fusarium solani* is suggested as a possible causal agent. The possibilities of insect involvement are also discussed.

MERCER, P. C. and THOMAS, D. (1976). Bacterial leafspot disease of *Glycine wightii* in Malawi. *Pest Articles and News Summaries*, **22** (2), 275.

A serious leafspot disease of the pasture legume, *G. wightii* in Malawi is shown to be caused by the bacterium *Pseudomonas glycinea*. Possible resistance to the disease is discussed.

MITCHELL, A. F. (1976). Measure a tree in 1975. *International Dendrology Society Yearbook* 1975, 28–36.

A summary of the best trees found and measured during the year, including many in Ireland and Scotland and in the eastern USA and Canada. When earlier measurements can be compared they are given and show some rapid increments particularly in western American conifers in Ireland and Scotland.

MITCHELL, A. F. (1976). Deciduous trees of Wisley. *The Garden*, **101** (5) May, 267–272.

An account of the numerous unusual trees around the RHS Garden and their current dimensions. The Cypress oak has grown rapidly in the eleven years since the previous measurement. There is a good number of the less common highly decorative Asiatic maples and there is one of the very few pecans known in Britain.

MITCHELL, A. F. (1976). Ginkgo in the USA. *The Garden*, **101** (4) April, 202–203.

A brief survey of the growth of Ginkgo with dimensions of some fifty of the largest. It is apparent that the biggest trees are by the east coast from Boston, Mass. to Charleston, South Carolina, and in the mid-Mississippi Valley in Missouri and Illinois. The Ginkgo is planted as a street tree from Montreal to New Orleans and survives even in Fifth Avenue, New York. It becomes scarce west of Wisconsin and only one of reasonable size was found in Nebraska, Iowa and Colorado. None was seen in the States of the eastern Rocky Mountains and only few and small by the Pacific Coast.

The strangest feature is that female Ginkgos are contorted, low and heavily branched, useless for street planting, but only in Pennsylvania. In South Carolina and in Missouri and in the Hudson Valley they have the same broad conic or ovoid crown as the males.

MITCHELL, A. F. (1977). Metasequoias in Great Britain and North America. *The Garden*, **102** (1) January, 26–29.

A contemporaneous comparison between the biggest specimens in each country in 1975/76. Thirty of the biggest found in Britain are listed and the concentration of these in the south-east with a group in N. Wales is noted. Fifty-six of the biggest seen in North America include some smaller ones from Canada and the west coast to show regional variation. It is noted that there were none in the Gulf Coast region and few in the south altogether but surprisingly the biggest by far were on Long Island and in Delaware, whilst Ohio, Pennsylvania, Massachusetts and Missouri grew Metasequoias rather smaller but comparable with the biggest in Britain.

NEUSTEIN, S. A. (1976–1977). A history of plough development in British forestry. I. Introduction and early developments. *Scottish Forestry*, **30** (1) January, 2–15. II. Historical review of ploughing on wet soils. *Scottish Forestry*, **30** (2) April, 89–111. III. Historical review of ploughing on drier soils. *Scottish Forestry*, **30** (4) October, 253–274. IV. Mounted ploughs (and other regeneration equipment). *Scottish Forestry*, **31** (1) January, 2–12.

NEUSTEIN, S. A. (1977). Wind damage—getting to grips with after-clearance work. *Forestry '77, a Farm Contractor specialist annual*, 48–49.

Describes the procedures required for bringing the forest back to its planned production evels. The marketing of produce and planning the harvesting operations are covered.

OVERELL, P. A. W. (1976). Cannock Forest, Staffordshire. *Arboricultural Journal*, **3** (1) September, 29–36.

A short history of Cannock Chase and Forest before and since afforestation began in 1929. Notes on the deer and recreational potential.

PARKER, E. J. (1976). Production of *Nectria coccinea* perithecia in culture on a natural medium. *Transactions of the British Mycological Society*, **66** (3), 519–520.

PATCH, D. (1977). Safety in tree work. *Arboricultural Journal*, **3** (2), February, 105–109.

Reviews the effects on the Health and Safety at Work etc. Act 1974 on the employers and employees in the tree surgery industry.

PEARCE, M. L. (1976). International ten provenance experiment (IUFRO S2.02-12 Sitka spruce), Report of Phase I and Phase II (Nursery) of experiment. Great Britain (South). In *IUFRO Sitka spruce International ten provenance experiment—Nursery stage results.* (ed. J. O'Driscoll). 106–212. Dublin: Dept. of Lands, Forest and Wildlife Services, and *XVI IUFRO Congress Proceedings Division II*, 154 (abstract only).

Background to current and earlier provenance experimental work with Sitka spruce is given. Deviations from working plan are recorded. All 14 assessment types were carried out with the exception of the length of growing season and were subjected to analysis of variance.

Though all seed dimensions, taken individually, gave a significant difference between provenances, it was felt that seed density was a more meaningful parameter. No significant variation between provenances was found for this parameter.

Draws the conclusion that periodicity of germination is not as critical an expression of provenance variation as is viability of the seed. Viability decreases clinally with northern latitudes.

Height at one year, though showing significant variation between provenances and strong clinal correlation with latitude, was not considered to be very meaningful. Transplant height at 2 years was on the other hand a better measure of difference between provenances. In this experiment there was a significant difference between provenances. Ranking of height growth altered very little between 1 and 2 years. Length of transplant growing season was measured by number of days to reach a certain stage. It ranged from 134–212 days and when correlated with height growth gave a value of $r=0{\cdot}9$.

The ultimate value of the provenances will be their performance in the field. The most southerly provenances would be expected to be affected by cold winds and their usefulness limited. The provenances from Queen Charlotte Islands would be expected to have the widest use while the Alaskan provenance would be limited to sites at the upper planting limit.

PEARCE, M. L. (1977). The Nothofagus in Britain. *Forestry and British Timber*, **6** (1) January/February, 20–22.

Historic account of the genera, taxonomic, silvicultural, mensurational and economic characteristics of the two more commonly grown species—*Nothofagus procera* and *Nothofagus obliqua*. Supporting photographs of tree form and leaf differences.

PEPPER, H. W. (1976). *Rabbit Management in woodlands.* Forestry Commission Leaflet 67 (London: HMSO, 50p).

After a brief outline of the rabbit's natural history and damage caused, protection measures, both physical and chemical are described. Population control measures are also described.

PHILLIPS, D. H. and ROWE, J. J. (1976). Warfarin: a question of balance. *New Scientist* **70** (1001) 20 May, 400–1.

A reply to criticism of the poisoning of grey squirrels with warfarin. Squirrels may not kill trees but their activities can cause a reduction in the market value of the timber. The poison dispensers are designed to avoid accidental poisoning of other mammals, and new ones are under development to minimise the existing risks.

PHILLIPS, D. H. and YOUNG, C. W. T. (1976). *Group dying of conifers.* Forestry Commission Leaflet 65 (London: HMSO, 30p).

Outlines the development, host range and control of the root disease *Rhizina undulata* Fr.

(FRANZ, J. M.*), PHILLIPS, D. H. (and STARK, R. W.**) (1976). Integrierter Pflanzenschutz gegen Schadinsekten und Krankheiten im Wald, (a German translation of a paper presented to the 2nd World Technical Consultation on Forest Diseases and Insects (FAO/IUFRO), New Delhi, India, under the title—Integrated management of forest insect pests and diseases). *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz*, **83** (1/2/3), 59–65.

Integrated management of forest pests, defined here as part of resource management, aims

*Biologische Bundesanstalt für Land- und Forstwirtschaft, Institut für biologische Schädlingsbekämpfung, Darmstadt.
**University of Idaho, Moscow, Idaho, USA.

at minimizing losses by pests and reducing environmental degradation, but maximizing socio-economic profits of the resource. A new approach is suggested to the ultimate decision whether or not to take action against the disturbing organisms: first, the socio-economic impact of the organisms is evaluated carefully before it is characterized as a "pest". Second, the ecosystem of the pest is described. This leads to the development of descriptive models as a basis for simulation models which are the beginning of the predictive process essential for integrated pest management and for action decision.

The control strategies and tactics available are briefly reviewed. They centre on protection and augmentation of natural enemy action as well as on alterations of the environment so as to make it unsuitable for the pest. Compatibility of methods and avoidance of degradation of the environment are the leading principles. Two examples show the complexity of approaches: control of the conifer root fungus (*Fomes annosus*) and of the gypsy moth (*Lymantria* (= *Porthetria*) *dispar*). Several compatible strategies are needed to obtain decisions which are not disruptive to the ecosystem. The integrative process of pest management is illustrated showing the basic components of the system, their linkages, information flows, and feedbacks to the forest management decision and planning process. The concepts described here constitute an integrative, holistic approach to pest management, made possible through the application of systems analysis and the availability of computers.

RATCLIFFE, P. R. (1977). Age determination in Red deer. *Deer* (*Journal of the British Deer Society*), **4** (2), February, 88–89.

Describes Lowe's key, represents the stages in tooth eruption and wear found in Red deer (*Cervus elaphus*) of known age from the Isle of Rhum.

RICHARDS, E. G. (1976). The national resource in small woodland, small woods, hedgerow and park timber. In *The Future of the Small Woodland.* A day conference, 29 March, 7–15.

An outline of the distribution of small woodlands in Great Britain, from the 1947–49 and 1965–67 Censuses of Woodland, and the changes noticed between the two census and since. Grants for woodlands are also mentioned.

ROGERS, E. V. (1976). The ultra low volume application of Silvapron T and Silvapron D herbicides in forest plantations in the UK. In *The use of herbicides in forestry in New Zealand.* FRI Symposium No. 18, 20–21 October 1975. Rotorua: Forest Research Institute, 218–223.

The constraints on the use of herbicides in UK forests imposed by the terrain and lack of access roads has prevented the use of herbicides in many areas. In 1969, the Work Study Branch of the Forestry Commission instigated an investigation into the use of spinning disc ultra low volume applications. After two seasons of trials, Silvapron T was developed for foliar spraying of woody weeds, and the method has also been introduced for applying Silvapron D to kill heather. Further work with other herbicides, including atrazine and asulam is in progress.

ROWAN, A. A. (1976). *Forest road planning.* Forestry Commission Booklet No. 43 (London: HMSO, 75p).

Details the criteria which affect the planning of roads, including harvesting and extraction systems, road standards, and spacing. Some examples are given.

ROWAN, A. A. (1976). Why classify terrain? *Timber Grower*, **61**, August, 26–27.

An outline of the use of terrain classification as an aid in road planning, and choice of harvesting machinery. The basis of the Scandinavian scheme are mentioned.

ROWAN, A. A. (1977). Terrain classification—a major factor in long-term planning. *Forestry '77, a Farm Contractor specialist annual*, 30–31.

An extended version of the article appearing in the *Timber Grower.*

ROWE, J. J. (1976). *Badger Gates.* Forestry Commission Leaflet 68 (London: HMSO, 15p).

Describes the design and erection of badger gates in rabbit fencing.

(GIBBS, E. P. J., McDIARMID, A. and) ROWE, J. J. (1975). Management of deer for experimental studies with foot-and-mouth disease virus. *The Veterinary Record*, **96**, June, 503–506.

Red, sika, fallow, roe and muntjac deer adapted to captivity in experimental units designed for working with foot-and-mouth disease. The red, sika and fallow deer readily accepted rolled oats and hay as their staple diet. This diet was replaced for the roe and muntjac deer with flaked maize, calf starter pellets and green browse. Etorphine/acepromazine and xylazine

were found to be suitable sedatives for detailed examination of the tongue and oral cavity of the various species of deer and gave adequate analgesia for the inoculation and collection of virus samples.

SMALL, D. (1977). Tourism-planning some aspects of recreation in forests. *Forestry '77, a Farm Contractor specialist annual*, 26–27.

A note on the way caravan and camping sites have been laid out in the New Forest, with due regard to the needs of the visitor and forest manager.

STEWART, G. G. (1976). Impact in Great Britain on increasing demand for recreation and tourist facilities on forests, forest management and policies. In *Papers presented to the Symposium on Forests and Wood, their role in the Environment*, Part II, 89–99.

Outlines the need for recreation in Great Britain and the ways in which the Forestry Commission has attempted to meet and promote that demand, without damaging other objectives such as wood production and conservation.

TAPPER, S. C.* (1976). Population fluctuations of field voles (*Microtus*): a background to the problems involved in predicting vole plagues. *Mammal Review*, **6** (3), 93–117.

The course of various investigations into vole cycles is briefly reviewed and it is shown that an increasing proportion of workers are looking for intrinsic mechanism of control which might cause the periodic fluctuations; however, no single line of investigation can be said to dominate the field and extrinsic factors such as food supply or predation could be heavily involved. The majority of work has failed to take into account the spatial aspects of these cycles and future work in this field might resolve some of the conflicts about the demographic aspects. As yet few workers have considered vole cycles on a geographical scale and just how these major changes in abundance relate to the local fluctuations of smaller populations is not known.

Various methods used to measure vole densities are reviewed and suggestions are made on how they can be used to provide information on different aspects of vole population studies.

THOMPSON, D. A. (1977). Ploughing techniques—a review of equipment and methods. *Forestry '77, a Farm Contractor specialist annual*, 16–17.

Describes the background to present recommendations for ploughing gley and deep peat soils. Gives recommended ploughs with possible outputs for each of three broad groups of soils.

WHAYMAN, A. A. (1976). Timberjack RW30 tree length harvester. FC/HGTAC Technical Note No. 25. *Forestry and British Timber*, **5** (5) October, 45–46.

A compact tree length harvester made in Canada. It fells, delimbs, and collects tree lengths of up to 10 m in a side-mounted bunk—bundles of trees are left at rackside. Up to 72 trees per hour have been harvested but a production of 50 trees per hour will be the sustained output. Maximum diameter that can be felled is 30 cm.The basic unit is a Timberjack 330 frame steered skidder with 94 h.p. engine. The cab has been mounted on the right hand side of the RW30, the operator sitting sideways to the direction of travel.

WHAYMAN A. A. (1976). Valmet 870 CK forwarder. FC/HGTAC Technical Note No. 23. *Forestry and British Timber* **5** (3) June/July, 33–34.

Finnish built 6 × 4 wheeled frame steered machine of 88 h.p. Fitted with Cranab 4010 hydraulic crane, the 870 CK will carry from 7 to 9 tonnes. Operator is housed in comfort and safety in the cab on which is mounted the crane, giving good all round visibility. The forwarder was found to be stable and climbed slopes up to 48% when fitted with chains on front and bands on the rear wheels.

Output of up to 11 m^3 per hour for sawlogs on 100 m extraction distance and 7–9 m^3 for 3 m pulp over the same distance.

WINTERFLOOD, E. G. (1976). The forests of East Anglia. *Forestry* **49** (1), 23–28.

History, geology and physical features are covered. Forestry Commission woodland planted since 1922 and its management is noted.

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*now Game Conservancy, Fordingbridge, Hants.

WITTERING, W. O. (1976). Work study for foresters—4. Standard times as a basis for incentive payment. *Forestry and British Timber*, **5** (2), 34–35.

Incentive schemes and their foundation using standard times are discussed. Details of producing standard time tables, e.g. working conditions, tools and the job specification are listed. Calculations for setting the price per standard minute are shown, together with examples. The progressive steps for calculating the rate for the job are illustrated.

WITTERING, W. O. (1977). Harvesting forest residues. *Forestry and British Timber*, **6** (2) March/April, 31–32, 43.

Discusses the potential harvest of forest residue, referring to the effect of nutrient loss by the removal of these residues. Laboratory analysis of the percentage of dry wood available from the various tree species is quoted.

The Karhula 312 CS whole tree chipper, recently acquired by the Forestry Commission, is described. Some of the other machines available on the market are mentioned, together with working techniques. The state of the art in Great Britain is described as are some of the problems still to be overcome.

WITTERING ,W. O. (1976). Work study for foresters—6. Costs and costing. *Forestry and British Timber*, **5** (6) November/December, 60–61.

The four main factors of costing—labour costs, labour overheads, machine charges and materials costs—are discussed. The method of constructing a costing of a complete operation is described. An example of working method comparison is given for a weeding operation. The trends in costs for machinery and labour are discussed and illustrated with a graph.

WITTERING, W. O. (1976). Work Study for foresters—5. More uses of standard time. *Forestry and British Timber*, **5** (3) August/September, 54–55.

The uses of standard time to (1) calculate output, (2) assess performance, (3) calculate labour requirements, (4) calculate machine requirements, (5) calculate productivity increases and (6) cost an operation, are dealt with in detail. Examples of the various calculations are given.

WITTERING, W. O. (1976). On show at Epinal. *Forestry and British Timber*, **5** (3) August/September, 16–17.

A description of a visit to Epinal Forestry Exhibition. Particular mention is made of the forwarders on display—Valmet 872, Latil T-4P. The small Sifer delimber/crosscutter and feller/delimber/crosscutter are described in some detail. Planting machines were also on show together with scrub cutters and weeding machinery.

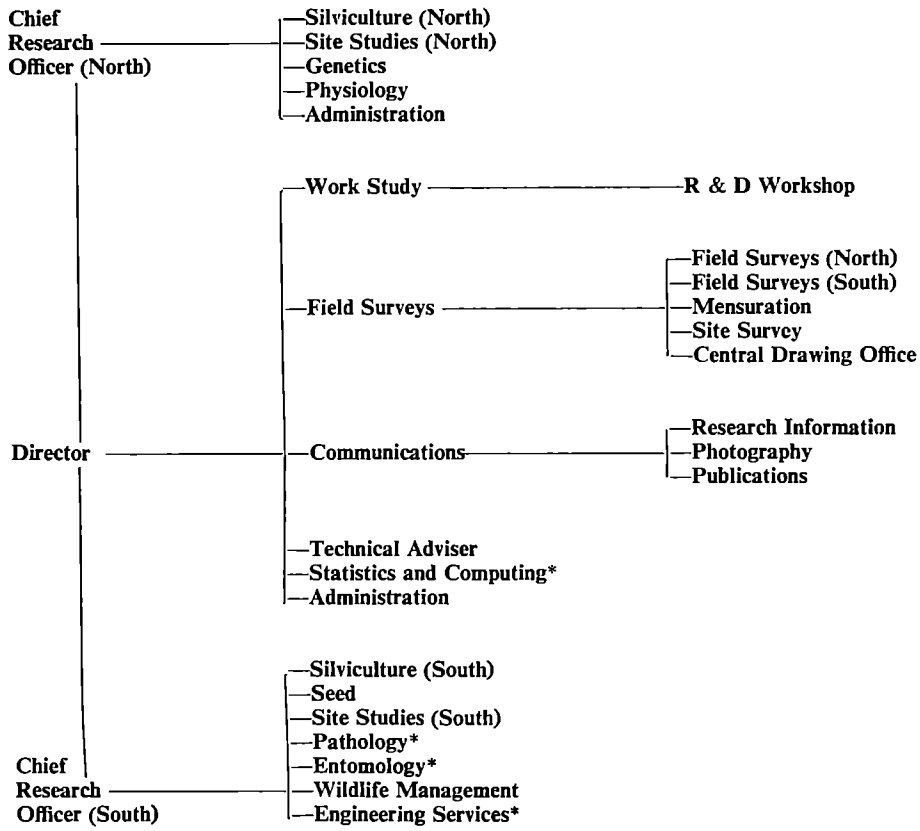
WITTERING, W. O. (1976–1977). Philately for foresters. *Forestry and British Timber*, **5** (2–6) & **6** (1–2).

A continuation of a series for readers who are interested in philately with a forestry slant.

WITTERING, W. O. (1977). Chipping in the forest—£100 million worth of chips for the taking. *Forestry '77, a Farm Contractor specialist annual*, 46–47.

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 1977

The main centres for research and development are:

FORESTRY COMMISSION RESEARCH STATION

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

FORESTRY COMMISSION NORTHERN RESEARCH STATION

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

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

FORESTRY COMMISSION HEADQUARTERS

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

Research on timber and other forest products is not carried out by the Forestry Commission but by the Princes Risborough Laboratory of the Department of the Environment's Building Research Establishment, Princes Risborough (Tel. 3101, STD Code 0844 4), Aylesbury, Buckinghamshire. The Forestry Commission keeps in close touch with this work, some of which is done jointly by the two organisations.

RESEARCH AND DEVELOPMENT DIVISION

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

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

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

SILVICULTURE (SOUTH) (*Alice Holt*)

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

ARBORICULTURAL ADVISORY SERVICE (Department of the Environment)

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

Office: Miss K. A. Rhodes: Miss J. M. Gay, B.Sc., Miss R. M. Sprinks

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

Research Foresters:		*Centre*
South East England Region	P. W. W. Daborn	Alice Holt
South East England Area	D. Elgy, J. B. H. Gardiner, M. L. Pearce, M.I.For: P. D. Howard, D. H. Jackson, A. M. Jenkin, P. Marsh, F. R. W. Stevens	Alice Holt Alice Holt
Bedgebury Area, Kent	A. W. Westall: M. J. Scott	Bedgebury Pinetum
South West England Region	D. A. Cousins	Westonbirt
South West England Area	K. F. Baker: D. W. H. Durrant	Exeter
Dean Area	T. J. Davis	Dean
Westonbirt Area, Gloucestershire	P. J. Webb, C. W. Webber, J. E. J. White, E. Leyshon	Westonbirt Arboretum
East England Region	I. H. Blackmore: P. A. Gregory	Santon Downham, Brandon, Suffolk

SITE STUDIES (SOUTH) (*Alice Holt*)

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

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

PATHOLOGY (*Alice Holt*)

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

Research Foresters:	C. W. T. Young: B. J. W. Greig, M.I.For., R. G. Strouts: J. E. Pratt, J. Dickinson, N.D.F.
Laboratory:	Mrs S. M. Dennis, B.Sc., Miss S. A. Medcalf, Miss M. K. Tepper: A. Jeeves, K. G. Crump
Office:	J. Empson: Mrs J. G. Anderson (Typist)

Northern Research Station
PATHOLOGY

D. B. Redfern, B.Sc., Ph.D., Head of Section
S. C. Gregory, M.A., Ph.D.
Research Forester: J. D. Low
Laboratory: Mrs H. Steele

ENTOMOLOGY (*Alice Holt*)

D. Bevan, B.Sc., Head of Branch
Miss J. M. Davis, B.Sc., F.Z.S., C. I. Carter, M.Sc., M.I.Biol., D. Wainhouse, M.Sc., Ph.D.
T. G. Winter

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

Northern Research Station
ENTOMOLOGY

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

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

WILDLIFE MANAGEMENT (*Alice Holt*)

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

Research Foresters:	L. A. Tee: H. W. Pepper: S. J. Petty (*Kielder, Northumberland*), P. R. Ratcliffe, B.Sc. (*Glenbranter, Strathclyde*)
Laboratory:	B. A. C. Don (*University College, Cardiff*): Miss C. I. Derrick, A. R. Hall
Office:	Mrs A. Bowcock

SEED (*Alice Holt*)

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

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

ENGINEERING SERVICES (*Alice Holt*)

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

Northern Research Station
R. M. McLuckie, T. Stewart

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

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

SILVICULTURE NORTH (*Northern Research Station*)

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

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

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

SITE STUDIES (NORTH) (*Northern Research Station*)

D. G. Pyatt, B.Sc., Head of Branch
Laboratory: D. T. McLaren, B.Sc.: Mrs M. M. Craven, B.Sc.

GENETICS (*Northern Research Station*)

R. Faulkner, B.Sc., M.I.For., Head of Branch
R. C. B. Johnstone, B.Sc., M.Sc., M.I.For., A. M. Fletcher, B.Sc., Ph.D., A.I.W.Sc., M.I.For., G. I. Forrest, B.Sc., M.Sc., Ph.D.
Research Foresters: C. McLean: R. B. Collins, I. J. M. Dawson (*Westonbirt, Glos.*), M. T. T. Phillips (*Newton, Grampian*), G. C. Webb (*Westonbirt*): W. Brown, W. J. Dyce (*Newton, Grampian*)
Laboratory: Miss A. P. Ash, Miss J. Martindale

PHYSIOLOGY (*Northern Research Station*)

M. P. Coutts, B.Sc., Ph.D., Head of Branch
J. J. Philipson, B.Sc., Ph.D.: M. R. Bowen, B.Sc., Ph.D.,* A. John, B.Sc., Ph.D.
Research Forester: J. Sivill
Laboratory: Miss B. A. Eaton, Mrs C. Kinnaird, Miss B. L. Nelson

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