

REPORT ON

FOREST RESEARCH

1979

FORESTRY COMMISSION



HMSO £3 net



Cover picture:

The Visitor Centre at Westonbirt Arboretum opened in May 1978 (CS 34153).

FORESTRY COMMISSION

REPORT ON
FOREST RESEARCH

for the year ended
March 1979

LONDON
HER MAJESTY'S STATIONERY OFFICE

© *Crown copyright 1979*
First published 1979

ISBN 0 11 710118 4

ADVISORY COMMITTEE ON FOREST RESEARCH

Membership at 31st March 1979

Chairman

PROFESSOR P. F. WAREING, Ph.D., D.Sc., F.L.S., F.R.S.
Professor of Botany and Microbiology, University College of Wales,
Aberystwyth.

Members

PROFESSOR J. P. M. BRENNAN, M.A., B.Sc., F.L.S., F.I.Biol.
Director, Royal Botanic Gardens, Kew.

PROFESSOR J. L. HARLEY, M.A., D.Phil., F.R.S.
Professor of Forestry, University of Oxford.

PROFESSOR J. P. HUDSON, C.B.E., G.M., M.Sc., Ph.D.
Formerly Director, Long Ashton Research Station, Bristol.

DR J. F. LEVY, D.Sc., F.L.S., F.I.Biol., A.R.C.S.
Department of Botany and Plant Technology, Imperial College of Science
and Technology, University of London.

PROFESSOR J. D. MATTHEWS, B.Sc., F.I.Biol., F.I.For.
Professor of Forestry, University of Aberdeen.

PROFESSOR L. ROCHE, M.A., M.F., Ph.D.
Professor of Forestry and Wood Science, University College of North
Wales, Bangor.

PROFESSOR A. J. RUTTER, B.Sc., Ph.D., F.I.Biol., A.R.C.S.
Professor of Botany and Plant Technology, Imperial College of Science
and Technology, University of London.

PROFESSOR T. S. WEST, B.Sc., Ph.D., D.Sc., C.Chem., F.R.I.C.
Director, Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen.

Secretary

MR N. E. STUTTER, M.I.P.M.
Forestry Commission, Forest Research Station, Alice Holt Lodge,
Wrecclesham, Farnham, Surrey GU10 4LH. Tel. Bentley (Hants) 2255
(STD Code 042 04).

The abbreviated title of this Report is:
Rep. Forest Res., Edin. 1979

CONTENTS

INTRODUCTION by D. R. Johnston, <i>Director of Research and Development</i>	<i>Page</i> 1
---	------------------

PART I

THE WORK OF THE FORESTRY COMMISSION RESEARCH AND DEVELOPMENT DIVISION

BRANCHES AND THEIR PROJECT GROUPS	4
SEED	8
SILVICULTURE (SOUTH)	10
SILVICULTURE (NORTH)	15
SITE STUDIES (SOUTH)	21
SITE STUDIES (NORTH)	24
FOREST GENETICS .	25
TREE PHYSIOLOGY .	27
FOREST PATHOLOGY .	29
FOREST ENTOMOLOGY	35
WILDLIFE MANAGEMENT	38
ENGINEERING SERVICES	39
FIELD SURVEYS .	40
FIELD SURVEY SECTION .	40
CENSUS .	41
MENSURATION .	41
DRAWING OFFICE .	41
WORK STUDY	42
STATISTICS AND COMPUTING	44
COMMUNICATIONS	45
RESEARCH INFORMATION .	45
PHOTOGRAPHY .	46
PUBLICATIONS	46

OTHER HEADQUARTER DIVISIONS

PLANNING AND ECONOMICS	47
HARVESTING AND MARKETING .	49

PART II

WORK DONE FOR THE FORESTRY COMMISSION
BY OTHER AGENCIES

FOREST SOILS

- NUTRITION AND FOREST SOILS *by* H. G. Miller, *Macaulay Institute for Soil Research, Aberdeen* 52

TREE PHYSIOLOGY

- FLOWERING AND SEED PRODUCTION OF SITKA SPRUCE *by* P. B. Thompsett, *Research Station, Long Ashton, University of Bristol*. 53
- APPLICATIONS OF PLANT TISSUE CULTURE IN FORESTRY *by* A. John, *Department of Forestry, University of Aberdeen*. 54

HERBICIDES

- HERBICIDE EVALUATION FOR FORESTRY USES *by* D. J. Turner *and* W. G. Richardson, *Weed Research Organization, Begbroke Hill, Yarnton, Oxford* 55

FOREST ZOOLOGY

- LONG HAIREF FALLOW DEER *by* R. H. Smith *and* Elizabeth Johnson, *Department of Zoology, University of Reading*. 57
- REPRODUCTION IN THE GREY SQUIRREL *by* Elizabeth Johnson, *Department of Zoology, University of Reading* 58
- THE ECOLOGY AND MANAGEMENT OF ROE DEER IN COMMERCIAL FORESTS *by* A. Loudon, *Department of Forestry and Natural Resources, University of Edinburgh* 59

TIMBER UTILISATION

- JOINT RESEARCH PROGRAMME ON BRITISH-GROWN TIMBER, PRINCES RISBOROUGH AND FORESTRY COMMISSION *by* T. Harding, *Princes Risborough Laboratory, Building Research Establishment, Department of the Environment* 60

APPENDICES

I	Publications by Forestry Commission Staff .	62
II	Research and Development Divisional Organisation	75
III	Staff engaged in Research and Development as at 31 March 1979 .	76
	<i>INDEX</i>	83
	<i>PLATES</i>	<i>Central inset</i>

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

Westonbirt Arboretum

On the 17 May, 1978 the Westonbirt Visitor Centre was opened by the Duke of Beaufort who unveiled a plaque commemorating the occasion in the presence of 200 invited guests. The Centre provides exhibition space, a shop for literature and souvenirs, a room for meetings and lectures and office facilities.

Oak Wilt

Oak wilt is a serious disease of oaks in North America which has not been found in Britain. There has been widespread public interest in, and concern over, the possibility that oak wilt might enter this country. The Research and Development Division has provided information and given advice during the year in order to identify and quantify the risks, and to ensure that appropriate controls are included in import regulations.

Nothofagus Collections in South America

Dr D. M. Moore of Reading University and Mr I. Peters, a photographer and mountaineer, visited Patagonia and Tierra del Fuego on our behalf to collect seed from various sources of *Nothofagus* species. Dr A. G. Gordon (Principal Seeds Officer) extended an F.A.O. consultancy visit to make contact with potential commercial suppliers of *Nothofagus* seed in Chile and Argentina.

Effects of Conifer Crops on Peaty Gleys

The effects of Sitka spruce and Lodgepole pine stands on the properties of a peaty gley soil have been studied at Falstone Forest (Northumberland). Lodgepole pine causes deeper and more intense drying out in the summer than Sitka spruce, while unplanted areas are much wetter at all times of the year.

Lodgepole Pine Seedling Orchards

The first of a series of Lodgepole pine seedling seed orchards was established at Coed Preseli Forest (Dyfed). Seed from these orchards should provide planting material with improved wind stability and more vigour than imported North Coastal Lodgepole pine.

Census of Trees and Woodlands

The planning needs of the forest and forest-based industries and of local authorities have led to the decision to undertake another National Tree and Woodland Census during the period 1979–1982. The Census will cover woodlands, small groups of trees, hedgerows, isolated trees in fields or parkland and urban trees. Additional staff have been recruited by Field Surveys Branch for this work.

Red Deer Project

A joint project with the Red Deer Commission, the Institute of Terrestrial Ecology and the Forestry Commission to study Red deer in woodlands has been running for two years. The particular field of study of the Forestry Commission has been the assessment and evaluation of damage to tree growth, and the population dynamics of Red deer.

International Exchanges

A. I. D. Horne (Field Surveys) returned in January after spending a year at the National Institute for Aerial Survey and Earth Sciences in the Netherlands. He received a diploma for aerial photo interpretation.

Dr J. Evans returned to Silviculture from Papua, New Guinea after three and a half years leave of absence at the University of Technology (Lae).

Awards to Staff

Mrs E. A. R. Empson, telephonist at Alice Holt Lodge was awarded the B.E.M.

Mr E. Watts, Leading Research Worker at Westonbirt Arboretum received the B.E.M.

Mr G. Buszewicz, formerly head of the Seed Branch, and currently serving with the Republic of Honduras, was awarded the M.B.E.

Mr F. Tomkins, a messenger at Alice Holt Lodge, was awarded the Imperial Service Medal for previous service with the Post Office.

Visitors

Open Days were held on 6, 7 and 9 July 1978 at Alice Holt Lodge. These were attended by 800 local school children, 700 invited guests, and approximately 4,000 members of the general public on the three days respectively.

During the rest of the year a total of 535 visitors came to Alice Holt Lodge from 12 countries. There were 18 parties including the Forestry Commissioners, the Scientific Advisory Committee to the Agricultural Chemicals Approval Scheme, and courses for MAFF Plant Health Inspectors, and F.C. Plant Health Inspectors from the English and Welsh Conservancies.

Individual visitors included Mr F. P. F. M. Borba, Secretary of State for Agricultural Development in Portugal.

The Northern Research Station received 628 visitors including Sirgudur Blondal, the Director General of the Iceland Forest Service, Katherine Clough, the Minister for Agriculture and Forestry, Prince Edward Island and 60 delegates from the IUFRO Conference on Silviculture held in Edinburgh.

Staff Changes

Transfers in: K. F. Miller (Forest Officer I, Silviculture North) transferred from North West England Conservancy. W. T. Waters (Forest Officer I, R. & D. Field Surveys, Census) transferred from South East England Conservancy. A. C. Miller (Head Forester, R. & D. Field Surveys, Census) transferred from Chester. P. Barwick (Forester, Santon Downham) transferred from East England Conservancy. N. Best (Forester, Site Studies South) transferred from South West England Conservancy. J. Boluski (Forester, R. & D. Newton Stewart) transferred from East Scotland Conservancy. R. A. G. Coxwell (Forester, Pathology South) transferred from South East England Conservancy. H.

Gillen (Forester, R. & D. Field Surveys) transferred from South East England Conservancy. D. J. Lyons (Forester, Silviculture South) transferred from Exeter. J. I. MacDonald (Forester, Silviculture South, Westonsbirt) transferred from West Scotland Conservancy. G. R. Menzies (Forester, Silviculture North, Newton) transferred from East Scotland Conservancy. C. J. Pearce (Forester, Work Study, Brecon) transferred from South Wales Conservancy. C. J. Roberts (Forester, R. & D. Brecon) transferred from South Wales Conservancy. M. R. T. Spornagel (Forester, Field Surveys) transferred from South Scotland Conservancy. J. G. Whyatt (Forester, Silviculture North) transferred from South Scotland Conservancy. M. G. Wheeler (Executive Officer, Finance) from South East England Conservancy.

Transfers out: G. J. Mayhead (Forest Officer I, Field Surveys) to North Wales Conservancy. A. A. Green (Head Forester, Fort Augustus) to East Scotland Conservancy. T. R. Sawyer (Head Forester, Work Study) to South West England Conservancy. D. F. Anderson (Forester, R. & D. Newton Stewart) to East Scotland Conservancy. M. Blud (Forester, Work Study, Brecon) to South Wales Conservancy. W. Brown (Forester, R. & D., NRS) to East Scotland Conservancy. N. Dixon (Forester, Field Surveys) to North West England Conservancy. D. Downs (Forester, Silviculture North) to North Wales Conservancy. D. W. H. Durrant (Forester, Exeter) to South West England Conservancy. J. M. Gissop (Forester, Field Surveys) to North East England Conservancy. P. A. Gregory (Forester, Santon Downham) to East England Conservancy. H. Milner (Forester, Work Study) to North East England Conservancy. R. Morris (Forester, Field Surveys) to North Wales Conservancy. J. E. Pratt (Forester, R. & D.) to North Scotland Conservancy. J. Sivill (Forester, NRS) to South West England Conservancy. A. M. Walker (Forester, R. & D., NRS) to East Scotland Conservancy. P. J. Webb (Forester, Westonsbirt) to South East England Conservancy. J. D. Wilson (Forester, Field Surveys, Barr) to South Scotland Conservancy. P. H. Hamilton (Higher Executive Officer, Branch B) to Forest Management Division, HQ.

Promotions: P. N. Edwards (Mensuration), M. N. Haworth (Work Study, Santon Downham) and R. McIntosh (Silviculture, North) to Forest Officer I. J. T. Stoakley (Entomology, North) to Principal Scientific Officer. D. Wainhouse (Entomology) to Senior Scientific Officer. W. G. Paterson (Silviculture North) to Chief Forester. N. Mackell (Silviculture North) to Head Forester. J. D. McNeill (Silviculture North) to Head Forester. P. R. Ratcliffe (Wildlife) to Head Forester. J. E. J. White (Silviculture South) to Head Forester.

Retirement: G. S. Forbes (Head Forester, R. & D., Kielder).

Death: G. Bartlett (Chief Forester, R. & D., Newton).

PART I

The Work of the Forestry Commission

RESEARCH AND DEVELOPMENT DIVISION BRANCHES AND THEIR PROJECT GROUPS

Seed

- Research p. 8
- Service p. 9

Silviculture South

- Plant Production p. 10
- Lowland Silviculture p. 10
- Forest Weed Control p. 11
- Arboriculture—Department of the Environment Contracts p. 12
- Short Rotation Coppice—Department of Energy Contract p. 14
- Arboriculture—Other p. 14
- Dendrology and Arboreta p. 15

Silviculture North

- Production of Planting Stock p. 15
- *Planting
 - Species Trials p. 17
 - Cultivation p. 18
 - Nutrition p. 19
- *Forest Weed Control
 - Wind p. 19

Site Studies South

- Foliar Analysis p. 21
- *Soil Analysis
 - Upland Production Forestry p. 21
 - Effects of Trees on Sites p. 21
 - Lowland Production Forestry p. 22
 - Amenity and Arboriculture p. 23
 - Meteorology and Phenology p. 23
 - Advisory Work p. 23

Site Studies North

- Classification and Improvement of Upland Soils p. 24

*No progress is reported during the year.

Forest Genetics

- Testing p. 25
- Seed Production p. 26
- Seed Stands p. 26
- Biochemical Variation p. 26
- Data Base p. 27

Tree Physiology

- Vegetative Propagation p. 27
- Flower Induction p. 28
- Establishment after Planting p. 28
- Root Growth and Form p. 29

Forest Pathology

- Fomes annosus p. 29
- *Armillaria mellea
- Dutch Elm Disease p. 30
- Beech Bark Disease p. 32
- Advisory Services p. 32
- Arboriculture, Department of the Environment Contract p. 34

Forest Entomology

- Population Studies p. 35
- Host Plant Susceptibility p. 36
- Biological Control p. 36
- Chemical Control p. 36
- *Taxonomy and Collection
- Elm Scolytids p. 37
- Conifer Lachnids p. 38
- Advisory Services p. 38

Wildlife Management

- Management of Deer, Squirrels and other Mammals p. 38
- *Management of Birds
- Damage Assessment and Evaluation p. 39
- Chemical and Mechanical Repellants p. 39
- Wildlife Management Techniques p. 39
- *Game Resource Evaluation
- Research Advisory Group Visit p. 39

Engineering Services

- Design and Manufacture of Equipment p. 39
- Maintenance of Electro-mechanical Services p. 39
- Maintenance of Existing Equipment p. 40
- Engraving Service p. 40

*No progress is reported during the year.

Field Surveys*Field and Site Surveys Section*

Surveys p. 40
 Computer Data Base p. 40
 Other Projects p. 41

Census Section

Census p. 41

Mensuration Section

Mensuration p. 41

Drawing Office

Drawing Office p. 41

Work Study

Forest Management: Method Study p. 42
 Forest Management: Servicing p. 42
 Forest Management: Work Measurement p. 42
 Harvesting and Marketing: Method Study p. 42
 Harvesting and Marketing: Servicing p. 43
 Harvesting and Marketing: Work Measurement p. 43
 Forest Authority p. 43
 Safety p. 43
 Training p. 44

Statistics and Computing

Data Preparation and Computing p. 44
 Statistical Service to Research and Development Projects p. 44
 Statistical Service to External Units p. 44
 Programming Service, General p. 44
 Programming Service, Mathematical/Statistical/Technical p. 44
 Statistical, Mathematical and Computing Methods p. 45
 Data Capture and Associated Computing p. 45

Communications:*Research Information Section*

Library p. 45
 Visitors p. 45
 *Liaison
 *Information Services

Photography Section

Advisory Services p. 46
 Aerial Photography p. 46
 *Illustrative Service
 *Photographic Library
 *Terrestrial Photography

Publications Section

Publications p. 46

*No progress is reported during the year.

OTHER HEADQUARTER DIVISIONS

Planning and Economics

Forest Policy p. 47

Guides to Management p. 48

Recreation p. 49

Harvesting and Marketing

Power Transmission Poles p. 49

Utilisation of Bark p. 51

SEED

Research

Nursery Experiments on Conifers

Investigations into the effect of irrigation on nursery germination were continued, paying particular attention to the effect of the seedbed condition at time of sowing. Three sowings of Sitka spruce seed were made: when the seedbed was very wet, when it was in good condition and when it was too dry. Due to a cold, wet, late spring, all three sowings were made within one week of each other. Prechilled and dry seed were sown using research and simulated conservancy techniques. In the former the seedbed surface was lightly raked before sowing; in the latter the seeds were sown directly on to the rolled seedbed surface. Two separate experiments were laid out; one in an area in which irrigation was applied when necessary, the other in an area without irrigation.

At no stage during the experiment was there an observable effect of irrigation on total germination. However, there was an unexpected and considerable effect of seedbed condition at sowing on the germination in both the irrigated and non-irrigated areas. At all stages of the experiment, total germination in seedbeds sown when wet was greater than in seedbeds sown in both other conditions. The response is unlikely therefore to be due to the seven day difference in sowing dates. The largest treatment effect observed was between conservancy and research sowing techniques, with the former yielding approximately two thirds of the seedlings yielded by the latter in irrigated and unirrigated plots. Prechilling had the usual effect of increasing the rate of germination in both experiments, although germination of non-prechilled seed was slightly faster in irrigated beds than in non-irrigated beds. Under irrigation the final seedling numbers were slightly reduced by prechilling, whereas without irrigation there were slightly more seedlings from prechilled treatments.

The most obvious effect of irrigation was in the difference in height of seedlings at the end of the season between the two experiments. Despite the relatively rainy conditions the average height of the seedlings in the irrigated experiment was over 10 per cent greater than that in the non-irrigated experiment. No height differences were observed between the seedlings from seedbeds sown under the three different conditions. The heights of seedlings grown in seedbeds sown by research and conservancy techniques were also similar, although seedlings sown under research conditions tended to be larger overall. This confirms the real benefit of irrigation because the increased height was achieved even with one third more seedlings. In both watering regimes prechilling seed also increased the seedling height by approximately 10 per cent.

It was confirmed that a coarse sand used as a seedbed cover gave much better germination for small-seeded conifers (*Thuja plicata* and *Chamaecyparis lawsoniana*) than the more conventional grit. Sowing prechilled seed also gave more seedlings than dry seed at all stages of the experiment. For both species, seedlings grown under sand were at least 20 per cent taller at the end of the season than seedlings grown under grit.

In another experiment three grades of Sitka spruce seed germinated less fast and less completely than the same seed ungraded. This can only be explained by assuming that the action of grading had a detrimental effect on the germination and vigour. The uniformity of the seedlings was not improved by grading, but this also may be due to grading damage.

Work has been done in the laboratory as well as in the field on the newly developed method of fluid drilling seeds. Conifer seeds gave as good if not better germination in plastic bags in incubators than was achieved by incubating the seeds in aerated water in a specially constructed incubator (which is the recommended method). In the field the latter method gave marginally the poorest germination. Sowing chitted seeds in gel gave almost exactly the same emergence percentage as sowing seeds in the normal way but after they had just begun to chit. The time to 50 per cent emergence of chitted seeds was approximately 10 days faster than for normal prechilled seed, although the final germination was marginally lower.

Broadleaved Seed Pretreatment

Work has continued on improving predictability of germination of some of the more deeply dormant broadleaved species. It is becoming clear that one of the biggest reasons for unreliable germination is the great variability between different seed lots in their pretreatment requirements. Unfortunately, gibberellin soaks have been found to have very little effect on stimulating the germination of most species.

Interim suggestions for seed treatments are to be found in the 1978-1979 seed catalogue available on request from Seed Branch.

A. G. GORDON, D. C. WAKEMAN

Service

The Branch has provided all its normal services but has extended the range of minor broadleaved species which were included in the seed catalogue for the first time last year. Again the response has been much greater than anticipated.

The 1978 conifer seed crop was relatively poor, with only light crops in Lodgepole pine, Noble fir, Douglas fir, Norway spruce, Japanese larch, Hybrid larch, Western red cedar and Western hemlock. More substantial collections were made of Scots pine and Sitka spruce. There was a big increase in the quantity of minor broadleaved seed collected, and small collections of Pedunculate oak were made. Unfortunately, broadleaved seed collections satisfied only a small part of the total requirements.

To compensate for the small home collections, attempts were made to import the balance of our requirements from abroad. However, it is clear that foreign sources can no longer produce the balance of our requirements and that home collections must be increased greatly.

Sales of conifer seed have shown a further small increase overall from last year, although there has been another sharp increase in the quantity of Norway spruce seed sold, probably mostly for Christmas trees. Supplies of conifer seed to the Commission have been maintained at about the same level as last year.

A. G. GORDON

SILVICULTURE (SOUTH)

Plant Production

Seedbed Herbicides

Oxyfluorfen was tested for crop tolerance. Hexazinone, ethofumesate, metatritron and methabenzthiazuron were tested for both crop tolerance and weed control with pre-emergent and post-emergent treatments. Butam, chlornitrofen, chlorpropham, cyanazine, dinitramine, K1441, napropamide, prometryne, terbuthylazine and WL29226 were also investigated as pre-emergent treatments.

These herbicides were tested on four conifers and five weed species and several showed considerable promise.

Conifers in Paperpots (Polythene Greenhouse)

'Osmocote' 18-11-10 (8-9 month slow release fertiliser), at 2 kg/m³ of Irish Moss Peat medium, gave superior plant growth to an 'Enmag' regime containing 1.5 kg/m³ supplemented by an NPK liquid feed.

Broadleaved Species in Containers (Polythene Greenhouse)

Beech treated with gibberellin (GA₃) to obtain improved height growth became very etiolated resulting in dieback of growing tips and failure to set a winter resting bud. Concentrations from 50 to 200 ppm at a rate of 2 ml per plant were tested.

Conifers in Paperpots (Forest Extensions)

After three years, Corsican pine raised for 16 or more weeks in the polythene greenhouse and given at least four weeks to harden off, were taller and survived better than both unhardened container plants and 1 + 1 transplants.

W. J. McCAVISH

Vegetative Propagation

Experiments were undertaken to examine the rooting of cuttings in heated beds of potentially important though little grown clones of Leyland cypress, × *Cupressocyparis leylandii*. The relationship between root initiation and time of cutting insertion and type of substrate received special attention.

Using the mist technique, stocks for field trials and for other Research Branches were raised from softwood cuttings of some 25 clones of elm, together with selections of Goat willow, *Salix caprea*, Sargent's cherry, *Prunus sargentii*, and five species of lime, *Tilia* spp.

J. JOBLING

Lowland Silviculture

Nothofagus

The range of seed collections of the South American species of *Nothofagus* were extended by Professor D. M. Moore of Reading University in 1978 and by Mr Iain Peters in 1979 whose visits to Terra del Fuego and Southern Patagonia were grant-aided by the Forestry Commission.

The 18 seed origins of *N. procera* and 9 of *N. obliqua*, sown at Fleet (Dumfries and Galloway) and Headley (Hampshire) nurseries in 1977 are being planted at

19 sites in 1979. These include both upland and lowland forests and a broad range of site conditions from the Scottish Highlands to near the south coast of England, and from mild west coast climates to the more extreme conditions of Thetford Forest (Norfolk) and Drummond Hill (Tayside).

Evidence from Fleet shows little variation in *N. obliqua* leaves but highly significant variation (length, width and vein number) in *N. procera* which suggests hybridisation in some seed lots. Similar observations noted in the 1960 Report (p. 37) have been confirmed on 20-year-old trees.

G. TULEY, R. LINES

Fast Growing Pines

Seven seed lots of *Pinus muricata* covering the whole natural range of the blue form have been acquired as well as 14 of *P. radiata* which cover all the Californian mainland populations. There was serious frost damage on *P. radiata* seedlings at Headley nursery (Hampshire) in November 1978, some damage on the southern origin of *P. muricata* but considerably less damage on those two seed origins from further north which are slower growing in the nursery.

G. TULEY

Provenance of Norway Spruce

An unusual spin-off from the International Norway Spruce Provenance Trial resulted from an enquiry for seed suitable for raising Christmas trees. Desirable characteristics for Christmas trees were found as recurring features on a group of provenances throughout the replications of this trial. This led to the selection of a provenance region of South West Germany (North of Lake Constance at 600 m elevation) as a suitable source of seed. Very high germination from seed in this zone was observed in the experimental nursery trials.

M. L. PEARCE

Forest Weed Control

Herbicide Screening in the Nursery

The hexazinone ('Velpar') screen reported on in 1978 showed no improvements in crop health for the second year of the species affected.

Alloxydim-sodium screened over five broadleaved and five conifer species at up to 6 kg product/ha of the 70 per cent active powder (4.2 kg ai/ha) had no effect on either category of plant. This was true even during the active growing period.

Control of Grasses and Herbaceous Broadleaved Weeds

Hexazinone was tested in both lowland and upland Britain. Good weed control was achieved at all six sites with 2 kg product/ha of the 90 per cent powder (1.8 kg ai/ha) applied at medium volume in the spring prior to tree growth. Only *Calamagrostis epigejos* recovered from treatment by the end of the growing season. The trees recovered quickly from initial minor herbicide effects.

Alloxydim-sodium was also tested at six sites in both lowland and upland Britain. Weed control of all grasses except *Holcus lanatus* was disappointing

even at 4.5 kg product/ha of the 70 per cent active powder (3.15 kg ai/ha). Most grasses recovered from treatment quickly though several grasses failed to flower due to the June application.

Glyphosate was tested in upland Britain. Early spring treatments gave disappointing grass control. Though summer treatments of 3.0 litres/ha (1.08 kg acid equivalent/ha) made in July gave acceptable weed control, they were rather damaging to the crop, possibly because tree growth remained soft and sensitive later than usual in 1978.

Low volume treatments were generally more damaging than medium volume treatments. Tree survival was not however affected. An August application was not damaging to the crop.

Control of Bracken

Six experiments testing glyphosate in lowland and upland Britain were laid out. Early indications are that glyphosate scorches the bracken in the year of application reducing frond cover, unlike asulam which has no great effect in the year of application. Results will be more definite in 1979.

Control of Woody Weeds

Three experiments in lowland Britain were started to test glyphosate ('Roundup') and triclopyr amine and ester ('Garlon') for the control of woody weeds. Early results indicate that triclopyr may prove to be the better herbicide, but in previous experiments this trend has been reversed in the year following application.

Control of Heather

In two experiments to test glyphosate on heather in lowland Britain the 'ULVA 8' equipment seems to show better early control than the 'Herbi' equipment. 2.25 litres product/ha (0.81 kg ae/ha) looks promising but 1979 results are required for confirmation.

Control of Gorse and Broom

Glyphosate and triclopyr are being tested on 3 sites; at present triclopyr looks the more promising herbicide.

Control of Rhododendron

Glyphosate and triclopyr are being tested on rhododendron regrowth.

W. J. McCAVISH

Arboriculture—Department of the Environment Contracts

Nutrition of Amenity Trees

Within season variation of foliar macronutrients (N, P, K, Ca and Mg) was monitored for the second successive year using an avenue of Common limes at Avington Hall (Hampshire). An index of the normal range of foliar macronutrient levels present in amenity tree species is being built up. The species sampled during 1978 were ash, beech and Norway maple and their cultivars together with Silver birch.

Nutrient response trials were set up using established avenues of Common limes at Hardwick Hall (Derbyshire) and Blickling Hall (Norfolk) as well as newly planted Corsican pine, Common alder and Goat willow on a refuse-filled chalk quarry at Greenhithe (Kent).

Motorway Planting

Further trials of container grown and bare rooted stock were established during the year on the M.5 (Devon and Gloucester), the A.47 (Norfolk) and M.23 (Surrey). The season of planting trial with birch on the A.3 at Esher (Surrey) demonstrated that properly hardened-off stock grown in Japanese Paperpots could be established throughout the trial period (August to May).

This experiment has been repeated and extended to cover a 12-month period using a site on the M.5 at Exeter.

Experiments to measure the interaction between grass sward and tree growth were started on the A.610/A.38 Ripley Interchange (Derbyshire) and on the A.69 Corbridge bypass (Northumberland).

In an experiment laid down on a heavily compacted, calcareous clay topsoil at the M.27 Portsmouth Harbour Interchange (Hampshire), survival and growth of transplants is being compared on ground ripped at varying intensities (using 60 cm tines mounted behind a D6 tractor) and unripped ground (Plate 2).

Urban Planting

In the first season of a pruning trial at Tern Hill (Shropshire), London plane standards, on which all branches including the leader were pruned back by 50 per cent of their length at planting, have overtaken unpruned standards in terms of overall height. Small-leaved lime standards treated similarly have caught up with unpruned trees, and in both species pruned trees have a more healthy appearance.

The effect of varying proportions of peat in the planting backfill for street trees is the subject of an experiment using fastigate rowan in Islington. Further work at Milton Keynes (Bucks) has included a trial of mole draining on a compacted clay embankment.

Production of Amenity Stock

Trials of defoliant for hardy nursery stock were carried out in October at Hillier Nurseries at Romsey (Hampshire) using RH2915, Ethrel R, DEF, potassium iodide and ammonium sulphate. The species used were Silver birch, Grey alder, London plane and hornbeam. All the chemicals tested produced significant defoliation compared with a control of water plus a wetting agent. Pretreatment with a 0.5 per cent solution of solubised ethephon as a growth retardant enhanced the defoliant action in all cases except with potassium iodide applied as a 0.8 per cent solution on Grey alder.

Experiments to measure the effect of root exposure on survival of transplanted seedlings showed a strong relationship between the moisture content at planting and subsequent survival of Norway maple, oak and *Nothofagus obliqua* seedlings.

Susceptibility to drying varied greatly between species with *N. obliqua* proving most, and Norway maple least, sensitive.

Arboriculture Advisory and Information Service

During the year, 1,497 enquirers contacted the service with 2,700 problems. Three major areas of concern, damage to trees, mature tree maintenance and growth of trees, reflected the 1976 drought and effects of debilitating diseases. Half the questions relating to damage to trees were entomological or pathological and were answered directly or with guidance from Forestry Commission entomologists and pathologists. Mature tree maintenance enquiries indicated a continuing demand for guidance about tree surgery contractors, and how pruning, felling and stump removal should be undertaken. Damage to buildings by tree roots remained an important subject but enquirers were anticipating possible damage by requesting details of root spread of tree species.

The interim results of arboricultural research have been published as Arboricultural Research Notes.

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

Reclaimed Colliery Spoil

Studies were carried out on selected regraded colliery spoil heaps in the north of England to assess the relationship between tree root development and the physical and chemical properties of the spoil. Whole root systems of six- to 10-year trees were examined. Experiments were started to determine methods of improving the survival and growth rates of young trees on typically compacted spoil.

J. JOBLING

Short Rotation Coppice—Department of Energy Contract

Encouraging yields and costings are predicted for clonal poplar and willow, *Nothofagus*, alder and *Eucalyptus*, grown on a short rotation coppice system. Harvesting all above ground growth (except leaves), the crop can be considered as feedstock for conversion to energy or as pulpwood for the paper and board industry.

M. L. PEARCE

Arboriculture—Other*Difficult Man-Made Sites*

Several meetings took place during the year with District and County Council Planning staff, and with University research workers and Forestry Commission Conservancy officers, to review the problems of tree planting and maintenance on a wide range of derelict and industrially despoiled land. The afforestation of old quarry workings figured prominently in the discussions.

J. JOBLING

Rural Arboriculture

Trials have started of several different designs of shelter to improve the local environment of recently planted trees. The early growth of a range of plant types is being studied.

G. TULEY

Dendrology and Arboreta*Dendrology*

During the year 161 estates, gardens and collections were surveyed for specimen trees, 98 of these being first visits and 63 for updating measurements and seeking new specimens. The Isle of Man was brought in for the first time and 14 gardens, parks and glens were visited; 91 trees measured.

The register which now contains 47,496 trees (28,639 conifers; 18,857 broadleaves) of 1,335 species and 761 cultivars is being re-written, gathering multiple entries from different visits under one head and changing figures to metric. As the species are done the cards are photocopied and a copy sent to the Royal Botanic Gardens at Kew and Edinburgh and to the Royal Horticultural Society. Thirty species, most of them major ones, have been sent out so far, and another 15 are ready to copy.

During the year, 39 illustrated lectures on trees were given, seven tree-walks conducted and two courses taken, a five-day residential course and a 10-part adult education course.

*Arboreta**Westonbirt*

The Visitor Centre was opened in May (front cover) and has been greatly appreciated. The Native Tree Glade has been largely planted and a start made with the shrub layer. The Hillier Cherry Glade received the final two big gifts from Mr Hillier and has now three specimens each of every fancy Japanese cherry (the 'Sato' cherries) in cultivation and a number of rare species. A comprehensive collection of willows, native species, hybrids and cultivar selections, has been planted along a wide ride on the south-west edge of Silk Wood. Old trees, mainly broadleaved, were still dying from the stresses of the 1976 drought and consequent infection by fungi. They have been removed and seem to be the last so afflicted.

Bedgebury

The siting and planning of a Visitor Centre has reached an advanced stage.

A. F. MITCHELL

SILVICULTURE (NORTH)**Production of Planting Stock***Seedbed Herbicides*

Oxyfluorfen was tested as a pre-emergent herbicide and was applied immediately after sowing at rates of 0.25, 0.5, 1.0, and 2.0 kg active ingredient per ha. Rates of 0.5 kg ai/ha and greater reduced the rate of germination of Sitka spruce and Lodgepole pine. No effect was observed on the germination of Japanese larch. Although this material is a good herbicide further testing as a pre-emergent spray will not be done because of the adverse effects on germination of the two major species.

Herbicides on Transplants

Experiments in two nurseries comparing diphenamid and simazine herbicides sprayed immediately after lining-out of Japanese larch showed that diphenamid at 8 kg ai/ha was an acceptable alternative to simazine which for larch is usually recommended at only half the normal rate (i.e. 2.25 kg ai/ha).

Glyphosate applied to Lodgepole pine and Sitka spruce transplants in May, July, September and November at rates of 0.5, 1.0 and 2.0 kg acid equivalent per ha produced varying degrees of damage. May and July applications at all rates produced severe damage to both species. The effect of the September and November applications cannot yet be fully evaluated since next season's growth may be affected. However the lower rates so far have been tolerated with only slight damage.

Partial Sterilisation

A repeat of the previous year's date-of-application experiment confirmed the result showing that late August is the best time for application of dazomet for sterilising conifer seedbeds.

Seedbed Cloches

Cloche experiments again demonstrated the beneficial effects of burying the edges of the polythene. The complete seal resulted in the underside of the polythene being continuously covered by condensation. Numbers germinating and height growth of Lodgepole pine, Corsican pine, Japanese larch, Douglas fir and Sitka spruce were improved by sealed cloches. The use of white polythene as opposed to clear did not give the anticipated improvements in numbers of Sitka spruce seedlings.

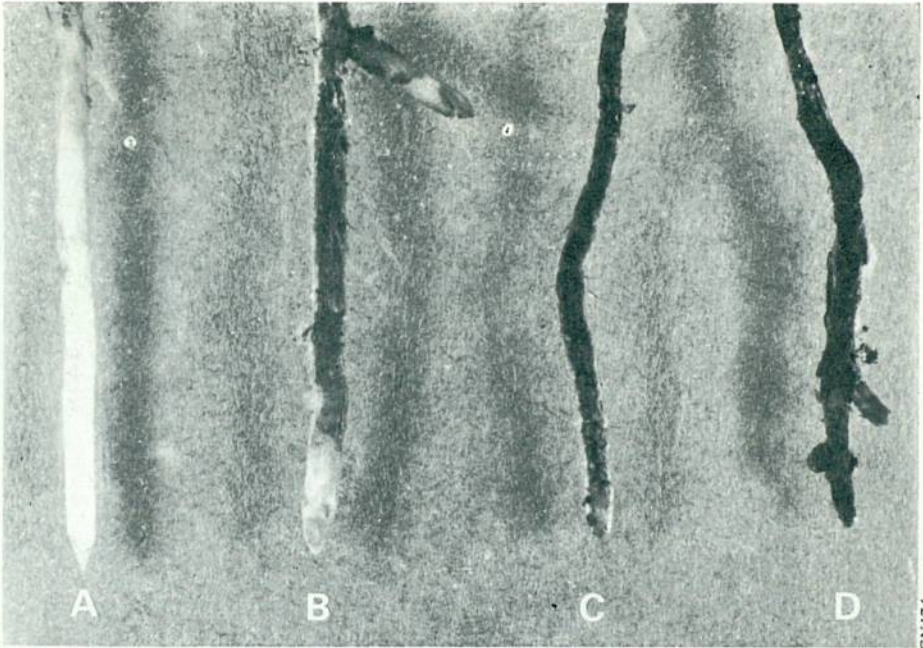
Vegetative Propagation

Sitka spruce: By raising seedlings in polythene greenhouses and taking cuttings at the start of the third growing season it has proved possible to produce clones with 40–50 ramets consistently. Apart from being the first step in a bulking-up programme of seed of good provenance this technique may be of considerable value in producing clonal stock for experimental purposes. Rooted Sitka spruce cuttings produce straight plants with no plagiotropism (cf. Hybrid larch).

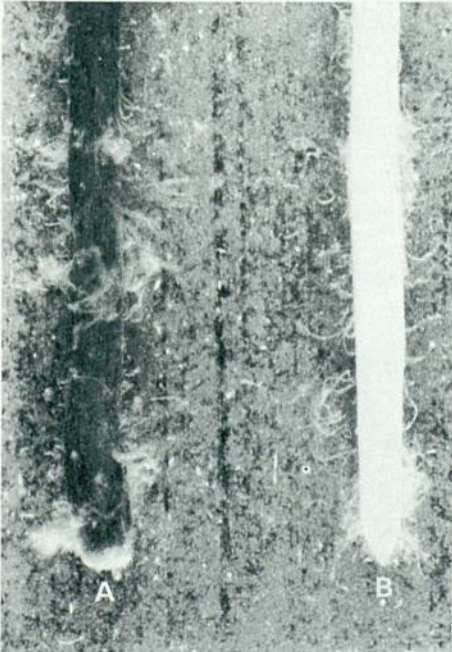
Hybrid larch: As with Sitka spruce it has been found possible to bulk-up good seed by producing the parent plants in polythene greenhouses. However the second generation cuttings have a greater tendency to be plagiotropic. The handling of rooted cuttings during the winter and during lining-out is also giving rise to unexpected difficulties.

Plant Handling

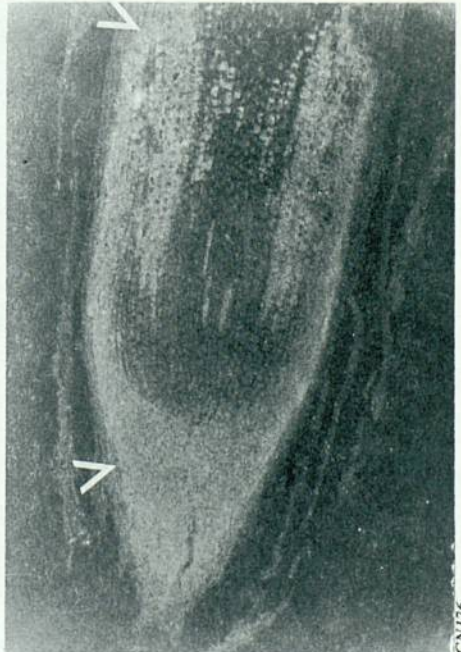
An experiment where plants in cold store were deliberately 'mishandled' confirmed that split polythene bags allowed a loss in weight of the plants during storage. Their subsequent performance in the field was poor. Bundles of plants which were soaked in water before bagging and storage performed very well giving good survival and height growth compared with plants treated normally, i.e. stored with dry foliage.



CN174



CN175



CN176

Plate 1

Root dormancy investigations (p. 29).

Top. Roots collected from Eddleston forest.

- A. an actively elongating root with a white apex;
- B. and C. external browning occurs near the root apex as dormancy progresses;
- D. a fully dormant root with brown apex.

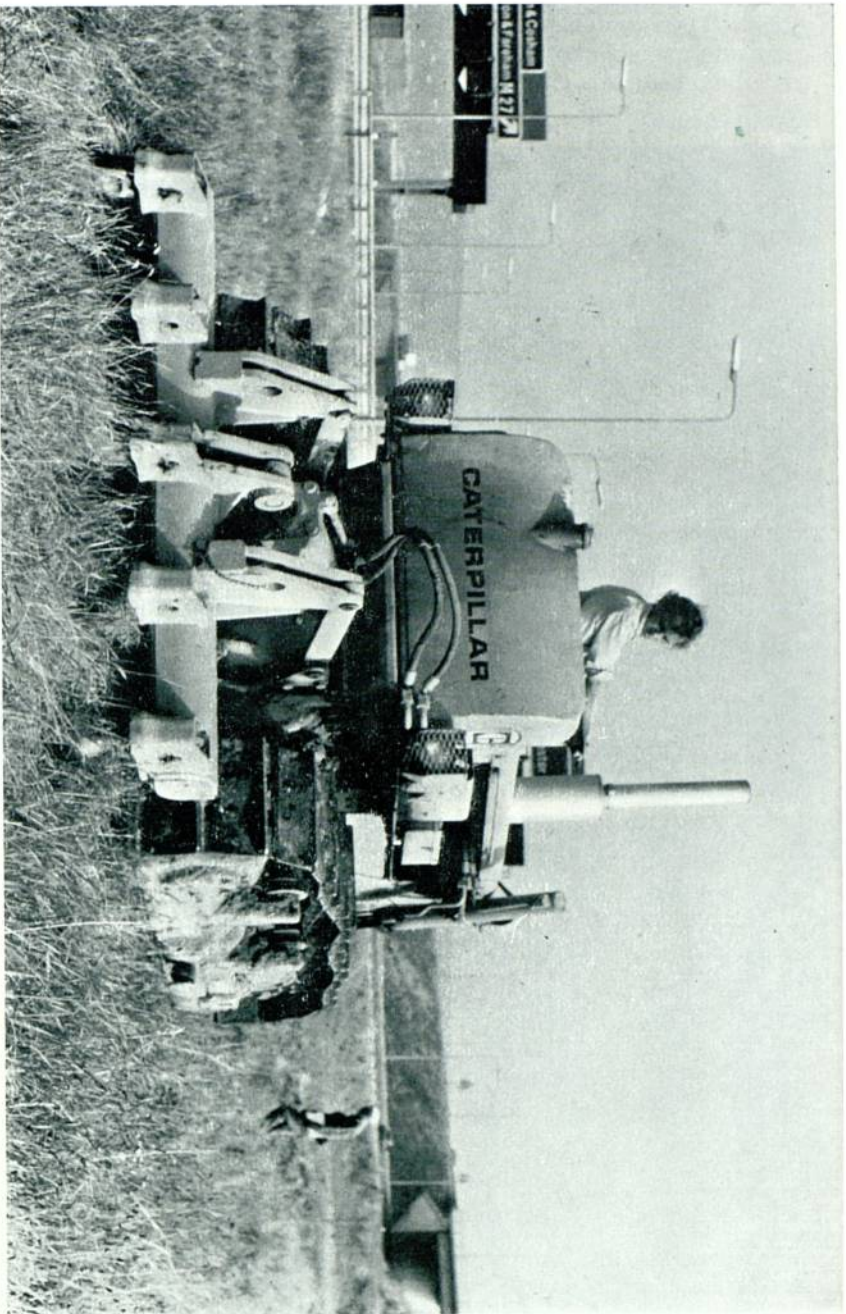
Below left. Roots from plants growing in aerated nutrient culture.

- A. a dormant root after treatment with abscisic acid;
- B. an actively elongating root with a white apex.

Below right. Longitudinal section of a dormant root of Sitka spruce viewed under the fluorescence microscope. The natural fluorescence of the cells highlights the position of the dormancy layers (arrows).

In all cases root diameter is approximately 2 mm.

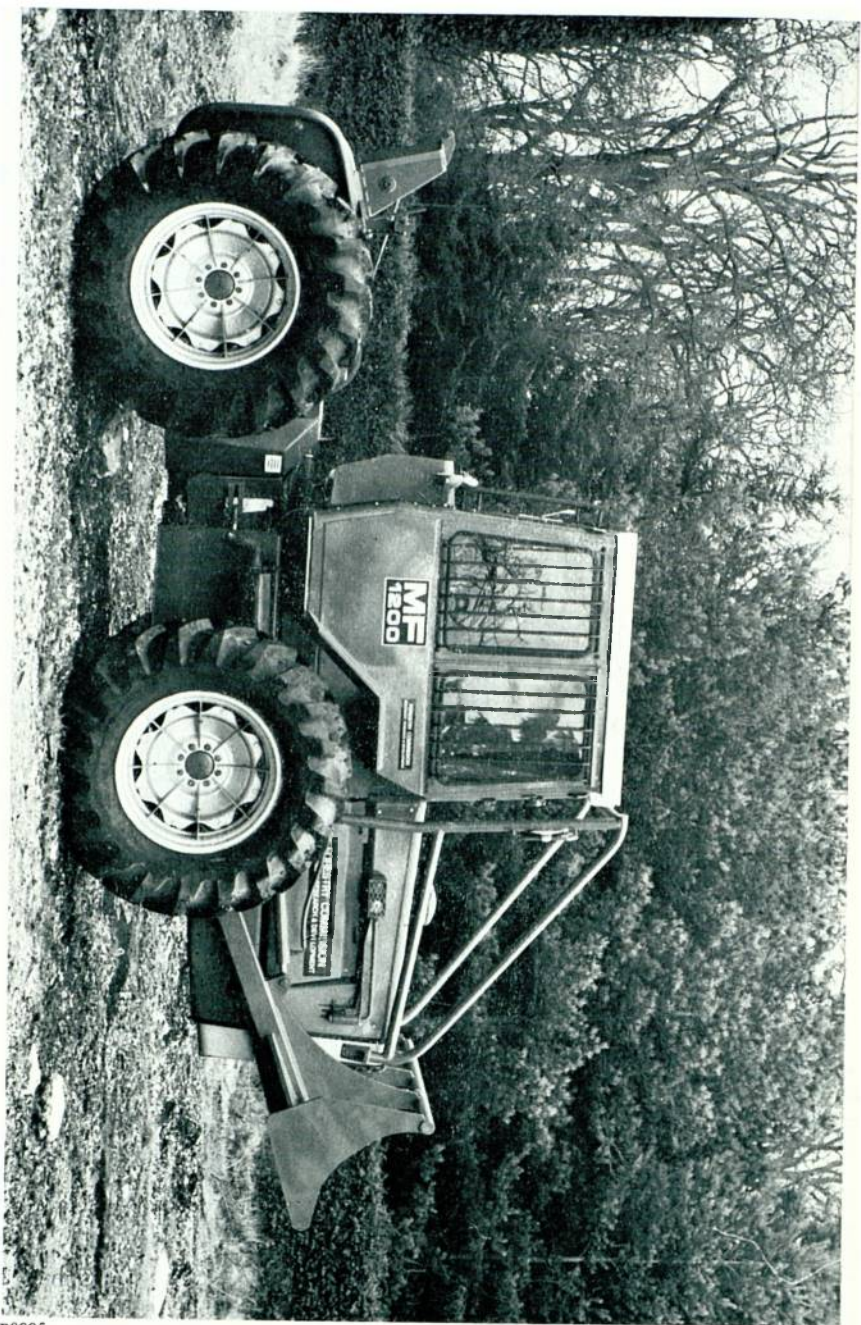
B*



D6538

Plate 2

Ripping to relieve soil compaction in an experiment on the establishment of trees on a motorway; part of the Forestry Commission arboricultural research contract for the Department of the Environment. (p. 13)



B8993

Plate 3

Modification of the Massey Ferguson 1200 agricultural frame steered tractor to a forest skidder by the fitting of a double drum radio controlled winch, front log rolling blade and protective guarding. (p. 43)

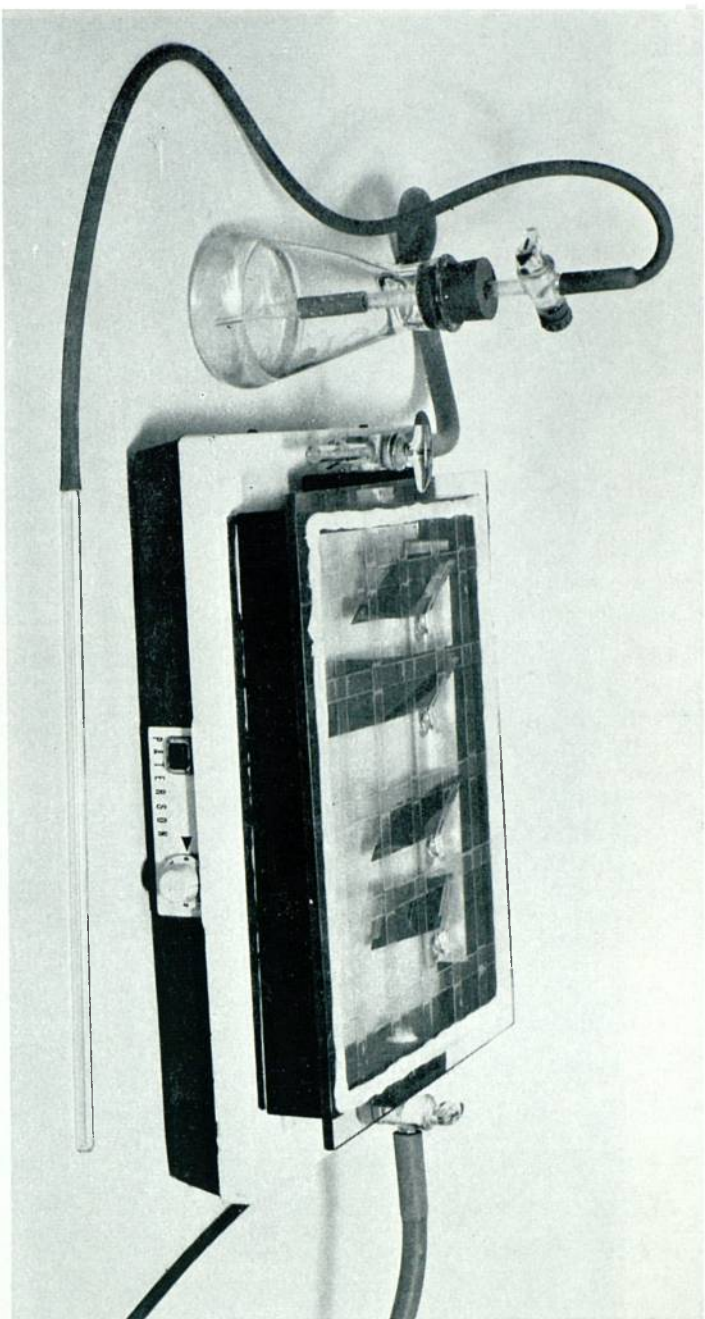


Plate 4

Prototype Ammonia chamber for developing Diazo film. (p. 46)

High contrast negatives are exposed, in contact with Diazo film to ultra-violet light for approximately 1½ minutes. The Diazo film is placed in the ammonia chamber which is seated on a warm hot-plate, as heat is required. Air is drawn out of the sealed chamber, the partial vacuum thus formed replaced with ammonia gas. After developing for about 10 minutes (density can be judged visually) the ammonia is drawn off by filter vacuum pump and flushed through by air. The highly soluble ammonia dissolves in water flowing through vacuum pump. The chamber can now be opened—the films removed for mounting.

Species Trials

Alternative Species

Trials of alternative species to those currently most widely used have long been part of research strategy. Recent widespread attacks by the Pine beauty moth on Lodgepole pine and a prudent desire to diversify away from Sitka spruce have given more emphasis to this project, and a re-appraisal of existing species trials has begun. Some little-known species may be suitable if the correct seed origin is chosen. For example, on an infertile peat site at Shin Forest (Highland) the tallest of seven origins of *Picea engelmannii* was 3.2 m at 10 years, while adjacent Sitka spruce was only 2.7 m.

IUFRO Experiments with NW American Seed Origins

The results of seed origin experiments based on the seed collections made by the International Union of Forest Research Organisations (IUFRO) were compiled for a major conference in Vancouver. Twenty-four forest experiments varying in size from 2–9.5 ha and two nursery trials were assessed and the results analysed both by individual and by groups of experiments. The species were Douglas fir, Lodgepole pine, Sitka spruce and Grand fir. These experiments are the first with a full range of precisely identified seed origins and they are already providing interesting pointers to possible earlier misconceptions.

Two forest experiments were planted with the IUFRO Grand fir origins in 1978 and ten more are being planted in 1979 at sites covering both upland and lowland conditions and ranging from Speymouth Forest (Grampian) in the north to Brendon Forest (Somerset) in the south. At each site 31–37 origins are included which adequately cover the major part of the range.

R. LINES

Provenance Experiments with Nothofagus Species

Nine seedlots of *N. obliqua* and 18 of *N. procera*, sown at Fleet Nursery (Dumfries and Galloway) and Alice Holt Nursery (Surrey) in 1977 are being planted at 19 sites in 1979. These include both upland and lowland forests and a broad range of site conditions, from the Scottish Highlands to the southern English Downs and from mild West coast climates to the more extreme conditions of Thetford Forest (Norfolk) and Drummond Hill (Tayside).

Measurements of leaves from this collection, which includes Chilean and British seed sources, show little variation in *N. obliqua*, but highly significant variation in leaf length, leaf width and in number of veins in *N. procera*. These data suggest that some populations contain natural hybrids between the two species.

R. LINES, G. TULEY

Air Pollution Effects on Trees

Evidence was presented to the Royal Commission on Environmental Pollution about the effects of pollution on trees in the central Pennines and other areas. A re-survey of the Pennine sites where lead dioxide candles were exposed in 1956–1959 (*Report* for 1957) has begun. The new study is designed to investigate pollution changes and to check sulphur dioxide levels in recent plantations.

Foliar analysis of Sitka spruce from near the aluminium smelter at Fort William (Highland) in 1977 shows a pattern of rapidly diminishing levels of

selected at Glentrool Forest (Dumfries and Galloway) to repeat the study over rougher topography during the 1979–80 winter.

Further work was carried out over a topographic model of Kershope Forest (Cumbria) at Bristol University, Department of Aeronautical Engineering. Highest, mean and variation-around-the-mean wind speeds were measured at 276 points. Using the last two parameters an index of turbulence intensity can be obtained. This information is to be tested against windthrow data to see if the 'exposure' element of Windthrow Hazard Classification can be improved.

Assessment of Exposure

Increased use is being made of 'exposure' flags by the Forestry Commission, and by researchers in both biological and engineering disciplines. The use of flags outside present forest areas is providing useful data for improving the 'Windiness zonation' section of Windthrow Hazard Classification.

Windthrow Hazard Classification

Advice and training of Forestry Commission and private forestry staff in both mapping and application of the technique occupied a considerable proportion of time during the year. Provisional alterations to the 'windiness zones' from data received from Soil Survey of England and Wales (Staines, 1979) give a zone 3 for the extreme SW of Cornwall, and strong suggestions of a zone 4 from Forestry Commission data for North and Central Scotland.

Thinning

Treatments were started in an experiment to compare types of thinning and relationships with windthrow at Bowland Forest (Lancashire). Treatments will be: line thinning, selective thinning and no thinning.

Wind Measurement

The gathering of wind data to relate to windthrow is expensive and fraught with technical problems. The information that can be extracted from standard anemograph charts and meteorological summaries is limited and time consuming to extract. To overcome these problems and to obtain information that will relate to tree vibration and the observed 'fatigue' problem associated with deterioration in root and soil contact over winter, a gust counter has been developed. Using a standard cup generator anemometer the electronic counter will count the number of gusts above a predetermined speed, and also the length of time winds are above the set speed. These two figures will then give average duration of gusts. Prototypes have been in use throughout the 1978–79 winter and have operated satisfactorily throughout very inclement weather. Icing up of the anemometer has been the only problem encountered, and improved counters are ready for testing.

T. C. BOOTH

REFERENCE

- STAINES, G. J. (1979). *Soils in Cornwall II, Sheet SW53 (Hayle)*. Soil Survey Record No. 57.

SITE STUDIES (SOUTH)

Foliar Analysis

Methods of Analysis

The ability of the 'Spectrascan' III Emission Spectrometer (*Report for 1978*) to analyse for up to five elements simultaneously has greatly improved the efficiency of the foliar analysis system. This instrument is now being used to analyse for P, K, Ca and Mg in plant material and for research into soil chemical properties. The limit of detection for phosphorus is approximately 1 ppm in solution (equivalent to 0.01 per cent oven-dried matter in Kjeldahl-type digests) which means that wet chemical methods are still required for the analysis of phosphorus in woody materials, where the concentration is less than this.

The last two or three years have seen a large increase in the number of samples presented for analysis and the number of elements required per sample. In order to handle the data, a 'Transdata' 309 editing system is being purchased. This will be linked to the analytical instruments to provide both a bulk data store and a computing facility for the conversion and editing of results.

A. WILLSON

Upland Production Forestry

Soil Physical Properties

During the past year we have gathered data from the drainage trial at Crychan Forest (Powys) to investigate the relationship between rainfall, interception, free soil water and run-off. Rainfall outside the forest has been monitored continuously by conventional rain gauges and inside the forest using a 40 m square net rainfall gauge (Calder and Rosier, 1976) and tipping bucket gauge (Edwards, Jackson and Fleming, 1974). Soil water levels in two plots have been monitored at three-hourly intervals by recording from 40 boreholes, and run-off from the drains by continuously recording the levels of water flowing over V-notch weirs. We wish to thank Dr I. R. Calder of the Institute of Hydrology for the loan of a tipping bucket gauge.

R. CARNELL

Effects of Trees on Sites

Species, Thinning and Spacing Trials

Studies of soil development in response to contrasted crops and management practices have continued (*Report for 1978*). Analysis of the soils is still in progress, but early indications are that very light intensities of first thinning might minimise the accumulation of mineral nutrients on the forest floor of some Sitka spruce plantations. Both normal thinning and no thinning promoted the development of thick litter layers in which minerals are retained, but light thinnings, e.g. one row in three, unexpectedly resulted in about 25 per cent less nutrients concentrated in the forest floor.

Whole-tree Harvesting of Sitka Spruce

Studies have continued of the likely nutrient loss from sites at which forest residues as well as the stem-wood are harvested. Sitka spruce crops of General Yield Class 12 are currently being analysed; early indications are that the

proportional loss of phosphorus in harvested crowns is 50 per cent greater in GYC 12 crops than in GYC 17. This implies a phosphorus drain from the site about four times greater than current harvesting losses, in return for an increase in dry matter yield of 70 tonnes per hectare at GYC 12.

M. A. ANDERSON, K. G. SHUKER

Lowland Production Forestry

Gravel Workings

Corsican and Bishop pine have both shown a significant response (Table 1) to deep cultivation in the Bramshill (Hampshire) cultivation/nitrogen trial (*Report for 1977*), but there have been no benefits from nitrogen fertiliser although pale green foliage had been noted in some older adjacent crops; this site had received some topsoil during restoration. One hundred and twenty-eight measurements of bulk density were made, in July 1977 and May 1978, along a transect at right angles to a tine slit and to a depth of 80 cm, in the shallow cultivation treatment. It was found that the loosening effect was apparent in July 1977 and extended 7–10 cm from the original tine slit, with dry bulk density less than $1.7 \times 10^3 \text{ kg/m}^3$. A higher density was found for about 10 cm on both sides of this zone and beneath the tine slit, with dry bulk density $1.9\text{--}2.4 \times 10^3 \text{ kg/m}^3$. In contrast by May 1978 the zone of highest density lay in the bottom of the old tine slit. This may have been due to illuviation of the fine particles during the intervening wet period. Thus although the loosening effect of shallow, spaced cultivation was measurable, the better growth and survival in the more intensive treatments suggests that the trees are sensitive to the higher densities which reappeared during the second winter.

TABLE 1

SURVIVAL AND HEIGHT GROWTH OF CORSICAN AND BISHOP PINE WITH DIFFERENT CULTIVATION TREATMENTS ON RESTORED GRAVEL WORKINGS AT BRAMSHILL FOREST, HANTS.

	Survival (per cent) after two years			Height (cm) after three years		
	Spaced shallow cultivation	Spaced deep cultivation	Complete deep cultivation	Spaced shallow cultivation	Spaced deep cultivation	Complete deep cultivation
Corsican pine	86	97	98	21	37	37
Bishop pine	75	90	90	37	54	60

Although ripping with winged tines (*Report for 1978*) loosens machine-compacted spoils very effectively, on sites with low slopes the loosened spoil subsequently wets-up to a porridge-like consistency (unless the cultivation has penetrated through into sandy materials). We are consequently recommending bolder topographic patterns, such as large ridges 30 m across and 1.5 m high in the centre, to give slopes of 1:10. Cultivation down these slopes should give adequate aeration and lateral movement of soil water, and thus help to maintain the improved structure.

D. F. FOURT, R. CARNELL

Ironstone and Open-cast Coal Sites

Trials of ripping on ironstone sites have brought up many large boulders, and the same result has occurred on open-cast coal sites where on occasions the effect has been welcomed as assisting the de-stoning operations. Land forming without the use of box-scrapers is being investigated on drag-line workings, so as to reduce machine passes and thus compaction.

D. F. FOURT

Amenity Forestry and Arboriculture*Penetration Resistance*

Measurements have been made on a number of deep mine spoils with a recording penetrometer. The technique works in all but the stoniest sites and provided that measurements are made with the soil at field capacity, valid comparisons can be made between treatments and sites. Probably the most straightforward application is in comparing cultivation in nursery soils.

R. CARNELL

Meteorology and Phenology

Routine recording has continued in collaboration with the Meteorological Office. Analysis of phenology data for the last seven years has suggested that in the drought year of 1976 Alice Holt had, temporarily, a climate equivalent to that at a point 500 miles further south-east.

M. A. ANDERSON, K. G. SHUKER

Advisory

Among a large and varied number of enquiries the two leading types concern the preparation of refuse tips for planting and the afforestation of chalk downland slopes too steep for arable cultivation.

Some general recommendations are in preparation for refuse tips, which include ridge or dome topography with a soil cover able to supply 150–200 mm of available water.

The downlands usually face east or west and are often too steep to cultivate, though a ripping treatment at plant spacing would undoubtedly be valuable. Mixtures of Corsican pine with sycamore, beech or Norway maple, and with ash on eastern aspects are suggested, at a ratio of 4:1, with the use of herbicides to control grass and in some cases with PK fertiliser.

D. F. FOURT

REFERENCES

- CALDER, I. R. and ROSIER, P. T. W. (1976). The design of large plastic-sheet net rainfall gauges. *Journal of Hydrology* **30**, 403–405.
- EDWARDS, I. J., JACKSON, W. D. and FLEMING, P. M. (1974). Tipping bucket gauges for measuring run-off from experimental plots. *Agricultural Meteorology* **13**, 189–201.

SITE STUDIES (NORTH)

Classification and Improvement of Upland Soils

Indurated Soils and Loamy Gleys

At Teindland (Speymouth Forest, Grampian) measurements of soil aeration have been added to the continuing study of the moisture regimes of podzol, gley and ironpan soils, all with indurated material. Air sampling probes were installed at four depths in each soil type under pine plantations and in the ironpan soil in unplanted heathland.

The podzol, which is freely draining, had good aeration throughout, including the indurated subsoil (oxygen concentrations about 20 per cent by volume and carbon dioxide concentrations less than 3 per cent). The gley soil, which has a shallow water table for most of the year, showed good aeration only to a depth of 25 cm, although for a few weeks in the summer, as the water table receded, oxygen penetrated to about 60 cm. The ironpan soil under heathland has an upper 'perched' waterlogged zone, 40 cm thick, over an indurated subsoil which is not wet. The upper zone had poor aeration throughout the period whereas the subsoil showed much higher oxygen concentrations (10–15 per cent) together with high concentrations of carbon dioxide (5–9 per cent). Under the forest the ironpan soil is never waterlogged and the aeration was similar to that of the podzol.

Gleys and Ironpan Soils

The study of the moisture and temperature regimes of four soil types under pole stage spruce at Newcastleton Forest (Borders) has been written up (Pyatt, McLaren and Craven, 1979).

At Falstone Forest (Northumberland) the effects of Sitka spruce and Lodgepole pine stands planted in 1952 on the properties of a peaty gley are being compared with the same soil under the original vegetation of Purple moor-grass *Molinia caerulea*. The difficulty of obtaining a site which originally had uniform soil properties and which was given uniform treatment during (partial) afforestation has been overcome. The stands form part of a species trial with randomised plots in which several species turned out to be quite unsuited to the site conditions and quickly died out, thereby leaving *Molinia* covered plots. So far it is clear that Lodgepole pine causes deeper and more intense drying of the peaty gley soil in the summer than Sitka spruce but the difference does not seem to be carried through to the winter, when the water table rises to a similar level under both species. The grass plots are much wetter at all times of the year.

Deep peats

The experiment at Naver Forest (Highland) on the irreversible drying of blanket peat under conifer plantations was abandoned after the pines were killed by Pine beauty moth. It will, however, now be possible to look for signs of re-wetting. A small investigation beneath a stand of Lodgepole pine in Shin Forest (Highland) has shown a similar rapid drying and shrinkage of the peat taking place around the time of canopy closure.

Samples have been taken from 194 examples of deep peat and physical and chemical analyses completed. The information is being prepared for multi-

variate statistical analysis to check and improve the system in use for classifying peatland for afforestation purposes. At first sight it appears that the vegetation types of the present classification are soundly based on a nutritional trend. More surprisingly, there may be some significant variation between deep peats on different geological formations.

D. G. PYATT

REFERENCE

PYATT, D. G., McLAREN, D. T. and CRAVEN, M. M. (1979). Physical properties of four soils at Newcastleton Forest, South Scotland. *North of England Soils Discussion Group*.

FOREST GENETICS

Testing

Pollinations

The between-provenance hybridisation programme for Lodgepole pine, which started in 1976 using single-pair matings, was continued with an additional 171 crosses between parent trees of central interior British Columbia (Burns Lake) and south coastal Washington (Long Beach) origins, 50 single-pair matings between interior Oregon (La Pine) and three south coastal origins. Plants from these and earlier crosses will be used to establish both F_1 seedling seed orchards and progeny tests on forest sites.

To provide research material for studies on the amount and importance of segregation of the F_2 generation Lodgepole pine hybrids, pollen mixtures were collected from six inter-provenance hybrid populations, and this was used for pollinating related parent trees in the same populations. The resultant families will be similar to those obtained from seeds collected from new seedling orchards.

Moderate flowering occurred in the Sitka spruce tree banks at Wauchope (Borders) and Ledmore (Tayside) and the polycross programme on previously untested clones continued; 131 clones were pollinated. In addition 32 specific crosses were made for a special study by Aberdeen University of the inheritance patterns of B-chromosomes. Many of the clones in the population study also flowered well. After ranking the clones on the basis of outstanding, average, and poor family performances for vigour, 38 crosses were made between individuals in these three groups to provide material on which to obtain reliable estimates of non-additive variance. The Scots pine polycross programme was almost completed with the pollination of an additional 119 clones.

Forest Progeny Tests

Lodgepole pine progeny testing continued with 41 families derived from single-pair matings between south coastal and north coastal American populations. These were planted on up to three sites in northern Scotland. Sitka spruce progeny tests planted on three sites compared 69 families derived from artificial crosses between 23 Sitka spruce plus trees, each pollinated with three different pollen mixtures, from Sitka spruce of probably Queen Charlotte Islands and Vancouver Island origins, and *Picea glauca*.

The computer program capable of handling the combined data from similar experiments on several sites, and which enables family \times site interactions to be examined (see 1977 *Report*, p. 25), is now used regularly for identifying the parents of superior families for seed orchard use. During the year, height data for all Sitka spruce and Scots pine half-sib progeny tests planted prior to 1975 were analysed using this program. Fifty-six out of 313 Sitka spruce and 67 out of 453 Scots pine plus trees under test, have been selected for superior vigour and low family \times site interactions. These will be further screened for superior stem form before final acceptance for inclusion in orchards and further breeding work.

Seed Production

Flowering Studies

Studies on flowering in Sitka spruce in conjunction with the Long Ashton Research Station were continued (see p. 53). The trials confirmed earlier preliminary results that GA_{4/7} mixtures were the most successful of the gibberellins tested. Mid-July was the most effective period of application; an additional application in mid-August further increased the amount of flowering. The position of the treated branches, in relation to the apex of the grafts, affected the amount and the sex of the flowers produced.

Seed Orchards

The first of a series of Lodgepole pine seedling seed orchards based on F₁ intra-specific hybrids was established at Coed Preseli (Slebech) Forest (Dyfed). The component families were derived from 60 single-pair matings between selected trees of north coastal Alaskan origins and a south coastal Washington (Long Beach) origin. A permuted neighbourhood design (see 1977 *Report*, p. 26) was used having an initial range of five unrelated neighbours in all directions. Plant espacement is 6 m \times 1.5 m. Thinning will be based on prescriptions derived from forest progeny test data aiming to leave the best 20 families. Seed from the orchards should provide planting material with improved wind-stability and more vigour than imported north coastal Lodgepole pine.

Seed Stands

Ten new seed stands totalling 67 ha were added to the National Register during the year. They included one beech and three oak stands. Six applications for registration were refused.

The National Register has been in operation since 1973 and the Genetics Branch is responsible for re-visiting each stand every five years to check the boundaries and any changes in quality caused by thinnings, windthrow or felling. During the year 54 registered stands were re-inspected and as a result sixteen stands were removed.

Biochemical Variation

Monoterpene analysis of Lodgepole pine shoot cortical resin has been used as a routine practical tool to identify the origins of doubtful or unrecorded seed sources.

The biochemical variation within and between a number of the relict indigenous stands of Scots pine in Scotland is being studied by monoterpene analysis

of shoot cortical resin and by isoenzyme analysis of the seed endosperm. This has been undertaken to provide information on genotypic variation in connection with (a) providing safe guidelines for defining sources of material satisfactory for use for replanting or extending existing native pinewoods, with minimum risk of contaminating the local genetic characteristics, and (b) for the conservation of a representative range of typical, unusual, and rare genotypes. Preliminary results from resin analysis indicate a very high degree of genetic variation within stands, and the presence of many family groups of varying sizes, composed of genotypically similar trees, within stands. Several types of variation, both clinal and locally discrete, have been found between stands, the most outstanding being the very different genotypic constitution of the north-western stands of Maree and Shieldaig, when compared with those in the more central regions of Scotland.

A small new international research group within the EEC was formed in July 1978 to prepare a joint plan for the biochemical examination of plant material from a wide range of Douglas fir origins. The Genetics Branch is represented on this group.

Data Base

The use of a computer-based data-bank to record all information on tree selection, vegetative propagation, clone banks, orchards and stages of progeny testing has been investigated. The system would include all records of seed, graft and family plant allocations and details of family, clone, orchard and seed stand performance. A trial data-base for the larch breeding programme has been mounted using the IDMS system available on the ICL 2980 computer at the Edinburgh Regional Computing Centre. From this, estimates of the time and costs of a full system for all species will be made. This work is nearing completion.

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

TREE PHYSIOLOGY

Vegetative Propagation

Grafting Sitka spruce

The leaf water potentials of adult scions grafted to juvenile rootstocks were examined in the 50 days following grafting in a greenhouse. Covering the plants with polythene bags significantly decreased water potentials in the scion from nine days after grafting and also led to an increase in the number of scions forming a union, from 31 per cent to 57 per cent. Repotting the root stocks two months prior to grafting increased the growth rate of the rootstocks but did not reduce stress in the scions nor increase the percentage of unions formed. However, it increased by 58 per cent the growth of scions in the first year and also terminal bud diameter at the end of the season.

M. R. BOWEN, M. P. COUTTS

Flower Induction

Flowering

In a preliminary trial, eight 9–10 m tall European larch trees, which had been grafted 22 years previously, were winched over in May. The roots on one side were severed close to the base over a 180° arc prior to winching. All of the trees remained alive and produced male and female strobili in the following year, with very profuse flowering on some individuals. The technique appears promising because of the accessibility of branches for the application of experimental treatments and for seed collection.

M. R. BOWEN, M. P. COUTTS

Establishment After Planting

Exposure of Sitka spruce seedlings before planting

Effects of exposure to drying conditions on survival, growth, and water relations were observed in a study related to plant handling. Two year old (1 + 1) Sitka spruce seedlings were exposed for 1–3 hours in a growthroom under mild conditions, i.e. air temperature 10°C, vapour pressure deficit 4 mb, irradiance 60 Wm² air movement 0.1 m/sec. Either the whole plant or the root or shoot were exposed, using dormant plants from cold storage and actively growing plants. After exposure the plants were potted and maintained under the growthroom conditions used during exposure, except that the temperature was raised to 15°C.

During exposure of the roots of both plant types, water moved out of the shoot into the root system, but this movement did not prevent a decrease in the water content of the fine roots, and the latter eventually collapsed. Leaf water potential (ψ_1) was reduced to about –15 bars by 3 hours of root exposure.

Dormant plants survived exposure much better than active ones. Typically, all dormant plants survived a two-hour period of root exposure, whereas only 25 per cent of the active plants survived. Root exposure reduced shoot extension of dormant and active plants. Root growth of dormant controls, which had not been exposed, began after about one week, whereas after root exposure it did not begin until after three or four weeks. In active plants, root growth stopped as a result of exposure, and was not resumed for several weeks.

Transpiration was found to have been reduced by prior root exposure in both dormant and active plants. In plants which survived the treatment, transpiration began to increase after three to six weeks, when root growth had started. In plants which eventually died, transpiration decreased steadily after planting.

Leaf water potential (ψ_1) of root-exposed dormant plants decreased to –20 to –30 bars 24 hours after planting. In plants which survived, ψ_1 then increased over a period of a few weeks, to about –10 bars, and once this lower level of stress was reached, roots began to grow. In plants which died there was no increase in ψ_1 and no root growth occurred.

In active plants, root exposure did not give rise to water stress immediately after planting. ψ_1 was about –10 bars by the end of the first light period and plants which survived maintained this level of very moderate stress, and the root system eventually resumed its growth. In active plants which died, ψ_1 began to decrease a few days after planting, and no root growth occurred.

The results suggest that plant survival does not depend on the rapid production of new roots, so much as on the plant's ability to reduce moisture stress to

a level at which roots can grow. It was clear that whole plant moisture content can provide no guide to the plant's potential for growth and survival, because the latter depends upon whether water has been lost via the shoot or the root.

M. P. COUTTS

Root Growth and Form

Root Dormancy (Plate 1)

Research on the waterlogging and droughting of Sitka spruce has demonstrated that dormant roots are more tolerant of adverse conditions than actively extending roots. Controlled environment experiments using rooted Sitka spruce cuttings growing in aerated nutrient culture showed that the naturally occurring plant growth hormone abscisic acid (ABA) reduced root elongation when applied in solution. After 10 days treatment all the main root axes of plants treated with 10^{-4} M ABA had stopped extending and were dormant. The dormancy was characterised by a superficial browning which was restricted to the cells of the cortex and progressed towards the root tip. In addition, a layer of lignified and suberised cells developed around the root apex, and the relatively impermeable layer may have a protective function.

The results of this investigation, using exogenously applied ABA, assist our understanding of root growth because the internal levels of this hormone increase during periods of environmental stress and ABA synthesis has been shown to occur in the root cap. There have been no previous reports of ABA-induced root dormancy although this hormone has been implicated in bud dormancy (Wareing, 1969).

J. J. PHILIPSON

REFERENCES

- WAREING, P. F. (1969). 'Germination and Dormancy' In *Physiology of Plant Growth and Development*. Ed. M. B. Wilkins, London, McGraw Hill, pp. 605-644.

FOREST PATHOLOGY

Fomes annosus

In an experiment where treatments were applied to the previous crop of Sitka spruce, stump removal significantly reduced the incidence of butt-rot caused by *Fomes annosus* and *Armillaria mellea* in 18-year-old trees (see Table 2). Stump

TABLE 2
BUTT-ROT INFECTION (per cent)

Treatment	<i>F. annosus</i>				<i>A. mellea</i>			
	Sitka spruce	Douglas fir	Lodgepole pine	Noble fir	Sitka spruce	Douglas fir	Lodgepole pine	Noble fir
Control	20.5	12.5	5.4	1.1	31.8	0.9	2.2	8.6
Stump Removal	2.1	2.7	0.0	0.0	5.0	0.0	0.7	0.0

treatment at time of felling with polyborchlorate or sodium arsenite failed to reduce infection. The results show that Sitka spruce is very susceptible to both *F. annosus* and *A. mellea* butt-rot. The mean vertical extent of *F. annosus* infection was 0.9 m in Sitka spruce and 0.5 m in Douglas fir.

B. J. W. GREIG

Dutch Elm Disease

Elm regeneration

Thirty plots have been established to monitor the survival of elm regeneration. In the past two years disease has increased from 5.0 per cent to 11.2 per cent, with plots in Surrey and Hampshire more severely diseased than those in the Severn Vale. Coppice shoots seem more vulnerable to infection than root suckers and many coppice stools are rapidly invaded by the Honey fungus, *Armillaria mellea*.

Elm regeneration was also assessed during the 1978 DED survey of southern England. In the 245 plots surveyed, elm less than 6 m tall was recorded in 233 plots and 85 per cent of this elm was healthy.

It must be recognised that the young elms are no more resistant to disease than the parent trees and may in time succumb to a new wave of infection.

B. J. W. GREIG

Survey 1978

The 1978 Dutch elm disease survey of southern England covered most of the area assessed in previous years, with the exception of the counties of Berkshire, Greater London Council, Hampshire, Kent, Surrey and Sussex (East and West). Estimates for the non-woodland (i.e. hedgerow and urban) elm populations of each county are contained in Table 3. Inevitably there has been a substantial increase in disease severity during the last two years. Even in the counties of Norfolk and Suffolk, where the impact of the disease has hitherto been fairly small, more than 10 per cent of the trees are now dead.

Table 4 contains an estimate of the total number of non-woodland trees that is comparable to those published in previous years. It can be seen that the total number of non-woodland trees is now down to 10 million, with 2.4 million of them being in the 'dying and recently dead' category, and 4.3 million 'long dead'. 1.8 million trees have disappeared since 1976. This is a felling rate of 900,000 trees a year, a little higher than in 1976, and shows that the clearance of dead trees is continuing, although it still lags behind the increase in disease.

The 1978 survey also included 60 plots in which woodland elm was abundant when they were last surveyed in 1972. Data from these plots has been used in the estimate of the numbers of woodland elm in Table 4. The percentage of dying and dead trees in woodland has increased from about 3 per cent in 1972 to 55 per cent in 1978. If felling is taken into account 61 per cent of the 1972 trees have succumbed to infection.

TABLE 3

ESTIMATES OF NON-WOODLAND ELM BY COUNTIES IN 1978
County boundaries as before reorganisation. Number of trees in thousands

	Proportion of the County Surveyed	Total	Dying and Recently Dead	Long Dead
Bedford	A11	300	79	215
Buckingham	A11	406	133	206
Cambridge	A11	217	58	31
Cornwall	3/10	75	31	4
Devon	4/10	387	134	30
Essex	A11	643	81	279
Glamorgan	4/10	63	29	15
Gloucester	A11	354	78	247
Hereford	A11	120	17	85
Hertford	A11	193	95	58
Huntingdon	A11	229	21	6
Leicester	A11	208	99	23
Monmouth	9/10	92	15	65
Norfolk	5/10	354	30	14
Northampton	A11	329	171	53
Oxford	A11	331	124	104
Shropshire	4/10	152	37	83
Somerset	A11	1,152	193	929
Stafford	3/10	37	10	20
E. Suffolk	A11	965	104	86
W. Suffolk	A11	387	32	15
Warwick	A11	455	190	208
Wiltshire	A11	724	214	469
Worcester	A11	92	36	47

The combined woodland and non-woodland totals are also shown in Table 4. It is calculated that out of a total of 17.1 million elms, some 10.6 million are dying or dead. Comparisons with figures for previous years suggest that about 5 million diseased trees have been felled since the start of the current epidemic in the late 1960s.

TABLE 4

DUTCH ELM DISEASE IN SOUTHERN ENGLAND
Numbers of trees in millions

	Total	Dying and Dead	Long Dead
Non-woodland	10.0	2.4	4.3
Woodland	7.1	2.1	1.8
Total	17.1	4.5	6.1

Beech Bark Disease

At Arundel Forest (West Sussex), sharp boundaries occur between soil types, producing distinct zones of nutritional chlorosis in the beech stands (Lonsdale, Pratt and Aldsworth, 1979). These sharp boundaries were used to test the hypothesis that nutrition can influence the development of beech bark disease. At three chlorotic sites the incidence of *Cryptococcus fagisuga* infestation was similar on either side of the boundary. Bark necroses were, however, more frequent in the chlorotic zones, especially at the nutritionally worst of the three sites.

During late 1976 and 1977 bark necroses and crown dieback developed on many large trees. A survey of affected trees in several counties in southern England showed that *C. fagisuga* infestation was almost invariably too light to have caused a sudden upsurge in beech bark disease. The necroses resembled those of the disease and *Nectria coccinea* was isolated from many trees. However the timing of onset of the condition and the low populations of *C. fagisuga* indicated that the factor predisposing the trees to infection was drought. A survey after the 1978 growing season showed that, although a species of *Nectria*—probably *N. coccinea*—was still present on most affected trees, few lesions had remained active and that callusing was usually present. Active attack had persisted mostly on trees with over 60 per cent crown dieback.

D. LONSDALE, J. E. PRATT

Advisory Services

Alice Holt Lodge

Six hundred and forty-three inquiries were received excluding those on Dutch elm disease.

By late May 1978, widespread browning of various evergreens was becoming increasingly apparent. In Douglas and Grand fir, yew and *Sequoia sempervirens* the damage ranged from partial browning of 1977 needles on scattered live shoots to the death of 1977 needles, buds and shoots with some browning of older needles. Similar damage occurred in 1969 (*Report for 1970*) and on circumstantial evidence it seems that, in both outbreaks, periods of unusually mild, winter weather rendered the plants liable to injury when very cold weather followed.

During the 1977–78 dormant period, many whitebeams in Eastbourne died as a result of extensive, girdling stem lesions on the lower stems. Identical damage to whitebeam was seen in 1968 and in 1973. From one stem lesion in each of these outbreaks, *Erwinia amylovora* (the Fireblight bacterium) was isolated by Ministry of Agriculture bacteriologists. The bacterium seems to have invaded the trees through uninjured stem bark and not, as usually happens, through blossoms, young shoots or wounds.

In the summer of 1978, *Phomopsis laurella*, the imperfect state of *Diaporthe nobilis* Sacc. and Speg., was found fruiting on numerous discrete, girdling bark lesions on current shoots of one Bay laurel (*Laurus nobilis*) in Hampshire and another in Wiltshire. Only one account has been found attributing pathogenicity to this fungus but in this it is suggested that the fungus kills shoots by spreading down from the tips (Grove, 1937).

In 1978 and in previous years, several instances of progressive branch dieback and the death of long, narrow bark strips were investigated on rowan (*Sorbus*

aucuparia) and rhododendrons. It has now been demonstrated experimentally that *Stereum purpureum*, the Silver leaf fungus, was responsible. The disease seems to be quite common on rowan, though seldom mentioned in the literature (Baker, 1972); and only one mention of the disease has been found on rhododendron (Cotton, 1925).

Grifola frondosa is well known as a cause of butt-rot in oak (Greig and Gulliver, 1976) but its effect on roots is never mentioned in the literature. In 1979 a large infected *Quercus robur* was excavated for us at Bedgebury Pinetum, Kent. About 5/6th of its roots had been destroyed by the fungus but no decay was evident at the butt, 45 cm above the ground. Mycelium-permeated dead bark extended several centimetres above the ground in a few places.

Further cases of *Collybia fusipes* on *Quercus robur* and *Q. borealis* provided additional evidence that this fungus is a common cause of root death and consequent crown dieback in these oaks (Report for 1978).

Hypholoma fasciculare was found in the decayed root system of a recently killed, ornamental crab (*Malus*) in circumstances suggesting that this normally saprophytic fungus was in fact the cause of death. Schell (1922) described it attacking the roots of a standing Sweet chestnut and we have in the past found it to be the apparent cause of the death of a small Pedunculate oak and of root decay in a live Sweet chestnut.

In February and March 1979, several nurseries reported damage to large numbers of one- and two-year-old *Nothofagus procera* and *N. obliqua*. Girdling lesions, probably dating from early winter, had caused dieback, often to the ground, but roots were undamaged. It is not yet clear whether winter cold was responsible or whether some living agent was involved.

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

Northern Research Station

One hundred and ninety-one enquiries were received during the year. Thirty-one of these concerned Dutch elm disease which has continued to spread in Scotland and North England. It was recorded for the first time in Ayrshire and near Invergordon in Highland Region. In the latter case a single tree, which was infected by the non-aggressive strain, showed evidence of infection having occurred as early as 1974.

The most noteworthy pathogen encountered during the year was *Brunchorstia pinea* (*Scleroderris lagerbergii*) which was found causing serious damage in a number of plantations of both Corsican pine (four cases) and Scots pine (six cases). In Harwood Forest (Northumberland) a number of 24 year-old Scots pine died as the result of breeding attacks by *Tomicus piniperda* on trees infected by *B. pinea*. A feature of the affected area was a high incidence of snow break which may have permitted a build up of both the fungus and the insect.

Twelve enquiries concerned fungal decay in standing trees. *Fomes annosus*, *Meripilus giganteus*, *Laetiporus sulphureus* were recorded but in the majority of cases the causal fungus was not determined.

Five cases of damage to conifer seedlings by *Botrytis cinerea* were investigated; all occurred in intensively raised plants, including three outbreaks in seedlings grown under polythene cloches.

Climate was the most frequent abiotic cause of injury (29 cases). Late spring frosts occurred in a number of locations in northern Britain causing severe

damage to newly flushed shoots of Sitka spruce and, in one case, foliage damage to several species of broadleaves.

Disorders related to the 1976 drought were recorded on nine occasions, mostly in *Fagus* and *Larix* species, but one case involved very large isolated Sitka spruce in west Scotland. Damage resulting from misuse of herbicides showed an increase over previous years and was encountered on seven occasions.

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

Arboriculture, Department of the Environment Contract

Decay in Amenity Trees

Results from trials on pruning wound paints indicated that bitumastic and latex products were the most successful at encouraging callus growth in both beech and lime. The ratios of wound areas occluded by callus, when protected by bitumen or latex compared with unprotected controls, increased in lime trees in the second and third seasons compared with the first season (c. 4.5 cf. c. 2.5). On the other hand, in beech the converse occurred and ratios were c. 1.5 compared with c. 2.5. Retention of the wound paint on the wound surface was considerably better for latex than for any other product but how this will affect decay development in the longer term is not yet clear. Trials have also been set up to monitor the effect of black plastic sheet on growth of callus and the prevention of decay. Laboratory work has indicated possible useful agents of biological control of decay in pruning wounds and field trials have been set up to examine the effects of inocula of *Trichoderma viride*, *Cryptosporiopsis fasciculata*, *Fusarium lateritium* and a *Bacillus* sp.

Laboratory and field trials have suggested that much of the tree's response to wounding occurs very quickly and the early stages of colonisation of pruning wounds and the effects of chemicals on them are being studied.

P. C. MERCER

REFERENCES

- BAKER, J. J. (1972). Report on diseases of cultivated plants in England and Wales for the years 1957–1968. *MAFF Technical Bulletin* 25, 195.
- COTTON, A. D. (1925). On the occurrence of the Silver leaf fungus in rhododendrons. *Gardeners Chronicle* 77, (1990), 112.
- GREIG, B. J. W. and GULLIVER, C. C. (1976). Decays in oaks in the Forest of Dean. *Journal of Forestry* 3, 157–159.
- GROVE, W. B. (1937). *British Stem and Leaf-Fungi*. Vol. 1, 195–6. Cambridge Univ. Press.
- LONSDALE, D., PRATT, J. E. and ALDSWORTH, F. G. (1979). Beech bark disease and archaeological crop marks. *Nature* 277, (5695), 414.
- SHELL, E. (1922). Diseases of the French chestnut tree—particularly the 'Ink Malady'. *Journal of American Leather Chemists' Association* 17, (7), 353–359.

FOREST ENTOMOLOGY

Population Studies*The Pine Beauty Moth, Panolis flammea*

In late summer 1978 further outbreaks were reported. Thirty ha were totally defoliated in Torrachilty Forest (Highland) and 50 ha were similarly affected in Bareagle Forest (Dumfries and Galloway). These outbreaks made it clear that Lodgepole pine in any part of Britain should be regarded as 'at risk' but also provided further evidence that, on experience to date, outbreaks are initiated only in Lodgepole pine on deep unflushed peat sites. Consequently pupal surveys were extended, from the original outbreak area of Caithness and Sutherland, to all significant areas of Lodgepole pine of susceptible age (about P70 or older) growing on such sites. The results indicated the need to spray up to 3,500 ha in 1979.

Pupal surveys, which are carried out by forest staff, are laborious even with intensity of sampling kept to the barest minimum. Monitoring of male flight activity by the use of female sex attractant pheromones offers the possibility of reducing the need for pupal surveys. At the end of the year plans were made for field experiments to be carried out by the Chemical Entomology Unit of Southampton University and by Commission Research Staff, using pheromone traps and materials supplied by a research team in West Germany.

J. T. STOAKLEY

The Pine Looper Moth, Bupalus piniaria

Pupal numbers in the 48 units sampled throughout the country during the winter of 1978/79 were low and only seven units recorded small increases. In 1977/78, Cannock produced the highest compartment mean with 34.8 pupae per m² and, this year, is again the highest but with only 5.6 per m².

Numbers of Pine beauty moth (*Panolis flammea*) pupae in the samples were very low, the largest mean being 1.2 per m² recorded at Delamere. A separate survey of *P. flammea* at Flanders Moss in Achray Forest (Central) found large numbers of Pine looper pupae.

R. M. BROWN

The Web-Spinning Larch Sawfly, Cephalcia lariciphila

The area of larch defoliated by this pest has continued to increase at the majority of forests affected, the largest increases were in South Wales. One exception was Rheola Forest (West and Mid Glamorgan) where the area defoliated in 1978 fell from 517 ha in 1977 to 306 ha. It is thought that the parasite *Olesicampe monticola* has largely contributed to this decline.

One new infestation was found in 1978 at Hafren Forest (Powys). Approximately 19 ha of larch were defoliated, though the sawfly was found to be widespread at lower population levels.

Tree deaths have been noted at several infestations and clear felling became necessary at Mortimer Forest (Salop, Hereford and Worcester).

The Unit of Invertebrate Virology, Oxford, found picorna viruses in six out of the seven infestations sampled in 1978. The Unit is continuing to search for an effective epizootic of *C. lariciphila*.

D. J. BILLANY

Host Plant Susceptibility

Insects and Lime Nectar

The nectar of 10 species of Lime (*Tilia*) flowers has been sampled during 1978 to identify those species which may produce excessive concentrations of certain sugars reputed to be toxic to honeybees. The sugars common to all lime flowers were fructose and glucose, but sucrose, although abundant in some, was not always present. Galactose, maltose and three distinct oligosaccharides were present in varying concentrations. The sugar composition of three named hybrids was quite different to that of their parent species.

C. I. CARTER, M. R. JUKES, MISS J. F. A. NICHOLS

Biological Control

Cephalcia lariciphila

All the *C. lariciphila* infestations in South Wales were sampled systematically at the overwintering stage for the presence of parasites. *Olesicampe monticola* was the only parasite found. In 1976 at Mortimer Forest (Salop, Hereford and Worcester) *O. monticola* was introduced into the *C. lariciphila* infestation. It has subsequently become established and 30 per cent parasitism found.

D. J. BILLANY

Cephalcia lariciphila—Pheromone Response and Sexual Behaviour

Studies continued in conjunction with the Chemical Entomology Unit, Southampton University, to investigate the chemical communication system of *C. lariciphila* and identify the pheromones present. Data obtained from Gas-chromatographic and Mass spectroscopic studies carried out on extracts of virgin female *C. lariciphila* suggest that the pheromones are acetates. It is hoped that synthetic samples will be available for testing in the field during 1979/80.

The host-finding ability of the parasite of *C. lariciphila*, *Olesicampe monticola* was also investigated. Experiments showed that the parasite is attracted to the odours of the host plant and the larval frass of *C. lariciphila*.

D. J. BILLANY

Gilpinia hercyniae

The Commonwealth Institute of Biological Control sent a further consignment of parasites specific to *G. hercyniae* larvae (see 1978 *Report*). Extremely low sawfly densities were encountered in the European collecting areas and only 550 cocoons were received. Releases of these were made at Rheidol Forest (Dyfed) and Coed Sarnau Forest (Powys) against natural populations of *G. hercyniae* which were also at a low population level.

D. J. BILLANY, C. I. CARTER

Chemical Control

The Pine Beauty Moth, Panolis flammea

Pupal surveys in autumn 1977 indicated the need to spray eighteen forest blocks (including two in private ownership) during the following season in order to prevent severe defoliation, which has been found to lead inevitably to death of

crops. The organophosphorus insecticide fenitrothion was selected and on advice from Professor R. J. V. Joyce, College of Aeronautics, Cranfield Institute of Technology, it was proposed to use a target-specific Ultra Low Volume method of aerial application. Although well-known abroad there was no previous experience of this method in Britain and clearance under the Pesticides Safety Precautions Scheme was given for only about one-third of the area to be treated at ULV. The remainder was treated at a conventional Low Volume rate of application. Spraying of a total area of 4,800 ha was carried out in June 1978 and effects on the human and natural environment were monitored by a number of official agencies. All aspects of the operation are included in a report (Holden and Bevan, 1979) prepared for the authorities responsible for the PSPS. All the indications are that ULV application is potentially cheaper, certainly very much more convenient for large operations and generally has significantly less impact on the environment than does application at LV. Therefore considerable emphasis is being placed on the further development of the ULV technique in conjunction with the College of Aeronautics at Cranfield and others who can make a scientific contribution to environmental aspects.

Further spraying will be necessary in June 1979 (see Population Studies) and much of the latter part of the year has been taken up with planning this operation.

J. T. STOKLEY

Hylobius abietis

The three field trials (*Reports* for 1977, 1978) testing the systemic organophosphorus insecticide phorate, were completed in 1978. These show that phorate gives good control of *H. abietis* for two full summers and for a third summer where tree growth is slow. The two rates of 0.5 and 0.75 gram ai per plant did not differ significantly in their performance, though the higher rate was marginally better. Effects of these treatments on growth of Sitka spruce are yet to be fully evaluated.

C. J. KING, S. G. HERITAGE

Control of Ips typographus in Imported Ladder Poles

A commercial scale fumigation, using methyl bromide, on imported ladder poles was tested during February 1979. To evaluate the efficacy of this gas on overwintering Scolytid larvae, broods of elm bark beetles (*Scolytus scolytus* and *S. multistriatus*) in elm billets were used to bioassay the treatment. This failed to achieve any measurable control of the insects which completed normal metamorphosis when incubated.

C. J. KING

Elm Scolytids

Field Attraction of Scolytus scolytus (F.)

The attraction of *Scolytus scolytus* (F.) to the four enantiomers of 4-methyl-3-heptanol, the major component of the aggregation pheromone, was studied in the field. Only the (—) threo isomer attracted significantly more beetles than the blank (control), and the response to this isomer was not significantly different from the response to commercial 4-methyl-3-heptanol, which contains all four isomers. There was no evidence for inhibition of attraction by the other three

isomers. Commercial 4-methyl-3-heptanol could therefore be used, in combination with other components of the aggregation pheromone, for population sampling and control by mass trapping of *S. scolytus*.

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

Conifer Lachnids

Information from biological studies and enquiries on conifer lachnids and their economic importance is being compiled for a forthcoming publication. The records collected clearly indicate a gradual increase in the variety of species present. Of the 27 species that have been identified from Britain, less than half can be native on account of their feeding either on Scots pine or juniper. The remainder have arrived since their host plants, either grown as ornamentals or commercial crops, have become widely planted.

C. I. CARTER

Advisory Services

At Alice Holt 80 enquiries were received from Forestry Commission staff and 50 at the Northern Research Station. The number of private enquiries received at Alice Holt was 175 while at the Northern Research Station there were 56.

REFERENCE

HOLDEN, A. V. and BEVAN, D. (editors) (1979). *Control of Pine Beauty Moth by Fenitrothion in Scotland*, 1978. Forestry Commission, Edinburgh.

WILDLIFE MANAGEMENT

Management of Deer, Squirrels and Other Mammals

Monitoring red deer reproductive performance in relation to age and growth over a range of forests continues. A system of relating these and other population variables to different forest structures is being established. Preliminary investigation of use by red deer of forests has confirmed that highly favoured sites can be identified prior to afforestation or re-stocking and should be incorporated in deer management to assist control. A method of using forest inventory data to predict interaction of red or roe deer with their forest environments is being tested.

A survey of the use of warfarin poison in forests showed the numbers of hoppers in use and the amount of poison distributed had increased from 1973 to 1977 but appeared to be levelling off. Crops in which poison was most commonly used were poor habitats for bank voles. Woodmice were only common in autumn and winter when warfarin poison is not put out for squirrel control. Material continued to be provided for the Ministry of Agriculture investigation of the relative susceptibility of avian and mammalian predators to warfarin-poisoned prey. A small proportion of squirrels resistant to a repeated dose of warfarin and diphacinone was identified in laboratory trials.

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

Damage Assessment and Evaluation

Damage surveys looked at the impact of red and roe damage in the red deer range in north and west Scotland, at the impact of roe deer in lowland forests and at the susceptibility of tree crops in the Chilterns to grey squirrels. Work on the responses of individual trees to the forms of damage most commonly encountered was begun. Comparison of *Nothofagus procera* with birch, oak, beech and *N. obliqua* suggested that *procera* was less susceptible to winter and summer roe browsing damage than the other four species.

The five-year Mammal/Bird/Damage Questionnaire for 1978 has resulted in a series of 10 Km maps showing the presence of a variety of mammals and birds in relation to Commission woodlands.

Chemical and Mechanical Repellants

Bio-degradable individual tree-guards have given satisfactory protection against rabbits, deer and horses. Big Game Repellent was the only chemical repellent to be tried and this failed to prevent significant roe and fallow deer browsing, although it has performed satisfactorily against deer in America.

Wildlife Management Techniques

Methods of evaluating glades, shade and ride alignment with water courses are under trial.

Research Advisory Committee Visiting Group

Dr J. D. Lockie and Dr I. Newton reviewed the work of the Wildlife Branch with particular reference to the research methods and approach to the work undertaken.

J. J. ROWE

ENGINEERING SERVICES

Design and Manufacture of Equipment

A measuring machine was built to measure such items as the radial distance between the annual rings of discs cut from trees. The machine consists of a linear table with electronic digitiser and a stereo projector microscope. The output from the digitiser is in the form of a visual display and can also be paper printout and computer compatible tape. This model, built initially for Entomology, will reduce the time spent examining tree discs etc.

The Crossbow technique, mentioned in last year's *Report*, has been tested as an aid to tree climbing. A line is fired over a suitable branch before the climber leaves the ground. In conjunction with Silviculture and Education and Training Branches a prototype system has been tried that should enable trees up to approximately 20 metres to be climbed quickly and safely. Details are being published later.

Maintenance of Electro-Mechanical Services

The audio-visual unit at Westonbirt (Gloucestershire) was modified to enable programmes to be made locally. A considerable amount of measuring equipment has been built this year, including 14 sets of height rods, shoot samplers etc.

Maintenance of Existing Equipment

One Polytunnel was completely rewired during the year. Aspirated screens were installed in two bays of the Cambridge greenhouse and one Polytunnel.

Engraving Service

The engraving machine supplied to Westonbirt has reduced the engraving work load to acceptable levels.

R. E. STICKLAND

FIELD SURVEYS BRANCH**FIELD & SITE SURVEYS SECTION**

These sections were integrated at the beginning of the year. All surveys are now under the supervision of Surveys Officers (North) and (South).

Surveys*Forest Inventory Surveys*

During the year, in Scotland and the Borders, surveys were completed in six forests, comprising a gross area of 52,173 ha (29,558 ha planted). Surveys are in hand in a further 10 forests extending to a gross area of 90,570 ha (47,887 ha planted) at the end of the year.

In England and Wales surveys were completed in 15 forests with a gross area of 49,662 ha (43,672 ha planted). In further eight forests, gross area 21,703 ha (20,935 ha planted), surveys were still in progress.

This rate of progress represents an output of some 3,200 ha per man year and in general shows significant progress towards an acceptable cycle of survey for the forest estate.

Site Surveys

In Scotland, full surveys were completed in 7,000 ha of established forests and in 5,500 ha of plantable reserves. Reconnaissance surveys for windthrow hazard classification were completed over 15,000 ha. In England and Wales full surveys were completed on 6,700 ha with reconnaissance surveys completed for a further 20,000 ha of plantations.

The four full-time surveyors were reinforced during the summer months by soil science and forestry students on vacation work.

Computer Data Base

During the year, the data base was updated for the two years to 31 March 1978 and preparations for the March 1979 update are well in hand.

Other work was principally the consolidation and improvement of the system. Development of the full potential of the data base as a management tool is receiving active consideration. Much time was also spent in advisory work and on the improvement of the production forecasting programmes.

Other Projects

A limited survey for Dutch elm disease was completed for Pathology Branch.

An investigation into the improved growth rates of plantations in South Scotland Conservancy due to fertiliser treatments is in progress.

Surveys Officer (North), Mr Locke, performed various services for Headquarters Divisions including draft answers for Parliamentary Questions, the preparation of maps and data for the Department of Agriculture and Fisheries for Scotland and updating Forestry Commission and Private Woodlands data for Planning and Economics Division and for various FAO and EEC returns.

CENSUS SECTION

Planning for the 1979–82 Census progressed towards the end of the year with the appointment of the Census Officer and one additional Head Forester in late autumn. The survey team of 13 surveyors was recruited from amongst University geography and ecology graduates who were approaching the conclusion of their training programme at the end of the year.

MENSURATION SECTION

The creation of a detailed sample plot data base occupied one-third of staff time and should be completed during the coming year.

The NERC studentship has now been running for 18 months and a practical individual tree growth model has been constructed. During the final half of the project, refinement of the model should be completed. This is expected to make a substantial contribution to the solution of general modelling problems.

The section has dealt with some 250 field enquiries in addition to volume and assortment investigations. Studies of the effect of fertilisers on tree form and forest growth are in hand.

Monitoring developments in computer hardware continues. Recent results in the field have been the introduction of portable data terminals for the Census and for use by Silviculture Branch and the acquisition of editing floppy disc units for data handling, listing and summarising for use by Mensuration Section and the Census.

DRAWING OFFICE

Air photo interpretation work and air plotting is developing satisfactorily.

A new map style, incorporating a clearer map base, better line definition and road depiction has been developed and introduced.

Photographic map processing has increased considerably but staffing and accommodation problems have prevented the achievement of optimum value from the equipment.

The increased rate of survey and the need to undertake a number of special projects has put the Drawing Office under great pressure with the consequence that a considerable backlog of work to be completed has built up.

K. P. THALLON

WORK STUDY

Forest Management: Method Study

Trials of the Dondi rotary ditcher were successful on mainly peat sites using a wheeled tractor, fitted with Finn Tracks, as the power unit.

An evaluation was made of the Massey-Ferguson D400C ploughing tractor. This machine performed well on hard ground but was unsuitable on soft ground or for mounted tine work.

The lightweight plough designed for North Scotland Conservancy was given extensive trials on very soft peat in Caithness where it was most effective.

There was further work on the rotary mouldboard plough which is now ready for initial field trials.

Forest Management: Servicing and Continuous Review

Field trials of the Herbi controlled drop applicator, modified to produce a measured dose, for spot treatment were very encouraging and an extended programme of trials are planned. The benefits in terms of ease of application and reduced chemical quantities are significant.

Work continued with the Lockinge-Ulvamast tractor-mounted, controlled drop applicator which was modified to give a placed or a drift spray. This technique has been successfully applied to lowland grass control but a possible extension of its application to upland heather control is under review.

A project to determine viable alternatives to the Husqvarna 165R clearing saw yielded only the Stihl FS 410 AV on which trials are currently in progress.

Several tractor powered, mechanical weeding machines were examined and work on the Scrubmaster 66 Scrubcutter and the Shaw weeding flail was completed. The introduction of a front power take-off (PTO) on the new Holder tractor has major implications and its effect will be determined.

Forest Management: Work Measurement

Studies have been carried out nationally with a view to producing a Standard Time Table for restocking.

An Output Guide for ploughing with the Challenger 33 and twin-tined plough in East Scotland Conservancy was published.

Harvesting and Marketing: Method Study

Further evaluation of the Sifer SS103 processor was carried out and certain modifications were made to the machine. A review of the system of working the processor was also undertaken. The main disadvantage of the machine is its limited terrain capability and a project to provide an improved base unit from R. & D. Workshops is underway.

A Sifer forwarder (KF40) was also made available for trials. It had many advantages but its relatively small wheels and poor ground clearance limit its application. Initial trials with the Mini Bruunett 578F forwarder are encouraging.

A trial of two County 754 tractors converted to 'Short' Falstone skidders was unfavourable but the adaptation of the mechanical winches for radio control was a successful result of the trials.

Modification of a Massey-Ferguson 1200 by R. & D. Workshops to produce a low-priced, high-powered skidder was undertaken and the machine is currently on initial field trial (Plate 3).

Work was completed with a Holder A55F fitted with a Hydrallogger and recommendations for modifications made.

Wheel chains were tested on a Holder A55 skidder and definite advantages were noted on slopes in excess of 17 per cent.

Other work included a review of a small Danish processor, Stripper II, which because of its size has a very restricted application and an evaluation of the Husqvarna SP30 processor on a Gremo TT12C forwarder base.

Work on Brandon Central Depot in East England Conservancy was completed and a final report containing the specification for a new structure was drawn up. In Brandon Depot and adjoining forests, trials of the Bray and Volvo 4300 front end loaders continued.

A national survey of choking techniques was undertaken and a report produced. A critical examination of aid tools available to harvesting operators was carried out.

A pilot trial classifying cable logging areas into appropriate cable system types, based on aerial photographs, took place, but the results did not offer sufficient correlation for this technique to be recommended on its own.

Harvesting and Marketing: Servicing and Continuous Review

A new chainsaw guide bar sprocket nose manufactured by Oregon called Guard Tip incorporating an asymmetric shape was examined. Some small loss of performance is offset by a marked reduction in kickback risk.

Oregon also introduced a Super Guard chain which also greatly reduces the danger of kickback. This was recommended following trials.

Two chainsaws were tested for noise and vibration under a new test procedure and the Husqvarna 340SG was added to the approved list.

An examination of cable crane systems including modifications where necessary is ongoing.

Many general enquiries regarding harvesting techniques and outputs were examined and advice given.

Harvesting and Marketing: Work Measurement

Standard Time Tables for Corsican pine and Scots pine clearfelling, Sifer processing, and felling for Sifer processing were issued.

Forest Authority

The use of the Rapco data collector has been extended and Time Study instructions for several activities were revised. A computer based data bank has been started.

Safety

Safety clothing for herbicide spraying and fire-fighting has been examined. This enabled firm recommendations to be made regarding the form and material of protective clothing.

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

An ongoing review of examination techniques relating to noise and vibration has been undertaken.

Training

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

A. J. G. HUGHES

STATISTICS AND COMPUTING

Data Preparation and Computing

Punching of the older sample plot data at the PMA bureau, Horley, has been completed. Validation and correction of these files continued as the largest task of the year. Towards the end of the year the IBM 1130 at Alice Holt was connected via a private line and 2400 baud modems to the Rutherford High Energy Laboratory and some sample plot files have been loaded via this link.

Increasing use has been made of the ICL 2980 computer at the Bush Estate and all files that were kept on the IBM machines at Newcastle have been transferred to it.

Statistical Service to Research and Development Projects

Advice on experiment and survey design, analysis and the interpretation of results continued to take up most of the statisticians' time. Special mention can be made of cross-sites analyses in progeny and provenance trials and of the development of sampling schemes for the new national census of trees and woodlands. Dr F. McNaughton and Mr R. Henderson, lecturers on loan from Napier Technical College, greatly helped the northern section by examining aspects of damage by deer and by *Panolis flammea*.

Statistical Service to External Units

Advice and assistance was given to Planning and Economics Division with linear programming and with smoothing techniques for the tabulation of thinning effects in mixed crops. The predictive value of pre-training tests was examined for Education and Training Branch.

Programming Service, General

Work continued on the revision of the major programs of the crop data base. Further programs were written to allow forest files to be split and recombined easily, and to allow the selection of subcompartments on any data field.

Using the IDMS package, work has continued on the integrated data base for tree breeding. A pilot scheme has been mounted for larch and several application programs have been run to estimate costs.

Programming Service, Mathematical/Statistical/Technical

A manual for the seed orchard design program (see 1978 *Report*) was produced and is available for enquirers (from the Northern Research Station). Part of this was produced by using the ERCC 'Layout' software package.

Among the programs written for the Census of Woodlands was one to calculate the total area of woodlands for a county using a laser digitisation of a green pressing of the 1:50,000 Ordnance Survey map and the known true area of woodlands in a sample of the land area.

Statistical, Mathematical and Computing Methods

Theoretical work on planar competition processes and on a time-series model of borehole water levels has continued. The problems of analysing monoterpene proportions where correlations are affected by the constraint that components total to 100 per cent has been given some attention.

Some of the techniques of structured programming are being adopted to lead to more readable, reliable and adaptable programs.

Data Capture and Associated Computing

At the Northern Research Station a Ferranti Freescan digitiser has been used to trace outlines of cross-cut tree discs and of *Fomes annosus* infection in them. Programs were written to estimate infected areas and to draw 3-D views of the tree trunks.

At Alice Holt, Arnell and Patterson Ltd linked a teletype to the stem analysis machine developed by Engineering Services Branch to produce a record of ring measurements on paper-tape. A suite of programs was written to edit the output and to calculate annual volume increments of individual trees.

Programs have been written to accept data from assessments recorded on MSI hand-held terminals and to produce hardcopy of the data and plot summaries for further analysis.

D. H. STEWART, R. S. HOWELL

COMMUNICATIONS

RESEARCH INFORMATION

Library

One hundred and eighty-six new books were acquired and subscriptions were taken out for nine new journals. Loans from library stock were 5,069 with a further 858 items borrowed from other libraries. A precise check revealed that 2,452 photocopies were provided instead of loans. This means that the total number of loan requests satisfactorily dealt with has risen to 8,379, three times the number dealt with ten years ago. This greater use of the library is reflected by an increase in the number of staff visits to the reading room (now 27 per day compared with 15 in 1974) and in the number of outside non-FC library visitors (averaging 2.5 per day against 1.5 in 1974).

In addition approximately 700 information enquiries, often requiring considerable searching are dealt with annually.

Visitors

The section was again responsible for the over-all organisation and arrangements for the three Open Days. Past experience and excellent co-operation by all members of staff ensured a smooth running event, a high level of presentation, and large attendance that was very appreciative of all that it saw.

PHOTOGRAPHY

Advisory Services

Audio Visual Aid

Diazo colour films have been used to produce projection transparencies for lecture purposes in a range of image colours—blue has proved to be the most popular background colour. Not only can they be made more quickly than the conventional black and white slides but, because of reduced glare, they are more acceptable to audiences and ‘blend’ more easily into a mixed pictorial/data presentation.

Initially, processing was done in a fume cupboard in the Entomology laboratory but this was inconvenient to both parties. The use of commercially available processors was considered and one was tested under normal working conditions. The results were variable, lacking colour saturation, and there was some slight escape of ammonia fumes.

Mr Jukes (Entomology Branch) suggested a very simple solution to the processing problem and built a prototype processor which has now been in use in the photography darkrooms for some time giving consistent and trouble free results (Plate 4).

Aerial Photography

The new twin-camera installation mentioned in last year’s *Report* was developed together with a remote control system. Though successful, its use was restricted by the construction of the baggage door. Structural considerations limited the size of the aperture which could be cut in the door. This meant that the full range of focal lengths of lens which were considered desirable could not be used.

It is now proposed that the mount should go into a main door where there will be no such limitations.

I. A. ANDERSON

PUBLICATIONS

Twenty-three titles were published during the year; sixteen by the Stationery Office included three prepared for the Department of the Environment and revision of two Booklets.

Reports

- Fifty-eighth Annual Report of the Forestry Commissioners, 1977–78 (£2·50).
- Report on Forest Research 1978 (£2·25).

Bulletin

- No. 14. Forestry Practice, edited by O. N. Blatchford (£3·50).

Booklets

- No. 44. The Landscape of Forests and Woods, by Dame Sylvia Crowe (£3·50).
- No. 46. Managing Small Woodlands, edited by R. E. Crowther (90p).

Forest Records

- No. 116. The EEC Plant Health Directive and British Forestry, by D. H. Phillips (70p).
 No. 117. *Gilpinia hercyniae*—a Pest of Spruce, by D. J. Billany (50p).
 No. 118. Woodland Mice, by J. Gurnell (70p).
 No. 119. The Pine Looper Moth, by D. Bevan and R. M. Brown (50p).

Leaflets

- No. 70. Forest Ploughs, by D. A. Thompson (60p).
 No. 73. Chemical Repellants, by H. W. Pepper (35p).

Research and Development Papers

- No. 119. The Health and Safety of Forest Workers, by D. A. Bardy.
 No. 120. The Training, Motivation and Social Promotion of Forest Workers, by J. F. Goodwin.
 No. 121. The Assessment of the Forest Resource Base, by G. J. Francis.
 No. 122. Genotype/Site Interaction in Tree Breeding, by R. C. B. Johnstone and C. J. A. Samuel.
 No. 123. Research Aspects in Forestry for Quality of Life, by G. D. Holmes.
 No. 124. The Impact of Forestry on Recreation, by C. Bancroft.

These six papers were prepared by the Forestry Commission for the 8th World Forestry Congress held in Jakarta, Indonesia.

Arboricultural Leaflets

The Stationery Office also published for the Department of the Environment the following leaflets which have been prepared by the Forestry Commission in connection with the continuing arboricultural research programme:

- No. 2. Honey Fungus, by C. W. T. Young (70p).
 No. 3. Sooty Bark Disease of Sycamore, by B. J. W. Greig and R. G. Strouts (40p).
 No. 4. Virus and Virus-like Diseases of Trees, by J. I. Cooper (70p).

Other Publications

The Catalogue of Publications was revised. In addition revisions of Booklets 26 and 38 were prepared and published.

K. W. WILSON

OTHER HEADQUARTER DIVISIONS**PLANNING AND ECONOMICS****Forest Policy***Multipliers*

Following earlier work on multipliers (see 1977 *Report*, p. 48), the literature on assessment of multipliers has been surveyed with the aim of identifying the particular type of multiplier considered and the variation in values found. The

review emphasises the need for care in reporting multiplier values. In particular, it is essential to distinguish the output multiplier (change in total regional output resulting from unit change in final demand for a particular sector's output) from various kinds of income multiplier (notably, that defined as the change in regional household income resulting from unit change in final demand for the sector's output).

Resource Costs of Labour and Land

An important consideration in assessing the benefit to society of an investment concerns the estimation of the opportunity cost of the factors of production employed, that is, the benefit foregone by not employing labour or land in the best alternative use. One approach to determining the resource cost of labour is to try to find out directly the sources of labour recruited by a particular enterprise, such as the Forestry Commission, and the likely effects of that recruitment on the enterprises from which labour has moved. Interviews with forest managers show that this method has marked limitations owing to uncertainty about the 'knock-on' effect on the industries from which labour may have been recruited. However, the evidence gathered suggests that there are substantial differences in the implied opportunity cost of labour recruited by the Forestry Commission in different areas and for different skills of worker, and that the opportunity cost may in general be somewhat higher than had previously been thought. The assessment of the opportunity cost of land acquired for afforestation is in principle rather simpler, the effects of a change in the use of a particular area of land being usually limited to activity on the hectares concerned, and the consequential effects of displacement of the particular land use smaller. Work has concentrated on the assessment of trends in factor use and output per hectare using resource costs in the best alternative use of the land, namely sheep farming. These assessments are aimed to provide a basis for projecting gross output and costs prior to capitalising the resulting net income stream and thus estimating the resource cost of the land.

A. J. GRAYSON

Guides to Management

Thinning

A major revision has been undertaken of current guides to economic appraisal. Particular effort has been devoted to the question of timing of thinning. Discounted revenue has been calculated for different ages of first thinning, assuming that the marginal tree size (that is the size at which standing value is first positive) is about 12 cm diameter or approximately 0.05 cubic metres. Leaving aside the implications of windthrow (see 1978 *Report*, pp. 50–51),⁽¹⁾ it is found that the maximum value of discounted revenue at 5 per cent is obtained for most species and yield classes when thinning starts at an age about 5 years later than that indicated in the Forestry Commission Management Tables (*Forestry Commission Booklet* No. 34). Where, as is usually the case in upland afforestation, roads have to be built in order to extract the thinnings the most profitable age for thinning, before considering windthrow risk, is even further delayed.

(1) Editor's Note: The legend on the horizontal axis of Figure 4 on p. 50 of the 1978 *Report* should read 'Yield Class'.

Fertilising

Until further direct evidence is available on response to fertiliser applications in terms of volume and wood quality, it is necessary for investment appraisal purposes to adopt a measure which gives a good approximation to the gain in revenue following a particular treatment. The increase in top height obtained over the life of the treated crop provides such a measure. This approach assumes that once the response to a particular fertiliser treatment is complete, the gain in height over the untreated crop will be retained throughout the life of the treated crop. Given an assessment of this increase in height, it is possible to assess the change in Yield Class (YC) over the life of the crop and hence the revenue increase. For example, the Forest Management Tables show for Sitka spruce at a felling age of, say, 55 years, top heights of 20·2 m and 22·7 m for YC10 and 12 respectively, a difference of 250 cm. Hence if an increase in top height of 100 cm is expected in a YC10 Sitka spruce crop as a result of a fertiliser application carried out several years earlier (that is there is now no further response), the gain in discounted revenue can be assessed sufficiently precisely taking 100/250 or 0·4 of the difference in discounted revenue between YC10 and 12.

R. J. N. BUSBY, M. F. GARFORTH, A. J. GRAYSON

Recreation

Survey of Visitors to Queen Elizabeth Country Park, South East England Conservancy

Advice was given on the planning of a survey conducted at Queen Elizabeth Country Park in Hampshire, a joint venture of the Forestry Commission and Hampshire County Council. The survey consisted of 1,300 short interviews administered to drivers of cars as they were about to leave the Park Centre Car Park. Interviewing took place during 142 one-hour randomly chosen periods in the year ended 31 October 1978.

Analysis of the results gave an estimate of 130,000 visits during the 12 months of the survey. Over half the visitors came from the Portsmouth conurbation which lies within 15 miles to the south west of the Country Park. Information collected on the towns where people came from is of potential value as a basis for establishing a relationship between visit rate and distance. More than half the visits were for a second or subsequent time, more than a quarter for a sixth or subsequent time. Average length of stay of those stopping at the Park Centre Car Park was 2·3 hours. As might be expected, the more frequent visitors were less inclined to enter the visitor centre.

R. Q. OAKES

HARVESTING AND MARKETING

Telegraph and Power Transmission Poles

The joint project with the Electricity Council under which attempts are being made to increase the permeability of spruce poles to wood preservatives continued.

At a yard in Gloucestershire, 120 Norway and Sitka spruce poles were sprayed with water from a local well to induce bacterial activity over a period of

107 days from early April to mid-July. At the same time a further 20 Sitka spruce poles were placed in a pond in the Forest of Dean.

The level of bacterial activity and the changes in permeability in the poles was monitored by the Biodeterioration Information Centre at Aston University. The results which are given in Figure 1 show that during the cold spring of 1978 the bacteria counts remained low until June, after which a peak in the population

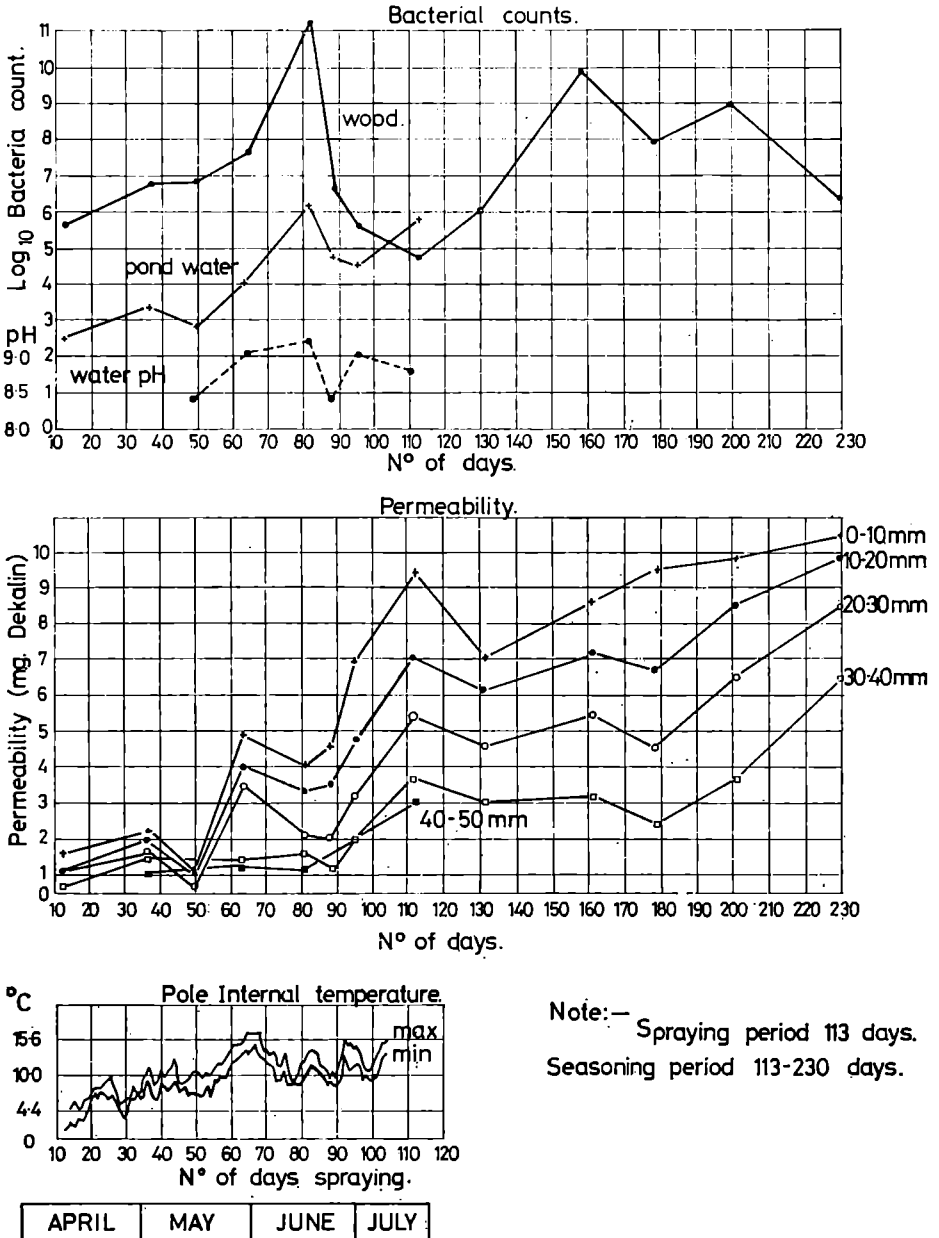


Figure 1: Home-grown poles—bacteria permeability and temperature graphs.

was reached; and, in the following month, the permeability of the poles, as indicated by the absorption of decalin, increased significantly. However, subsequent trials in which creosote was applied under pressure have, so far, been disappointing in that the minimum radial penetration seldom exceeded 10 mm. This is thought to be largely a result of the slow rate of drying in the poles, and the problem is now being examined further.

The first major sale of British-grown Scots pine poles to an Electricity Area Supply Board, for many years, was effected; and the Post Office added Corsican pine to the list of species acceptable for telegraph poles.

The Utilisation of Bark

There was a notable increase in the sale of bark for equestrian uses, such as gallops, dressage and jumping arenas, and a new company entered the field to market it for these purposes. For all uses, by the end of the year, about one dozen organisations were marketing bark from seventeen production units. However, much bark in Scotland remains un-utilised.

J. R. AARON

PART II

Work done for the Forestry Commission by Other Agencies

FOREST SOILS

NUTRITION AND FOREST SOILS

By H. G. MILLER

The Macaulay Institute for Soil Research, Aberdeen

Investigations into the relationship between tree growth and nutrient cycling in closed-canopy crops of Sitka spruce continue (*Report for 1973*). In the two oldest experiments growth responded both to nitrogen fertiliser, an effect that disappeared in the presence of phosphorus, and to high rates of phosphorus and potassium when applied together (*Report for 1978*). This pattern has also appeared after four years at Kershope (Cumbria) and is weakly developed, but not significant, in the five-year response at Strathyre (Central). The five-year response at Elibank (Border), however, is very different (Figure 2), responses

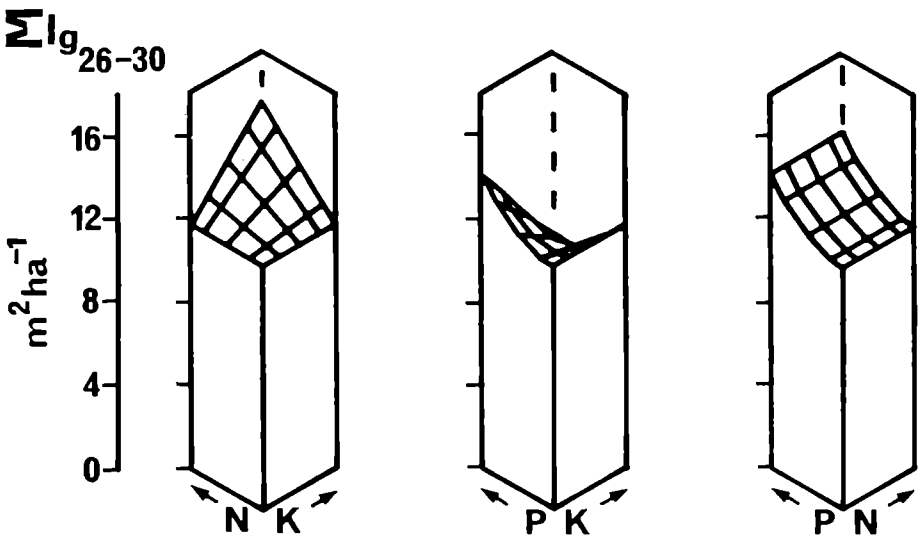


Figure 2: Response surfaces fitted to five years' basal area growth at Elibank ($r = 0.62$, $P < 0.05$). Rates of application were 0, 78, 200, 322 and 400 kg N/ha, 0, 39, 100, 161 and 200 kg P/ha and 0, 58, 150, 242 and 300 kg K/ha.

being to phosphorus alone or to nitrogen and potassium when applied together, and a somewhat similar pattern appears to be developing after three years at Kilmichael (Strathclyde). The variations in response between experiments suggest that careful attention should be given to the effects of nutrient interactions. These are now being investigated in the glasshouse where a preliminary series of experiments, using peat substrate, has suggested remarkably good agreement between the results obtained using only 23 pots in a central composite rotatable design (the design used for the field experiments) and the results from 192 pots in a full factorial design. Accordingly, the central composite rotatable

design is now being used to investigate growth and nutrient uptake in pots of humus taken from each of the six experimental sites.

Models of the cycle of nutrients based upon the results from the study of Corsican pine at Culbin (Grampian) emphasise the important role of inputs from the atmosphere in rain, aerosols and dust, particularly for elements such as potassium and magnesium (Miller *et al.*, 1979). These inputs, therefore, continue to be determined in the new experiments, and recently particular attention has been given to the sulphur content and acidity of rainfall in relation to possible atmospheric pollution. Sulphur input averages 15 kg/ha/yr for all six sites, whereas pH values fall from west to east as rainfall decreases and, presumably, pollution increases on moving down wind of the main industrial centres. Furthermore, the ability of the tree canopy to raise the pH of throughfall water is less marked in the eastern than in the western forests. Nevertheless, pH values are seldom outwith the range reported for rural areas of Scandinavia and never fall to the lowest values reported for some regions of England and north-eastern USA.

REFERENCE

- MILLER, H. G., COOPER, J. M., MILLER, J. D. and PAULINE, O. J. L. (1979). Nutrient cycles in pine and their adaptation to poor soils. *Canadian Journal of Forest Research* **9**, 19–26.

TREE PHYSIOLOGY

FLOWERING AND SEED PRODUCTION
OF SITKA SPRUCE

By P. B. TOMPSETT

Research Station, Long Ashton, University of Bristol

These and earlier studies (Tompsett, 1978a, b) have consistently demonstrated that applying gibberellin A_{4/7} increases flowering and seed production in mature Sitka spruce. Other experiments have thrown light on the physiological mechanisms controlling flowering.

Flowering on Mature Scions

Only some gibberellins produce a good flowering response. Gibberellins A₁ and A₇ gave only small increases in male flowering on small grafts in a polythene house. Gibberellins A₄ and A₁₃ were totally ineffective, but gibberellin A₃, previously thought inactive (Tompsett, 1978b), gave a significant increase in male flowering. The most reliable increases, however, were obtained by applying gibberellin A_{4/7} mixture to older grafts in the field. For the third successive year this mixture of gibberellins much increased flowering (Table 5) and seed production (seeds increased in 1978 from none in controls to 89 per branch). The seeds germinated normally and grew vigorously under standard progeny-testing conditions.

An investigation at Wauchope Tree Bank showed that raising gibberellin A_{4/7} + A₃ concentrations increased female flowering up to an optimum (4

mg/ml) above which the number of strobili was reduced (Tompsett and Fletcher, 1979). It also showed that gibberellin applied to branches in the second branch whorl from the top gave the most female cones (Table 5) and viable seeds.

TABLE 5

MEAN NUMBERS OF FEMALE CONES PER BRANCH PRODUCED IN 1978 BY HORMONE TREATMENT OF MATURE SITKA SPRUCE BRANCHES IN 1977

Experiment at Wauchope Tree Bank.
Twenty replicate branches per treatment.

Treatment	Branch whorl at base of			
	Highest internode	Second internode down	Third internode down	Fourth internode down
Gibberellin A _{4/7}	5.25	9.05	2.25	4.42
Control	0.1	0	0	0

Apical Growth and Flowering

Various treatments known to influence flowering, such as hormone application and disbudding, were tested on suitable scions early in the growing season, and their effects on rates of bud growth were assessed. The growth rates of buds were significantly increased by treatments that induced strobilus formation. This supported the idea (Tompsett, 1978c) that the early growth of apical meristems may determine what type of bud develops later.

REFERENCES

- TOMPSETT, P. B. (1978a). Flowering physiology of Sitka spruce. *Forestry Commission Report on Forest Research* 1978, 55-56.
- TOMPSETT, P. B. (1978b). Effects of environmental and growth regulator treatments on the flowering of mature Sitka spruce. *Monograph of the British Crop Protection Council* 21, 75-81.
- TOMPSETT, P. B. (1978c). Studies of growth and flowering in *Picea sitchensis* (Bong.) Carr. 2. Initiation and development of male, female and vegetative buds. *Annals of Botany* 42, 889-900.
- TOMPSETT, P. B. and FLETCHER, A. M. (1979). Promotion of flowering on mature *Picea sitchensis* by gibberellin and environmental treatments. The influence of timing and hormonal concentration. *Physiologia Plantarum* 45, 112-116.

APPLICATIONS OF PLANT TISSUE CULTURE IN FORESTRY

By A. JOHN

Department of Forestry, University of Aberdeen

Webb (1978) has demonstrated that morphogenesis can be achieved in mature embryos of Sitka spruce and Lodgepole pine by manipulating the media on which embryos are grown. Further experiments have been established to

determine the potential of plant tissue culture in vegetative propagation of forest tree species.

This study of micropropagation of conifers is empirical. Media content, pre-treatment and post-induction conditions must be defined for each species. Cultures of Lodgepole pine and Sitka spruce have been established from mature embryos and attempts are being made to refine the method described by Webb and Street (1977). Embryos of the two species vary in their response to specific treatment when taken from seed defined only by provenance, but Lodgepole pine embryos from a specified cross gave more regular responses to treatment. Hybrid larch has not been grown in sterile culture previously and preliminary experiments suggest that it is possible to achieve shoot proliferation in mature embryos, but the rate is very low and is not affected by dark pretreatment of excised embryos.

Induction of shoot proliferation in apical buds, taken from one-month-old sterile seedlings, has been attempted in all three species with little or no result. It seems probable that the correct culture medium is not yet fully defined. No shoot proliferation has been observed in cultured buds from one-year-old Sitka spruce seedlings.

Micropropagation of shoots from mature embryos has potential for producing clonal plants, although the numbers achieved using present methods are low. The present procedure might be suitable for research but is unsuitable for commercial production unless some method is devised further to increase the numbers of clones being propagated. Plants produced by micropropagation could be introduced into the large scale cutting propagation programmes envisaged by Biggin (1977).

Most emphasis on micropropagation has been placed on the induction of morphogenesis in mature embryos. Other plant parts are capable of undergoing controlled development, and hypocotyl explants are being studied. It is intended to investigate other potentially morphogenetic material such as cotyledon explants, induced interfascicular buds and epicormic buds.

REFERENCES

- WEBB, K. J. (1978). Growth and morphogenesis of tissue cultures of *Pinus contorta* and *Picea sitchensis*. *Ph.D. Thesis, University of Leicester*.
WEBB, K. J. and STREET, H. E. (1977). Morphogenesis *in vitro* of *Pinus* and *Picea*. *Acta Horticulturae* 78, 259–270.

HERBICIDES

HERBICIDE EVALUATION FOR FORESTRY USES

By D. J. TURNER and W. G. RICHARDSON

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

Screening work with pot-grown crops and weeds has continued along lines described in previous reports (Turner and Richardson, 1977, 1978).

Studies relating to weed control in seedbeds

A further six herbicides have been tested. Four of these new materials, acifluorfen (RH6201), bifenox, metolachlor and fluridone, may find uses in seedbeds after conifer seedlings have emerged. However, only bifenox appears to be suitable for use before seedling emergence or with broadleaved species.

Many promising compounds from previous experiments have now been tested under nursery conditions by Forestry Commission research staff. It is encouraging to find that the field results generally agree with those obtained in the pot experiments. The ideal treatment would obviously be one which has no effect on conifers or broadleaves, either before or after seedling emergence, but which selectively kills all weeds likely to be encountered in seedbeds. A single herbicide is unlikely to meet these requirements and most attention is therefore now being given to mixtures. For example, it is believed that it may be worth reinforcing the activity of the currently recommended herbicide diphenamid, by adding compounds with more specific effects against problem weeds, such as chickweed (*Stellaria media*) and Sheep's sorrel (*Rumex acetosella*).

Studies relating to transplant lines and young plantations

During 1978 six new herbicides were examined. Some of these may be useful for solving specific problems. However, most attention is now being given to previously tested herbicides of obvious potential, such as atrazine, terbuthylazine and hexazinone ('Velpar'). Three main aspects are being investigated. Firstly, the effects are being examined of applying atrazine and other herbicides used for grass control in July rather than in spring as now recommended. In pot trials, summer applications have been found to be more effective, particularly against grasses which are grown in peat soils. Some representative results are shown below. The activity of summer sprays can often be increased by additions of an emulsified oil such as 'Actipron', or extra surfactant. Summer treatments appear to have no adverse effect on important crop species, including Sitka spruce, Lodgepole pine and Douglas fir.

EFFECTS OF TRIAZINES ON PURPLE MOOR GRASS, *Molinia Caerulea*
Percentage control achieved by end of season

Treatment	Applied 26 March		Applied 18 July	
	Mineral soil	Peat soil	Mineral soil	Peat soil
8 kg/ha atrazine	100	15	100	100
2 kg/ha terbuthylazine	68	0	100	30
4 kg/ha cyanazine	35	8	81	74
	Standard error $\pm 11.9\%$			

Secondly, attention is being given to heather control with triazines. As already reported, moderately high rates of several compounds are active against heather but have little effect on most conifers (Turner and Richardson, 1978). At present, atrazine, a relatively cheap compound whose patent has expired, is of most interest. Both spring and summer applications are effective. Mixtures

with phenoxy herbicides may be useful: in a preliminary experiment, 2 kg/ha of atrazine with 2 kg/ha of 2,4-D or MCPA (as salt) had more effect than 4 kg/ha of either compound alone.

Finally, work with herbicides for controlling woody weeds continues. In this connection, triclopyr is probably of most interest. Rates of from 1 to 4 kg/ha, as salt or ester, kill pot grown oak, beech and birch without noticeably affecting certain conifers. Sitka spruce appears to be particularly resistant. As well as killing broadleaves, triclopyr controls gorse and many broadleaved herbaceous weeds, including rosebay willow-herb. It is moderately active against heather and could possibly be used for controlling this weed in spruce plantations. However, this treatment would be expensive by comparison with phenoxy herbicides or atrazine.

REFERENCES

- TURNER, D. J. and RICHARDSON, W. G. (1977). Research on uses of herbicides in forestry. *Forestry Commission Report on Forest Research 1977*, 56.
- TURNER, D. J. and RICHARDSON, W. G. (1978). Herbicide evaluation for forestry uses. *Forestry Commission Report on Forest Research 1978*, 56-57.

FOREST ZOOLOGY

LONG-HAIRED FALLOW DEER

By R. H. SMITH and ELIZABETH JOHNSON

Department of Zoology, University of Reading

The five crosses set up in the forest enclosures in September 1977 (Smith *et al.*, 1978) all produced fawns during the following summer. The table shows the phenotypes of the offspring, together with their identifying code numbers.

Enclosure	Buck	Doe	Fawn
1	L11 Short	L14 Short L1 Long	L22 Short L24 Short
2	L9 Long	L16 Short L15 Intermediate L18 Long	L21 Short L20 Long L19 Intermediate

The doe L8, the only survivor of the poaching of enclosure 4, did not produce a fawn.

In September 1978, the deer in enclosure 2 were caught up using long nets, and the does and fawns were moved to enclosure 4 with the doe L8 and a short-haired buck L25. The long-haired buck L9 was transported to an enclosure in the New Forest (Hampshire) to mate with four short-haired does which could not be carrying genes for long-hair. Two additional crosses were set up in an enclosure next to the Mortimer Forest Office (Shropshire) using a short-haired buck L23, a short-haired doe L3 and a long-haired doe L2. The does L1, L2 and L3 were the fawns hard-reared at Reading in 1976.

In June 1978, the fallow deer fawn, L19, was taken from the enclosures in Mortimer Forest and hand-reared at Reading University. The individual hand-rearing resulted in the fawn becoming imprinted on its handlers so that it was possible to obtain useful measurements of growth rates and various physiological parameters.

With the assistance of our electronics workshop, work has proceeded on the development of an electronic unit capable of monitoring heart rate, temperature and respiration by telemetry. Since the ultimate aim is to monitor these parameters from deer maintained in the forest enclosures where they will be subjected to the same natural conditions as the herd in the adjoining forest, telemetry is the only feasible method.

The present design comprises an externally mounted box containing transmitter, batteries and circuit which switches in sequence from a measure of heart rate via implanted electrodes and temperature, via thermistors. We have recently presented details of the instrumentation at an International Conference on Telemetry and Radio Tracking in Biology and Medicine (Johnson, Miller and Smith, in press). Although the external unit can be used successfully in domestic animals we have not succeeded in attaching it in a way which can prevent an unrestrained deer from removing it. We now wish to develop a totally implantable multichannel transmitter with an external power source. Current advances in subminiature components and hybrid circuits make this development feasible. We are presently applying for grants to cover the cost of this development.

There seems little doubt that such a transmitter unit will be useful, not only in assessing whether a long coat is a physiological advantage or disadvantage, but also in future studies on the metabolic requirements of normal deer under different environmental conditions.

REFERENCES

- JOHNSON, E., MILLER, M. and SMITH, R. H. (in press). Telemetry of heart rate and temperature in fallow deer. In: *Handbook of Telemetry and Radio Tracking in Biology and Medicine*. C. J. Amlaner and D. W. MacDonald (Eds.). Pergamon Press.
- SMITH, R. H., JOHNSON, E., HORNBY, J. E. and HOLT, A. C. E. (1978). Long-haired fallow deer. *Forestry Commission Report on Forest Research 1978*, 57-58.

REPRODUCTION IN THE GREY SQUIRREL

By ELIZABETH JOHNSON

Department of Zoology, University of Reading

Research into the reproductive physiology of the grey squirrel is continuing with a Forestry Commission/SRC CASE student (Miss G. Webley) and a post-doctoral research assistant financed by the Forestry Commission (A. J. Tait).

The two squirrel enclosures at Alice Holt are now in use with three squirrels of either sex established in each. A camouflaged high seat has been provided for observations of the interactions between the male and female squirrels. It is as

yet too early to know whether breeding will take place in the enclosures. If the squirrels do have normal sexual cycles in the enclosures it will be possible to resolve a number of the outstanding problems of the reproductive physiology of the female squirrel, such as whether ovulation is spontaneous or induced and the source of progesterone during pregnancy.

Work is in progress to develop an antiserum to the male sex hormone, testosterone, in order to make accurate measurements of this hormone in the blood of male squirrels during periods of testicular activity and regression. Antisera have been raised in goats and in rabbits and are now being tested for affinity and specificity before being used in a radio-immunoassay.

The ability to accurately measure levels of testosterone in male squirrels as well as progesterone in female squirrels will greatly facilitate investigations into the effects of reproductive inhibitors. Plans are now well ahead to investigate inhibitors of both male and female reproductive processes. These will require detailed laboratory studies before any field trials are contemplated.

THE ECOLOGY AND MANAGEMENT OF ROE DEER IN COMMERCIAL FORESTS

By A. LOUDON

*Department of Forestry and Natural Resources,
University of Edinburgh*

The purpose of this two-and-a-half-year study is to assess the accuracy of current census methods for roe populations, and to assess the ability of management to reduce roe numbers. Before these questions can be answered, it is important to gain some understanding of the influence of forest structure and local management on the performance of roe populations. Essentially, the research falls into two related parts: (1) analysis of material collected from culled animals, (2) assessment of deer density using indirect methods (pellet group counts) and direct methods (spot lamp and driven counts).

The analysis of samples collected from animals culled from 13 forests in South Scotland and North-east England Conservancies suggests that the age and structure of a forest has a considerable influence on the performance of roe populations. The differences between roe populations are most marked by comparing deer shot from young, newly planted ground with deer shot within high forest and second cycle plantations. In general, roe living on young, new plantations are heavier than deer within second cycle forests, have a more rapid growth rate (achieving adult body weight at 11–12 months) and are more fertile (twinning rate of 1.8–2.0 kids per doe compared with 1.2–1.3 per doe for restocked forests).

Weekly counts of roe deer using spot-lamps suggest that a heavy winter cull of does has little influence on the numbers of deer seen or on the sex ratio. This suggests that deer density in restocked sites is relatively unaffected by rifle shooting despite very heavy winter culling in some forests. Counts of pellet groups in young, restock sites and in thicket stage plantations suggest that there is a higher density of deer within thicket stage forests; these does are generally unavailable for culling.

Monthly driven counts are being made of roe on newly planted young plantations (with good visibility). These counts show that despite some annual fluctuations in numbers the carrying capacity of these habitats lies between 10–12 deer per 100 ha. Differences in body weight and fertility between young and mature forests indicate that roe on developing plantations are at a lower density than deer in second cycle forests. This is supported by evidence from pellet group counts and work from the continent (Klein and Strandgaard, 1972).

Future work is designed to examine in greater detail the influence of forest structure on the performance of roe populations and culling rate by local ranger staff. In addition, a model of changes in forest structure up to the year 2010 A.D. is being developed from information provided by Forestry Commission field surveys. This model will enable some prediction of future culling rates, population performance and management requirements for roe populations in North-east England and South Scotland Conservancies.

REFERENCE

- KLEIN, D. R. and STRANDGAARD, H. (1972). Factors affecting growth and body size of roe deer. *Journal of Wildlife Management* 36 (1), 64–79.

TIMBER UTILISATION

JOINT RESEARCH PROGRAMME ON BRITISH-GROWN TIMBER

By T. HARDING

Princes Risborough Laboratory, Building Research Establishment

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

Comparison of the Effect of Rectangular Spacing on Wood Properties

Earlier work on spacing had examined the effects of planting distances on wood density and wood yields. Another aspect of spacing arises when trees are planted in a rectangular pattern instead of the more conventional square patterns. Rectangular planting is adopted when site preparation is such that distances between rows are particularly wide, as with the deep ploughing of some peats and the windrowing of slash on cut-over sites. Differences in growing space within and between rows might be expected to lead to the development of a crown with an oval outline and an associated effect on stem-section shape. However, examination of 20-year-old Sitka spruce from a single site where trees have been planted in three patterns, at 3·7 m between rows and 0·9 m within rows, at 2·8 × 1·2 m, and 1·8 × 1·8 m, showed no evidence for planting pattern having an effect on stem cross-section shape. However, there was a greater incidence of large knots in the rectangular plantings with these larger knots tending to be more abundant in those sections of the stem where branches had grown into the space between the rows.

The Effects of Fertiliser Application on Wood Quality

The interaction between wood density and rate of growth has been examined mainly for trees where vigour is determined by available growing space. Another method for enhancing vigour is by the application of fertiliser and it has been shown that basal area increment of pole stage crops of spruce can be increased by up to 20 per cent following fertiliser treatment (Binns and Mackenzie, 1969). It is a matter of some interest to know whether this response has an effect on the wood, in particular on its density, which differs from that of other forest practices which enhance vigour. The effect of fertiliser application has been examined using Norway spruce which showed a response to both nitrogen and phosphorus; however, while the application of phosphorus did not apparently alter the growth rate/wood density relationship, treatments with nitrogen appear to reduce density by up to 5 per cent with no associated increase in ring widths. This aspect is receiving further attention.

Computer-aided Log Conversion for the British Softwood Sawmilling Industry

Work has continued on developing the computer-aided log conversion model into a practical tool to aid softwood log conversion. On-line measurement of log shape and dimensions has been made possible by laser scanning equipment developed in co-operation with Plesseys Ltd, and this has been evaluated in trials in two sawmills cutting for different markets. The accumulated data is also being used to assess the improvement in conversion yield that computer control would offer.

Given this improvement, further work will be directed at developing the necessary on-line data processing equipment and alignment aids to provide a working demonstration of the system.

REFERENCE

- BINNS, W. O. and MACKENZIE, J. M. (1969). *Report on Forest Research 1969*, p. 71, Forestry Commission.

APPENDIX I

Publications by Forestry Commission Staff

BANCROFT, C. (1978). *The impact of forestry on recreation*. Forestry Commission Research and Development Paper, 124.

After consideration of the status of countryside recreation in Britain the role of the Forestry Commission in providing for recreation is discussed. There is an increasing demand for recreation in the countryside and it is believed that for townspeople, especially, the social benefits are significant. The Forestry Commission is in a good position to make a major contribution to meeting this public need and the style of its provision is detailed.

Strategic planning based on reliable data enables resources to be put to best effect and recreation planning and research are considered. Indication of the likely future pressures of demand reveals the scale of provision required and helps in the formulation of appropriate policies and priorities. The paper concludes that positive management policies shall be needed to cater sensibly for the increasing pressures of demand. Forestry makes a contribution to the quality of life by providing for some of society's recreational needs, and by judicious planning this can be achieved without serious conflict with the main objective of timber production.

BARDY, D. A. (1978). *The health and safety of forest workers*. Forestry Commission Research and Development Paper, 119.

The mechanisation of forest operations which has taken place in the last 25 years has created new problems affecting the health and safety of forest workers. The transition from hand tool to machine systems has in the last 10 years been quite extensive and whilst the number of employees per unit of production has declined, the severity of accidents (expressed in terms of working days lost) has increased.

Occupational health hazards due to changes in the working environment have become apparent, notably in connection with noise, vibration and chemical contamination.

In many cases, national legislation has been framed to make forestry machines safer and to encourage the adoption of sound ergonomic principles at the design stage. In recent years, there has been an increasing endeavour on the part of member countries of economic organisations to harmonise this sort of legislation and thereby provide equitable standards of international status.

Important contributions to improving the health and safety of forest workers have been made by the introduction of Work Study techniques, by the increased use of systematic training and by the commissioning of both technical and medical research.

BEVAN, D. and BROWN, R. M. (1978). *The Pine looper moth*. Forestry Commission Forest Record 119.

The Pine looper moth, *Bupalus piniaria* (L), is one of the most serious primary pests of pine in central and eastern Europe, Scandinavia and Russia. It was first found in Eire in 1969. It is indigenous to Great Britain and is common in most of our pinewoods. The first outbreak in this country occurred at Cannock Chase Forest (Staffordshire) in 1953, and there was a recurrence of trouble there in 1963. Laigh of Moray (Culbin) Forest (Grampian), Tentsmuir Forest (Tayside) and Wykeham Forest (North Yorkshire) have also harboured populations that required chemical control. At several other forests numbers have at times risen to uncomfortably high proportions but have not occasioned treatment.

It appears that the conditions most suited to serious infestation by this defoliator can arise in the 'pole' and later stages of a plantation's growth. As there are very considerable areas of young pinewoods in this vulnerable stage in various parts of the country, the Pine looper is potentially a very important pest. It is the purpose of this Record to enable it to be identified at all stages of life, and to provide some information regarding its life cycle and forest importance.

BIGGIN, P. (1979). Herbicides for use in forest nurseries. *Scottish Forestry* 33 (1) January, 9-14.

Several useful herbicides have become available in the last few years and research results and recommendations for use in northern nurseries are described for diphenamid, nitrofen, atrazine and dazomet. Diphenamid is a tried and tested pre-emergent herbicide now in general use on conifers. Nitrofen has similar uses to diphenamid but the latter gives more effective control of the important weed species. Atrazine has been tested for forest establishment weeding and has been extended after trial to transplant lines in the nursery. Dazomet is now in general use for partial sterilisation of seedbeds but damage late in the growing season can occur. Research continues on other herbicides such as propyzamide and glyphosate but they cannot yet be recommended.

BILLANY, D. J. (1978). *Gilpinia hercyniae*—a pest of spruce. Forestry Commission Forest Record 117.

Gilpinia hercyniae, the European spruce sawfly, presents a serious threat to the extensive upland spruce plantations in Britain. The pest has a particular impact on Sitka and Norway spruce. The larvae feed on the needles and can cause complete defoliation. The paper summarises the available biological information and presents useful methods of detection, survey, damage appraisal and control. The sawfly is described as being quite common in widely dispersed blocks of spruce (including Serbian spruce) throughout England and Wales, but so far major outbreaks have only occurred in Wales and it has not been observed further north than Durham. The paper describes recognition, detection and life-cycle. The damage seems to be confined to the crown of the trees. Outbreaks seem to be susceptible to naturally occurring biological control. This takes the form of a host-specific nuclear polyhedrosis virus (NPV), and the spread of this virus is assisted by small birds, particularly titmice, which feed on infected larvae and then pass the virus infected faeces which further disperses the NPV. Chemical control is not advocated, particularly in ecologically 'new' plantations.

BILLANY, D. J., BORDEN, J. H. and BROWN, R. M. (1978). Distribution of *Gilpinia hercyniae* (Hymenoptera: Diprionidae) eggs within Sitka spruce trees. *Forestry* 51 (1), 68–72.

The distribution of *Gilpinia hercyniae* (Hartig) eggs was determined in a total sample of 15,360 needles taken from 16, 16–17 year old Sitka spruce trees at Hafren Forest (Powys). The percentage of needles occupied by eggs was 1.09 per cent. The data indicated significant differences between egg populations in four crown levels and three foliage age classes (1–3 years), with a preference for eggs to be laid at the top of the crown in one-year-old needles. There was no significant relationship between any of four aspects and egg population. Calculation of the total egg population based on the number of needles in each age and crown level class (mean of 10-tree sample), and assigning probabilities that needles in a given class would be occupied, disclosed that 76 per cent of the population would be in one-year-old needles and 83 per cent would be in the two middle crown levels. Oviposition preference by females could be accounted for, in part, by positive phototaxis, avoidance of the darker basal and central regions of the tree, rejection of significantly smaller needles in the basal crown level, and by fairly immediate acceptance of peripheral foliage by an alighting female. It is concluded that an effective egg survey need only sample one-year-old needles in the top crown level.

BLATCHFORD, O. N. (Editor) (1978). *Forestry practice*. Forestry Commission Bulletin 14.

A summary of methods of establishing, maintaining and harvesting forest crops with advice on planning and other management considerations for owners, agents and foresters.

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

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

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

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

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

5. A few males dispersed out of larch into adjacent spruce forests and were captured in virgin female-baited traps up to 135 m distant from infested larch. Virgin female-baited traps at 0–0.5 m from the ground captured over seven times the number of males as traps at 1, 2 or 4 m, supporting visual observations that the preferred flight level for males is very near the ground.

6. Horizontal board traps with an acetate surface coated with 'Stikem Special' were superior to Pherocon 1C, vertical board and gypsy moth traps in that order.

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

BRASIER, C. M. (1978). Stimulation of oospore formation in *Phytophthora* by antagonistic species of *Trichoderma* and its ecological implications. *Annals of Applied Biology* **89**, 135–139.

This account discusses the hypothesis that the formation of oospores by *Phytophthora* in response to *Trichoderma* is a defensive response to a potential antagonist or competitor (Brasier, 1975b). This form of microbial interaction could well be a common feature of plant diseases, and in the terminology of recent authors (e.g. Baker and Cook, 1974) would be an antibiosis met with by a defensive probiosis.

BRASIER, C. M. and GIBBS, J. N. (1978). Origin and development of the current Dutch elm disease epidemic. In *Plant Disease Epidemiology*, (Editors, Scott, P. R. and Bainbridge, A.) 31–39.

A review paper describing the history of the British Dutch elm disease epidemic, and summarising published work on variation in *Ceratocystis ulmi* and on the progress of the disease through different elm populations.

BRASIER, C. M. and STROUTS, R. G. (1978). *Phytophthora hibernalis* in Britain. *Plant Pathology* **27** (2), 99–100.

A note on the discovery of this fungus (the first record for Britain of this *Citrus* foliage and fruit pathogen) in soil around dead roots of a Lawson cypress hedge. A brief cultural description is given and the Lawson cypress disease symptoms are described.

BRASIER, C. M. and GRIFFIN, M. J. (1979). Taxonomy of '*Phytophthora palmivora*' on cocoa. *Transactions of British Mycological Society* **72** (1), 111–143.

Morphological and physiological studies (chromosome type, colony morphology and growth rate on carrot agar, cocoa pod lesion characteristics, morphology and size of sporangia, sporangial pedicels, chlamyospores and sex organs, compatibility type, growth on a synthetic medium, response to *Trichoderma*, and temperature relations) were made with c. 950 *Phytophthora* isolates from cocoa (*Theobroma cacao* L.) attributed to *P. palmivora* (Butl.). The survey covered isolates from all the major cocoa growing areas of the world.

The majority of the isolates could be assigned to one of three distinct forms, termed S, L and MF4. The S-type is attributed here to *P. palmivora*, which is redefined. Both L and MF4 are considered to be distinct species of *Phytophthora*. The L-type could not be identified with any known species and is described here as *P. megakarya* sp. nov. *P. palmivora* occurred worldwide on cocoa, whereas *P. megakarya* was obtained only from West Africa and MF4 only from Central and S. America and the West Indies.

BURDEKIN, D. A. (1978). Tree diseases—a broad pathological review. In *Treeless Britain?*, Lorch Foundation 4th Lecture, 7–14.

Examples of British tree diseases are described and discussed. Devastating tree diseases which have occurred elsewhere in the world are compared and contrasted with British diseases. The risk of introducing new diseases to Britain is reviewed and the need for stringent import regulations is emphasised.

(EICHHORN, O. and) CARTER, C. I. (1978). Investigation into conifer woolly aphids (Hemiptera, Adelgidae) in Japan, with the description of two new species. *Zeitschrift für angewandte Entomologie* **86** (3), 273–289.

Notes are given on the morphology and biology (especially on hosts, distribution, life cycle and phenology) for four of the eight Japanese species of the family Adelgidae: *Dreyfusia todomatsui* In., *Aphrastasia pectinatae* spp. *isiharai* In., *Adelges japonicus* (Monz.) and *Adelges karamatsu* stat. nov. Furthermore, two new holocyclic species, *Adelges isedakii* sp. nov. and *Sacchiphantes torii* sp. nov., are described, both having *Larix* and *Picea* as their hosts.

CROWTHER, R. E. (Editor) (1978). *Managing small woodlands*. Forestry Commission Booklet 46.

Provides basic information on the establishment and management of small woods emphasising ways and means of modifying forestry practice to meet their particular problems.

DANNATT, N. (1978). Reforestation of land after storm and fire. *Forestry and British Timber* 7 (2), February, 24, 26 and 34.

A symposium on the reforestation of forest land destroyed by storm and fire, organised by the governments of West Germany and Holland on behalf of the FAO/ECE/ILO timber committee in Geneva, was held last year. Twenty delegates from 12 countries assembled at Hanover and for the subsequent two-and-a-half days visited three forest districts in Lower Saxony. They also paid a visit to forests in the province of Drenthe in Holland.

DEWAR, J. (1978). The case for regional silviculture. Report of 17th Discussion meeting, Reading. *Forestry* 51 (1), 3-19.

The hypothesis was put that British silviculture has become too stereotyped to make the best use of the varied growing conditions, to respond to unforeseen opportunities and to ensure against biological hazard. Silvicultural regions were suggested as a means of gaining the advantages of variety in terms of better adaptation of silviculture to edaphic and climatic factors without the disadvantages in terms of increased complexity of management. A majority of the participants tended to refute the hypothesis but it was recognised that there were advantages to be obtained from a more regional approach to silviculture.

EVANS, J. (1978). Some growth effects of hail damage and drought in *P. patula* plantations. *South African Forestry Journal*, June, 8-12.

Internodal stem analysis of *Pinus patula* growing in the Usutu Forest, Swaziland, revealed past abnormalities in growth due to hail damage and low rainfall. Hail caused breakage of leaders and, where severe, the resulting loss in tree height could lead to serious errors in measuring site growth potential if the damage was not known to have occurred. Low rainfall on two occasions in the 1960s, but especially 1963/1964 and 1964/1965, appears to have caused a five per cent drop in total forest productivity.

EVANS, J. (1978). A further report on second rotation productivity in the Usutu Forest, Swaziland—results of the 1977 reassessment. *The Commonwealth Forestry Review* 57 (4) No. 174, December, 253-261.

At rotation age the oldest stands of second rotation *Pinus patula* were slightly less productive than the first, showing a decline of about seven per cent in volume yield. Substantial decline was largely confined to one forest block; in the other four blocks productivity of the two rotations was about equal. This final, rather poor performance of the second crop, compared with the position both in 1969 and 1973, appears almost wholly due to prolonged winter droughts in recent years. There is no evidence yet of a long-term productivity problem arising from site degrade due to short-rotation plantation forestry.

FARMER, R. A. (1979). Restocking of burnt areas. *Scottish Forestry* 33 (1), 1-8.

Substantial areas of burnt plantations have to be restocked following two years of high fire losses. The special problems likely to be encountered in restocking burnt areas are discussed and recommendations for treatment are made. It is essential to provide good access through the fire debris for replanting and tending, to protect plants from insect pests and to restock as quickly as possible after the fire.

(THOMPSETT, P. B. and) FLETCHER, A. M. (1979). Promotion of flowering on mature *Picea sitchensis* by gibberellin and environmental treatments. The influence of timing and hormonal concentration. *Physiologia Plantarum* 45, 112-116.

Male and female flowering was significantly promoted by gibberellin A_{4/7} and A₃ mixtures applied beneath bark flaps on branches of 11-year-grafted mature scions of *Picea sitchensis* growing in the open in Scotland; 4 mg/ml gave more flowering than higher or lower concentrations of gibberellin and application in June was more effective than in July.

Gibberellins also increased male flowering on mature scions when applied directly to the buds in a polythene house. A gibberellin A_{4/7} + A₉ mixture produced greater numbers of

strobili when applied to 2-year-grafted plants in May and June than when applied in July and August. Flowering of 5-year-grafted plants increased with increasing concentrations of a gibberellin $A_{4/7} + A_3$ mixture up to 19.7 mg/ml above which flowering decreased.

Modifying the environment by keeping in a polythene house enhanced the combined male and female flowering of 5-year-grafted mature scions above the amount on control plants outside, the effect being more marked in June and July than in August and September. Larger numbers of gibberellin applications or longer total lengths of time in the polythene house gave significantly greater amounts of combined male and female strobili.

FRANCIS, G. J. (1978). *The assessment of the forest resource base*. Forestry Commission Research and Development Paper 121.

The productive forest area in Britain has doubled since 1920. It has been achieved, for the most part, by afforestation with exotic coniferous species. This has been accompanied by changes in management practices. Future increases of production are dominated by the increasing softwood production.

Major crop inventories are carried out on a cycle of 15 years. Sample checks of inventory data and updating of major changes are made to coincide with the revision of production plans. The availability of reliable data is an essential ingredient of such plans.

Wood production plans of two types are prepared. First, long term plans extending over 20 years reviewed quinquennially. Second, short or medium term plans extending up to five years ahead reviewed annually. Between them they serve needs connected with the development of wood using industries, resource planning, operational planning, marketing, budgeting and the evaluation of the results of forest operations.

The choice of appropriate management practices, for afforestation and stand management, is linked with site assessment.

Changes in management practices may affect wood characteristics and in turn potential end use of the wood. This requires assessment of any change in wood properties and the consequences for end use performance as well as any economic implications involved.

GARFORTH, M. F. (1979). Mixtures of Sitka spruce and Lodgepole pine in South Scotland. History and future management. *Scottish Forestry* 33 (1), 15–28.

Large areas of Sitka spruce-Lodgepole pine mixtures were established in the Forestry Commission's South Scotland Conservancy during the 1950s and 1960s. The paper discusses the silvicultural options open to the forester when considering future management, and discusses the factors influencing the choice of option. Broad guidelines are given for the selection of future silvicultural regime.

GIBBS, J. N. (1978). Oak wilt. *Arboricultural Journal* 3 (5), 351–356.

A brief review for British readers of the present status of oak wilt in the United States. Its potential for damage in Europe if it were to become established here is also discussed.

GIBBS, J. N. (1978). Intercontinental epidemiology of Dutch elm disease. *Annual Review of Phytopathology* 16, 287–307.

The first part of the paper is concerned with the history of the disease, its geographical spread, and the impact it has made on elm populations. Where possible, quantitative data on the cumulative toll taken by the disease have been analysed. The second part of the paper deals in greater detail with the host, pathogen, and vectors, and the role of various aspects of environment, including man.

GIBBS, J. N. and SMITH, M. E. (1978). Antagonism during the saprophytic phase of the life cycle of two pathogens of woody hosts—*Heterobasidion annosum* and *Ceratocystis ulmi*. *Annals of Applied Biology* 89, 125–128.

There are two forms of antagonism in the dead host. The 'primary' process of competition between pathogen and antagonist for uncolonised host tissue and the 'secondary' process of replacement of the pathogen by the antagonist within the host tissue it already occupies. For biological control, primary antagonists are likely to be more valuable than secondary antagonists.

GOODWIN, J. F. (1978). *The training, motivation and social promotion of forest workers*. Forestry Commission Research and Development Paper 120.

Forestry is practised in small scattered areas on less than 10 per cent of the total land area of a heavily populated country. The training, motivation and social promotion of that half of the total labour force which is employed by the State forest service (Forestry Commission) is the main concern of this paper. The needs of those employed in the private sector of the industry are met by a variety of self-help schemes supported by government grants.

GORDON, A. G. and WAKEMAN, D. C. (1978). The identification of sampling problems in forest tree seed by X-radiography. *Seed Science and Technology* 6, 527-535.

The results of a practical sampling exercise conducted during the 1975 Forest Tree Seed Workshop in which the proportion of empty seeds was assessed non-destructively by X-radiography are presented. They show that a large proportion of the participating analysts were unable to produce four representative replicates of 100 seeds from working samples of *Pinus oocarpa* seeds. Sampling difficulty was related to the number of empty seeds in the samples. The problems of sampling forest tree seeds which naturally have a high proportion of empty seeds are discussed.

GREIG, B. J. W. and STROUTS, R. G. (1977). *Honey fungus*. DOE/FC Arboricultural Leaflet 2.

Honey fungus is one of the commonest causes of death of trees and shrubs in Britain. The leaflet describes the fungus, its life history and the diagnostic features of the disease. Lists of susceptible and resistant species are given and control methods are described.

GREIG, B. J. W. (1979). Species susceptibility to *Fomes* butt rot. *Quarterly Journal of Forestry* LXXIII (1), January, 21-25.

A *Fomes annosus* susceptibility trial, comprising 11 conifer species, was prematurely felled when the trees were 16 years old. Examination of the root systems and stems of the trees after felling revealed the following percentage incidence of *F. annosus* infection, Western hemlock (21), Leyland cypress (19), Douglas fir (11), and Western red cedar (7); in the remaining seven species the incidence ranged from 0 to 2. Maximum vertical extent of infection was 1.1 m.

The low incidence of infection in the spruces may be related to poor growth, rather than inherent resistance. The results confirm that young grand fir are relatively resistant to *F. annosus*.

HOLMES, G. D. (1978). *Research aspects in forestry for quality of life*. Forestry Commission Research and Development Paper 123.

The paper discusses:

The benefits of forests as elements of the human environment.

The interrelations between forests and forestry and the main features of the environment.

The special problems associated with the conduct of research aimed at evaluating the effects of forestry on the environment.

The conservation and management of animal resources and the role of research in resolving the conflicts between wildlife and other uses of the forest.

The conservation of plant resources and the importance of conserving gene resources both of tree species and of associated vegetation species.

The role of forests for recreation and landscape improvement and the difficult problems of defining public tastes and preferences and also of evaluating benefits and their distribution throughout society.

The special value of trees outside the forest in town and country.

The value of IUFRO as a point of contact between research workers in this field.

JOHN, A. (1978). An anatomical study of root initiation in stem cuttings of Hybrid larch. *The New Phytologist* 81 (1) July, 111-116.

The stages in the development of roots in stem cuttings of Hybrid larch have been investigated. Callus develops from a new meristem after the establishment of a cortical vascular system. Roots arise from near the tip of this cortical vascular system and emerge as partially differentiated structures after approximately 42 days.

JOHNSTON, D. R. (1978). Irregularity in British forestry. *Forestry* 51 (2), 163-169.

The world's forests at present yield one cubic metre per hectare per annum. The very small area of plantations yield seven or eight times as much per hectare. To satisfy an increasing

population it is inevitable that agriculture will encroach upon forest land and that plantations will become relatively more important as a source of wood.

Specialisation is leading to differing emphases in forest policy in different regions and the relevance of irregularity depends in fact upon the relative importance of the various policy objectives.

Irregularity means different things to different people but to the forester it implies mixed species, all-aged crops or crops having a wide range of size classes.

The available evidence on the relationship between irregularity and production is not always unequivocal but, in general, even-aged and low-thinned crops produce a somewhat greater yield than all-aged or crown thinned stands. Mixtures can sometimes produce more volume than any of the constituent species alone but the production of the species having the highest yield class can probably not be increased by including slower growing species within the crop. There is little evidence one way or the other on the relationship between man-made irregularity and health.

Foresters feel that it is imprudent from the points of view of management and aesthetics to create large areas of uniform forest but socio/economic trends favour regular working. These conflicting considerations can be reconciled by creating variable forests composed of regular stands. In particular, a small wood planting grant designed to favour broadleaves might better be given for a mixture of small pure stands designed to give a predominantly broadleaved appearance, than for a tree by tree mixture of broadleaves and conifers.

JOHNSTONE, R. C. B. and SAMUEL, C. J. A. (1978). *Genotype/site interaction in tree breeding*. Forestry Commission Research and Development Paper 122.

Great Britain offers a contrasting range of climatic conditions in which selected breeding material has to be evaluated. Height data from six-years-old progeny tests of *Picea sitchensis* and *Pinus sylvestris* planted on a number of sites throughout the country are considered. The occurrence and interpretation of interactions between selected families and planting sites are discussed with particular reference to the adaptability of the species and the effect on selection strategies in breeding programmes.

LARSEN, R. T. F. (1979). The problems of Red deer as they affect forestry in Scotland. Paper given at British Deer Society Meeting, Edinburgh, November 1978. *Deer* 4 (8), 410–412.

Historically, forests have been the natural habitat for Red deer in which they sheltered from man and other predators.

In Scotland, the clearing of most of the forest drove them into the hills and in the last two centuries they have had to compete with sheep for a large part of the open grazing. The coming of stalking as a sport, as opposed to hunting for flesh, has caused a resurgence in their numbers but large-scale afforestation now competes with deer 'forests' for space, particularly for wintering ground.

Red deer can devastate young plantations by browsing and older crops by bark stripping. Although some revenue can be obtained from trophy stalking and venison sales, this does not offset the damage and the cost of employing rangers and building external and internal deer fences is very high.

Even if deer numbers on the open hill were greatly reduced fences would still need to be maintained, but the pressure on them and therefore the cost of such maintenance would be less. To an extent, forest design can take into account the behaviour of deer within plantations so as to reduce damage and make control easier, and research into these factors is being co-ordinated between the Forestry Commission, the Red Deer Commission and the Institute of Terrestrial Ecology.

LONSDALE, D., PRATT, J. E., (and ALDSWORTH, F. G.) (1979). Beech bark disease and archaeological crop marks. *Nature* 277, (5695), 414.

Aerial photographs of a 25-year-old beech plantation showed patterns of nutritional chlorosis which resulted from the presence of a 'Celtic' field system. This is the first reported occurrence of archaeological crop marks in a forest plantation. The implications for beech bark disease research, archaeology and forestry are discussed.

MACCASKILL, D. (1978). Fair play and foxes. *Scottish Forestry* 32 (2), 93–100.

The article refutes the charge that foxes in forests result in greater damage to domestic stock, and suggests that a more enlightened attitude towards the animal is overdue.

MCCAIVISH, W. J. (1978). Forest weed control with different formulations of atrazine, propyzamide and an atrazine/cyanazine mixture applied by hand-held controlled drop applicator. From *Proceedings Symposium Controlled Drop Application*, Reading, April 1978. 193-198.

Experiments were carried out in 1975 testing low volume applications applied by hand-held controlled drop applicator. Two formulations of propyzamide and atrazine plus one of an atrazine/cyanazine mixture were tested.

Weed control on various grasses was tested plus crop tolerance, height growth and survival of a few conifers.

Weed control was acceptable on only two of the five sites tested. The conifers treated were unaffected by the low volume applications.

Differences between the various suspension concentrates were indicated by the different swath width produced when weed control became evident.

MCCAIVISH, W. J. (1979). Newly-tested herbicides. *Forestry and British Timber* 8 (2), 22-23.

The development of the herbicides glyphosate, propyzamide, 'Velpar', 'Krenite', and triclopyr for forest uses is discussed.

A glyphosate screen of several conifers plus information on forest weed control of grasses, bracken, heather and woody-weeds such as birch, bramble, blackthorn and coppice species is described.

Grass control with propyzamide and 'Velpar' are discussed, crop tolerance and rates of application are dealt with.

Foliar treatment with 'Krenite' or triclopyr to woody-weeds is described as well as crop toxicity aspects.

All five herbicides improve operator safety and environmental protection by virtue of the low mammalian toxicity levels, and lack of obnoxious smell and taint of the products in either air or water.

MACKIE, J. (1978). Forests in the landscape. *The Countryman*, Spring, 86-92.

The Chairman of the Forestry Commission takes a broad view of new developments in forestry management.

MAYHEAD, G. J. and BROAD, K. (1978). Site and the productivity of Sitka spruce in southern Britain. *Quarterly Journal of Forestry* LXXII (3) July, 143-150.

Many of the major forest blocks in Wales and south west England were sampled in an attempt to relate the general yield class (GYC) of Sitka spruce to easily measured site factors. Except for elevation, the relationships with GYC were poor.

Elevation/GYC regression lines are illustrated for use by management and research; however, the variation accounted for was low and did not normally exceed 60 per cent. Exposure bore no relationship to GYC within regions although in several individual forests over 60 per cent of the variation was accounted for. Within regions, exposure was poorly related to elevation, but in many individual forests the variation accounted for exceeded 30 per cent. GYC tended to be higher on the north to south east facing aspects.

The maximum variation accounted for using multiple regression to predict GYC was 46 per cent South Wales outwith the coalfield.

MERCER, P. C. (1977). Pests and diseases of groundnuts in Malawi. I. Virus and foliar diseases. *Oleagineux* 32 (11), 483-488.

Diseases and pests of groundnuts in Malawi and their prevention and control are described in order of decreasing importance. Distribution maps and plates are provided wherever possible. The state of knowledge of each in Malawi is discussed.

MERCER, P. C. (1978). Pests and diseases of groundnuts in Malawi. II. Disorders of pods, kernels and seedlings. *Oleagineux* 33 (3), 119-122.

Disorders of pods, kernels and seedlings of groundnuts in Malawi and their prevention and control are described in order of decreasing importance. Distribution maps and plates are provided wherever possible. The state of knowledge of each in Malawi is discussed.

MERCER, P. C. (1978). Pests and diseases of groundnuts in Malawi. III. Wilts, post-harvest physiological and minor disorders. *Oleagineux* 33 (12), 619-624.

Wilts, post-harvest, physiological and minor disorders of groundnuts and their prevention and control in Malawi are described in order of decreasing importance. Distribution maps and plates are provided where possible. The state of knowledge of each in Malawi is discussed.

MERCER, P. C. (and KISYOMBE, C. T.) (1978). The fungal flora of groundnut kernels in Malawi and the effect of seed-dressing. *Pest Articles and News Summaries* 24 (1), 35-42.

Isolations from groundnut kernels in Malawi showed *Aspergillus niger*, *A. flavus*, Mucorales, *Macrophomina phaseolina*, *Fusarium* spp. and *Penicillium* spp. to be the most common members of the fungal flora. In the laboratory a seed-dressing containing thiram had a strong inhibiting effect on the kernel flora with the exception of *A. flavus*, although it was able to afford some protection to healthy kernels against *A. flavus* attack in soil in test tubes. When grown individually in plate cultures the most commonly isolated fungi were generally only slightly inhibited by thiram in the agar. Field trials over three seasons showed that dressing the seed with fungicide had little effect on yield and this practice is thus not generally recommended.

MERCER, P. C. (1979). Three-dimensional mapping of stain and decay columns in trees. *Annals of Applied Biology* 91, 107-112.

A visual and a computer method were used to produce three dimensional maps of stain and decay columns within trees. The merits of each method are discussed. Using these methods, tests were made to establish the accuracy of a pulsed-electric-current resistance meter (Shigo-meter) to estimate stain and decay columns in a non-destructive manner.

MITCHELL, A. F. (1978). The origin of the species. *Vole* 2 (3), 24.

A brief history of the introduction of various exotic tree species into Britain.

(WILKINSON, J. and) MITCHELL, A. F. (1978). *Hand guide to the Trees of Britain and Northern Europe*. London, Collins.

A simple, non-technical guide to all the native and some of the introduced trees in Britain.

ORROM, M. (1978). The interpretive policy and visitor centres of the Forestry Commission. *Museums Journal* 77 (4), March, 171-173.

The main objective of the Forestry Commission is timber production but it is recognised that there is a strong public demand for recreation facilities and the Commission is in a unique position to help meet this demand.

In developing the nation's forests for recreation, the aim is to provide facilities for the quiet enjoyment of the countryside and to create an awareness of the forest environment. The basic requirements are car parks, as access to forests is only permitted on foot, lavatories and waymarked walks, but once these primary needs have been met and public interest in a forest has been established then the evaluation of interpretive possibilities can be undertaken and an interpretive programme introduced. The Commission is developing a network of visitor centres in forests throughout the country. So far twenty-three centres have been opened, nine in England, ten in Scotland and four in Wales.

PARKER, E. J. (1978). *An annotated list of problems which affect some Zambian wild fruit trees*. TIRC/NCSR Research Paper No. 6.

Lists fungi, insects, and miscellaneous causes of damage affecting 14 of the more important species of wild fruit-bearing trees indigenous to Zambia. Such host tree species are priorities of, or candidates for, tree improvement research aimed at the domestication and commercial utilisation of tropical wild fruits. This paper collates information, including recent field observations by the author, on pathological conditions which can affect the host tree species. The documentation of such background knowledge is important, as the causes of damage could become potentially serious problems if plantations of improved host tree varieties were to be established.

PEPPER, H. W. (1978). *Chemical repellants*. Forestry Commission Leaflet 73.

Chemical repellants are used in parts of Europe and North America to aid establishment of forest trees by protecting them against browsing. When tested in British forestry plantations, however, repellants have rarely been effective, and have usually proved prohibitively expensive. Between 1965 and 1977 the Wildlife Research Branch of the Forestry Commission tested 34 repellants—31 proved inadequate; 2 suitable for forest use; and 1 suitable for garden use.

No effective systemic repellants have been found, so contact repellants only are available. A contact repellant requires repeated application since it is eroded by weather, and also any subsequent growth is unprotected. The repellants effective under British conditions are 'Aaproct', 'Dendrocol 17' and 'Fowikal'. Aaproct has consistently reduced over-winter browsing damage by 95 per cent against Roe deer, Fallow deer and rabbits. The manufacturers claim it will also prevent bark stripping by rabbits and clipping by hares. Dendrocol 17 appears to be similarly effective in preventing winter browsing by deer. Short-term protection of garden roses and ornamental shrubs against browsing by Roe deer may be obtained at any time of year with Fowikal. No repellant has yet been found that will prevent fraying damage by deer.

(ODAM, E. M.,) PEPPER, H. W. (and TOWNSEND, M. G.) (1979). A study of the persistence of warfarin on wheat bait used for the control of Grey squirrels (*Sciurus carolinensis*). *Annals of Applied Biology* **91**, 81–89.

Wheat was treated with ¹⁴C-warfarin sodium (0.02 per cent, w/v ai) using the recommended method for preparing bait for the control of grey squirrels (*Sciurus carolinensis* L.). The persistence of this anticoagulant on sterilised grain was determined by monitoring the rate of change of radioactivity in five different treatments. The time taken for the initial concentration of warfarin to decrease by half in the samples buried in three forests with different soil types varied between 9 and 60 days, and appeared to be correlated with the soil conditions and rainfall. Wheat kept in a hopper exposed to the weather showed no loss of warfarin during the 12 month study period, although warfarin was lost from a pile of bait left exposed on the soil surface.

A sixth radioactive treatment involved normal wheat (as purchased from a merchant) since most squirrel control work is done with unsterilised wheat. This showed that during the summer months when squirrel control is permitted the buried unsterilised wheat germinated, but there was no detectable radioactivity in the shoots. Warfarin was lost from both sterilised and unsterilised grain at similar rates when buried in the same forest.

PHILIPSON, J. J. and COUTTS, M. P. (1977). The influence of mineral nutrition on the root development of trees. II. The effect of specific nutrient elements on the growth of individual roots of Sitka spruce. *Journal of Experimental Botany* **28** (105), 864–871.

Sitka spruce seedlings were grown with divided root systems in sand culture and the application of N, P and K was varied while maintaining a complete supply of other nutrients. There was a localised stimulation of the growth of roots to which nutrients were applied and N produced the greatest stimulation; P was also important but K did not enhance growth.

Measurements of Ca and Mg concentrations in the roots showed that differential root growth, which is influenced by the concentration of N and P in the bathing medium, could not be adequately explained by the effect of N or P on the uptake of the immobile cations.

The two parts of the divided root system appeared to compete for assimilates; the enhanced growth of one root was accompanied by reduced growth in the other, and *vice versa*.

PHILLIPS, D. H. (1978). *The EEC Plant Health Directive and British forestry*. Forestry Commission Forest Record 116.

This paper discusses the EEC Plant Health Directive (77/93/EEC) and its background, in so far as it affects the forester and the arboriculturist. The directive aims to exclude dangerous alien pests and diseases from the EEC area and to limit the spread of some organisms at present only of local occurrence in the territory of the Member States. The paper gives brief notes on the pest and disease organisms concerned and summarises the measures prescribed against them. It also compares these measures with those in British plant health legislation before the United Kingdom became a member of the EEC.

PHILLIPS, D. H. (1978). Plant health regulations. (Summary of Forestry Commission Forest Record 116—The Plant Health Directive and British Forestry). *GC & HTJ* **184** (11), 33.

PHILLIPS, D. H. (1978). The EEC plant directive. *Quarterly Journal of Forestry* **LXXII** (4), 223–225.

PHILLIPS, D. H. (1978). EEC Plant Health Directive—forestry aspects. *Forestry and British Timber*, October 1978, 12.

These three titles refer to one paper, prepared at the request of the Tree Council to publicise the forestry aspects of the EEC Plant Health Directive, which is briefly summarised and explained.

(WILLIAMS, B. L., COOPER, J. M. and PYATT, D. G. (1978). Effects of afforestation with *P. contorta* on nutrient content, acidity and exchangeable cations in peat. *Forestry* 51 (1), 29–35.

Nutrient contents, acidity and exchangeable cations in the upper 300 mm of peat beneath Lodgepole pine have been compared with those in peat from contiguous unplanted areas at each of six sites. Nitrogen, phosphorus and potassium contents, which are significantly higher in flushed blanket bog peat than in peat from either raised bog or unflushed blanket bog, are not significantly altered by the presence of trees. Calcium and magnesium contents, on the other hand, although similar in peat from different bog types, are lower in peat beneath the tree crop. Exchangeable Ca^{2+} , Mg^{2+} and K^{+} are replaced by Na^{+} and H^{+} in planted peat but the increase in H^{+} content exceeds the loss of base cations, reflecting a higher number of exchange sites. This increase accounts for lower values of both base saturation and pH in planted peat and is attributed to enhanced decomposition promoted by aerobic conditions beneath the tree crop.

REDFERN, D. B. (1978). Infection by *Armillaria mellea* and some factors affecting host resistance and the severity of disease. *Forestry* 51 (2), 121–135.

Infection by *A. mellea* in Britain occurs by means of rhizomorphs; the transfer of mycelium at root contacts is probably not important as a means of spread. Following the initial phase of rhizomorph penetration, established infection in the cambium is preceded by ectotrophic spread of mycelium in the bark scales.

Field investigation confirmed reports in the literature that in susceptible conifers the greatest number of deaths generally occurs approximately 6–8 years after planting. However, attacks can also occur in much older crops and the reasons for this are discussed.

Inoculation experiments showed that suppressed trees and those experiencing conditions of reduced light intensity are more susceptible to infection than dominant trees and trees in full light. Species susceptibility in a variety of soils was studied by inoculation of trees 20–30 cm tall. Of the conifers tested *Pseudotsuga menziesii* and *Abies grandis* were more resistant than *Picea abies*, *P. sitchensis*, *Larix kaempferi* and *Pinus sylvestris*. *Quercus robur* and *Fagus sylvatica* were more resistant than all the conifers except *A. grandis*. Soil type influenced disease development and the proportion of trees infected was higher in an acidic sand soil than in an alkaline clay soil.

RENNOLLS, K. (1978). Top height, its definition and estimation. *Commonwealth Forestry Review* 57 (3) No. 173, 215–219.

It is shown that the concept of the top height of a forest stand has sometimes not been well defined and that some of the usual assumptions that are made in estimating top height are invalid. A straightforward extension of the usual definition of top height is shown to meet some difficulties. Finally, a simple practical alternative definition is proposed which overcomes all the difficulties discussed.

RICHARDS, E. G. (1977–78). Planting goals in Britain. *Arbor* 6 (3), 6–7.

The history since 1919 of successive Government policies on forestry is outlined and a case presented for further afforestation of poor agricultural land.

ROOKE, D. (1978). The cost of conifers. The Commission reply. *Rucksack* 9 (3) Spring, 12–13.

In reply to a previous article by the Forestry Action Group, this defends the Commission as regards current planting policies (landscaping, choice of species etc.) and the economics of Government investment in forestry. The point is made that the Commission's objectives and planting programme are decided by Parliament and thus indirectly by the public.

(SCHILLING, A. D. and) RUSHFORTH, K. D. (1978). *Prunus* affinity *himalaica*—a fine birch! *The Garden* 103 (10), 416–417.

An interesting *Prunus* collected in Nepal, which has a polished mahogany-coloured bark, is described. The tree was introduced as a seedling and at Kew was *Betula utilis* for some years. Propagation by cuttings of this and other small tree cherries is described.

RUSHFORTH, K. D. (1978). Tree genera—7. The spruces—*Picea*. *Arboricultural Journal* 3 (4), 246–255.

The morphological characters of *Picea* are discussed, noting the range of variation, with examples. Site requirements, methods of propagation, diseases and insect pests and growth characteristics are discussed with respect to cultivation in Great Britain. The species of *Picea* recognised are grouped together and described. The groupings used are: (a) *Picea omorika*. (b) *P. breweriana*. (c) *P. spiculosa*, *P. brachytyla*, *P. jezoensis*, *P. sitchensis*. (d) *P. bicolor*, *P. likiangensis*, *P. purpurea*, *P. glehnii*. (e) *P. abies*, *P. obovata*, *P. orientalis*, *P. maximowiczii*. (f) *P. glauca*, *P. rubens*, *P. mariana*, *P. engelmannii*, *P. pungens*, *P. mexicana*, *P. chihuahuana*. (g) *P. asperata*, *P. koyamae*, *P. polita*. (h) *P. wilsonii*, *P. morrisonicola*. (i) *P. smithiana*, *P. shrenkiniana*.

RUSHFORTH, K. D. (1979). Speak o' the riches and joys of Cathay. *Quarterly Journal of Forestry* LXXIII (1), January, 7–20.

Sino-Himalayan plants are important to the understanding and exploitation of our native and important exotic trees. The destruction of native stands places a great value on the genetic material introduced by plant collectors, such as Wilson and Forrest earlier this century, and this paper describes some of the trees of known wild origin, and others found on a tour of a score of English and Welsh gardens. The paper ends with a request for further information on other Sino-Himalayan trees of known wild origin.

STEWART, G. G. (1978). Inter-relations between agriculture and forestry in the Uplands of Scotland. A forestry review. *Scottish Forestry* 32 (3) July, 153–182.

The paper considers the relationship between forestry and agriculture in the Scottish uplands. It examines the large scale pattern of development of forestry which has taken place as well as the small scale pattern which has developed in conjunction with agriculture, and considers the advantages and disadvantages of each from the forestry point of view.

Conclusions are reached on a possible scale of development of forestry, the likely future pattern of the relationship between the two industries and the overriding importance of good land use as the principal criterion for land use decisions.

THOMPSON, D. A. (1978). *Forest ploughs*. Forestry Commission Leaflet 70.

This leaflet describes and defines ploughs available to the forester. Although the function and limitations of ploughs are outlined no discussion of evidence or use is included. Ploughing tractors are a subject in their own right and where they are named it is merely to indicate the size and configuration which has been found satisfactory. Single mouldboard ploughs can be made to throw either to the right or left and therefore no further mention will be made of this.

WALLIS, K. (1978). New developments for forestry spraying. *Forestry '79 A Farm Contractor specialist Annual*, p. 10.

A brief resumé of current spraying practice for herbicides and a review of current developments.

WITTERING, W. O. (1978). Research Note—an inflatable felling wedge. *Arboricultural Journal* 3 (4), page 256.

The Nordfeller wedge, made of fibre-reinforced rubber, is inserted in the felling cut and is inflated by the exhaust gases of the chainsaw engine. A pressure of up to 8 tonnes is available to bring the tree down.

WITTERING, W. O. and SAWYER, T. R. (1978). The time for the job. (The Rapco Data Recorder described). *Forestry & British Timber* 7 (7) August/September, 72–73.

The inaccuracies of the stop watch and the problems of re-studying standard timetables are described. A new British electronic time recorder, the Rapco Data Recorder, is basically free from these errors and after trials which are currently being undertaken, will replace the stop-watch.

YOUNG, C. W. T. (1978). *Sooty bark disease of sycamore*. DOE/FC Arboricultural Leaflet 3.

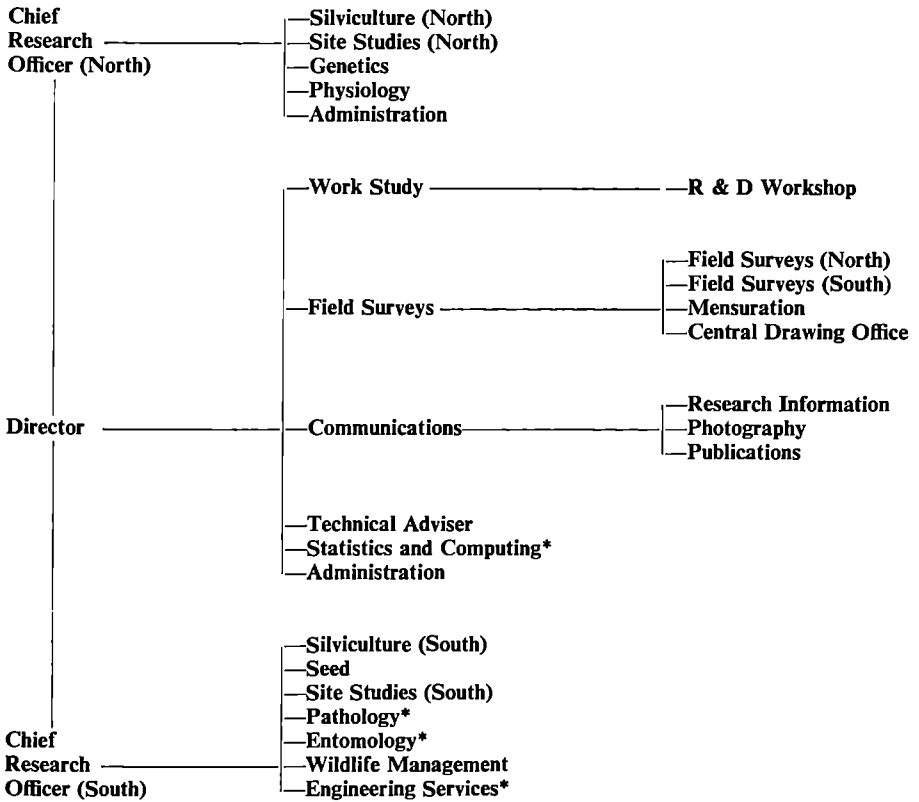
Cryptostroma corticale, the fungus that causes Sooty bark disease, was first found in 1889 growing as a harmless saprophyte on felled Sugar maple in Canada, and—except in two

instances—it appears as a saprophyte in subsequent N. American records. It was found in Britain in 1945, seemingly as a saprophyte on the dead standing remains of a broken sycamore stem in Wanstead Park, N.E. London; three years later it was again observed in the same park, but this time as the apparent cause of virulent disease in some 40 recently killed or dying sycamores. In the next two or three years the disease caused such mortality in and around Wanstead Park that it appeared a potential threat to the continued existence of sycamore in Britain, but by 1953 it had subsided and trees were no longer being killed. In the following two decades the disease did not develop much in places more than about 30 miles from London, and for most of that time it caused little appreciable damage, appearing in lethal form for only a year or two at irregular intervals before subsiding again.

In 1976 there was an unprecedentedly severe outbreak of Sooty bark disease, and its geographic range increased to places some 160 miles from London. This apparent change in the behaviour of the disease, however, was probably a consequence of exceptional weather conditions, and not of any inherent change in the causal fungus.

APPENDIX II

Research and Development Divisional Organisation



*Branches with sections at the Northern Research Station.

APPENDIX III

Staff Engaged in Research and Development

As at 31 March 1979

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. 0844 4 3101), 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. (<i>Alice Holt</i>)
Administration and Finance Officer N. E. Stutter, M.I.P.M. (<i>Alice Holt</i>)
Director's Secretary Mrs V. O. C. Lampard (<i>Alice Holt</i>)

Chief Research Officer (South) D. H. Phillips, M.Sc., Ph.D., F.I.Biol., M.I.For. (<i>Alice Holt</i>)
--	--

(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.(For.), M.I.For., Head of Branch

H. Insley, B.Sc.(For.), M.I.For., J. Jobling, B.Sc.(For.), A. F. Mitchell, B.A.,

B.Agric.(For.), V.M.H., G. Tuley, B.Sc.(For.), M.I.For., W. J. McCavish, B.Sc.(For.),

M.I.For., J. Evans, B.Sc.(For.), Ph.D., M.I.For.

Office: Miss K. A. Rhodes. Mrs P. Pharo

ARBORICULTURAL ADVISORY SERVICE (Department of the Environment)

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

F. R. W. Stevens

STAFF LIST

77

Research Foresters:

East England Region

P. W. W. Daborn	Centre
D. Elgy, J. B. H. Gardiner	Alice Holt
M. L. Pearce, M.I.For.:	Alice Holt
P. D. Howard, P. Marsh,	Alice Holt
C. W. Shanks, F. R. W. Stevens	Alice Holt
A. W. Westall: M. J. Scott	Bedbury Pinetum
I. H. Blackmore: P. R. Barwick	Thetford
D. A. Cousins	Westonbirt

West England Region

K. F. Baker: D. J. Lyons	Arboretum
T. J. Davis	Exeter
J. I. MacDonald, C. W. Webber	Dean
	Westonbirt
	Arboretum
J. E. J. White, E. Leyshon	Westonbirt
	Arboretum

SITE STUDIES (SOUTH) (*Alice Holt*)

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

Research Foresters:

D. F. Fourt, L.I.Biol.: N. Best, K. G. Shuker

Laboratory:

Mrs S. A. Wright: P. S. Wood, D. Goddard, Miss C. A. Howard, Mrs D. A. Waddell

Office:

J. G. Jackman

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.: 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,
 R. A. G. Coxwell, P. G. Risby

Laboratory:

Mrs S. A. Kirk, Miss T. C. Osborne, Miss M. K. Tepper:
 A. Jeeves, K. G. Crump

Office:

J. Empson: Mrs J. G. Anderson (Typist)

Northern Research Station

PATHOLOGY

D. B. Redfern, B.Sc., Ph.D., Head of Section

S. C. Gregory, M.A., Ph.D.

Research Forester: J. D. Low

Laboratory: Mrs H. Steele, B.Sc.

ENTOMOLOGY (*Alice Holt*)

D. Bevan, B.Sc.(For.), Head of Branch

Miss J. M. Davies, B.Sc., F.Z.S., C. I. Carter, M.Sc., M.I.Biol., D. Wainhouse, M.Sc., Ph.D., T. G. Winter

Research Foresters:

R. M. Brown, L.I.Biol.: D. J. Billany, C. J. King, C. Walker, B.A.*

Laboratory:

M. Jukes, L.I.Biol.: N. J. Fielding, J. I. H. Walker, Miss J. F. A. Nichols

Office:

J. Ellison

Northern Research Station

ENTOMOLOGY

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

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

*On 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.(For.), M.I.For., M.I.Biol.

Research Foresters: L. A. Tee: H. W. Pepper, P. R. Ratcliffe, B.Sc. (*Glenbranter, Strathclyde*); M. Roe, C. S. Taylor

Laboratory: Mrs B. A. Mayle, D. A. Brydon, Miss D. V. Kitson
Office: J. G. Jackman

SEED (*Alice Holt*)

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

Laboratory: D. C. Wakeman: Miss E. M. L. Bewick, Miss B. L. Nelson,
 Mrs A. A. Rees, B.Sc.: D. C. F. Rowe, B.Sc.: Miss E. Farr

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

ENGINEERING SERVICES (*Alice Holt*)

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

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

Chief Research Officer (North)

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

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

SILVICULTURE NORTH (*Northern Research Station*)

J. Atterson, B.Sc.(For.), M.I.For., Head of Branch
 R. Lines, B.Sc.(For.), F.I.For., P. Biggin, B.Sc.(For.), T. C. Booth, B.Sc.(For.), M.I.For.,
 K. F. Miller, B.Sc.(For.), M.I.For., R. McIntosh, B.Sc.(For.), M.I.For., D. A. Thompson,
 B.Sc.(For.), M.I.For.

Research Foresters:

Special Projects J. Hunt: J. G. Whyatt

Centre

Northern Research
 Station

North Scotland Region W. G. Paterson

Newton, Grampian

North Scotland Area C. E. S. Fleming

Lairg, Highland

North East Scotland Area C. H. Blackwood: G. R. Menzies
 D. Yeats

Newton, Grampian

North West Scotland Area N. Mackell: D. S. Coutts

Fort Augustus,
 Highland

Central Scotland Region J. H. Thomson

Northern Research
 Station

East Scotland Area A. L. Sharpe: J. D. Lindsay

Perth, Tayside

South East Scotland Area A. H. Reid: J. B. McNeill

Northern Research
 Station

West Scotland Area A. R. Mair: E. A. Crofts

Kilmun, by Dunoon,
 Strathclyde

Borders and North England Region E. Baldwin

Mabie, Dumfries and
 Galloway

STAFF LIST

79

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

SITE STUDIES NORTH (*Northern Research Station*)

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

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

GENETICS (*Northern Research Station*)

R. Faulkner, B.Sc.(For.), M.I.For., Head of Branch

A. M. Fletcher, B.Sc., Ph.D., A.I.W.Sc., M.I.For., G. I. Forrest, B.Sc., M.Sc., Ph.D.,
J. G. S. Gill, B.Sc., M.I.For., C. J. A. Samuel, B.Sc., Ph.D.

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

Laboratory: Miss A. P. Ash, Mrs L. J. H. Lomax

PHYSIOLOGY (*Northern Research Station*)

M. P. Coutts, B.Sc., Ph.D., Head of Branch

J. J. Philipson, B.A., Ph.D.

Laboratory: Miss M. Brown, Miss B. A. Eaton, B.Sc., Miss H. M. Grieve, B.Sc.

ADMINISTRATIVE STAFF (*Northern Research Station*)

F. W. C. McLauchlan

T. Lees: Mrs M. Brown, Miss S. Marron, J. W. Ralston,
Miss S. J. Cochrane, Miss E. K. M. C. Inglis

Typists: Mrs L. B. Barr (Superintendent): Mrs L. M. Connolly,
Mrs S. M. Swan, Miss E. McGuigan, Mrs I. G. Armit, Mrs
P. McKenzie

Telephone Operator: Mrs A. A. Martin

Messenger: C. Stewart

WORK STUDY (*Alice Holt*)

A. J. G. Hughes, B.Sc.(For.), M.I.For., Head of Branch

R. O. Smith, B.A., M.M.S., M. J. R. Ingoldby, St. J. G. D. Bland-Flagg, M.M.S.

Machinery Research and Development

R. B. Ross, M.I.Mech.E.

W. S. Mackenzie

Office: W. E. Powell: Mrs P. J. Holcombe, Mrs J. N. R. Burbidge,
Mrs R. J. Hales (Typist)

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

FIELD SURVEYS (*Alice Holt*)

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

FIELD SURVEY SECTION

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

Foresters stationed at Alice Holt:

D. Case, M. D. Whitlock

Foresters stationed throughout England and Wales:

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

Foresters stationed throughout Scotland:

R. F. Bartlett, J. Straiton: J. Boluski, N. Bonsfield, F. W. E. Burlton, A. R. Brown,
D. G. Caird, J. Davidson, G. R. Dunbar, D. E. Ellis, R. Evans, H. Gillen, J. A.,
McIntyre, H. Schneider, M. R. T. Spornagel, A. A. Tait, G. Taylor, D. S. Whitaker,
P. J. Williams

MENSURATION SECTION

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

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

CENSUS SURVEY SECTION

W. T. Waters, N. D. F.

Foresters: A. C. Miller, R. W. Twallin
Office: Miss S. M. Haywood

DRAWING OFFICE (*Edinburgh*)

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

STATISTICS AND COMPUTING (*Alice Holt*)

R. S. Howell, Head of Branch

R. C. Boswell, B.Sc., M.I.S., G. J. Hall, B.Sc., K. Rennolls, B.Sc., M.Sc., I. M. S. White, B.Sc., M.Sc., Miss J. Smyth, B.Sc.: R. Gill, B.Sc., M.Sc., Mrs M. J. White

Research Foresters: A. E. Coates, C. A. Thorne*Data Processors:* Mrs E. Butler, Mrs A. P. Daborn, Mrs P. F. Newell, Mrs S. M. Nicholls*Office:* S. Hankin, Miss C. I. Derrick: Mrs A. H. Clements (Typist)STATISTICS AND COMPUTING (*Northern Research Station*)

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

Mrs J. Thompson, M.I.S.* G. D. Bell, B.Sc., B. G. Miller, B.Sc.

Data Processors: Mrs W. M. Slater, Mrs M. StanleyCOMMUNICATIONS (*Alice Holt*)

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

RESEARCH INFORMATION SECTION

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

P. J. Langley, M.A.: Miss C. W. Bradshaw, B.Sc. (Librarian): Miss C. A. Woods, Mrs M. Butt, Mrs L. D. Birchall (Typist)

PHOTOGRAPHY SECTION

I. A. Anderson, F.I.I.P., Head of Section

Mrs T. K. Evans, F.R.P.S., J. Williams (Graphics Officer), Miss M. Trusler

PUBLICATIONS SECTION

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

Mrs A. C. Costain: S. Potheary

TECHNICAL ADVISER (*Alice Holt*)

W. H. Hinson, B.Sc., Ph.D.

ADMINISTRATIVE STAFF (*Alice Holt*)*Branch A:* Mrs D. R. Harper*Branch B:* Miss E. Johnson*Establishment:* Miss J. R. Lacey: Miss G. B. Hayden, Mrs W. B. Groves, Miss L. M. Raggett, Mrs S. Locke: Mrs K. Padley*Finance:* M. G. Wheeler: Miss S. Addinall, Mrs C. A. Yeomans*Office Services:* L. W. Thomas: Mrs K. S. Butcher: Miss E. Angus*Typists:* Miss M. Hopkin (Superintendent): Mrs E. L. Allen, Mrs B. E. Dickinson, Mrs F. E. Edwards, Mrs J. Richardson, Mrs E. A. Walters*Photoprinters:* F. H. Khawaja: Miss E. A. Hill*Telephone Operators:* Mrs E. A. R. Empson, B.E.M., Mrs J. M. Plant*Receptionist/Messenger:* Mrs L. Gower*Messengers:* D. M. Chandler, F. C. Tompkins*Gardens:* D. Worsfold*Workshop:* R. H. Butt

*Seconded: Staff Side Secretary.

*FOREST RESEARCH, 1979**Other Headquarters Staff*PLANNING AND ECONOMICS DIVISION (*Edinburgh*)

A. J. Grayson, M.A., B.Litt., M.I.For., Head of Division

R. J. N. Busby, B.Sc., M.Sc., F.I.For., M. F. Garforth, B.Sc., R. Q. Oakes, B.A., R. Whyte,
B.Sc.(Econ.), M.Phil., R. A. Cochrane*Office:* Miss M. O'HareHARVESTING AND MARKETING DIVISION (*Alice Holt*)

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

MECHANICAL ENGINEERING DIVISION (*Alice Holt*)

W. J. Muddle

INDEX

	<i>Page</i>		<i>Page</i>
Arboriculture	12, 14, 23, 34	Nutrition	19, 21, 41, 49, 52, 61
Bark	51	— amenity trees	12
Beech bark disease	32	<i>Panalis flammea</i>	35, 36
Bees	35, 36	Paperpots	10
Broadleaves	10	Phenology	23
<i>Bupalus piniaria</i>	35	Pheromones	36
Census of woodlands	41	Pine	
<i>Cephalcia lariciphila</i>	35, 36	—, beauty moth	35
Coppice	14	—, looper moth	35
Cultivation	18, 22, 23	<i>Pinus muricata</i>	11
Decay	34	— <i>radiata</i>	11
Deer	38, 57, 59	Planting	
Defoliants	13	—, coal tips	14, 23
Disease, Dutch elm	30, 33	—, motorway	13
—, other	32, 33	—, urban	13
Drainage	21	Ploughing	18, 42
Drought	13	Pollution	17, 52
Exposure	20, 28	Propagation	10, 16, 26, 54
Fenitrothion	37	Provenance	11, 17, 25, 26
Flowering	26, 28, 53	Recreation	49
Foliar sampling	21	Repellants	39
<i>Fomes annosus</i>	29, 45	Restocking	19
Gibberellin	9, 26, 53	Root growth	19, 29
<i>Gilpinia hercyniae</i>	36	<i>Scolytus</i> spp.	30, 37
Glyphosate	12	Seed	
Harvesting	42, 49	—, orchards	26
— whole tree	21	—, pre-chilling	8
Herbicides	10, 11, 15, 42, 56	Seedbeds	8, 15, 56
<i>Hylobius abietis</i>	37	—, fluid-drilling	9
<i>Ips typographus</i>	37	—, irrigation	8
Lachnids	38	Shelterbelts	18
Monoterpenes	26	Soil	
Motorway planting	13	—, gley	18, 24
Nectar	36	—, indurated	24
Nothofagus	10, 13, 17, 21, 33, 39, 52	—, ironpan	24
		—, peat	24
		Squirrels	38, 58
		<i>Tilia</i> spp.	36
		Tissue culture	54
		Wind	19, 20
		—, throw	20

Enquiries relating to this publication should be addressed to the Publications Officer, Forestry Commission Research Station, Alice Holt Lodge, Wrecclesham, Farnham, Surrey GU10 4LH.

FORESTRY COMMISSION PUBLICATIONS

SELECTED ISSUES

Reports

58th Annual Report of the Forestry Commissioners for the year ended March 1978 (£2.50)

Report on Forest Research for the year ended 31 March 1978 (£2.25)

*Control of Pine Beauty Moth by Fenitrothion in Scotland (£2.50)

*The Wood Production Outlook in Britain (£2.00)

Bulletin

No. 14. Forestry Practice (£3.50)

Booklets

No. 26. Volume Ready Reckoner for Round Timber (80p)

No. 46. Managing Small Woodlands (90p)

Leaflets

No. 65. Group Dying of Conifers (30p)

No. 67. Rabbit Management in Woodlands (50p)

Forest Records

No. 77. Hedgehogs (50p)

No. 120. Pine Beauty Moth

Arboricultural Leaflets

No. 3. Sooty Bark Disease of Sycamore (40p)

No. 4. Virus and Virus-like Diseases of Trees (70p)

(Postage extra)

Published by Her Majesty's Stationery Office and obtainable from Government Bookshops at the addresses shown overleaf (post orders to P.O. Box 569, London SE1 9NH) or through booksellers.

A Catalogue of Publications will be sent on application to Publications Section, Forestry Commission Research Station, Alice Holt Lodge, Wrecclesham, Farnham, Surrey GU10 4LH.

*Available only from the Forestry Commission at the above address.

HER MAJESTY'S STATIONERY OFFICE

Government Bookshops

49 High Holborn, London WC1V 6HB

13a Castle Street, Edinburgh EH2 3AR

41 The Hayes, Cardiff CF1 1JW

Brazennose Street, Manchester M60 8AS

Southey House, Wine Street, Bristol BS1 2BQ

258 Broad Street, Birmingham B1 2HE

80 Chichester Street, Belfast BT1 4JY

*Government publications are also available
through booksellers*